ORDNANCE FIELD GUIDE

VOLUME III

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ORDNANCE FIELD GUIDE

RESTRICTED

Edited by

LT. COL. Wm. C. FARMER

VOLUME III

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Dedication

This manual is dedicated to our comrades-in-arms of the Ordnance Department who have gone into the combat zones all over the world in support of the Arms and Services in their struggle against the Axis.

Their resourcefulness, initiative, and devotion to duty through month after month of arduous labor under difficult and hazardous conditions should serve as 'Guide' to the Ordnance Department for many years to come.

It is especially dedicated to those Ordnancemen who left their families to serve their country on Bataan, in Africa, Italy, France, Germany, Burma, China, and many other far-flung battlefields, and who will never return.

Contents

The Ordnance Field Guide

In the years to follow the defeat of Germany and Japan, the United States must play a major role. Regardless of what particular plan for the maintenance of security and peace may finally be adopted, one thing, at least, is certain: Our army must be ready to do its part in the great work. This work calls for an army flawlessly equipped, and thoroughly trained. Ordnance is both determined and prepared to do its part by insuring to that army the finest ordnance equipment and the best trained ordnance personnel in the world.

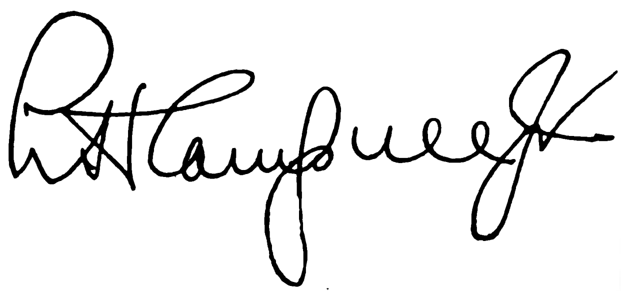
The experience of World War II has shown, to even the casual observer, the prime importance of that mobility and firepower which modern ordnance provides. And to the trained military mind ordnance now, as never before, spells the difference between success and failure.

The myriad changes in ordnance during World War II complicate and increase the study and the work of our ordnance officers to a vast extent. The training of our ordnance officer corps, one of the prime charges of the Ordnance Department, must not only be effective but it must be complete. Each man must possess, in addition to a mastery of his own special subject, a sweeping knowledge of modern weapons, a working acquaintance with all automotive practice and a comprehensive understanding of an officer's duties and responsibilities.

To provide for this training, many have felt the need of a supplement to the hundreds of Technical Manuals and Training Courses, each of which treats exhaustively of a single subject. Not only is it desirable to have the outlines of many manuals, course texts, and training aids in one book but this book should incorporate the military knowledge and experience which could be compiled only from all available sources.

To prepare this compendium of modern ordnance a large group of ordnance officers and enlisted men volunteered to work on such a project. Lt. Col. William C. Farmer, a member of the Staff and Faculty of the Ordnance School, Aberdeen, Maryland, headed the group. Their material has been drawn from very many sources: Textbooks, manuals, service magazines, directives, dispatches, reports of observers from every battlefront and throughout the world, and last, but not least, their own vast store of experience.

How well Colonel Farmer and his associates have accomplished the important work with which they were entrusted, is revealed in the pages which follow.



Major General, Chief of Ordnance

Preface

After several years of service with ordnance troops and staffs, both in the United States and overseas, it was the feeling of the editor that a definite need existed for a 'manual' of such broad scope that it would serve as an encyclopedic 'guide' and 'self-educating' text for ordnance officers in the field. The "Ordnance Field Guide" has tried to meet this challenging assignment.

This manual covers a wide range of material. Principal sources appear in the bibliographies which are appended to the various subjects discussed, and which also furnish a ready guide to the many War Department publications that cover in greater detail the various matter pertaining to the organization and administration of the Army, the technical and military subjects, and the materiel, functions and operation of the Ordnance Department here presented. Other sources are: Ordnance School and industrial textbooks, service magazines, standing operating procedures, ordnance plans, administrative orders, and other data obtained from overseas theaters, reports, conference notes, lectures, observers' reports, and the combined knowledge of some 200 Ordnance officers and enlisted men who have compiled and written the original manuscripts for the various sections of the manual.

Each officer and enlisted man who has contributed to this book is a specialist in some particular phase of ordnance operations or materiel. Many of them have served in the field, in Alaska, the Aleutian Islands, Australia, the Caribbean Area, the Far East, Guadalcanal, the Hawaiian Islands, Italy, the Middle East, New Guinea, New Hebrides, North Africa, Sicily, and the United Kingdom. Practically every type of ordnance field duty, with troops or staffs, is represented by their experiences. The Silver Star, the Legion of Merit, the Purple Heart, and the star-studded campaign ribbons worn by various contributors attest to their wide range of field activities. Every specialized course of instruction on ordnance materiel and operation offered by the various Ordnance schools is represented by a contributor to this work. Many of these officers are also graduates of the Command and General Staff School (in either the general or service staff course) or of other service schools.

The contributors have donated their services with no other remuneration than the satisfaction of aiding in a work that should help many ordnance officers to assimilate more quickly many of the complexities of their profession, thereby contributing to the efficiency of the entire Army and the war effort of the Nation.

The royalties from the sale of this book will be donated to the Army Emergency Relief Society.

In re-writing and editing the work of the various contributors, there has been no attempt to conform to a single standard of writing, and naturally many styles will be encountered due to the large number of contributors. All have attempted to treat the subject matter assigned to them in a 'down-to-earth' manner, and have tried to cram as much 'meat' as possible in the space allotted.

The data contained herein is *not* to be considered official. In using this manual, the reader must bear in mind that the composition, size, and duties of units and the quantities and types of equipment allotted to units are subject to constant change. In making field use of the data contained in this book, a check should first be made as to whether the then existing units and equipment are based on T/O & E's which are later than those upon which the discussions in this manual are based.

Similarly, ordnance materiel is subject to re-design and improvement and operational technique improves with added experience.

All ordnance equipment charts, tables of organization and equipment, and similar material reproduced herein, in whole or in part, bear the official War Department designation and the date of issue.

It is suggested that the reader post any changes or revisions which might be later issued from official sources in his copy of the "Ordnance Field Guide." In this way, the book can be kept up-to-date and will retain its value as an accurate source of information.

The editor felt that in a work of this nature continuity of subject matter was most important. Therefore, there are no cross-references on minor subjects, although larger subjects have been cross-referenced when deemed necessary. It was believed, however, that the repetitions of information in the Guide would serve a useful purpose.

A study of this Guide cannot be expected to make the reader an expert in any one subject, but it should give a useful background for nearly every situation with which the ordnance officer can reasonably expect to be confronted in the field. It should also lay the groundwork for any specialization the reader might wish to pursue at a later date.

The original intention of the editor was to prepare an ordnance textbook of broad scope as a guide for training purposes. Due to the advanced state of Ordnance Training for World War II, a compromise between a textbook and a field reference guide has been compiled to serve for the duration of the present conflict.

The editor contemplates a revision of the "Ordnance Field Guide" shortly after the termination of the present war. It is expected that the experience gained in the editing of this edition, coupled with the many ordnance lessons of the war which will be available at that time, should enable the preparation of a much more comprehensive and cohesive textbook. A standardized set of books of this type would in the opinion of the editor be of extreme value in the post-war training of ordnance officers and troops, whether at ordnance schools, ordnance training centers, civilian colleges, or in the field. Criticisms, suggestions, and contributions from ordnance personnel, both in the garrison and in the field, will therefore be welcome at any time, and will be used to the fullest extent in the contemplated future revisions of this manual. They should be sent to the editor at the address below noted.

Special acknowledgment is made to Col. Willis R. Slaughter, Commandant, The Ordnance School, for making available the facilities of The Ordnance School during off-duty hours for research, illustrations and typing. The "Ordnance Field Guide" would not have been possible without his encouragement, appreciation and whole-hearted support.

Col. L. A. Codd, Executive Assistant to the Chief of Ordnance who took a personal interest in the Editor's idea for such a Guide, did much to make the project possible.

The Editor cannot conclude this preface without stating that he has been most effectively assisted by Major John B. Scott in the overall and detailed planning editing, rewriting and coordinating of the material for the volumes of this work.

WILLIAM C. FARMER,
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Staff and Faculty
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January 1, 1945.

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The following officers and enlisted men of the Ordnance Department have contributed their time and efforts in compiling and writing the original manuscripts on the various subjects covered in this volume. The amount of work done ranges from one or two hours on some of the smaller contributions to many, many hours taken from their limited spare over a period of two or three months.

No attempt is made to give specific credit to a particular writer, but all contributors are listed under the pertinent chapter heading. In some cases an article or a portion thereof was prepared by the Editor or by those assisting him.

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CHAPTER 1

BOMB RECONNAISSANCE AND DISPOSAL

INTRODUCTION

Bomb Disposal is one of the newest, smallest, and least known branches of the rdnance Department. Its work, nevertheless, is of vital importance since its urpose is to make possible the smooth flow of supplies wherever the enemy has ried to interrupt it by attacks from the air. Since every Ordnance officer in the ield is very likely to find himself in a position where he will require the assistance f a bomb disposal unit, it is essential that he know something about the history, rganization, and background of this Ordnance branch as well as the type of work t does.

HISTORY

Prior to the current war there was no need for scientific disposal of dud ammuition, because artillery fire fell only in combat areas where it was of little danger o any vital part of the battle, or where it could readily be blown up if it were. erial bombing was still in its infancy and amounted to nothing more than an lternate method of using artillery projectiles, because the first World War was vell under way before anyone thought of designing a bomb specifically for use rom an airplane.

The air blitz on Britain in 1940, however, made it painfully apparent to the ritish that dud bombs were no longer harmless items which could be carried way or blown up where they lay. About 10 per cent of all the bombs dropped on he British Isles during those first years of the war failed to explode and, with he number of bombs dropped as high as it was, that meant a great many unxploded bombs lying about the factories and cities. These might well have been isposed of by former methods with little loss of life had it not been for the fact hat as many as seventy-five out of a hundred, in some raids, were not duds, but ombs with delayed action fuzes which would explode sometime during the three r four days immediately following the raid. The introduction of time fuzes made very dud a potential menace. The average citizen, air raid warden, or soldier was ot able to tell which bombs were likely to blow up in a short time and which ere not. The constant detonating of bombs for days after each raid kept the opulace in a state of nerves, which did not bode well for the general welfare. gain, the fear that some unexploded bomb might not have been located and ould be lying under one's home or workbench, its clock ticking off the hours of ife left to the worker, had a harmful effect on the nation's production. Factories hut down for days at a time because of the presence of a bomb which might well ave been removed by properly trained personnel. The consequence of this was prompt call for volunteers to meet the new menace; and with the formation of n organization to deal with the problem, bomb disposal was born.

Britain's early volunteers knew nothing much about the missiles which were ausing so much trouble, but they had been chosen for their sound technical backrounds and for their courage, both of which qualifications were quickly put to e test. Their methods for handling various types of fuzes were learned by trial nd error, and, while successful trials were welcomed, errors were invariably ostly. It is the information gained by these courageous men and paid for with eir blood that made bomb disposal what it is today—a scientific and technical rocedure for handling and rendering safe unexploded bombs or other missiles.

The need for bomb disposal in the United States was foreseen, because of British xperience, before we became actively engaged in the war. In 1941 the problem as carefully studied with the result that responsibility for the disposal of unxploded bombs was given to the Ordnance Department. Shortly after the attack n Pearl Harbor, a group of officers and noncommissioned officers was dispatched England to study the subject at first hand, and simultaneously the Bomb Disosal School at Aberdeen Proving Ground was organized. While the American ission was in England, a group of British officers and enlisted men came to this untry to handle the training of the first classes of the new school. The English officers were all men with outstanding records in bomb disposal operations i England, and they brought with them a complete line of the equipment they ha developed to deal with unexploded bombs. Obviously, the first American bom disposal men were organized and trained to use British methods and equipmen It was not long, however, before our own research and development staff bega to devise methods which, upon being put to the test in the field, proved wholl satisfactory for the purposes for which they were intended; and, since the forma tion of American bomb disposal, many new tools have been adopted. Today Amer ican bomb disposal troops are located on every fighting front equipped wit American tools and trained in American methods none of which were adopte without sufficient field testing to insure their adequacy.

While modern bomb disposal methods have been standardized to some exten each bomb really presents a special problem of its own. A study, however brie of the following pages should convince the reader that the problem is a comple one with variable factors that are almost endless. It is not the purpose, howeve of this text to go into any very detailed description of either enemy fuzes o methods used by the Allied Nations of handling them. The latter subjects ar classified information to serve as a protection to bomb disposal men on the fightin fronts, because it has been learned through bitter experience that the enemy use what he learns of our techniques to construct deadly booby traps.

There are two main divisions to bomb disposal work. The first is known as bom reconnaissance. It consists of the recognition of various items which the enem or ourselves might drop, combined with the knowledge of how one can tell whethe or not an unexploded bomb is present under various confusing conditions as we as a method for protecting all personnel concerned while a report is submitte and a bomb disposal unit summoned. The term 'UXB' is a contraction commonl used to refer to unexploded bombs. Originally, reconnaissance was not considere a necessity since it was thought that anyone who found a bomb could call th proper help for the disposal of it. However, bomb disposal units in the Britis Isles were kept so busy answering false alarms that special training was decide upon as the only means by which true reports could be obtained, and a consequer saving of time and highly trained manpower achieved.

The second division of bomb disposal work is, of course, Bomb Disposal itself- the job of defuzing missiles and removing them to bomb cemeteries for final dis position. This job involves considerably more technical knowledge than bom reconnaissance since the bomb disposal man must not only be able to do every thing done by the reconnaissance man, but also must know how to get at a bom regardless of where it may be (a case is on record of a 20mm shell recovere from a man's body by the joint efforts of a surgeon and a bomb disposal officer must know how to make it safe, which involves a complete understanding of a fuzes currently in use as well as all which might possibly be used, and must kno how to get it out of its resting place, and move it carefully through populate areas to a safe place for its final disposal.

Before passing to some of the technical aspects of the subject, it may be interest to note that, since the early days of bomb disposal in England, the origin ideas regarding its purpose have changed considerably. The reader will recall th it was originally conceived in order to keep production from bogging down and uphold civilian morale. More recently it has been learned that bomb dispos troops are even more valuable for the protection and maintenance of supply, con munication, and replacement lines in battle areas and even for the clearing beaches in landing operations. It is no longer, then, a service which is tied close to the civilian defense organization of a country, but actually a part of the comb team wherever that team may be functioning. Bomb disposal is now on the offe sive, rather than on the defensive. This close association with combat troops h brought other problems to the bomb disposal units in the field. Because the specialized knowledge of ammunition is of such great assistance in that type work, they are frequently called to clear munition dumps of booby traps. This, course, has brought about the addition of mines and booby traps to the course study which each BD man must undergo before being sent to the field. Su knowledge immediately led field commanding officers to use their available bon disposal units for booby trap removal work in many cases where engineer troo were not available in sufficient numbers to handle the situation. It should be emphasized, however, that this is not the main function of bomb disposal units, but, rather, a sort of "extra added attraction."

Introduction to Bombs

Disposal and reconnaissance personnel must be able to identify known bombs of all the warring nations and to make a good guess as to type and functioning of any types which might be encountered and which are as yet unknown. To do this satisfactorily it is important to know some general principles of bomb construction as well as to determine upon standard terminology.

Bombs are hollow projectiles containing explosive materials which are fired by means of a fuze either at a predetermined time after being released by the carrier plane, upon impact with the target, or at a predetermined time after impact with the target.

Suspension Lugs are eye bolts, T-lugs, or other devices on a bomb by means of which it is carried in the planes bomb rack. The number, type and location of these lugs on a bomb are important features in identifying it.

Fuzes are the devices by which the detonation of the explosives within a bomb is initiated. They may be located in the side of the bomb, in its nose, and/or in its tail. More detailed consideration will be given these items later.

Charge/Weight Ratio is the percentage obtained by dividing the weight of explosive material by the total weight of the loaded bomb.

Base Plates are the means by which the rear end of the bomb body is closed off. They are often known as filler plugs although that title is not too accurate since they very frequently are not plugs and many times are not the points at which the bomb is filled. Base plates may be of five general types:

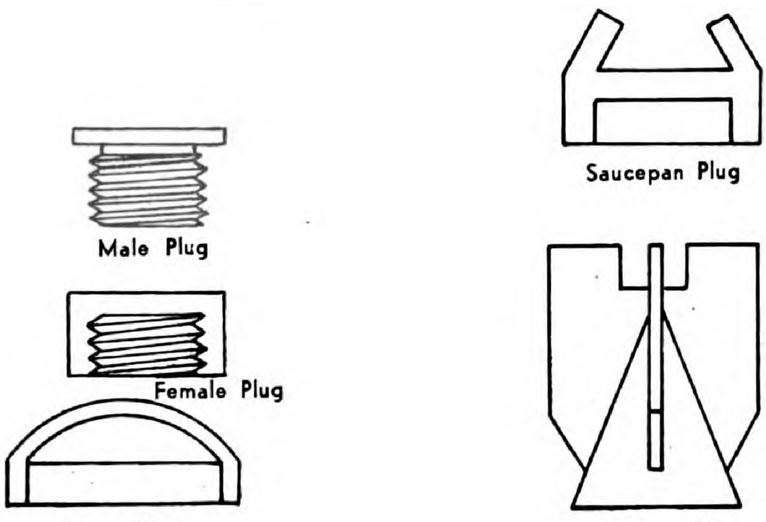


Figure 1. Base Plate.

Male plug: A male type plug which screws into the base of the bomb to close it.

Female plug: A female type cap which screws over a neck on the base of the bomb.

Dome plug: A semihemispherical plate which fits over the entire rear end of the bomb and is held in place either by screws, rivets, or its own threading.

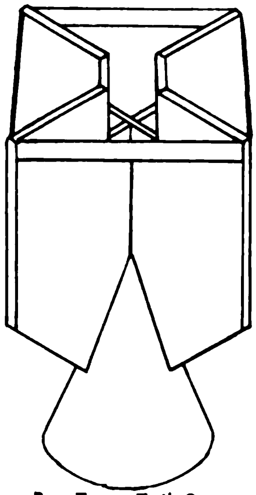
Saucepan plug: An angle-type plate which fits into the rear end of the bomb and to the upper flange of which is screwed or riveted the bomb's tail assembly.

Tail cone plug: In some bombs, notably the Japanese, the explosive content is precast and may run completely back into the tail cone. In this type of bomb, there is really no base plate, the entire tail assembly actually taking its place and acting as part of the bomb body.

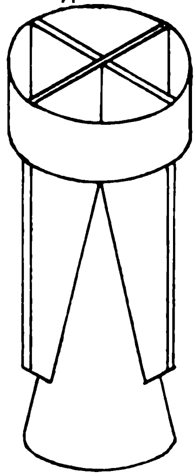
Tail Assembly is the most distinguishing feature in the identification of most bombs. There are a great many types which will be described in further detail when specific bombs are dealt with. For present purposes let us speak of general principles of tail construction only.

The tail cone is the conical shaped portion, the base of which fits the base of the bomb and to the sides of which are fastened the tail vanes. In some bombs, particularly the American, there is no real tail cone, the tail assembly clamping directly to the bomb body without any cone to act as joiner.

The tail vanes serve the same purpose on a bomb as do the feathers on an arrow, namely to guide it more accurately in flight and to cause it to strike the target nose first. Tail vanes may be full blades, solid from one end to the other; they may be cut out to leave room for the propeller blades of a tail fuze; or they may be nothing more than rods to support the tail struts, as is frequently seen in Italian bombs. Another point to check when examining the tail assembly of a bomb is the place at which the tail vanes form their lowest point of contact with



Box Type Tail Strut



Ring or Crown Type Tail Strut

Figure 2. Types of Tail Struts.

the tail cone. It might be at the base of the cone or at any distance up the sides—such location being a definite characteristic of the bomb in question.

Types of Tail Strut. The box type and the ring or crown types are the principle types seen in the field. The former, when looked at from the end forms a square, while the latter has a circular shape. Struts may be made of metal rods or strips or may be wide bands of metal. They may be riveted, screwed, or welded to the tail vanes or they may be an integral part of them as is the case with the cast magnesium alloy tail assemblies used on some German and Italian bombs.

One other feature to watch for in examining tail assemblies is the method of fastening them to the bomb body. Is it screwed, riveted, welded or clamped? How many screws or rivets are used, what material are they made of, and how are they arranged?

Bomb Bodies. In the examination of a bomb, its body should be carefully studied. There are streamlined bodies, those which are totally lacking in ballistic design, and all intermediate stages. The bodies may be one piece forgings or castings, well or poorly machined. They may be made of several pieces welded or riveted together. There may be special attachments on the body which would serve to help identify the bomb. The color and the markings have very definite significance and should be carefully noted. Further details in this respect will be given later.

With these general points established, we can now proceed to a consideration of the various types of aerial missiles.

Generally speaking there are four types of missiles which may be dropped from the air:

1. High Explosive Missiles.
2. Chemical Bombs.
3. Pyrotechnics.
4. Containers.

The most important of these are the High Explosives which include High Capacity, General Purpose, Semi-Armor Piercing, Armor Piercing, Anti-personnel and Anti-Submarine Bombs as well as Navy Mines. These H.E. Missiles range in weight from items of less than a pound to the large British 12,000 lb. bombs commonly known as triple block busters.

High Capacity. A new development in the manufacture of H. E. bombs has recently been highly publicized. These are the large bombs which the British call High Capacity. Their weight is usually measured in tons rather than pounds since they come in two, four, and six ton sizes. Their principle characteristics are a lack of ballistic design and a very high charge/weight ratio. The latter point is the cause of the former since the terrific blast of the detonation of these bombs makes it unnecessary to design them for pin-point accuracy. In other words, these bombs are not streamlined in the slightest degree, but, rather, have the appearance of a huge water boiler with a square bomb tail on one end.

General Purpose. These bombs, frequently called demolition bombs, are used for area pattern bombing and are intended to do damage more by means of the blast they create than by striking any specific target. As a consequence their cases are usually straight sided and their charge/weight ratio is high (from 45 to 70 per cent). The bomb, of course, has a thin case (from ¼ to ½ inch thick) which breaks into small fragments roughly at 45 degree angles along the edges. These bombs have fine blast effect and good earth shock if they penetrate the ground before exploding.

Semi-Armor Piercing. Bombs of this type are a sort of compromise between General Purpose and Armor Piercing Bombs. They are used against specific targets of large size. Their cases are usually slightly streamlined and their charge/weight ratio is moderate (from 25 to 45 per cent). The case of this type bomb is generally a one piece forging, often turned on a lathe and having a thickness from one-half to one inch. Fragmentation of semi-armor piercing bombs is relatively good with small fragments broken at 45 degree angles.

Armor Piercing. For attacking specific small targets such as ships, docks, and submarine pens, armor piercing bombs are used. The streamlined case aids in directing the bomb accurately while its thick case (1 to 2 inches) holds it together until it has penetrated to the inside of the target where its delay fuze causes it to detonate. The charge/weight ratio is, of necessity, low (from 4 to 25 per cent) and as a consequence the blast effect is poor. This is of small consequence, however, since the detonation takes place in a confined area where the low blast is magnified by the condition of confinement. This is the type of bomb which is often propelled by rocket or jet propulsion and, sometimes, directed by radio.

Anti-Personnel. Frequently called fragmentation bombs, these missiles are used to cause casualties among personnel or often to damage light material such as airplanes. They weigh from one to several hundred pounds and have a low charge/weight ratio. Their fragmentation is very good usually due to special case design, although some very find fragmentation bombs have cases which are merely castings. Other types of case design include the compressed helical spring used for some Italian and American types, concrete with imbedded fragments as found in German and Italian types, and specially grooved or serrated cases similar to the standard American hand grenade.

Anti-Submarine. This missile is actually an aerial depth bomb and is designed to spring the plates of a submarine by the concussion of its underwater detonation. It needs no streamlining and so has straight sides and blunt nose with a thin case and very high charge/weight ratio. The fuze may be an impact or hydrostatic type.

Navy Mines. Fall into three categories. *Contact mines* are moored and must be struck by a ship if they are to fire. *Controlled mines* are not aerial missiles at all, but are fired by means of a switch on shore. *Influence mines* fire when a ship passes either due to its magnetic field or due to the sound of its engines. Influence mines are usually dropped by parachute. They have very light cases made of some non-magnetic metal, usually aluminum. These mines, therefore, have high charge/weight ratios and high blast effect if dropped on the ground. They may have impact fuzes in case they land in areas other than water. The Navy mine disposal units are charged with disposal of these weapons and, since they utilize a large number of very tricky mechanisms no Army personnel, including bomb disposal, should handle or approach such missiles. If reconnaissance must be performed, it should be done without noise and without any magnetic metal on the person of the reconnaissance agent.

Figure 3. German Parachute Mine.

Chemical Bombs. Second to high explosive bombs in importance, are chemical bombs, not because anyone has used gas bombs so far in this war, but because incendiaries fall under this classification. Chemical bombs include incendiary, smoke, and gas bombs.

Incendiaries can be divided into three principle types known as: combustible case, combustible filler and incendiary, and anti-personnel bombs. The combustible case type is one with a case made of some material, such as magnesium, which will burn if sufficient heat is applied to it. These bombs have a small primer ignited by a fuze. The primer ignites a filler which develops enough heat to cause the case itself to burn. A typical filler would be thermit. The combustible filler type incendiary may be one with a thin case filled with some combustible material which is ignited and scattered by a bursting charge, or this type may have a strong case for penetration. In the latter instance, when the bomb explodes, the main filling is either ejected through the base of the bomb, or blown out by rupture of the case. Bombs off these types might contain gasoline, petroleum jelly, phosphorous impregnated pellets, thermit pellets, etc.

The last type of incendiary is one with a scattering charge which is large enough to make approach to the bomb dangerous and so gives the fire a good start, or one with an anti-personnel bomb attached to the incendiary proper.

Incendiaries may weigh anything from one pound up to five hundred pounds or more. The smaller types are dangerous because the great numbers in which they are dropped make the firefighting problem of a city a very difficult one. Although it has been estimated that eighty per cent of the small incendiaries will land in streets and parks, and only half of the rest will start fires, an idea of the problem can be gained by recalling that a single plane can carry from one to two thousand of this type of bomb and can drop them over an area of, roughly, three miles by one quarter mile. Since ten per cent of the bombs dropped will start fires, we can picture one plane causing from one to two hundred house fires in that area. Multiply that plane by ten and we have from one to two thousand fires. Then remember that a large city even with help from its neighbors is not normally equipped to handle more than fifty fires simultaneously, if that many. To this problem add the water mains broken by the high explosive bombs from an additional forty bombers and you have some idea of the near impossibility of coping with a fifty plane air raid using small incendiaries.

Smoke. Bombs of this class are either an adaptation of the combustible filler type incendiary or a specially designed bomb. In either case, they are thin-walled and filled with some chemical designed to produce a heavy smoke.

Gas. Bombs for dropping gas are, like smoke bombs, either adaptations of combustible filler incendiaries or specially designed. Among the latter we find very thin-walled bombs containing persistent gases and requiring no bursting charge. Among the former type are the bombs used to spread non-persistent gases.

Pyrotechnics. These bombs include the signals and the flares and flash bombs used for night reconnaissance.

Parachute Flares have aerial burst fuzes which cause the flare container to open in mid-air or to kick out the parachute from which is suspended a candle or group of candles. The latter are ignited either by their own fuze or by the same fuze which opened the container. The burning candles then float slowly earthward lighting up a large area for an extended period of time. Unexploded flare bombs can be dangerous to personnel. Untrained troops should not touch either the flare, its container, or the parachute.

Photoflash bombs are used for night photography. They look very often like other bombs or like containers. They use no parachute and make only an instantaneous flash. These bombs, too, are dangerous if found unexploded since they develop a tremendous amount of heat.

Signals. Are usually float type flares which are used to mark the position of airmen forced down at sea. They burn for a long time with a bright flame.

Containers. After an air raid, the area under attack is usually littered with containers of many varieties. Some look much like bombs, while others may have characteristics of their own. The important thing to remember about them is that many of them contain burster charges which can easily kill a man and consequently they are not to be tampered with. Certain types of gasoline and other tanks are, of course, wholly harmless. A reconnaissance agent will order them to be removed directly. Others, such as the containers for small anti-personnel bombs, incendiaries, etc., he will order to be placed under guard until bomb disposal personnel can be brought.

Introduction to Fuzes

A fuze is a device which initiates the explosive train which, in turn, causes the main explosive content of the bomb to detonate. It should not surprise the Ordnance soldier to learn that quite complicated mechanisms are often employed for this purpose, but there are a great many people (including some service personnel) who are under the impression that a bomb explodes in much the same fashion as a paper bag full of water when dropped from a third floor window onto a straw hat. Actually, of course, the main explosive charge in a bomb is too insensitive to fire merely due to the shock of impact with the ground. If this were not the case, it would be impossible for a plane to jettison its load over friendly territory when necessary. The main charge of a bomb must be set off by a much smaller quantity of somewhat more sensitive explosive known as the booster. The latter, in turn is fired by a smaller charge known as the detonator which is ignited by the primer, a very small quantity of highly sensitive explosive. The entire chain of events is known as the explosive train and can be visualized by means of an analogy. To light a piece of coal, we do not apply a match directly, but rather use a chain, similar to the one above, in which the match is the primer, the paper is the detonator, the kindling wood is the booster and, finally, the coal is the main charge. In this latter case, the person who strikes the match is performing the function of the bomb's fuze. The primer may or may not be an integral part of the fuze. If it is not, the fuze is often called a pistol to distinguish it from other fuzes which actually contain the explosive primer.

Fuze Types by Functioning

Fuzes may be classified in several ways such as the means employed to fire them and the purpose for which they are employed. By means of firing, they break down in to four classes: mechanical, electric, chemical, and clockwork. Actually, of course, a clockwise fuze is a mechanical device, but there is such a large number of clockwork fuzes and they are so specialized that it is considered advisable here to make a separate classification.

Mechanical Fuzes function either by direct action, by means of a cocked striker, or due to inertia. The direct action fuze consists of a striker usually held away from the primer cap by means of a shear pin and having some form of external projection which will, upon impact with the target, drive the striker inward, shearing the shear pin, and causing the striker to hit the primer. This type fuze is always a nose fuze since it must make direct contact with the target.

The cocked-striker type fuze depends on some action, such as inertia, to free a spring-loaded striker and allow the spring to drive the striker into the primer. A case similar to this is the way by which pressing a trigger frees the striker in a pistol or rifle. If a cocked rifle were dropped and the jar of hitting the ground caused it to fire, we would have a functioning almost identical with the type of bomb fuze we have been discussing.

Inertia type fuzes usually depend on a striker which, when the fuze is armed, is held away from the primer only by a small spring. Upon impact with the target, the striker's weight overcomes the resistance of the spring and the striker moves so as to hit the primer.

Electric Fuzes depend upon the heating of a fine wire to ignite the primer instead of upon the action of a striker. There are several sources from which the current may originate, namely a battery, a condenser, or a generator. In the case of battery and condenser type fuzes, there must be some sort of switch in the circuit designed to close at the proper time and so permit passage of current through the wire which is known as the firing bridge. The most common switches are: (1) a coiled spring suspended inside a metal ring; (2) a metal ball on a piece of wire also hung inside a metal ring so that vibration will cause the ball to touch the ring; (3) a little mercury in a non-conducting tube with two electric contacts so that movement of the tube will cause the mercury to bridge the contacts; (4) some sort of direct action switch closed either by inertia, by the movement of a rod which extends out of the bomb itself, or by direct contact with the ground obtained by placing the switch outside of the bomb and connecting it to the fuze by cables. Battery type fuzes, of course, contain their own charges. Condenser type receive their charges from batteries in the plane. Arming time lag is obtained in this type fuze by passage of the current from one condenser through a resistance to a second condenser. Generator type fuzes obtain their current either by rotation of vanes or by induction caused by passage of a magnetic bar through a coil.

Chemical Fuzes are designed to fire at some more or less predetermined time after release from the plane. In general they depend upon the release of a chemical which eats upon some type of material which is used to restrain a cocked striker. When the material is sufficiently softened by the chemical action the striker is freed and its spring forces it into the primer.

Clockwork Fuzes are essentially alarm clocks in which a cocked striker is freed instead of the hammer which rings the alarm. They vary in their time intervals from a matter of seconds (for use with flares, containers, etc.) to several days. These fuzes are very tricky to handle, at times, since the clock ıy stop and, upon being disturbed, may start again and run out their time thout further failure.

Fuze Types by Purpose

[f fuzes are to be classified by purpose rather than by method of functioning, : can say that there are impact fuzes, aerial burst types, proximity, hydrostatic, d protective fuzes.

Impact Fuzes. It is possible to break this type of fuze down into four classifi- :ions dependent upon the time at which the fuze fires, *i.e.*, instantaneous, short lay, long delay, and time delay fuzes. Before considering each of these in tail, let us consider the requirements of a good impact fuze regardless of its lay time. Firstly, this type fuze, as with any fuze, in fact, must be safe to rry. Without this feature a fuze would be apt to cause more casualties among : side using it than among the enemy. Safety features for this purpose will ry from simple safety pins, which keep the striker away from the primer, to ıborate collar devices, or they may consist of simply not having any explosive ıterial in the fuze at all as previously mentioned for pistols. A second feature a good impact fuze would be possibility of jettisoning, that is, the fuze must so built that the bombardier can, if necessary, drop the bomb without permitting e fuze to function. It is often necessary to unload bombs over friendly terri- ry, and in such cases we must have a means for keeping the fuze from function- g. This might be simply a method for preventing withdrawal of the safety vice at the time the bomb is dropped. In mechanical fuzes this is the generally cepted method for jettisoning. In electric fuzes of the condenser type, a arge is not introduced into the fuze at the moment of release, as it would under normal conditions. A third feature of a good impact fuze is the ming time lag. Every fuze is unarmed before it is dropped. If it were not, would not be safe to carry since any untoward jar might cause it to function. ıe method of arming it (analogous to cocking a rifle) must be such that the ze is not armed while still in or close to the plane. There must be a time lag fore it arms so that any bump against the bomb bay doors will not cause it to e, and also so that it will not explode if dropped from the plane on the takeoff, while the plane is flying at too low an altitude. The arming time lag, then, otects the plane from its own bombs. It is achieved by various methods pendent upon the type of fuze and the type of bomb in use. In some cases, r instance, it might be nothing more than a spring-loaded safetybolt which is ld in place by a small cotter pin. The cotter pin is withdrawn by means of long wire (the arming wire) fastened to the plane itself. When the bomb lls to the end of the arming wire, the cotter pin is withdrawn from the fuze d the spring throws the safety bolt out, arming the fuze. It might be, as is ry common, propeller blades which rotate and unscrew a locking bolt or some her device from the striker thus allowing it to function. This method of taining arming time lag can vary from vanes which need to rotate only half dozen or so times as with certain British fuzes, to those, like some of our vn, which must rotate five hundred or more times. In electric fuzes of the ndenser type the lag is obtained by means of resistances inserted between con- nsers. We have already mentioned that impact fuzes may be built to give layed action bursts. A good thing for an impact fuze to have, then, would be me method for making a choice between two or more delays. This point would especially advantageous if the choice could be made at the moment the bomb dropped since it would give the bomber a choice between high and low vel bombing after he was out on the mission whereas such choice having to made before the fuze is placed in the bomb limits the bomber to one course action. For instance, a bomb with a fuze having a ten second delay can be opped from much lower altitude than one with a 0.1 second delay, since the rmer would give the plane plenty of time to get out of range before the tonation. The 10 second fuze, of course, would have to have a much shorter ming time lag than the high altitude fuze, since the first would be in the air much less time than the second. Other qualifications of a good impact fuze e those which might be applied to any Ordnance materiel, which is to say, should be reliable, of simple design, economical to manufacture, and lastly must be storageable.

Instantaneous fuzes are impact fuzes which fire the moment the bomb hits any material resistance to its flight. The primer in such a fuzė flashes directly into the detonator. These fuzes are used for high altitude bombing where blast or fragmentation is desired.

Short delay fuzes are used to allow time for the bomb to penetrate a target before detonating. They are most commonly used with armor piercing or semi-armor piercing bombs and have delays of, say .01 to several tenths of a second. The delay is generally achieved by means of a powder train which is ignited by the primer and which in turn ignites a flash pellet which fires the detonator.

Long delay fuzes are for the purpose of allowing the dropping plane to get clear before the explosion. They are generally used in low altitude bombing and their delays may range from several seconds to a matter of minutes.

Time delay fuzes are used for the value of the delay before explosion; that is, for the damage to the enemy's morale, for the interruption of his production and other activity, and to make him afraid to approach any 'dud' bomb which might be dropped. These fuzes cause delays from five minutes to more than one hundred hours.

Aerial Burst Fuzes. In order to open containers in midair, or to fire photo-flash bombs, parachute flares, and similar missiles, aerial burst fuzes are used. They may function by means of clocks, powder trains, electrical generators, or direct action of some sort. The delays which are used vary with the altitude at which the burst is desired.

Proximity Fuzes. These are intended to give a burst just prior to the moment at which the bomb strikes the ground. Many attempts have been made to achieve a good proximity fuze, but the best method so far of achieving the same result has been in the use of a super quick impact fuze with some sort of rod sticking out of the nose of the bomb to transmit jar to the fuze before the bomb itself actually strikes the ground. The most successful proximity fuzes as such have been barometric types. The Germans attempted a fuze early in the war which depended upon air pressure in a tube, but it was later modified to include a rod running through the tube and sticking out the forward part of the bomb. A good proximity fuze would be of great value in attacks against troops and light ground installation because it would give the maximum blast and fragmentation of which the bomb is capable.

Hydrostatic Fuzes. Depth bombs and similar missiles use fuzes which fire underwater. To achieve this result, a fuze must function either on impact with the water with a short or long delay, or it must fire due to the water pressure itself after the bomb has penetrated. The latter is the more satisfactory since a hydrostatic fuze can be designed to give a burst at some definite depth.

Protective Fuzes. There are three types of protective fuzes. First, the 'anti-withdrawal fuze' is used to protect time delay fuzes and prevent the enemy from pulling them out of the bomb before they have a chance to fire. Before the use of anti-withdrawal fuzes, it was standard practice to simply pull out the time fuze and remove its detonator. Now that is no longer possible. This effect is achieved in several ways. Either some device is placed in the fuze pocket back of the fuze to make any withdrawal of the latter fire the bomb; or such device might be built directly into the fuze itself; or, as is the case with the Japanese, some sort of locking device can be built into the fuze or fuze pocket so that the fuze simply cannot be withdrawn although any attempt to do so need not detonate the bomb. Once it was impossible to withdraw a fuze, it become necessary to devise some means for preventing bomb disposal personnel from working on fuzes while they were still in the bomb. This was achieved by means of the anti-disturbance fuze, which is a device designed not to arm itself until some time after the bomb has hit the ground and come to rest. Once it is armed, however, it is far more sensitive than the normal impact fuze, and any attempt to move the bomb or any jarring of the bomb is quite likely to fire this fuze. The third protective fuze is the self-destroying fuze, a device meant to keep the enemy from learning certain features of construction in bombs or fuzes. For instance, radio-guided glider bombs have self-destroying fuzes in their radio sets to keep the enemy from learning the wave length at which the bomb is guided. These may be simple impact fuzes with small explosive charges, or they may be elaborate time fuzes of various types.

For the purpose of uniformity among the Allies in identification of fuzes and as an aid in co-ordinating reports on new fuzes recovered, a system of designation has been used which is different from the Japanese designation. Mechanical impact nose fuzes are designated as A type; mechanical impact tail fuzes as B type; time fuzes as C type; and aerial burst fuzes as D type.

Let us, then, proceed to an examination in greater detail of the subject matter which bomb disposal involves, always remembering that a great deal of classified material has been omitted and that the reader, consequently, should not consider himself qualified to handle 'hot' bombs and fuzes simply by reason of having studied this text.

GERMAN BOMBS

German objects dropped from planes may be classified according to their construction and use as follows:

High Explosive Bombs	Pyrotechnics
Chemical Bombs	Containers

High Explosive Bombs

High Explosive Bombs have steel bodies filled with explosive substances, and are grouped according to use and construction as follows:

Demolition Bombs;
Anti-Personnel Bombs;
Navy Mines, (Not generally within the scope of Army bomb disposal activity, and therefore not discussed in the text).

Demolition Bombs, generally referred to as HE bombs, vary in size from 50 Kg. to 2,500 Kg. (1 kilogram being 2.2 lbs.), and are used primarily to destroy installations. This group of bombs may readily be identified by having a cone and four fins to form the tail assembly. This tail assembly is attached to the base of the bomb body by means of screws. German demolition bombs differ from those of other nations in that they use an electrical fuze which is located in a traverse fuze pocket. This fuze pocket is a metal cylinder which extends through the diameter of the bomb body near its center. There may be one or two of these fuze pockets in the bomb. The body and tail of the bomb may be dark green, sky blue, black, aluminum, or olive drab in color. Demolition bombs are suspended horizontally in the plane by means of a single eye bolt in the case of small bombs and by a single 'H' type suspension lug for large bombs. The bomb has a filler cap or plug at the base of the bomb body to confine the explosive filler. Demolition bombs are manufactured in five types to be most effective against different types of targets.

They are:

Spreng Bombe Cylindrisch;	Panzer Cylindrisch Rakete Satz;
Spreng Bombe Dickwandig;	Radio Controlled Bombs.
Panzer Bombe Cylindrisch;	

The Spreng Bombe Cylindrisch (explosive bomb thin walled), having a wall ¼" to ¾" thick and a high charge weight ratio, comparable to that of U.S.G.P. bombs, produces a powerful blast effect and is effective against light construction. The S.C. bombs are produced in the following sizes; 50 Kg., 250 Kg., 500 Kg., 1,000 Kg., 1,800 Kg., 2,500 Kg. These bombs are recognized by having a tail cone and fins of sheet steel with a yellow stripe on the cone between each of the fins. They usually have a body of three pieces, the heavy nose and base being welded circumferentially to parallel side walls. The S.C. 250 Kg., S.C. 500 Kg., and S.C. 2,500 Kg. are the only German bombs having two fuze pockets and therefore the bombs generally fuze with long delay and anti-handling fuzes.

The Spreng Bombe Dickwandig (explosive bomb thick walled), having a wall ½" to 1½" thick and a charge weight ratio comparable to that of U.S. semi-armor piercing bombs, is able to penetrate buildings of ordinary construction without breaking up. Due to the thick case which breaks up into good sized fragments, the small S.D. bombs have excellent effect against personnel. The large S.D. bombs, equipped with short delay fuzes, are effective against lightly armored installations and vehicles. The S.D. bombs are manufactured in the following sizes; 50 Kg., 250 Kg., 500 Kg., 1,700 Kg. These bombs are recognized by having a tail cone and fins of sheet steel with a red stripe on the cone between each of the fins. The S.D. 1,700 Kg. has a blue stripe on a yellow stripe, and is of one-piece case or forged steel construction. S.D. bombs have only one fuze pocket.

The Panzer Bombe Cylindrisch (armor bomb), having a very thick wall 1½" to 2", a heavy nose, and a low charge weight ratio comparable to that of the U.S.A.P. bomb and being of one piece cast or forge steel construction, is able to penetrate an armored target without breaking up. When equipped with a short delay fuze, this bomb is most effective against armored ships and ground

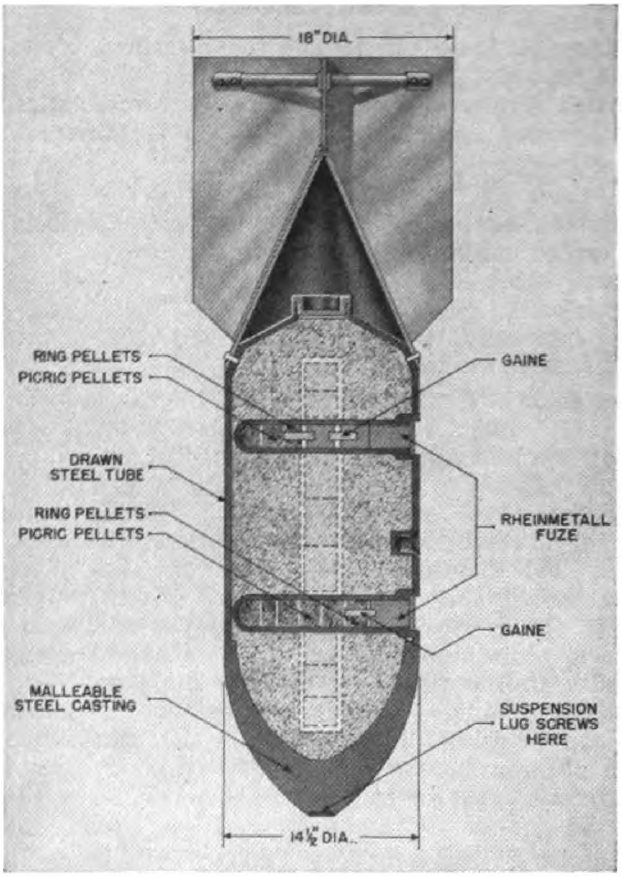


Figure 4. 250 Kg. German Demolition Bomb. Spreng Bombe Cylindrisch.

installations. P.C. bombs are manufactured in the following sizes; 500 Kg., 1,000 Kg., 1,400 Kg. The bombs are recognized by having a tail cone and fins of light magnesium alloy, with a blue stripe on the cone between each of the fins. P. C. bombs have only one fuze pocket.

The type of tail assembly used on S.C., S.D., and P.C. bombs, in addition to giving the type of bomb, also indicates the size of the bomb. The 50 Kg. bombs have no supports between the fins. The 250 Kg. and some 500 Kg. bombs have box-type struts, ⅝" steel rods extending at right angles from each fin and welded to each fin. The remaining 500 Kg. bombs and all larger bombs have ring type struts, a band approximately 6" wide surrounding the four fins and welded to or cast with the fins.

Attachments found on S.C., S.D., and P.C. bombs include:

The Kopfring; The Dinort Rod.
The Stabo;

The Kopfring is a steel ring triangular in cross section which fits around the nose of the bomb to present a flat surface ½" to 2" wide. The purpose of the Kopfring is to increase impact and therefore to reduce the penetration of the

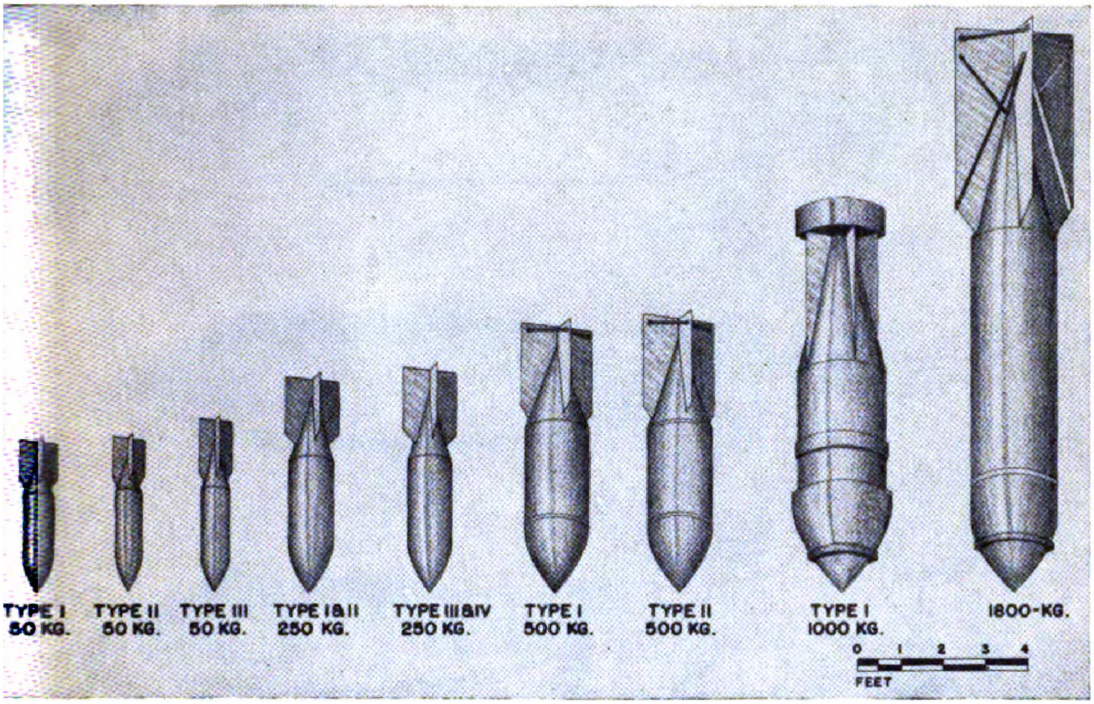


Figure 5. German Bombs, General Purpose.

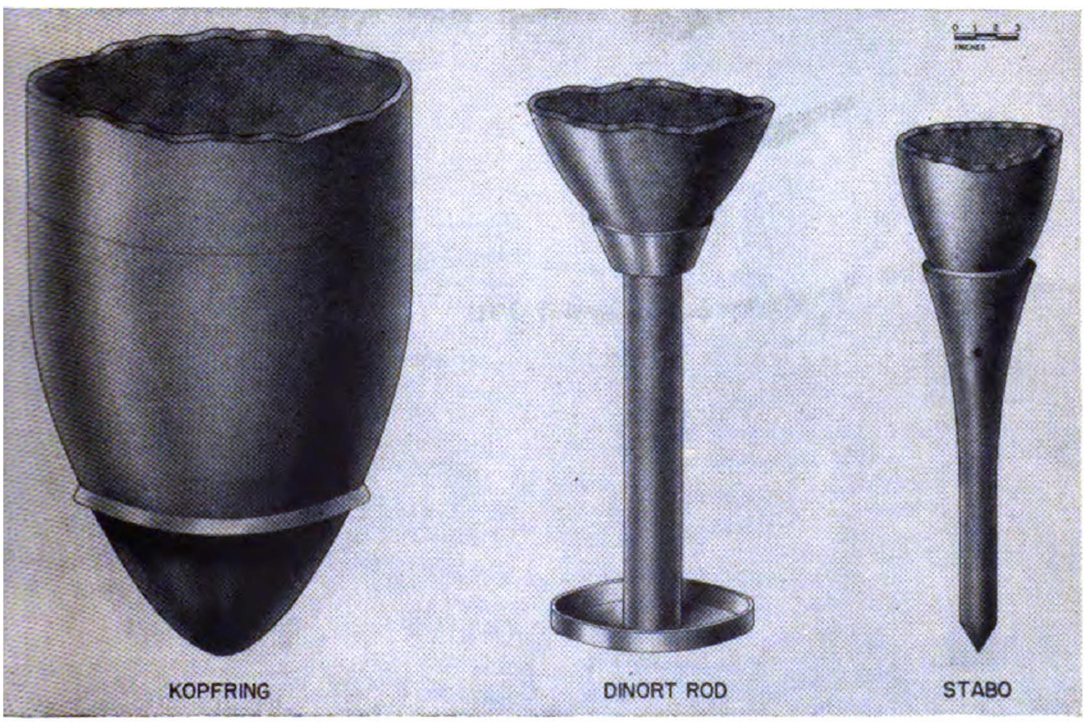
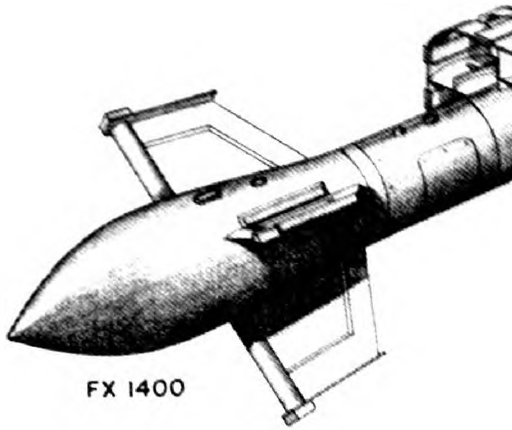


Figure 5a. Kopfring-Dinot Rod-Stabo.

1000 KG
PCRS



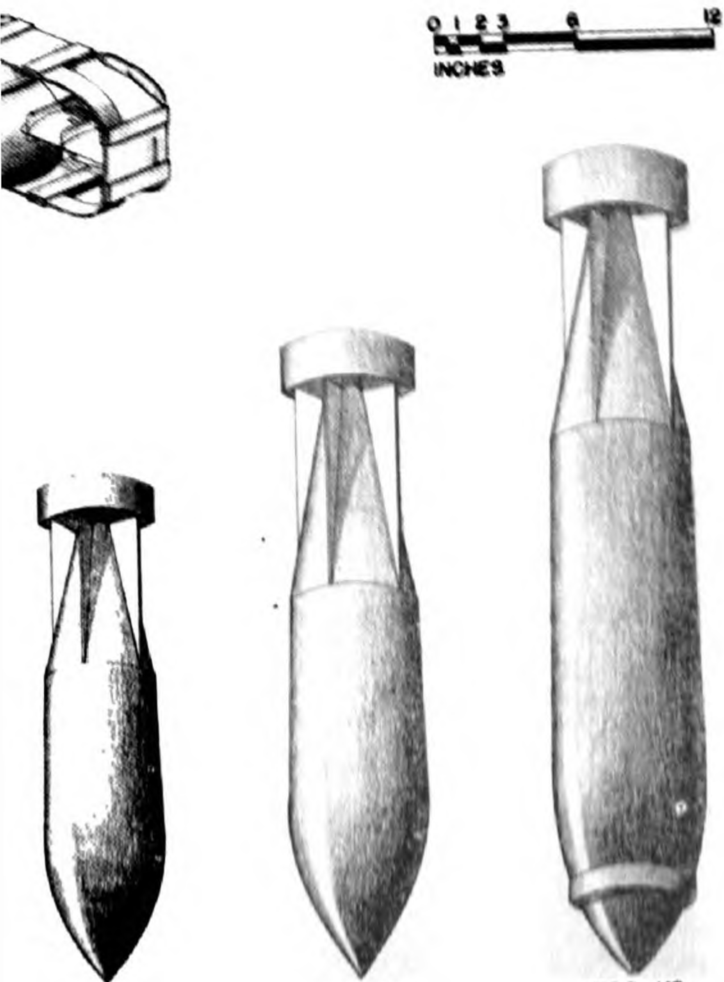
FX 1400

50 KG

250 KG

TYPE II
500 KG.

TYPE I
500 KG.



1000 KG   1400 KG   1700 KG

German Bombs

bomb prior to detonation. The Kopfring may be welded to large bombs or attached to small bombs by a bracket bolted to the nose of the bomb.

The **Stabo** is a steel spike 1¾″ to 3″ in diameter, 18½″ to 27½″ long, pointed at one end with a female thread at the other. The bomb must have a short adapter with male threads and welded on the nose to receive the Stabo. The Stabo

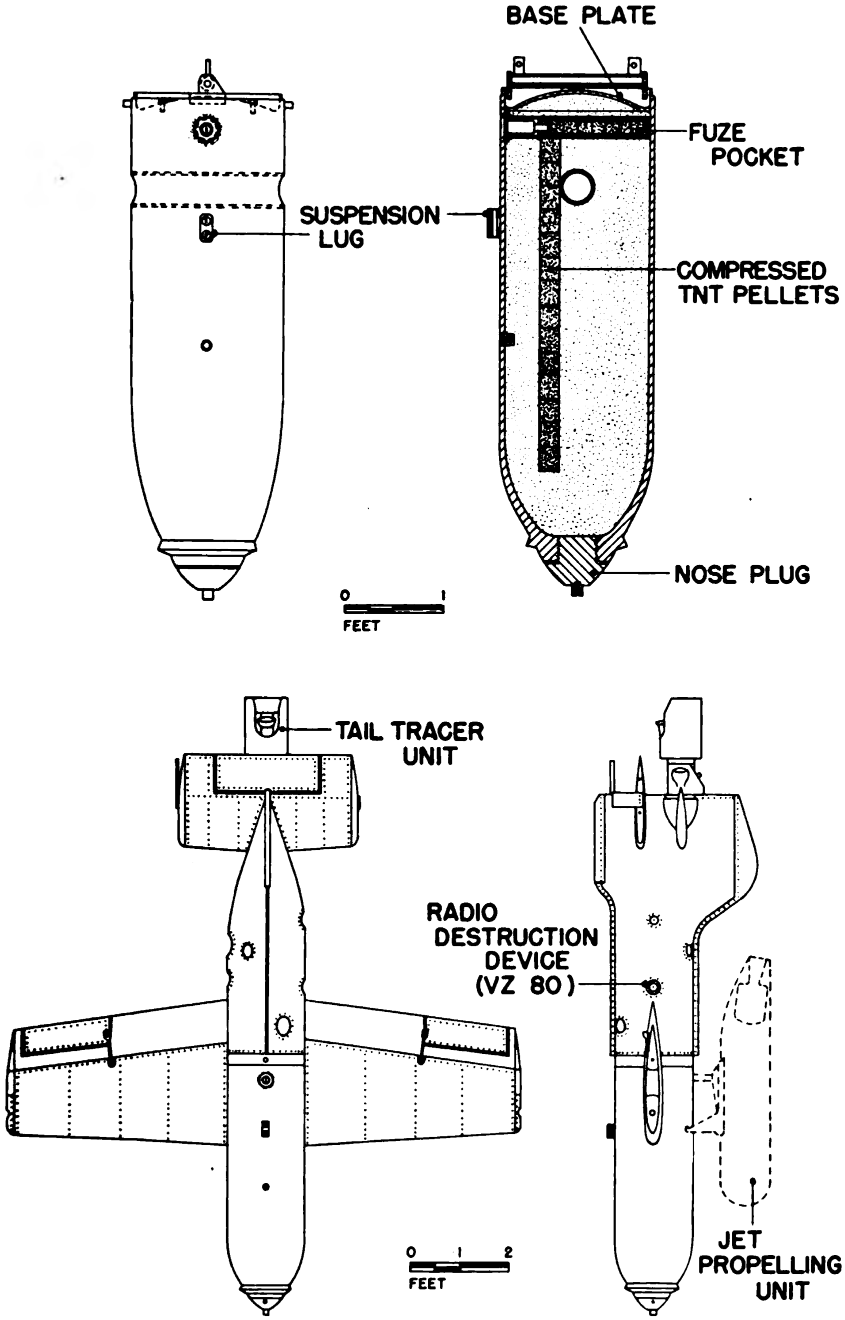


Figure 6a. Radio Controlled, Jet Propelled, Glider Bomb HS 293.

prevents the bomb from ricochetting when dropped from low altitude. The Stabo is generally used with the S.C. 250 Kg. and S.C. 500 Kg. which have two fuze pockets and the S.D. 70 Kg. which has the threaded nose adapter case as part of the bomb body.

The **Dinort Rod** is a C.I. pipe 3″ in diameter and 14½″ to 23½″ long with a plate 4½″ to 12½″ in diameter at one end, and a cup at the other end that fits

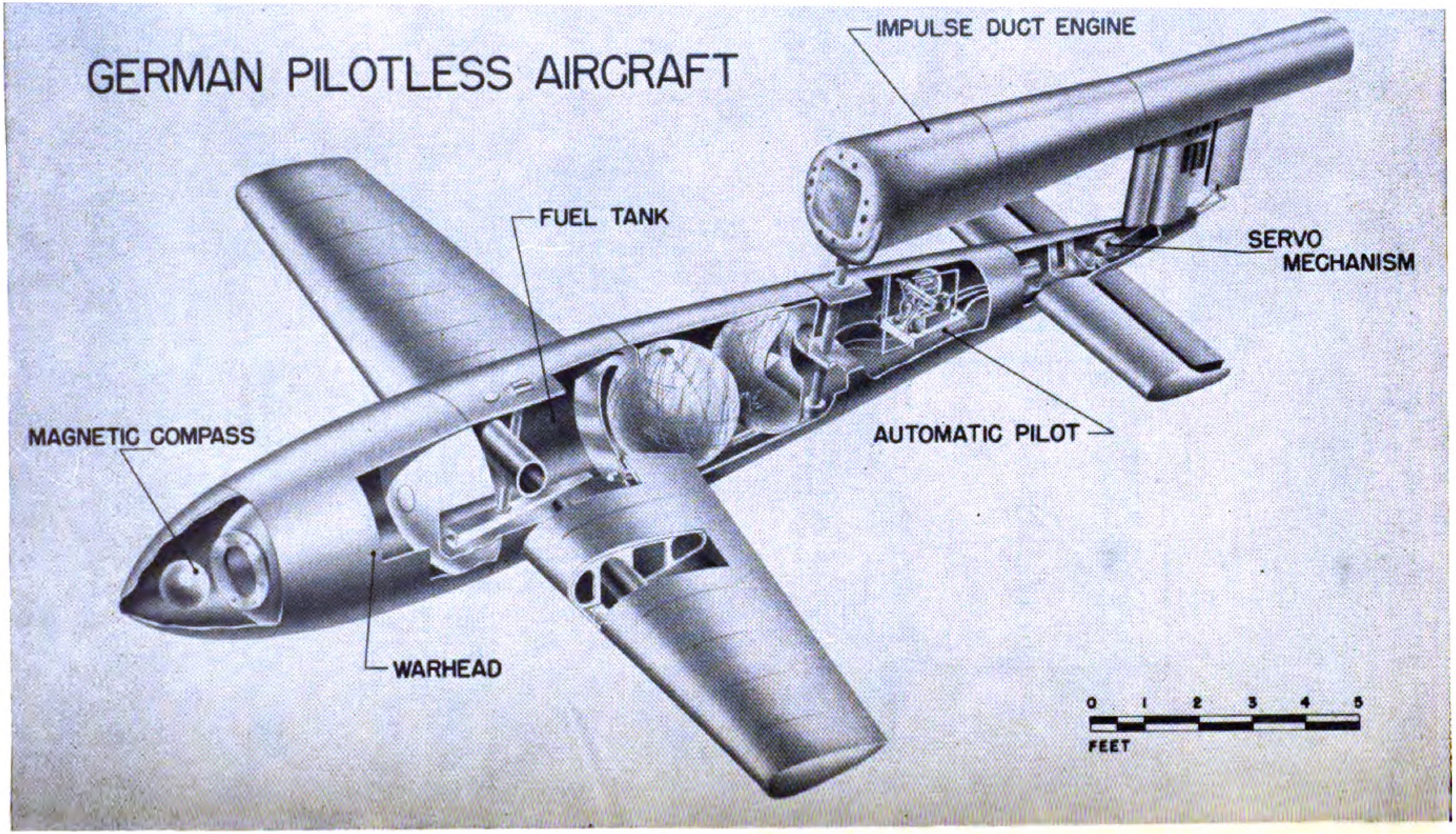


Figure 6b. German Pilotless Aircraft (Robot Bomb) V-1.

over the nose of the bomb; in the center of the cup there is a male threaded rod ½" in diameter. The Dinort Rod is attached by screwing the rod into the opening in the nose of the bomb. The purpose of the Dinort Rod is to cause the bomb to detonate above the surface of the target to attain maximum fragmentation damage. It is generally used on the S.D. 50 Kg., S.D. 70 Kg., S.D. 2550 Kg., and S.D. 500 Kg. bombs.

Panzersprengbombe Cylindrisch Rakaten Satze (armor piercing rocket bombs) are constructed in four sections; a one piece steel body containing the explosive, a steel ring spacer containing the charging head for the electric fuze, a steel cylinder containing the rocket material, and the tail assembly. The tail assembly is a magnesium alloy drum with 12 fins, 4 of which are wider than the remaining eight. In the drum are the tubes through which the gases from the burning rocket material escape in producing the force which drives the bomb forward. These bombs are used primarily against shipping as they develop a velocity great enough to penetrate armor even when dropped from low altitude. These bombs are manufactured in three sizes; 500 Kg., 1,000 Kg., 1,800 Kg. The color of these bombs is light blue with four dark blue stripes on the tail drum.

Radio Controlled Bombs of two types have been used by the Germans, including: the H.S. 293 and the FX 1,400.

The H.S. 293 is an armor piercing bomb weighing 900 Kg. with a tail assembly similar to a plane and wings attached to the bomb body. This bomb is jet propelled for 6 seconds after released to give a high initial velocity. Between the bomb body and the tail assembly is located the radio compartment. The direction of the bomb is controlled by radio from the control plane. The overall length of this bomb is 10' 5", the span of the wings 10' 2", the span of the tail is 3' 8".

The FX 1,400 consists of a 1,400 Kg. armor piercing bomb with wings and tail similar to the H.S. 293. The flight of this bomb is also controlled by radio. The overall length is 10' 10". The wing span 4' 10". The span of the tail is 4'. This bomb has 8 flares in the tail which while burning give light and smoke by which the flight can be followed by the control ship.

The following charts give the main features of the principal German Demolition Bombs:

GERMAN BOMBS
GENERAL PURPOSE
SPRENGBOMBE CYLINDRISCH

Weight in kilo-grams	Overall length Body and tail	Length of Body	Diameter of Body	Width of Tail	Type of Strut	Length of Tail	Material of Tail	Charge/Weight Ratio	Number of Fuzes
50	43.0"	27.5"	8.0"	11.0"	None	16.0"	SS	47.4%	1
250L	64.5"	46.0"	14.5"	20.0"	Box	25.0"	SS	55.0%	2
250K	64.5"	47.0"	14.5"	20.0"	Box	25.0"	SS	55.0%	1
500K	77.5"	56.0"	18.5"	25.0"	Box	29.5"	SS	44.0%	1
500L2	77.5"	58.0"	18.5"	18.5"	Ring	29.5"	SS	44.0%	2
1000	110.0"	73.5"	26.0"	25.0"	Ring	46.5"	SS	54.0%	1
*1200	110.0"	73.5"	26.0"	25.0"	Ring	46.5"	SS or Mag.	61.0%	1
1800	126.0"	106.0"	26.0"	26.0"	Ring	44.5"	SS	54.4%	1
*2000	126.0"	106.0"	26.0	26.0"	Ring	44.5"	SS	58.9%	1
2500	196.0"	------	13.0"	------	Ring	------	SS	------	2

* Same as S.C. 1,000 Kg. and S.C. 1,800 respectively with special heavier explosive filling.

GERMAN BOMBS
SEMI-ARMOR PIERCING
SPRENGBOMBE DICKWANDIG

Weight in kilograms	Overall length Body and tail	Length of Body	Diameter of Body	Width of Tail	Type of Strut	Length of Tail	Material of Tail	Charge/Weight Ratio	Number of Fuzes
50	42.5"	23.0"	8.0"	11.0"	None	25.5"	SS	31.8%	1
70	43.0"	28.0"	8.0"	11.0"	None	16.0"	SS	31.8%	1
250	64.5"	35.0"	14.0"	20.0"	Box	25.0"	SS	33.3%	1
500A	80.0"	53.5"	17.0"	17.0"	Ring	35.5"	SS	55.0%	1
500E	68.0"	42.5"	15.5"	16.0"	Ring	26.0"	SS	13.9%	1
1700	129.5"	92.0"	26.0"	26.0"	Ring	46.5"	SS or Mag.	45.0%	1

ARMOR PIERCING
PANZERBOMBE CYLINDRISCH

500	78.0"	54.0"	15.0"	15.0"	Ring	30.5"	Mag.	18.8%	1
1000	82.0"	59.0"	19.5"	19.5"	Ring	31.5"	Mag.	14.2%	1
1400	110.0"	76.5"	20.0"	21.0"	Ring	43.0"	Mag.	29.5%	1

ROCKET BOMBS

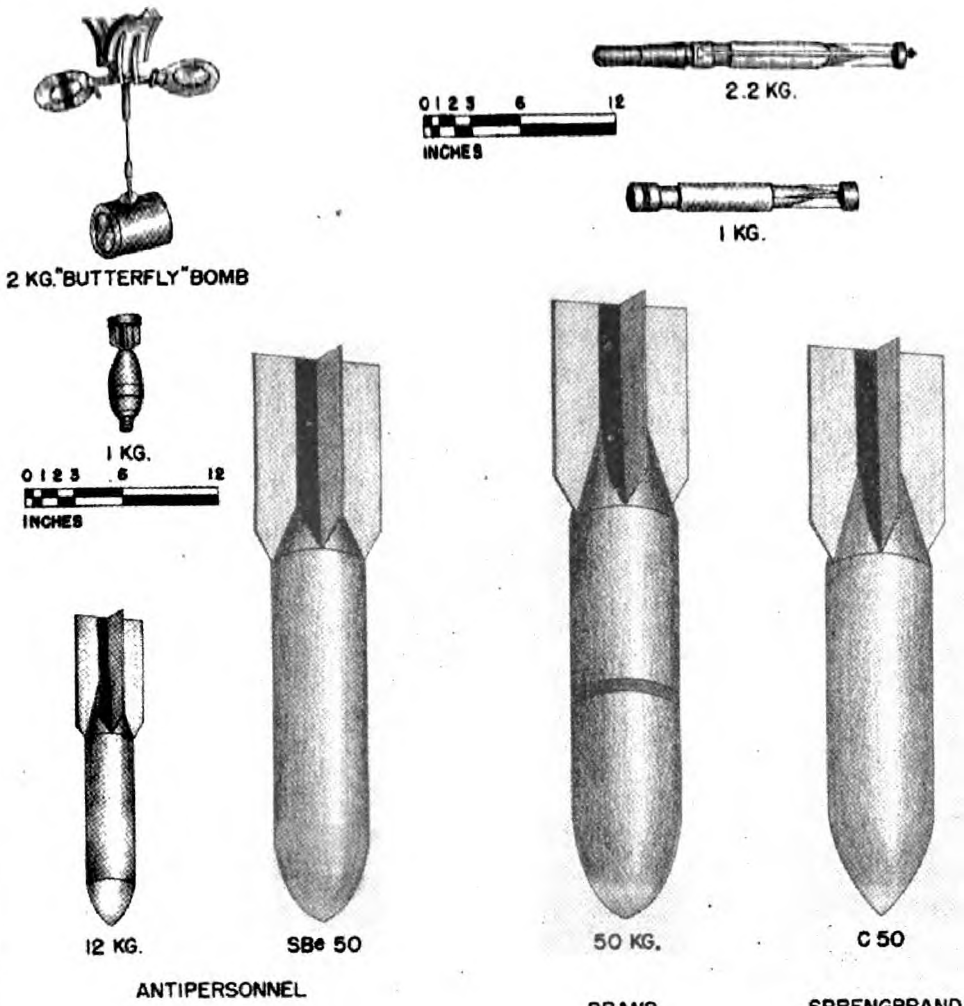
PC 500RS	82.0"	33.0"	11.0"	20.0"	None	20.0"	Mag.	1
PC1000RS	87.0"	45.0"	15.5"	22.0"	None	20.25"	Mag.	1
PC1800RS	107.0"	66.5"	21.0"	22.0"	None	20.5"	Mag.	1

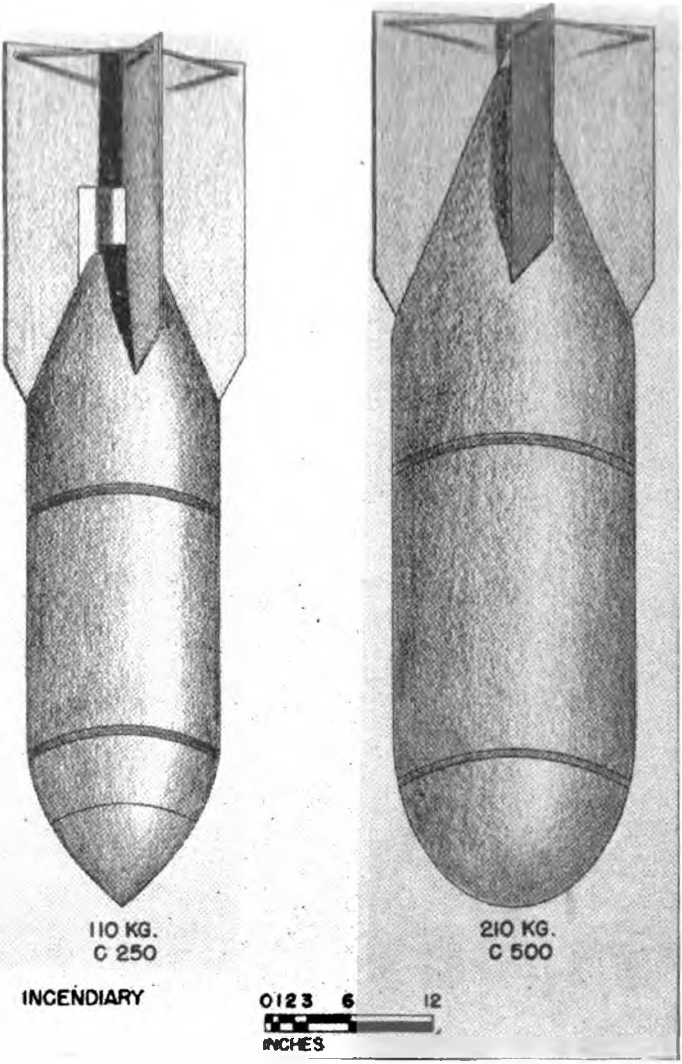
Anti-Personnel Bombs in general are smaller than demoliition bombs and have thick steel cases to achieve maximum fragmentation against personnel. They are often referred to as S.D. Bombs (Thick Walled) and have red stripes on the tail cone. The anti-personnel bombs are listed by weight and type case as follows:

SD 1 Kg.
SD 2 Kg.
SC 10 Kg.
SD 10/A Kg.
SBe C 50
SBe C 250

The SD 1 Kg. bomb is a converted 50mm mortar projectile being 6⅝" long and 50mm in diameter. Its color is dark green or yellow. It has a tail consisting of a ½" pipe, with 6 fins and a ring type fin support. The bomb has a special mechanical nose fuze, the AZ (73), which is always armed. The fuze which extends from the nose of the bomb is prevented from firing prior to impact by the bomb being carried in containers with the fuze of one bomb extending into the tail pipe of the preceding bomb.

The SD 2 Kg. bomb is called the 'Butterfly Bomb' due to its appearance—which is not at all like that of a butterfly (Figure 7). The body is a cast steel cylinder 3" by 3.1" with an opening in the side for the fuze. The fuze, being mechanical, has an arming spindle to which a 6" arming cable is attached. The arming cable passes through a bar to which is attached the arming vanes consisting of two


2 KG. "BUTTERFLY" BOMB
2.2 KG.
0 1 2 3 6 12
INCHES
1 KG.
1 KG.
0 1 2 3 6 12
INCHES
12 KG.
SBe 50
ANTIPERSONNEL
50 KG.
BRAND
C 50
SPRENGBRAND


110 KG.
C 250
INCENDIARY
210 KG.
C 500
0 1 2 3 6 12
INCHES

barrel type flaps and two circular end flaps. When the bomb is in the container, the barrel flap fits around the sides of the bomb and the end flap fits over the ends of the bomb. Upon release from the container in which the bombs are carried, the spring-loaded flaps fly open, slide up the arming cable and serve as arming vanes. Some models of this bomb have had the barrel flap removed and have had the end flap cut down to be triangular. The color of this bomb is dark green or yellow with red stripes on the end flaps. This bomb may be equipped with either the (41) fuze, selective impact or Aerial burst, (67) fuze, time delay, (5 Min. to 30 Min.), or the '70B anti-handling fuze'.

The SC 10 Kg. bomb is 3¼" in diameter and 23" long including tail and nose fuze. The cast steel body is ½" thick. Its color is dark green or aluminum. The tail consists of a cone and four fins with no fin supports. This bomb uses the AZC 10 (h.u.t.) #3 mechanical impact nose fuze. These bombs are dropped in clusters of 5 or in containers holding up to 37 bombs.

The SD 10/A bomb has the same body as the SC 10 Kg. The only difference being in the fuze and type of explosive filler. The SD 10A uses the Z (66) fuze which is armed mechanically by a rotating vane and fired by an impact-generating electric current which causes instantaneous detonation. The SD 10/A bomb has a red stripe on the tail cone similar to that on SD type demolition bombs.

The SBe C50 is a concrete case bomb weighing approximately 35 Kg. The C50 in the nomenclature means that the bomb takes up the same space in a plane as the SC 50 Kg. bomb. This is a common method used by the Germans for deriving nomenclature. The 'Be' is the abbreviation for the German word 'bredon' meaning concrete. This bomb is the size of the German SC 50 Kg. bomb and is bright green. It has a thin steel inner case surrounded by 1¾" of concrete. The nose is reinforced with a steel plate. This bomb has one transverse fuze pocket and uses a standard electric fuze. The filling of this bomb is less powerful than TNT to prevent pulverizing the concrete case.

The SBe C250 has the same construction and color as the SBe C50 and is the size of the SC 250 Kg. bomb and weighs approximately 150 Kg.

Chemical Bombs

Chemical bombs include Incendiary Bombs, Smoke Bombs, and Gas Bombs.

Incendiary Bombs are divided into four main types:

- Combustible Case;
- Incendiary and Anti-Personnel;
- Combustible Filler—Flam;
- Combustible Filler—Brand.

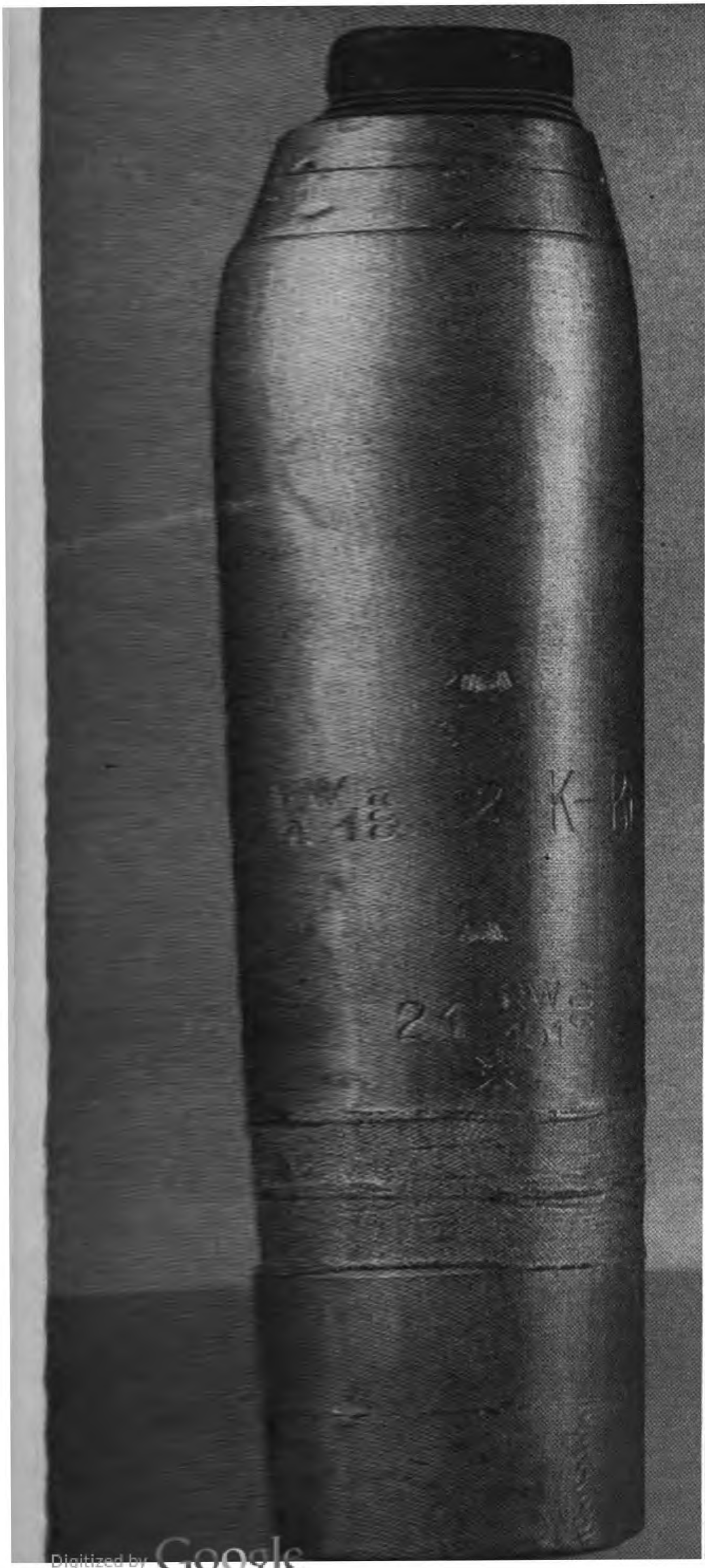
The Combustible Case Type has a cylindrical case of magnesium alloy (electron) which burns at 2,400°F. and a filler of thermite which burns at 4,500°F. The tail of these bombs consists of a cone and three fins with a brake ring type strut. The color of the body is aluminum and the tail dark green.

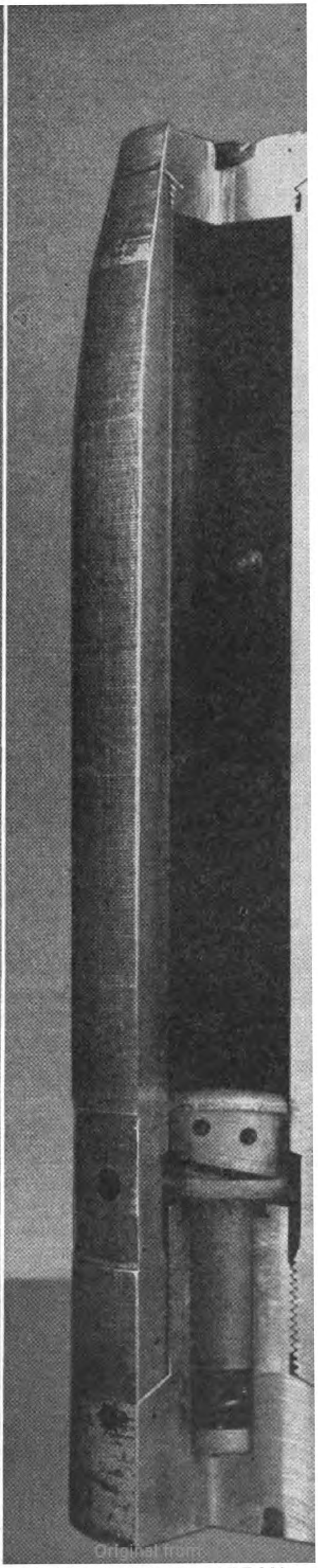
The 1Kg. combustible case incendiary bomb is 2" in diameter and 14" long. The fuze, consisting of a simpler striker and primer in a flat nosed body, screws into the nose of the bomb. The fuze has a safety pin which is attached to the container in which the bombs are dropped. Upon release from the container the safety pin is pulled arming the fuze. The fuze fires an impact igniter. The thermite is fired by the igniter and in turn ignites the magnesium case which burns approximately 15 min. This bomb may have a small explosive charge in the base which detonates about 2 min. after the case starts burning, scattering the burning magnesium over a wide area.

Incendiary and Anti-Personnel Bombs. The 1.3 Kg. incendiary bomb is the same as the 1 Kg. with a slightly different fuze. The fuze of the 1.3 Kg. incendiary has no safety pin and has an explosive charge in it which detonates from heat of the burning after ½ to 5 min. for anti-personnel effect.

The 2.2 Kg. incendiary bomb is 2" x 20". It has the same body as the 1 Kg. The fuze has been modified to take a steel cylinder containing a delay train to which is attached a steel cylinder containing explosive. The explosive nose detonates 2 to 5 min. after the case starts burning.

The 2 Kg. incendiary is similar to the 2.2 Kg. bomb. The fuze of the 2 Kg. has a separator charge which blows the explosive nose several yards from the





incendiary part of the bomb. The explosive nose then detonates 4 to 7 minutes later as a small anti-personnel bomb.

The Combustible Filler Flam Type Incendiary Bombs are similar in size and shape to certain SC type demolition bombs. These bombs have thin steel bodies painted black with two red bands. These bombs use an electric fuze located in a transverse fuze pocket. The filler is oil jell. There is a burster of TNT, aluminum powder, and charcoal in the center of the body to split the body and ignite and scatter the oil.

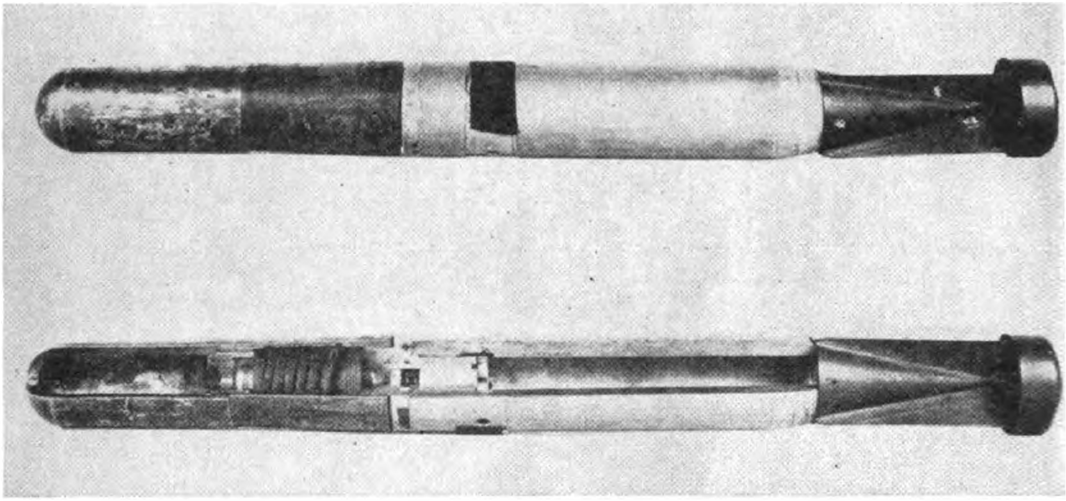


Figure 9. 2.2 Kg. German Incendiary and Antipersonnel Bombs. Length 20.5".

The C250 Flam bomb is similar in size and appearance to the SC 250 Kg. bomb, having the nose base welded to the body. It has an opening in the nose from which a steel tube extends to the fuze pocket. A steel impact rod in this tube activates the special electric fuze, AZ (26), in the event the thin body crumbles on impact. In addition there is a dummy fuze located between the suspension eye bolt and the tail.

The C 250B Flam bomb is similar in size and appearance to the C 250 Flam bomb, but differs in construction. Its body consists of two thin steel plates molded to include a cone at the base, and welded longitudinally. The four fins are welded directly to the cone part of the body. This bomb has no dummy fuze pocket, the real fuze being at the position of the dummy of the C 250 Flam. It has no opening in the nose and no impact rod.

The C 500 Flam bomb is the size of the SC 500 Kg. bomb, its body is welded longitudinally similar to the C 250B Flam bomb. The burster tube, 2" in diameter, located slightly off center extends the length of the bomb and has a filler plug as the nose of the bomb. The fuze is located between the nose and the suspension eye bolt.

The C 500C Flam bomb is the same as the C 500 Flam with the following exceptions:

Fuze located between suspension eyebolt and tail;

Burster tube is 4" in diameter and is located in center of bomb.

The Combustible Filler Brand Type Incendiary Bombs. The Brand C 50 and Brand C 250 are similar in size and construction to the SC 50 Kg. and SC 250 Kg. demolition bombs respectively. These bombs are painted dark green with a red band around the body and a red base. The filling is benzine, phosphorus, and rubber. A standard electric fuze and gaine are used to split the case and to ignite and scatter the incendiary filling.

The Sprengbrand C 50 is similar in appearance to the Brand C 50. There is no red band. There is a male plug in the nose. That section of the body to the rear of the fuze pocket contains 73 small thermit and magnesium fire pots. The nose of this bomb contains 13 lbs. of TNT. The special gaine used with an electric fuze ignites and expels the fire pot thru the base of the bomb, and after a 5 second delay detonates the TNT.

Smoke Bombs. Smoke bombs generally use a mixture of chforosulphonic acid and sulfur trioxide to generate white smoke to cover the movement of troops and to prevent observation by antiaircraft gunners. "N" in the nomenclature of these bombs stands for 'nebel' meaning smoke.

The NC 50 smoke bomb is similar in size and construction to the SC 50 Kg. bomb with the following modifications. The pocket for the electric fuze has a plate welded over it and there are 5 round holes in the base of the bomb and four triangular flaps at the apex of the tail cone to allow the smoke to escape. The body and tail are aluminum with a white nose and one white band around the body. The mechanical impact fuze AZ (46) is located on the base of the bomb with its arming wire extending through the tail cone.

The NC 250 smoke bomb is similar in size and construction to the C 250 Flam bomb. The body is silver with a dark green tail. This bomb uses the E1AZ (26) fuze.

Gas Bombs. Gas bombs have colored rings to denote the types of gas they contain as follows:

White—Tear gas;
Blue—Nose gas;
Yellow—Blister gas;
Green—Lung gas.

Probable sizes of German KC Bombs are:

KC 10 —same as SC 10 Anti-personnel bomb.
KC 50 —same as C 50 Flam bomb.
KC 250—same as C 250 Flam bomb.
KC 500—same as C 500 Flam bomb.

Pyrotechnics

Pyrotechnics are bombs containing materials which burn giving off an intense light over a wide area and are classed as:

Flares;
Photoflash bombs.

Flare. A flare consists of one or more candles attached to a parachute, both being carried in a case, with a fuze that functions in the air igniting the candle and expelling it and the parachute from the case. Due to the parachute the candle floats slowly to the ground lighting a wide area for several minutes.

The Ausf. E. Flare case is a thin steel cylinder 7″ in diameter and 42″ long with a dome shaped nose and plate at the base attached by 4 aluminum shear screws. There are 4 two inch fins welded to the sides of the case at the base. One pair being 3″ long, the other being 16″. The case is black with 'Ausf. E' stenciled on a silver background near the nose. The fuze is a type 9 aerial burst.

The Single Candle Flare is 3″ in diameter and 19″ long. Ten of these flares are carried in the Mark 500 Boden container. This container may also carry 9 single candle flares, and 6 SD 2 Kg. (butterfly) bombs. The container opening and releasing the flare functions the mechanism pull type igniter Z (31) which serves as the fuze to ignite the candle and expell the candle and parachute.

Photoflash Bombs. The photoflash bomb, BL C50 (Blitz Licht), is similar in size and shape to the SC 50 Kg. demolition bomb. Its case is yellow or aluminum with a dark green tail. It has an aerial burst fuze type 9 which functions in the air, igniting and expelling the pyrotechnic filler which burns brilliantly, lighting an area momentarily for night photography.

Containers

Containers are used to drop small anti-personnel and incendiary bombs. They vary in size from 8″ x 43″ to 26″ x 123″. These containers are equipped with aerial burst fuzes which open the containers in the air and allow the bombs to fall individually. The container is generally marked to show the quantity and type of bomb carried.

German Bomb Fuzes

German Bomb Fuzes are numbered in such a way that the number assigned to a fuze is an indication of the fuze type. An understanding of this numbering system is essential to an understanding of German fuzes. In every case the last digit of the number determines the classification to which the fuze belongs. For instance the following fuzes are all of the same type: (25)A, (35), (55)Tp. In each case the last digit is 5, and we call them Series 5 Fuzes. Below is a table listing most of the known German fuzes according to type (Series) and bombs found in.

Type	Purpose	Bombs Used In	Examples of Fuze Numbers
1	Selective Mechanical Impact or Aerial Burst	SD 2 (Butterfly) Parachute Flares	(41) (41)A (31)
2	Unknown		
3	Mechanical Impact	SD 1 Combustible case incendiaries SC 10	(73)A 8312, 13A, (13)A, (63), (63)A, (63)B AZ C10 (hut) 3
4	Special Mechanical Impact	SC 2500	(24)A
5	Electric Impact	Any SC, SD, PC, or SB 1000	(5), (15), (25), (25)A, (25)A, (25)A, (25)B, (25)C, (35), (45), 55, (55), (55)A, (55)A/M, (55)Tp
6	Special Impact Fuzes	C250 & C500 Flam NC250 SD 10/A NC50	(26) (66) (46)
7	Time Delay	SD 2 (Butterfly) Any SC, SD, PC	(67) (17) (17)A (17)A* (17)B (17)B* (17)b* (57)
8	Electrical Impact for Water Targets	Any SC, SD, PC FX1400 Hs 293	28 (28)A (28)B^{2} (28)B^{6} (28) (B)^{2} (28)B^{07} (38) (38)B (38)SI
9	Aerial Burst	Parachute Flares Flash Bombs Containers PCRS Rockets	9 (9) (9)* (9)A (59) 59A (59)A (59)B, (69)A, B, C, D, E (79)A (79)B (89) (89)B (89)C (49)AI, II, III (49)BI, II, III (49)CI, II, III
0	Protective Devices	SD 2 Any SC, SD, PC	(70)B (70)A 50, (50), 50b, Zus 40

As can be readily seen, the number of any fuze is a good indication of the use to which the fuze is intended to be put. Remember, though: Do not rely on fuze markings too implicitly. The Germans have frequently used time delay fuzes without markings and anti-handling fuzes with false markings. This table and the rest of this chapter are given merely for the information of the Ordnance soldier. Leave the positive identification and handling of all bomb fuzes to Bomb Disposal personnel. They have the specialized knowledge and equipment necessary for this job.

Classification of Fuzes

For purposes of discussion, German fuzes are best grouped according to the types of missiles in which they are found, rather than according to their place in the fuze table given above. The following groupings have been made and each will be discussed in a separate section:

1. Fuzes used in HE Bombs;
2. Aerial Burst Fuzes;
3. Fuzes used in Fragmentation Bombs;
4. Miscellaneous Special Fuzes.

HE Bomb Fuzes are contained in a transverse fuze pocket, rather than in the nose or tail as is the case with bombs of other countries. The pocket or pockets (some bombs have two) are located in the side of the bomb either directly in front of or directly behind (in the case of two pockets, one is in front and one is behind) the suspension eyebolt or lug.

The fuze is held in the pocket by two rings: first, a locating ring, the purpose of which is to keep the fuze lined up properly in the fuze pocket; second, a locking ring which is screwed down over the locating ring to hold the fuze firmly in the bomb. Screwed into the bottom of the fuze is the gaine, a steel or bakelite case which contains the detonator and sub-booster (lead azide and PETN respectively). This is a very powerful charge and should be treated with great care. Surrounding the gaine is a ring of picric acid, and the balance of the fuze pocket is filled with pellets of the same explosive.

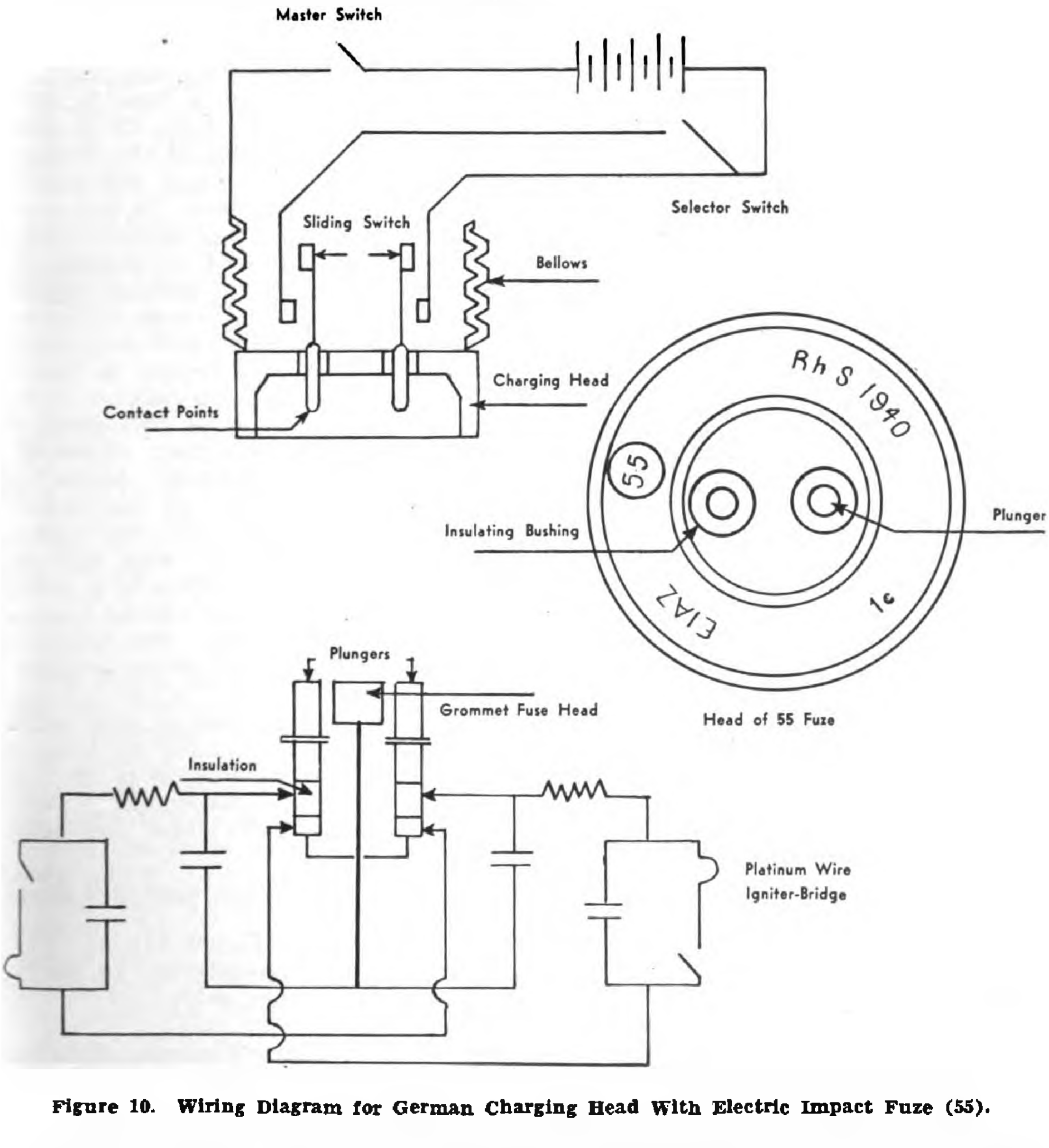


Figure 10. Wiring Diagram for German Charging Head With Electric Impact Fuze (55).

Warning. *German fuzes may be equipped with anti-withdrawal devices. Under no circumstances remove a fuze. Leave it to Bomb Disposal personnel only.*

Fuzes used in HE bombs may be divided into three classes each of which will be treated in a separate paragraph.

1. Electric Impact;
2. Time Delay;
3. Protective.

Electric Impact Fuzes are the standard German HE bomb fuzes. The '5' and '8' Series fuzes and the (26) all are of this type. In order to illustrate their operation the (55) is chosen as an example, and its wiring diagram and that of the charging system in the plane are shown below. When the bomb is loaded into the plane, the charging head, which is part of the bomb rack, is snapped on to the fuze head. The two pins on the charging head push down the fuze plungers (which are insulated from the fuze case) so that the upper metal section slides down to the upper or charging contact, while the insulated section of the plunger slides opposite the lower, or arming contact. Now if the master switch is closed, the battery is placed in a circuit (broken by the sliding contacts) running from the battery to the sliding contacts, the rear pin, the rear plunger, the charging condenser C_2, the fuze case, charging head, master switch, and battery. As the bomb is dropped, the charging head is carried with it for a short distance before being jerked free. As it moves downward, the sliding contacts brush past each other completing the charging circuit. At this instant the charging condenser C_2 is charged. After the charging head is jerked free the plungers rise to their original position and the fuze now arms itself. Electricity flows from C_2 through the resistor R_2 to the firing condenser F_2, then through the bottom of the forward plunger and back to C_2. F_2 thus is charged up and the fuze is armed, the process requiring about 1½ seconds. In case the bomb strikes the ground at this point the trembler switch T_2 closes, discharging the F_2 through the igniter bridge B_2. The igniter bridge is a mixture of silver powder and lead styphnate, the silver powder serving as a conductor and, being heated by the passage of the current, firing the lead styphnate, which ignites a delay element which burns for 14 seconds before igniting the gaine. The selector switch in the plane determines whether the fuze is fired as instantaneous or delay. If this switch is closed, the battery will charge both the charging condensers C_1 and C_2 on release of the bomb. The charging and arming of the instantaneous circuit is the same as for the delay. B_1, however, ignites the gaine directly. Note that either the delay charging condenser C_2 or both C_1 and C_2 may be charged. Since the arming time of the delay circuit is about 1½ seconds and that of the instantaneous about 10 seconds, the reason for this is apparent. In case the fuze is set to fire instantaneously and is released from low altitude, it will still fire with a 14 second delay, since F_1 will not have time to charge. This is a safety feature. There is another safety feature as well. In case the fuze should become charged before release, it cannot become armed until after release. The plungers are held down so that the insulated section comes opposite the lower contacts, breaking the arming circuits.

Shown below are the heads of the current standard electric fuzes as they would appear in a bomb. The two plungers are plainly visible, surrounded by bakelite insulation. Note also the locating pins that maintain proper orientation of the fuze in the fuze pocket. This pin always points toward the nose of the bomb. Circled numbers indicate fuze numbers and other markings designate time and plant of manufacture.

Warning. *Do not push down the plungers of any fuze. Some fuzes will fire if this is done.*

The uses to which the fuzes are put are as follows: (See Figure 11).

1. Standard demolition bomb fuze provides choice of instantaneous, 14 second delay, and two fractional second delays. Used in large bombs only.
2. Provides choice of two fractional second delays.
3. Standard demolition bomb fuze for bombs 500 Kg. and smaller. Provides choice of instantaneous or 14 second delay. Used to obtain above ground burst for fragmentation. Wire leads from fuze to switch at nose of bomb. Do not cut this wire. Bomb will explode.
4. Used in large bombs only. Provides a fractional second delay unless bomb strikes a target too hard to penetrate in which case it fires instantaneously.
5. Standard fuze for use against shipping provides choice between 5 seconds delay and two fractional second delays.
6. Special fuze for use in flam bombs. Instantaneous circuit fired by a trembler switch or by a pressure switch activated by an impact rod running back from the nose of the bomb.

7 and 8. There are three of these: (49)A, (49)B, (49)C. They the used in the PCRS Rocket Bombs and provide a fractional second delay only. They are designated as '9' Series (aerial burst) fuzes because they ignite the rocket propelling charge just after the bomb is released, in addition to firing the bomb on impact.

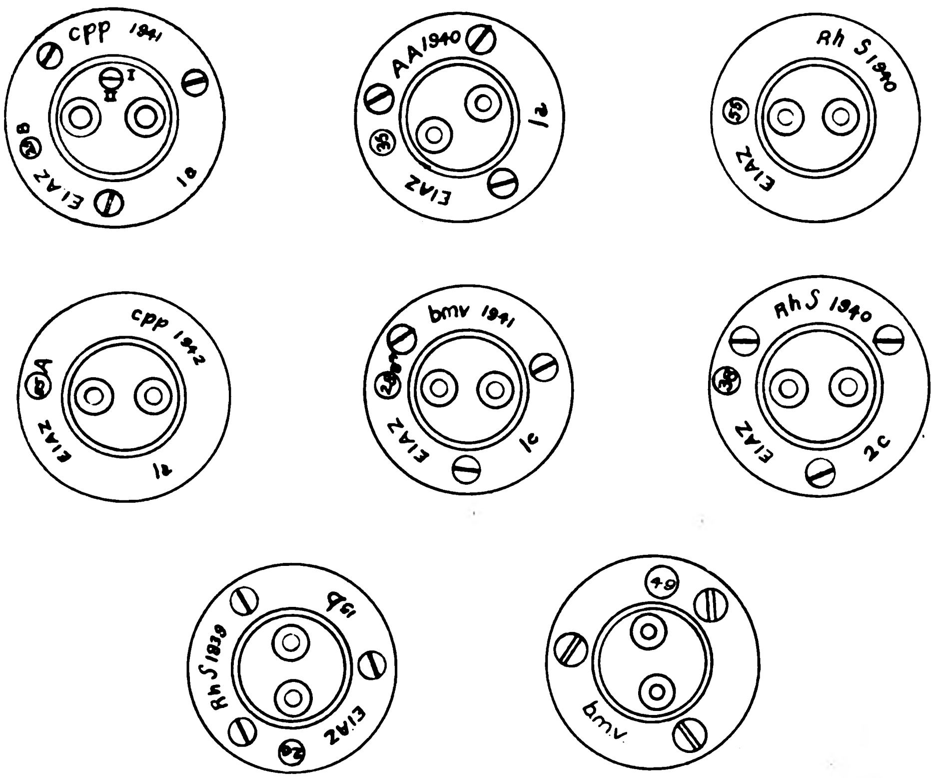


Figure 11. Electric Fuze Heads.

Time Delay Fuzes: The Germans have two types of time delay fuzes, clockwork and chemical. Both types look like electric impact fuzes, having the same type of case and the same plungers in the head.

The clockwork fuzes consist of two separate elements, an electric impact fuze and a clock. Both are contained in the same case. The electric impact fuze fires when the bomb strikes the ground and starts the clock. The clock works in much the same way as an alarm clock releasing a cocked firing pin at the expiration of its time setting.. There are two clockwork time delay fuzes currently in use, heads of which appear in Figure 12.

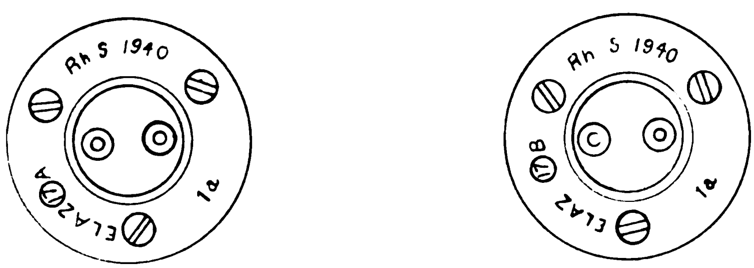


Figure 12. Clockwork Time Delay Fuze Heads.

Note: These fuzes are often found unmarked and it is possible that they might be found with false markings. They are usually accompanied by anti-withdrawal and anti-disturbance devices.

The chemical delay fuze operates as follows. A cocked firing pin is held in place by a celluloid washer. At the instant of release a small explosive charge in the fuze is fired electrically, opening a small tank containing acetone. The acetone slowly dissolves the celluloid washer until the firing pin is finally released. At present the Germans have one fuze of this type, the head of which is illustrated in Figure 13. This fuze has an anti-withdrawal device incorporated in it.

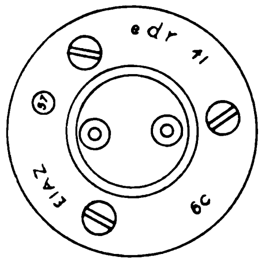


Figure 13. Chemical Delay Fuze Head.

Protective Fuzes. Anti-withdrawal fuzes are used to prevent removal of a time delay fuze (or any other fuze) by firing the bomb in case withdrawal is attempted. The Germans have one of this type known as the Zus 40. This fuze, fitted with a gaine is placed underneath the clockwork fuze, so that the gaine of the latter extends well below the top of the striker arm. The striker is held away from the primer by a small spring-loaded detent which in turn is

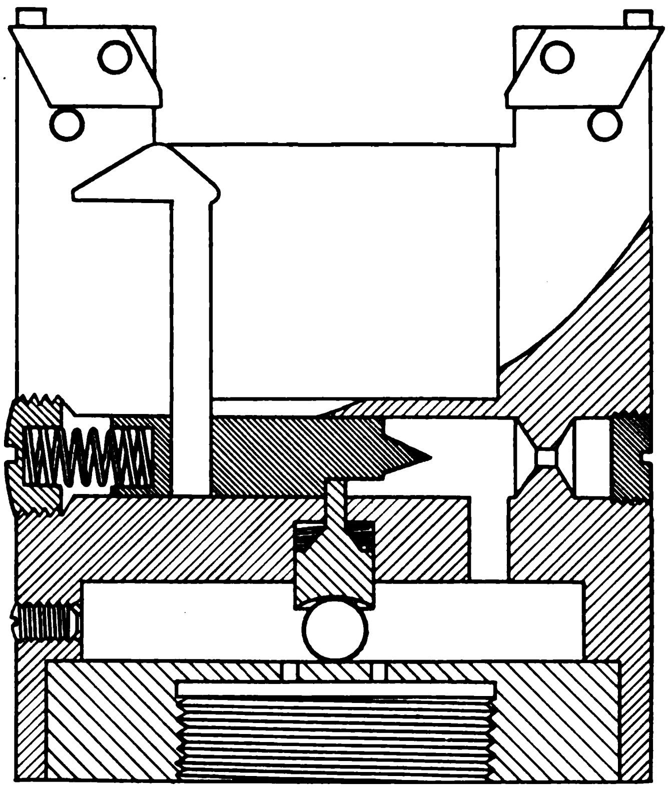


Figure 14. German Anti-Withdrawal Fuze ZUS 40.

held in place by a steel ball. On impact, the steel ball is driven out from under the detent by inertia so that the striker is unlocked. It is now held back only by the striker arm which rests against the gaine of the clockwork fuze. If the latter is withdrawn, its gaine clears the striker arm, so that the striker is driven into the primer, which sets off the flash pellet and the gaine. The knife edges on the top of the Zus 40 dig into the sides of the fuze pocket so that it remains in place when the clockwork fuze is withdrawn.

The (57) chemical delay fuze incorporates its own anti-withdrawal device.

Anti-disturbance fuzes are used for two purposes. The usual use is to prevent the removal of a bomb containing a time delay fuze. They can also be used alone as booby traps. The standard German anti-disturbance fuze (50) is illustrated

Figure 15. German Anti-disturbance Fuze Head (50).

below. It is fired by the slightest jar or vibration. In operation it is exactly like an electric impact fuze, only the trembler switches are much more sensitive. An extremely high resistance between the charging and firing condensers gives it an arming time of about five minutes. Thus it does not become armed until long after the bomb has struck the ground and come to rest. Although usually used as a protective fuze in conjunction with time delay fuzes, the (50) is sometimes used by itself as a booby trap. It may have false markings. This fuze will fire if the charging plungers are depressed.

Aerial Burst Fuzes are usually used in flares, photoflash bombs, and in containers for small incendiary and anti-personnel bombs. They are also found occasionally in Sprengbrand HE incendiary bombs. German aerial burst fuzes are of three types.

1. Electrical Delay;
2. Pyrotechnic Delay;
3. Clockwork Delay.

The (9) fuze is the standard electrical aerial burst fuze. The charging condenser C is charged in the same way as a normal electric impact fuze. As the flare (con-

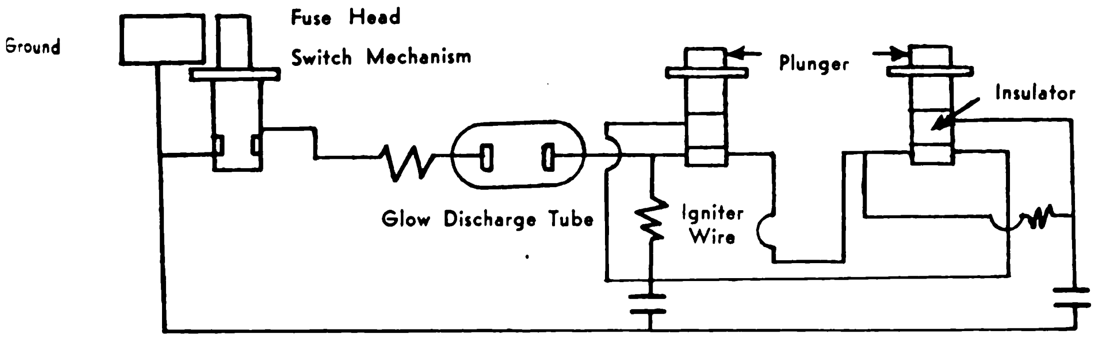


Figure 16. Diagram of German Electrical Aerial Burst Fuze (9).

tainer) falls, the electricity leaks into the firing condenser F. When the voltage in the firing condenser reaches a critical value, an arc breaks in the glow discharge tube G, so that a surge of current flows through the igniter bridge B. Fuzes of this type give delays of 2 to 5 seconds.

The Germans make several fuzes of this type, differing only in the delays obtainable on each fuze. They consist of two pyrotechnic delays, each of which is ignited by a bridge connected to one of the plungers. The selector switch in the plane, therefore, gives the bombardier a choice between the two settings available. There are several fuzes of this type, the (59)A, 59A, (59)B, (69)A,B,C,D,E, (79), (79)A. The most common of these are the 59A, (59)B and (79)A, illustrated in Figure 17.

Of all the aerial burst fuzes there are three having clockwork delays, the (89), (89)B, (89)C. The (89) is no longer used, so that the (89)B and (89)C are the only ones in use today. These two are very common, however. In operation they are quite similar to the time delay clockwork fuzes, (17)A and (17)b*, except that the clocks are started on release from the aircraft instead of on impact. The possible settings, of course, are much shorter, ranging up to about 80 seconds for the (89)B and 160 seconds for the (89)C. Illustrated in Figure 18 is the head of the (89)B. That of the (89)C looks exactly the same except for the number.

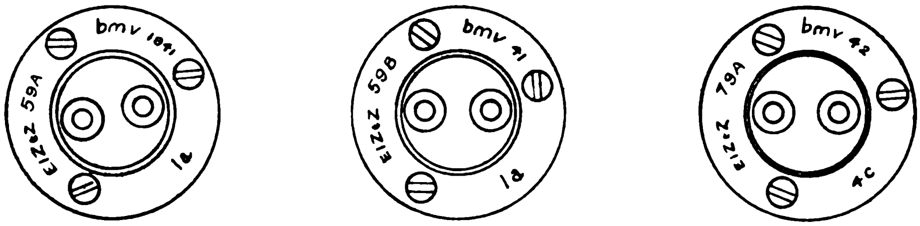


Figure 17. German Electrical Aerial Burst Fuze Heads.

Fuzes Used in Fragmentation Bombs. German fragmentation bomb fuzes are not interchangeable as are most other German fuzes. Each fuze is designed to be used in a specific bomb, although other fuzes may be used in that bomb also. With one exception all of these fuzes are mechanical in operation.

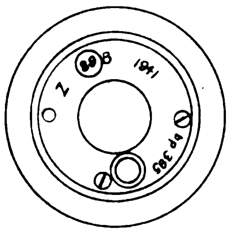


Figure 18. Clockwork Time Delay Aerial Burst Fuze Head.

The SD 1 bomb uses the (73)B fuze, which is screwed into the nose of bomb. In this fuze the striker and primer are held apart by a creep spring. On impact the cup is forced to the rear breaking the shear wire and driving the striker rearward. At the same time inertia forces the primer to move forward, sliding within

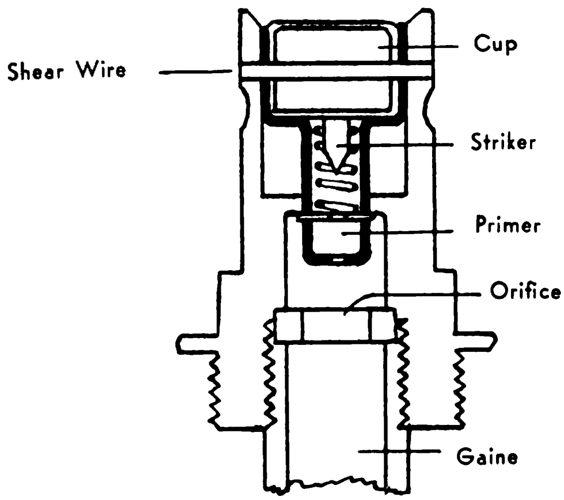


Figure 19. 73B Fuze Used in SD 1 Fragmentation Bombs.

the aluminum housing, so that the primer is pierced by the striker. Unexploded bombs of this type should be handled with great care since the striker may be lodged in the primer and a jar may shake it loose, in which case the primer is very likely to fire. If the cup has not been forced in, this cannot happen.

There are four fuzes designed for use in the SD 2 (Butterfly) bomb: (41), (41)A, (67), (70)B. They are all mechanical in operation and are fastened in the side of the bomb.

The (41) and (41)A fuzes are essentially the same. They have a setting switch on the head of the fuze with settings marked A.Z. (Impact) and ZEIT (Time). If set at A.Z. they fire on impact. If set at ZEIT they fire as aerial burst fuzes 2½ seconds after release from the container. Both fuzes are armed by the unscrewing of the arming stem to which the butterfly vanes are attached. Six revolutions arm the fuze. Screwing the stem back in will not disarm the fuze. If set at ZEIT, the fuze may be in a very sensitive condition if found as a dud. When the (41)A fuze is used in place of the (41), the side flaps of the bomb are eliminated and the end flaps are cut down to small triangles.

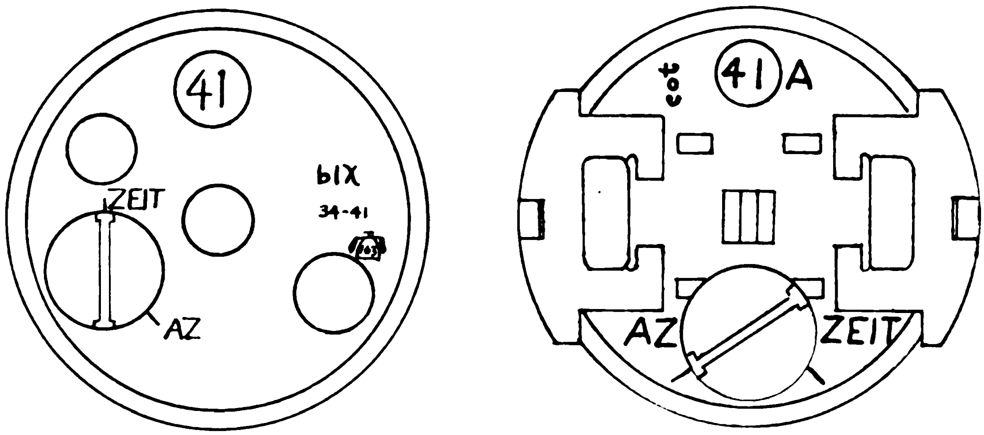


Figure 20. (41 and (41)A Fuze Heads Used in S.D.2 (Butterfly Bomb).

The (67) fuze is a clockwork time delay fuze that may be set for delays up to 30 minutes. This fuze is armed (*i.e.*, the clock is started) by unscrewing of the arming spindle the same as the (41). Screwing the spindle back in will not stop the clock. The switch on the head of this fuze with settings marked A.Z. and

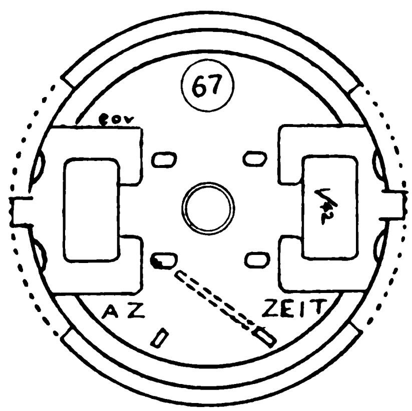


Figure 21. (67) Clockwork Time Delay Fuze Head.

ZEIT is a dummy and has no function whatsoever. If found as a dud, this fuze may be in sensitive condition. A slight jar may start the clock and there is no way of telling how much time it has left to run.

The (70)B is an anti-handling fuze. The arming is initiated by the unscrewing of the arming spindle as in the (41) and (67). A small clockwork mechanism is started, runs for about two seconds and then stops. Upon impact with the ground it starts again, running for about 10 seconds, at the end of which time the fuze is armed. The firing pin is now held by a trigger mechanism actuated by a large weight suspended on the end of a fine spring. Any jar or shock will cause this weight to move, releasing the firing pin. As in the other butterfly bomb fuzes, this fuze is not disarmed by screwing the arming stem back in. This fuze must always be considered to be extremely sensitive.

These butterfly bomb fuzes are all similar in that the arming is initiated by the unscrewing of the arming spindle. Screwing this spindle back in will not disarm these fuzes. If the spindle has risen so that the square shoulder is about 3/8″ about the fuze, it must be considered as armed, and therefore dangerous. The (41), (67), and (70)B are exactly the same as the U.S. M129, M130 and M131 fuzes.

There are two of these fuzes used in SC 10 and SD 10/A bombs: the A.Z. C10 (h.u.t.) 3 and the Z(66). The former is used in the SC 10 and the latter in the SD 10/A. The two fuzes may be readily identified by their shapes (see German anti-personnel bombs).

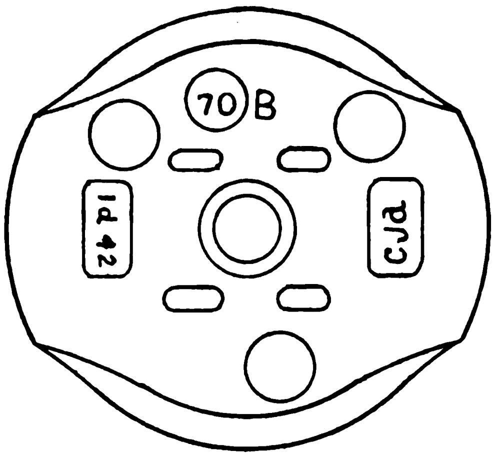


Figure 22. (70)B Anti-handling Fuze Head.

The A.Z. C10 (h.u.t.) 3 is an 'all-ways' type of fuze. In this type of fuze the striker and primer holder are held apart by a creep spring. If the bomb lands on its nose the hammer drives the striker back against creep spring and inertia drives the primer holder forward so that the primer is pierced. If the bomb lands

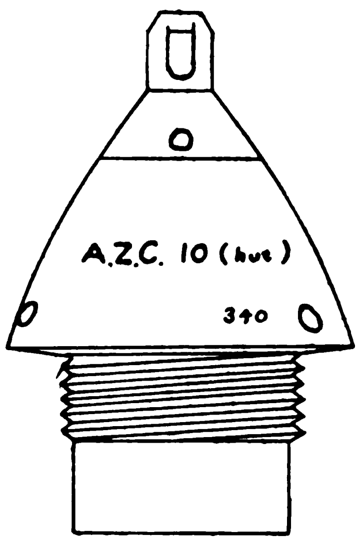


Figure 23. A. Z. C10 (h.u.t.) Fuze.

on its side, both the striker and primer holder are thrown to the side. The cone-shaped ends of the chamber cam them together so that the primer is pierced. This type of fuze is potentially quite dangerous, since the primer may have been pierced by the striker and have failed to fire. A slight jar may be sufficient to osen it so that the creep spring can pull the striker out, causing the primer fire.

The Z(66) is an electric impact fuze mechanically armed. It is easily recog-zed by the die cast metal rotor with six vanes. When the bomb is dropped the r stream turns the rotor causing it to screw out clear of the fuze head arming e fuze. On impact it is forced inward, pushing a small magnet through a coil wire. This generates a current in the coil, which is wired to an igniter bridge milar to that used in electric fuzes. This fires the igniter bridge, which, in turn, es the gaine. This fuze, while it should be handled carefully, is not nearly so ıngerous as the A.Z. C10 (h.u.t.) 3.

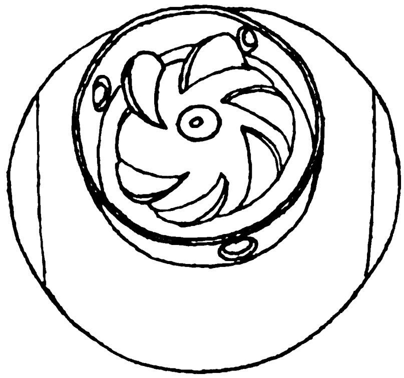


Figure 24. Z(66) Electric Impact Fuze.

Miscellaneous Special Fuzes. The fuzes used in combustible case incendiaries e all simple inertia impact fuzes located in the nose of the bomb. They consist a fixed firing pin and a primer holder held off the firing pin by a relatively ff creep spring. On impact, the primer holder is carried forward by inertia, ercoming the creep spring. There is little likelihood of finding these fuzes with e firing pin embedded in the primer since the creep spring is quite strong.

Fuze used in the NC 50 smoke bomb is a simple inertia impact fuze located in e tail of the bomb. Like the incendiary bomb fuzes it is not likely to be in nsitive condition, although, of course, it should be handled with care.

JAPANESE BOMBS

Japanese Bombs are manufactured to the individual specifications of the Army d the Navy air forces. Consequently, there are two different series of bombs d fuzes which have not been standardized for common use by the two services. ıere is, accordingly, a marked correlation between command areas and the entity of the bombs used.

Though it is difficult to make generalizations for identifying the bombs of the o series, there are certain features which remain constant. Army bombs ıploy a single hinged suspension lug which can be folded against the body storage or transit. The Navy uses a rigid suspension lug consisting of a -bolt welded on to a steel disc, which in turn is attached to the bomb by elding or riveting. Usually there is only one lug, but certain bombs have two entical lugs mounted in diametrically opposite positions. As a rule, all types Navy bombs are painted gray over an undercoat of red lead. With the Army, e overall color varies with the type of bomb—black for high explosive, gray r incendiary. Both services employ additional colored bands to designate her features. Identification may sometimes be made from markings stamped to the case or into the fuze. An anchor marks almost all Navy equipment, ıereas Army materiel may bear either a star or crossed cannons.

Note: Army tail vanes extend from beyond the apex of the cone to within ı inch or two of the body tail joint. Navy tail vanes do not come down to the ody, but only about halfway down the tail cone. They are not rounded, but me to a definite point on the exterior side.

Japanese Army Bombs

High Explosive General Purpose Bombs compose a well-standardized series in which design and construction are quite uniform. The four sizes, 15 Kg., 30 Kg., 50 Kg., and 100 Kg., are painted black, with a yellow band and a white band painted around the body. The nose may be tipped with red. The size is indicated by '15 K,' '30 K,' etc., stencilled in white near the nose. All are suspended horizontally and may be fuzed in the nose or tail, except the 15 Kg. size which is fused in the nose only and has an additional folding suspension lug on the tail for vertical suspension. Nose sections are made separately and are attached to the tubular body with a threaded joint. The body of the 15 Kg. bomb consists of steel rings slipped over a central tube.

The diameters and lengths (without fuze) follow:

15 Kg.	(33 lb.)	— 3½ inches by 25⅓	inches;
30 Kg.	(66 lb.)	— 5⅞ inches by 33½	inches;
50 Kg.	(110 lb.)	— 7⅛ inches by 41	inches;
100 Kg.	(220 lb.)	— 9½ inches by 53	inches.

Use of Time Fuzes in Army Bombs. The only time fuze known to be used by the Army is not interchangeable with the standard fuzes and requires a modified nose section in which it is fitted on the bombs. To date this modification has been found in the 50 Kg. HE and 100 Kg. HE bombs only. When modified for use with the time fuze, the bombs are also fitted with a tail brake to slow the rate of fall and prevent excessive penetration. The brake consists of a flat square of sheet steel with a circular section cut out of the center. It is welded across the after end of the tail fins. When the time fuze is used in the nose, normally no tail fuze will be encountered. The fuze arrangement does not effect the color scheme of the bombs.

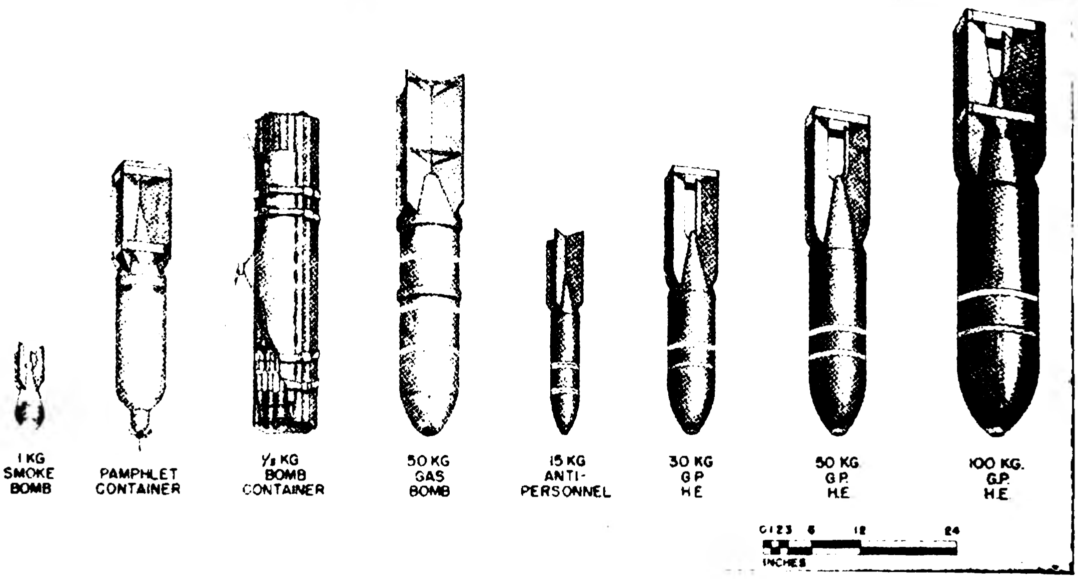


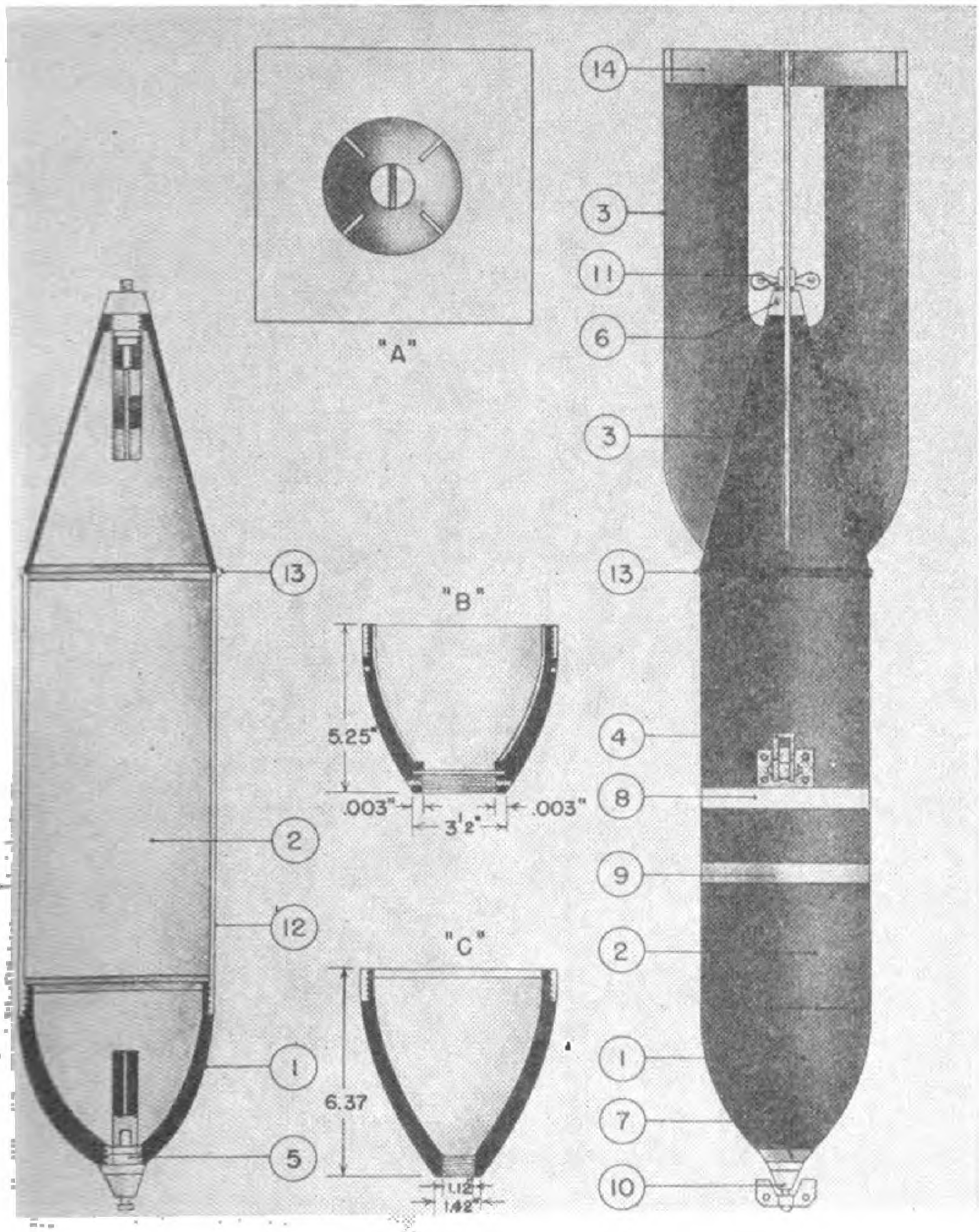
Figure 25a. Typical Japanese Army Bomb.

1 Kg. (2.2 lb.) Smoke Bomb has been variously reported as incendiary, anti-personnel, and smoke bomb. It is now thought to be a smoke bomb used chiefly as a marker, though the danger through incendiary action and fragmentation must still be recognized.

Suspension: Singly in horizontal position. Color: Nose and tail, white or unpainted; mid-section, black. Over-all length: 10.5 inches. Diameter: 3 inches.

Pamphlet Container consists of a sheet steel body (the existence of a cardboard body has been reported also) with a cardboard tail. An aerial burst nose fuze causes the case to split open in mid-air and scatter the pamphlets.

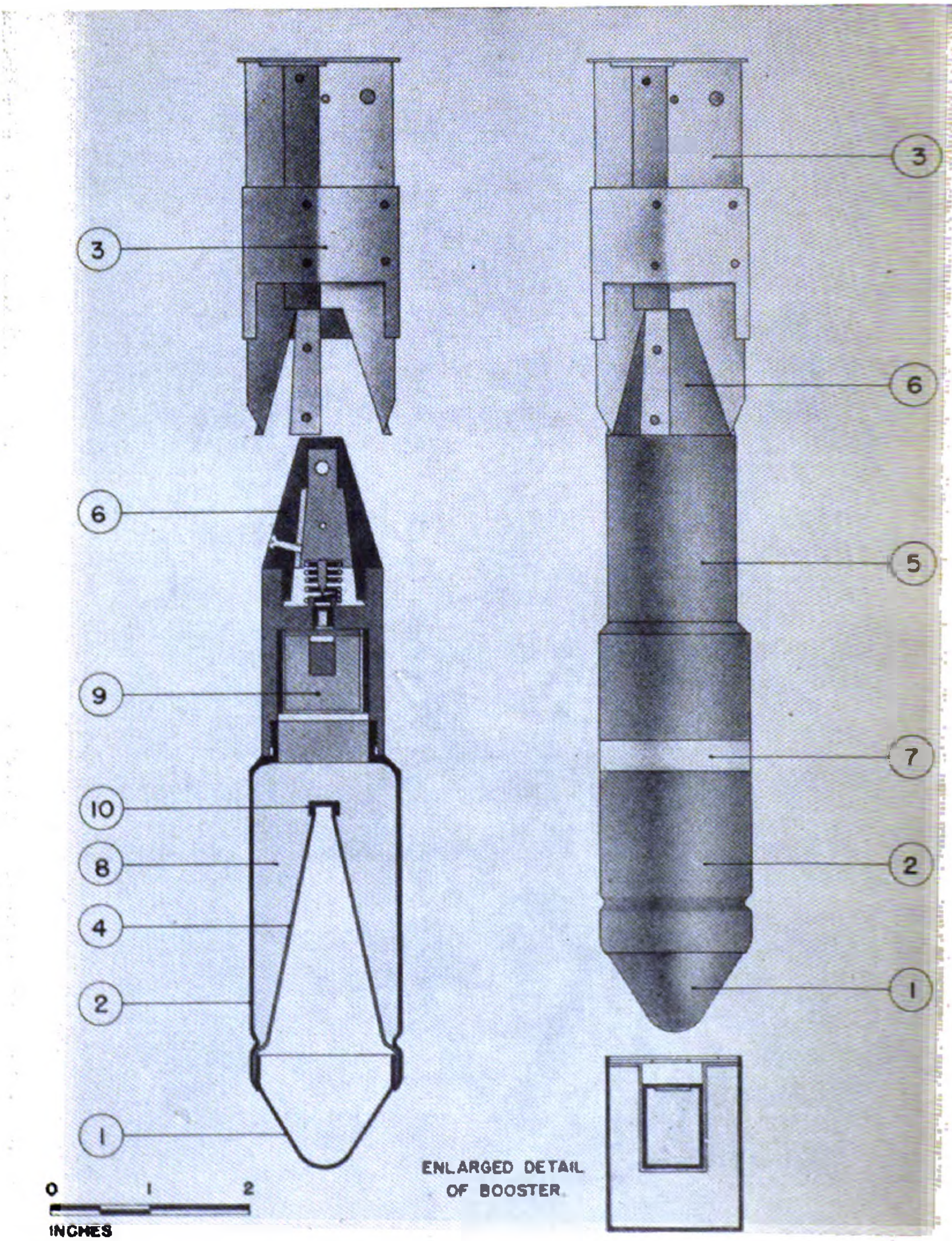
Color: Light brown. Length: 37 inches (without fuze). Diameter: 7⅛ inches.



LEGEND

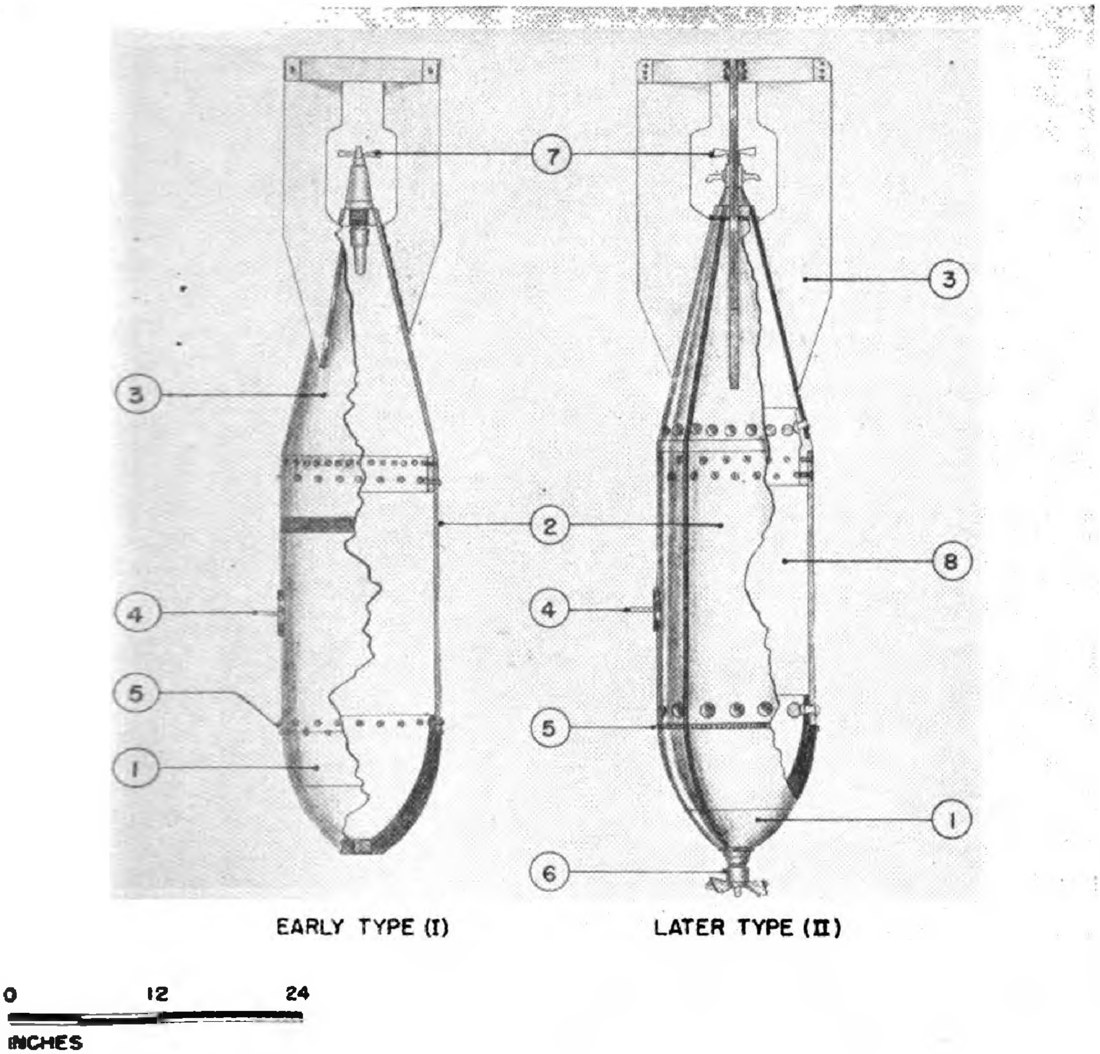
1 NOSE PIECE.
2 BODY (BLACK).
3 TAIL ASSEMBLY (BLACK).
4 SUSPENSION LUG.
5 GRUB SCREW (NOSE FUSE).
6 GRUB SCREW (TAIL FUSE).
7 RED BAND.
8 WHITE BAND.
9 YELLOW BAND.
10 NOSE FUZE.
11 TAIL FUZE.
12 7 MM CASING.
13 WELD.
14 STRUTS (GREEN).

Figure 25b. Typical Japanese Army Bomb.



LEGEND	
1 NOSE PIECE	6 TAIL FUZE
2 BODY	7 YELLOW BAND
3 TAIL ASSEMBLY	8 FILLING
4 INNER CONE	9 BOOSTER ASSEMBLY
5 TAIL EXTENSION	10 CONE CAP

Figure 25c. ½ Kg. Anti-parked Aircraft Japanese Army Bomb.



LEGEND	
1. NOSE FUZE.	5. WELD.
2. BODY.	6. NOSE FUZE.
3. TAIL.	7. TAIL FUZE.
4. SUSPENSION LUG.	8. EXPLOSIVE.

Figure 26. Typical Japanese Navy Bomb.

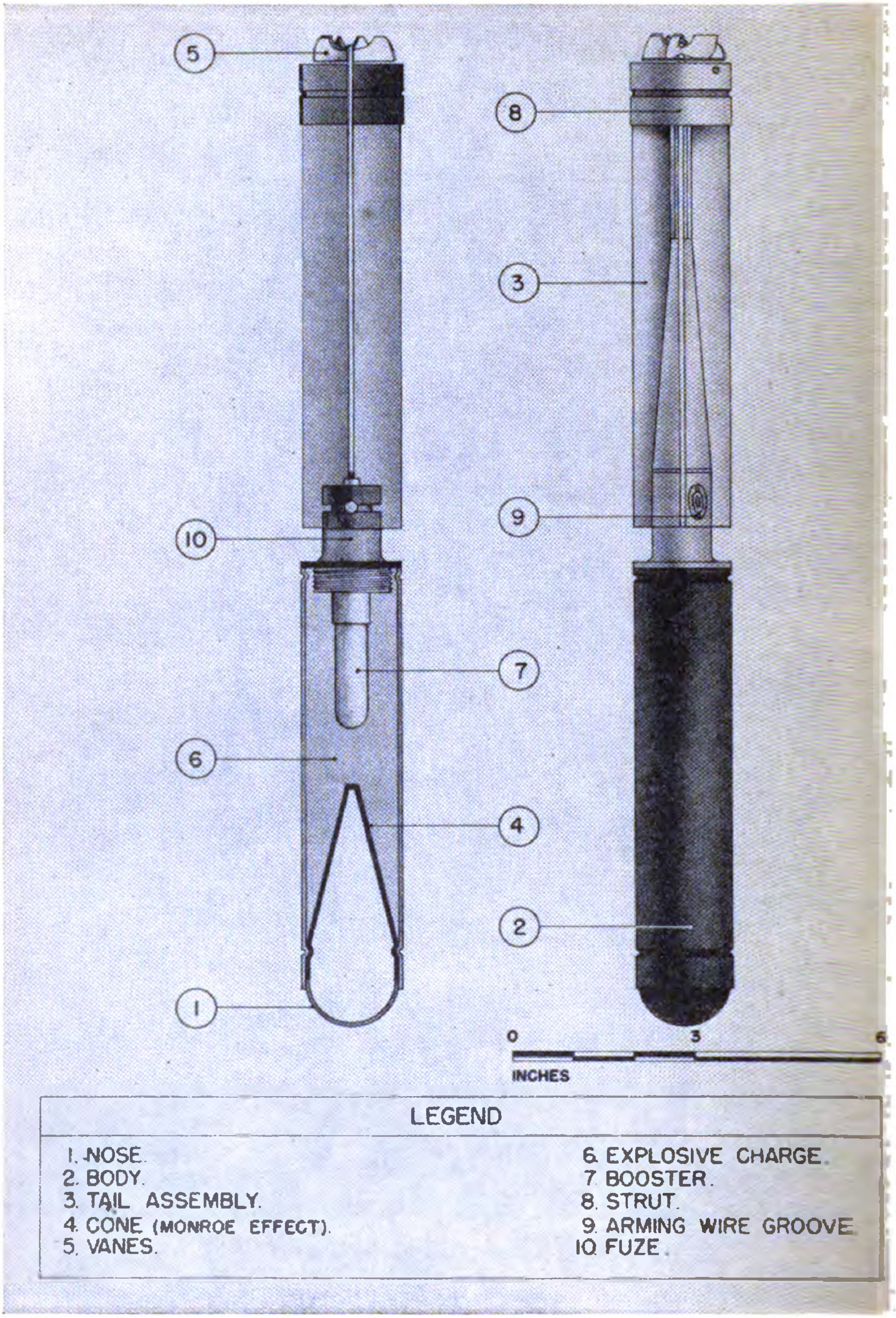


Figure 27. 1 Kg. Antiaircraft Japanese Navy Bomb.

50 Kg. (110 lb.) Incendiary. The nose of this bomb is of heavy construction and is filled with high explosive and fuzed with a simple impact fuze. The body and tail are of light construction and form a liquid-tight container for the incendiary material, which consists of many cylindrical rubber pellets impregnated with white phosphorus. The pellets are packed in a carbon disulfide solution. The phosphorus pellets ignite spontaneously when scattered and exposed to the air after the explosion.

Length of bomb: 40 inches. Diameter: 7 inches. Color and markings: Gray overall; one yellow band and one white band around body.

50 Kg. (110 lb.) Gas Bomb Case, Incendiary Filled is designed for use as a chemical gas container, has the same general construction as the incendiary described above. It is sometimes used as an incendiary with a filling identical to the above.

Length: 45 inches. Diameter: 7.5 inches. Color and marking: (a) as an incendiary—gray overall, one yellow band, one white band; (b) as gas bomb—gray-green overall, red and blue band on nose.

Bomb Cluster—1/3 Kg. (¾ lb.) Bombs are packed 76 in a corrugated steel container which separates when the arming wires are drawn from the retaining bands as the container falls from the plane. Individual bombs consist of standard rifle grenade bodies to which a special tail assembly has been fitted.

Note: The body (2) is crimped around the nose (1) and screwed to a tail extension (5) into which the fuze (6) is screwed. The tail assembly (3) is fastened to the fuze by screws. The bomb's explosive charge is shaped to utilize the 'Monroe effect' on exploding. These bombs are very sensitive to handle when armed and consequently must not be touched by untrained personnel.

Color of container: Black. Length: 41.5 inches. Diameter: 8 inches. Color of individual bombs: Black with yellow band. Length: 10.25 inches. Diameter: 1.5 inches.

Japanese Navy Bombs

Navy 1 Kg. (2.2 lb.) High Explosive Bombs are packed 40 in a sheet steel container which is designed to separate in mid-air and release the cluster. Two groups of 20 bombs each are packed inside a 3 segmented cylinder, which is fitted around separate nose and tail pieces. The assembled unit is held together by two detachable metal binding straps. After release from the plane, and after a fixed delay, the nose of the container is blown off in mid-air and the binding straps are released. The individual bombs then fall separately, arm during descent, and explode on impact.

Weight of assembled container and bombs: Approx. 60 Kg. (132 lb.). Color of container: Gray overall nose tipped with green, followed by broad brown band; 2 half-inch white bands mark position of binding straps. Length overall: 41 inches. Diameter: 9½ inches.

Note: The tubular body of the bomb itself is of seamed construction with an inverted cone in its nose to give the 'Monroe effect.' A nose cap of aluminum is pressed into the forward end of the body. The fuze is screwed into the rear end of the body.

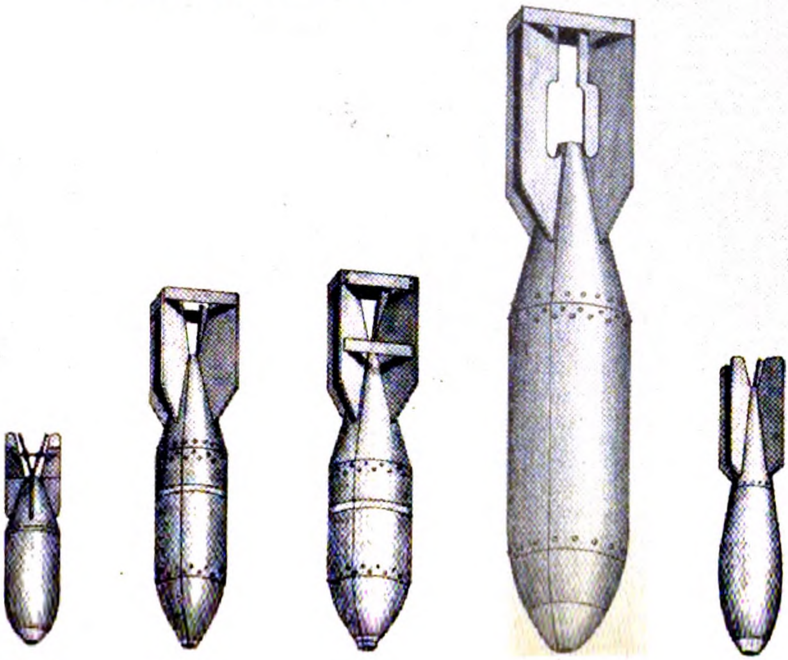
Color of individual bombs: Unpainted steel and aluminum. Length: 17⅝ inches. Diameter: 1¾ inches.

Five-bomb container. Probable weight, 60 Kg. (132 lb.). Information is incomplete on this piece of ordnance. The container is believed to carry five bombs of 7 to 10 Kg. (15 to 20 lb.). The main body of the container consists of a split cylinder of sheet-steel, with a suspension lug mounted in the center of the upper half.

Further details of assembly are not known, but the assembled unit is believed to have the same external form as a standard high explosive bomb. The two halves of the cylinder are held together by light rivets instead of by detachable binding straps as in the cluster described above. Features of construction indicate the use of an aerial burst fuze which initiates a bursting charge to open the case and disperse the individual bombs in mid-air.

Color of container body: Gray. Length of split cylinder: 22¼ inches. Diameter: 9½ to 9¾ inches.

CONTAINER FOR
1 KG. ANTIPERSONNEL BOMBS



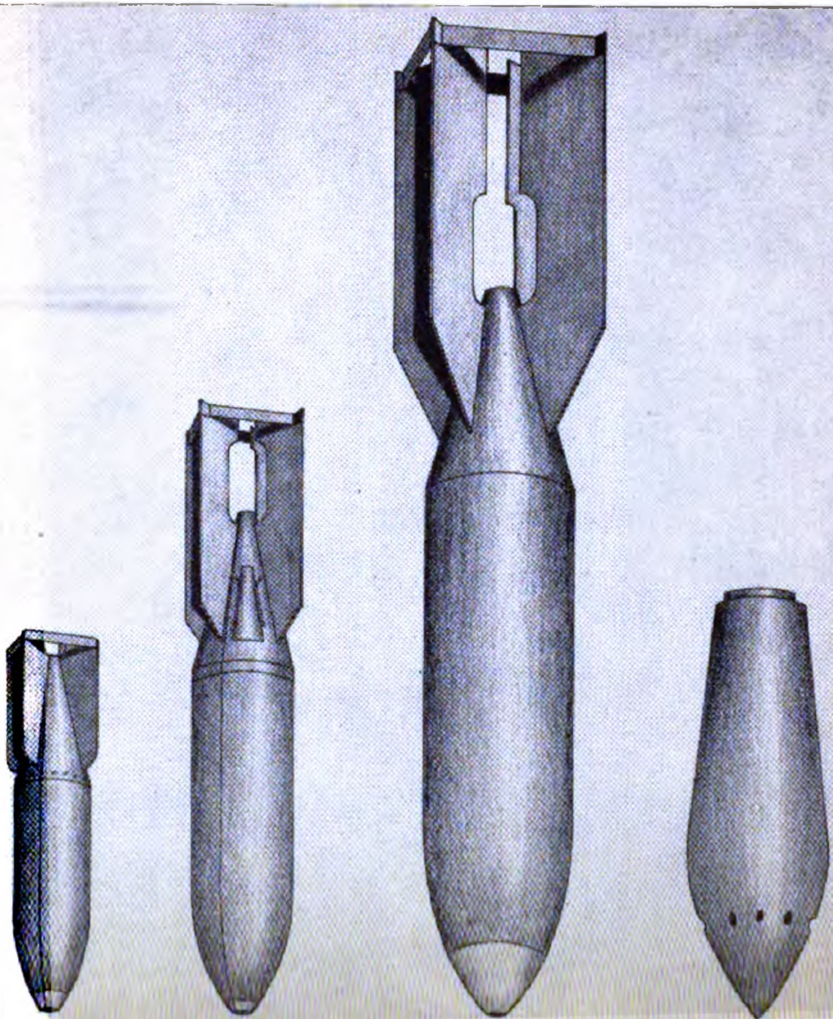
32 KG
INCEND

60 KG.
G.P.H.E.
TYPE "97"

60 KG.
G.P.H.E
TYPE "98"

250 KG.
G.P.H.E.

32 KG.
S.A.P.



63 KG. S.A.P. | 250 KG. S.A.P. | 800 KG. S.A.P. | 800 KG. A.P.

60 Kg. (132 lb.), Type 97 is the commonest Navy bomb used. The heavy nose section is attached to the cylindrical body by a welded joint and a series of large rivets. The tail section is attached by a series of screws. The bomb is fuzed in the nose only.

Color and markings: Gray overall; nose and tail tipped with green; thin red stripe longitudinally down the sides of the case. An additional single band, light blue in color, is painted around the body. Length: 40 inches. Diameter: 7⅞ inches.

The same bomb case is sometimes used with incendiary filling instead of high explosive. Different external marks will indicate this change.

60 Kg. (132 lb.), Type 98 Bomb is somewhat larger by size and weight than the 'Type 97,' described above, but is included in the same nominal weight class. The most characteristic feature is the protruding central portion of the nose, which is unique among Army and Navy designs. Certain variations in construction occur, but the form of the bomb is not changed. Typically the bomb has only a single set of struts between the tail fins. Rivets at the nose joint have been replaced by spot welds.

Marking: Identical with Type 97 HE. Length: 42 inches. Diameter: 9.4 inches.

250 Kg. (550 lb). Two models of this bomb vary somewhat in form, but not in use. Both are constructed of a heavy nosepiece riveted and welded to a cylindrical body. (Series of rivets at the nose may be replaced by large spot welds). Tail sections are attached by a series of screws. Unlike the smaller Navy bombs, the 250 Kg. size can be fuzed in nose or tail. Color and markings are the same as with the smaller general purpose HE bombs.

Dimensions of early type. Length: 72 inches; diameter: 13.8 inches. Dimensions of later type. Length, unknown; diameter: 12 inches.

60 Kg. (132 lb.) Thermit Electron Incendiary Bomb consists of a 60 Kg. Type 97 bomb case in which the HE filling has been replaced by four inserts of 'electron' metal (magnesium alloy) filled with thermite. The struts between the tail fins are painted red on the incendiary model instead of green as on the HE general purpose bomb.

60 Kg. (132 lb.) Thin-Cased Incendiary has the same approximate external form as the 60 Kg. Type 98, but the cylindrical body and tail cone are of much lighter-weight metal. Alternate fillings consist of solidified oil or fitted, pie-shaped, rubber pellets impregnated with iron and aluminum.

Color: Gray overall; tail struts, red. Length: 41 inches. Diameter: 9½ inches.

32 Kg. (70 lb.) Aerial Burst Incendiary-Shrapnel Bomb. A high explosive charge in the tail and central tube splits the case and disperses the contained pellets in mid-air after a distance of fall which may be varied by setting of the aerial burst fuze in the tail. An impact fuze is used in the nose. Each pellet consists of a steel spool inside a steel sleeve. White phosphorous fills the space around the spool.

The bent fins constitute an unusual feature designed to impart a rotation to the bomb, necessary to arm the fuze.

Color: Gray overall; tail fins and nose tipped with silver. Length: 24½ inches. Diameter: 5¾ inches.

250 Kg. (550 lb.) Aerial Burst Incendiary-Shrapnel Bomb is fuzed nose and tail, similarly to the 32 Kg., and has a bend near the ends of the fins to cause rotation. It has the same aerial action as the smaller bomb, and the incendiary-shrapnel pellets are similar.

Color: Gray overall; nose tipped with silver; tail struts, red. Length: 69 inches. Diameter: 12 inches.

Bombs Designed for Penetration are designed primarily for attack against ships. The nose and body are constructed as a one-piece shell in order to withstand impact on hard surfaces. Four bombs compose this series.

32 Kg. (88 lb.) Semi-Armor-Piercing Bomb, rarely found, has a one-piece streamlined body, and though little is known of its use, it is included here under the classification 'Semi-Armor-Piercing,' because the construction most closely resembles this type. It is fuzed in the nose only.

Color: Gray overall; tail struts and nose, green. Length: 32¾ inches. Diameter: ⅝ inches.

63 Kg. (139 lb.) Semi-Armor-Piercing Bomb has a one-piece body with a male base plate. The tail cone is of lighter construction than the general purpose bomb and is not filled. It is fuzed in the nose only.

Color: Gray overall; tail struts and nose, green. Length: 42¼ inches. Diameter: 8⅞ inches.

250 Kg. (550 lb.) Semi-Armor-Piercing Bomb is fitted with a heavy screw-in base plate and is fuzed both in the nose and in the base. The tail cone has three doors which may be opened to permit insertion of the fuze in the base plate.

Color: Gray overall; nose, green; tail struts, green. Length: 68 inches. Diameter: 11½ inches.

800 Kg. (1,760 lb.) Armor-Piercing Bomb is converted from an extremely heavy-walled armor-piercing projectile of approximately 16-inch caliber. Indentations for fitting a nose cap are present on the nose, but it is thought that this fitting is not used when converted as a bomb. The construction of the tail is not known. Two fuzes are fitted side by side in the base plate.

Color and markings: Not known. Probably the usual Navy gray, with nose and tail tipped in green. Length (without tail): 48.3 inches. Diameter: 16.1 inches.

Use of Time Fuzes in Navy Bombs. The Navy employs two time fuzes, one nose fuze and one tail fuze, which are interchangeable with the standard fuzes used in the general purpose HE bombs.

In addition to the standard general purpose bombs in which time fuzes may be used, one bomb is constructed for use especially as a time bomb. This is a 60 Kg. bomb which has a steel plate welded across the tail to impede its fall and a heavy steel ring welded around the nose to reduce penetration. The nose time fuze only is used. The general construction of the body suggests that the time bomb is the same basic design as the Type 97 GP HE model with the special features added.

Accurate dimensions are not available.

Color and markings: Gray overall, nose and tail tipped with green; 1 one-inch brown band on the nose ring.

Typical use of the time fuzes in the standard general purpose bombs would be as follows: 60 Kg. General Purpose, Type 97 or Type 98—nose time fuze only. 250 Kg. General Purpose, either old or new type, time fuze in nose or tail or both.

In addition, the nose time fuze could be used in the 40 Kg. S.A.P., the 60 Kg. S.A.P., the 250 Kg. S.A.P., and in the Navy incendiaries, but such use is not anticipated. The tail time fuze fits only the 250 Kg. bombs mentioned.

2 Kg. (4.4 lb.) Sea Markers consist of nothing more than a light container filled with aluninum powder. They are thrown by hand from aircraft, and on impact with water the case breaks open and the metal powder spreads on the surface to form a shiny slick. They are used as navigational aids and practise targets. Two types are known which differ chiefly only in the material of the container. In one type the container is made of tin, the other is cardboard. Dimensions are nearly identical.

Color: Aluminum. Length: 12¼ inches. Diameter: 3 inches.

2 Kg. (4.4 lb.) Smoke Float. This smoke generator is used as a navigational aid. It consists of a pyrotechnic smoke candle (black smoke) mounted inside a buoyant metal container.

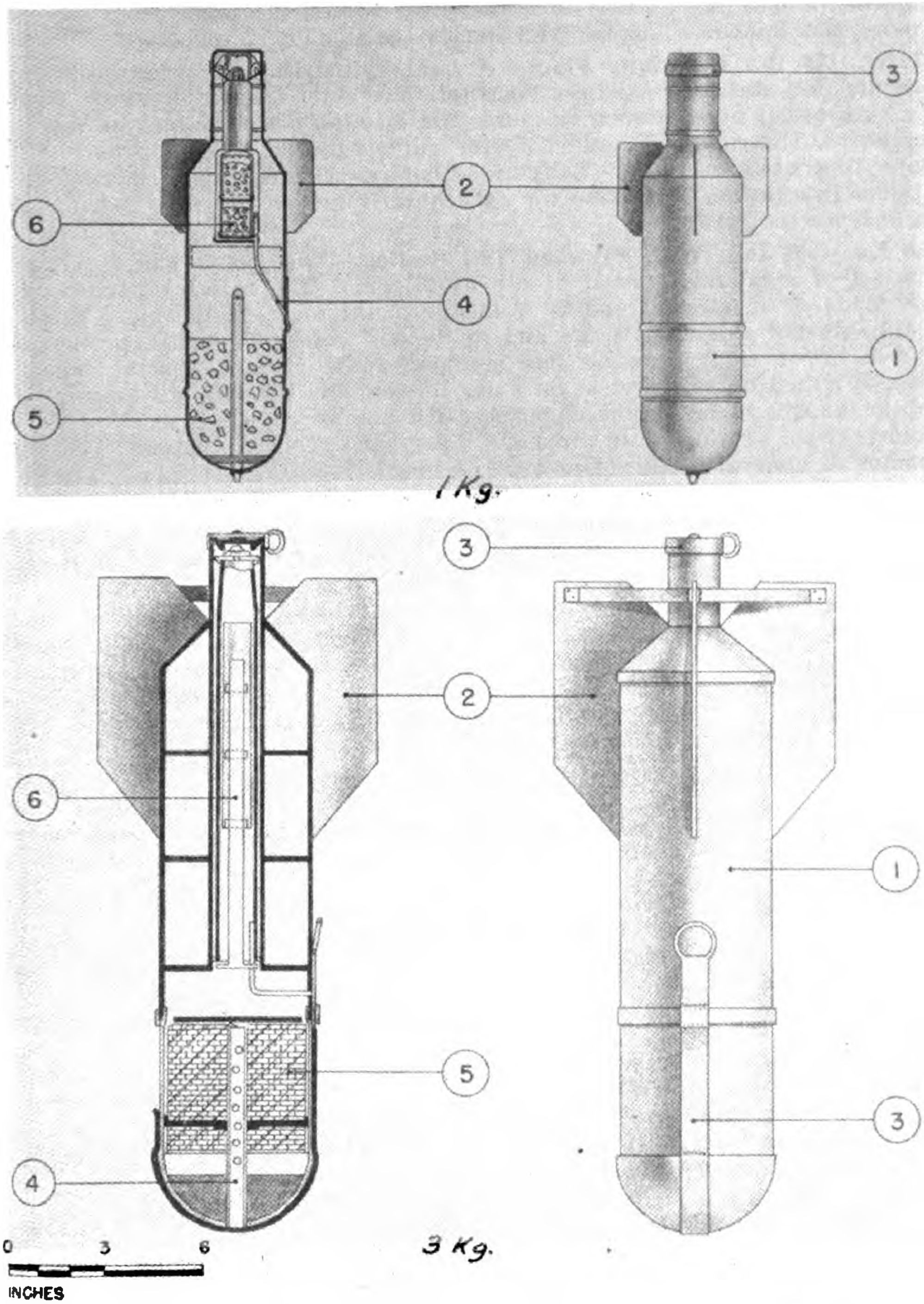
It is ignited by the action of a pull-igniter in the top before it is thrown from the plane.

Color: White. Length: 18½ inches. Diameter: 4¾ inches.

Float Lights. 3 types of aircraft float lights have been found which vary in size and external form, but which are identical in operation. Sealing strips which are removed before the light is thrown from the plane cover holes which allow water to enter the metal container when it is immersed. This generates acetylene gas from a charge of calcium carbide and also actuates a spontaneous igniter.

A fourth type of light has a pyrotechnic powder filling which is ignited spontaneously on immersion.

Weight	*Color*	*Length*	*Diameter*
1 Kg. (2.2 lb.)—No. 1	Gray	11.5 in.	2.8 in.
1 Kg. (2.2 lb.)—No. 2	Gray	13.8 in.	2.9 in.
3 Kg. (6.6 lb.)—No. 3	Yellow	21.8 in.	4.8 in.
No. 4	Gray	22.5 in.	6.3 in.



LEGEND	
1. BODY.	4. INLET TUBE.
2. TAIL FINS.	5. CALCIUM CARBIDE.
3. TEAR STRIPS.	6. CALCIUM PHOSPHIDE.

Figure 28. Japanese Navy Float Flares.

31 Kg. (68 lb.) Practice Bomb. Though it has the general form and appearance of a high explosive bomb, the main filling is inert (concrete). A spotting charge in the base is exploded on impact by a special tail fuze.

Color: Not known. Length: 34.5 inches. Diameter: 7 inches.

33 Kg. (73 lb.) Parachute Flare. A light cylindrical steel case contains the parachute and the flare candle. Four tail fins extend about halfway down the body. An aerial burst nose fuze causes the ejection of the parachute and candle in mid-air. The candle is ignited by the pull as the parachute opens.

Color of container: Gray: Length: 34 inches. Diameter: 6½ inches.

Special Precaution. Removing the parachute from the case may pull the igniter cord and fire the flare.

250 Kg. (550 lb.), With Plywood Tail Section. This bomb has a tail section composed of eight fins instead of the usual four. The forward portion of each fin is made of sheet-steel and is welded directly to the tail cone. These steel fin stubs do not extend past the end of the tail cone. The after portion of the tail consists of eight plywood fins mounted radially on a central tube. This section is bolted on to the steel fin stubs to complete the full tail assembly. The bomb is thought to be a general purpose HE bomb.

Color: Gray overall; nose tipped with green. Overall length: 70½ inches. Diameter of body and tail: 14 inches.

250 Kg. (550 lb.) Approx.—Streamlined Design. This bomb has a one-piece forged or cast steel body which resembles British design in its stream-lined form.

Color: Olive drab overall; nose and tail tipped in green. Length overall: 71½ inches. Diameter: Not known.

600-700 Kg. (1,320-1,540 lb.)—Estimated. This bomb is probably of the general purpose HE type. It is the largest of this class known to be produced by the Japanese. The bomb body is of smooth one-piece construction, with a four-finned tail assembly attached by a series of countersunk screws.

Color: Blue (gray?) overall; nose and tail tipped in green. Length overall: 112 inches. Diameter: 17 inches.

Japanese Bomb Fuzes

Classification. Four general types of Japanese bomb fuzes have been recovered by allied forces. There are many variations among the four types. The four types are:

a. Mechanical impact nose fuzes;
b. Mechanical impact tail fuzes;
c. Long delay or time fuzes;
d. Aerial burst fuzes.

Japanese fuzes are also classified as Army and Navy in the same way as Japanese bombs.

Army fuzes have the following characteristics:

1. There are holes in the arming vanes for an arming wire.
2. Safety pins are never used.
3. Most fuzes have a primer flash cap as part of the fuze.

Navy fuzes are distinguished by the following facts:

1. There are no holes in the arming vanes.
2. Safety pins are sometimes used.
3. The primer flash cap is seldom an integral part of the fuze.

Both the Army and Navy use fuzes of the four types mentioned. In the following paragraphs we will discuss fuzes from the A, B, C, and D classification (See Introduction) rather than as Army and Navy fuzes, because the latter distinction is more of construction than of functioning. Hence, whether A type fuzes are mentioned, the description of the working principles involved can apply to either Army or Navy fuzes of Type A.

In order to cover the subject thoroughly, but concisely and without repetition. we will outline the general functioning of fuzes of each of the four types and after each type we will describe in detail one of the most common fuzes of that type. If further detailed information is desired reference should be made to TM E9-1983, "Enemy Bombs and Fuzes."

A Type. All A type fuzes recovered to date, except the A-5(a), operate on the arming principle of rotation of vanes while the bomb is descending, and functioning on impact with the target. Shear wires and/or creep springs are used in some fuzes as an additional safety factor. The most common example is the A-3(a).

The A-3(a) is a Navy mechanical impact nose fuze used in many Navy bombs particularly the 60 and 250 Kg. incendiary, general purpose, and semi-armor-piercing bombs. It is made of brass and is 5.5 inches long by 2.06 inches wide. The arming vanes and striker point are steel. The upper portion of the body contains the shaft for the sriker. A shear wire passes through the body and spindle. The body is threaded for the standard Navy gaine or magazine. Four vanes are secured by four screws to the nose cap and upper body. On release from the plane, the arming wire is withdrawn from the wire loops, allowing the nose cap to rotate, thus screwing itself up and away from the striker. When the body reaches the stop screw, the cap jams, and on impact, the cap and spindle are driven inward, and the striker pierces the gaine. The A-3(a) fuze is likely to be found in the nose of the bomb with either a B-2(a) or B-3(a) in the tail.

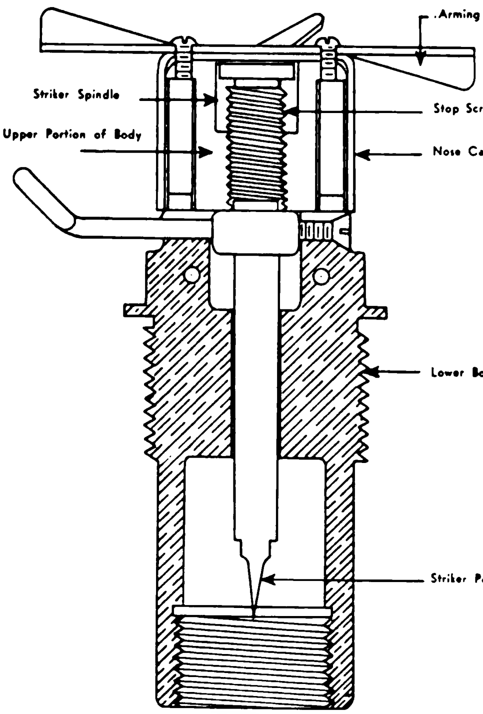
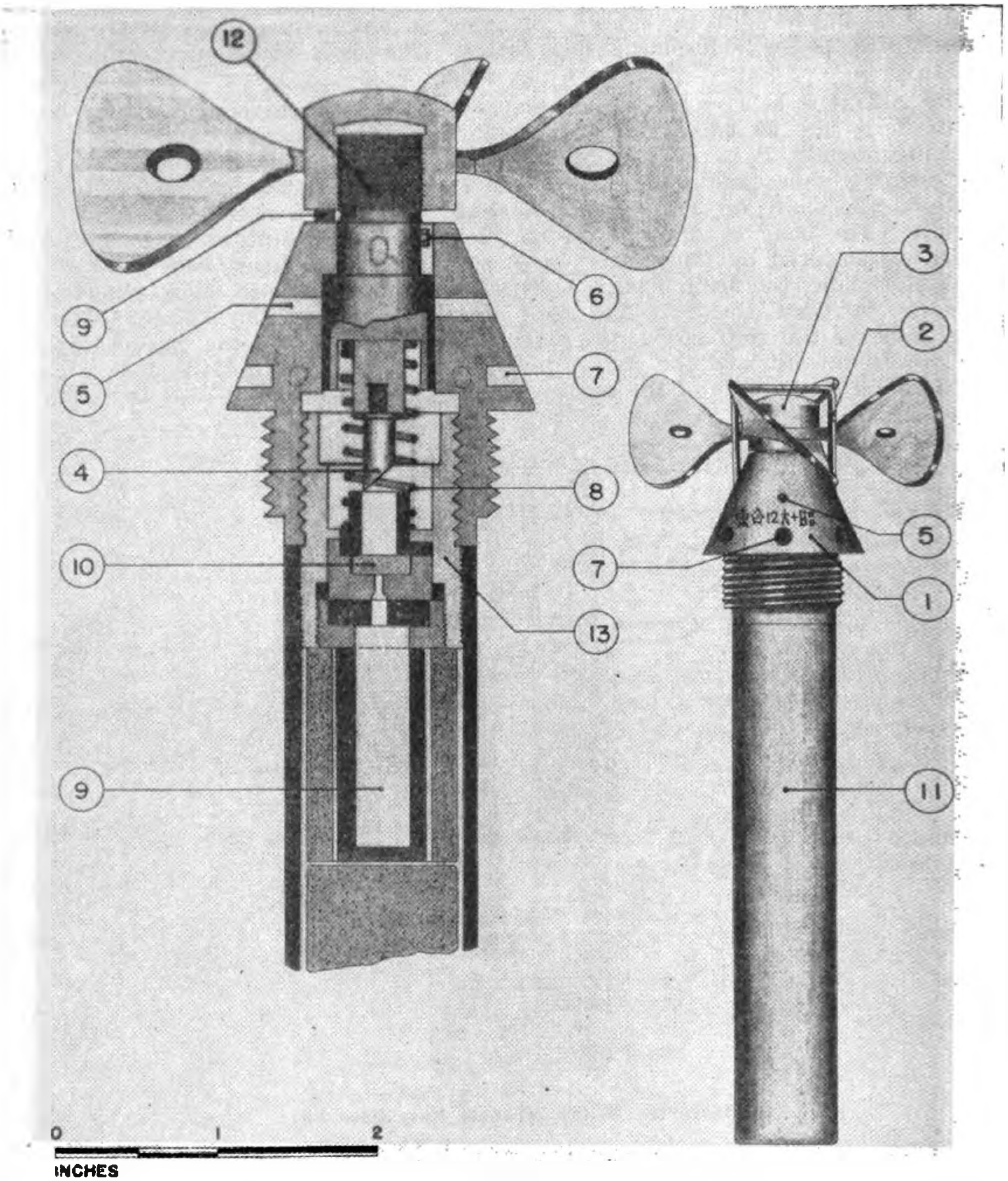


Figure 29. A-3(a) Japanese Navy Nose Fuze.

In connection with A series fuzes it is of interest to note that the **A-3(b),** a fuze which functions and looks almost exactly the same as the A-3(a), was used in the rubber-pellet type incendiary bomb which was dropped near Brookings, Oregon, in September 1942.

B Type Fuzes arm on the same principle as A type and function on impact when an inertia block, containing a striker point, moves down on to the detonator. B fuzes used in bombs that have explosive in the tail section do not have extension rods to the vanes; but those fuzes that fit into the base plate of the bomb usually require an extension rod to the vanes, which are located in the apex of the tail cone.

Typical of the B fuzes is the B-1(a) which is an Army fuze (note holes in arming vanes in the illustration). This mechanical impact tail fuze is found in 30, 50, and 100 Kg. general purpose Army bombs. It is made of brass except that it has a steel spring and firing pin. It is 2.85 inches long without the booster and 1.55 inches wide.



LEGEND

1. BODY.
2. U-SHAPED SAFETY WIRE.
3. ARMING VANE ASSEMBLY.
4. STRIKER.
5. SHEAR WIRE HOLE.
6. GUIDE PIN.
7. SPANNER HOLES (6).
8. CREEP SPRING.
9. STOP STUD.
10. PRIMER.
11. BOOSTER.
12. ARMING SPINDLE.
13. SLEEVE.

Figure 30. B-1(a) Japanese Army Tail Fuze.

The fuze body (1) houses the arming vane assembly (3) which is secured by a U-shaped wire (2). The striker (4) is screwed into the arming spindle (12) and is kept away from the primer (10) by a creep spring (8). Six spanner holes (7) are present, along with a hole (5) for a shear wire. No shear wire

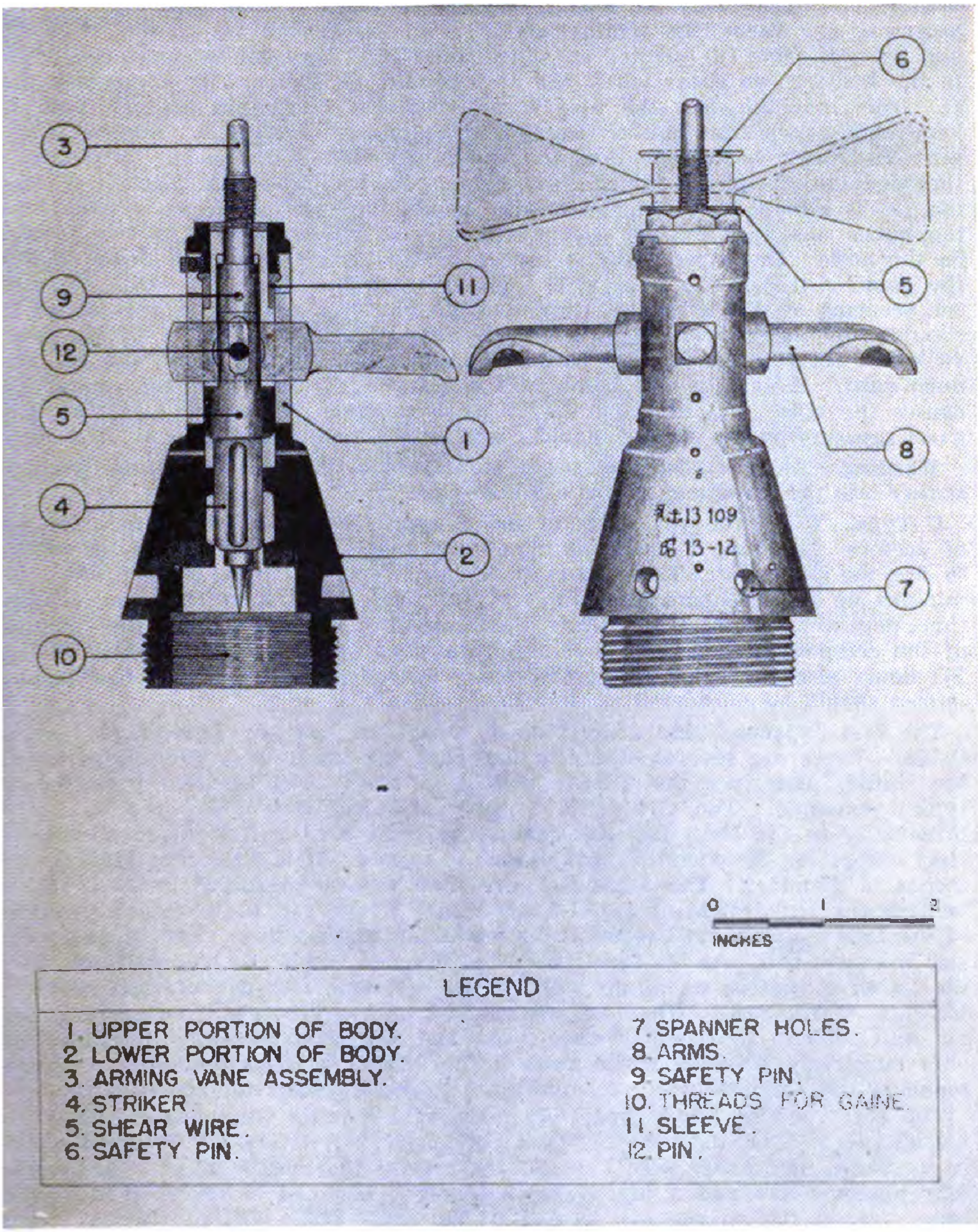


Figure 31. B-3(a) Japanese Navy Tail Fuze.

is fitted; however, a guide pin (6) prevents the arming spindle (12) from rotating with the vanes. A sleeve (13) permits the tail booster (11) to be connected to the body (1). Stop studs (9) are found on the vane cap and on the fuze body to prevent the vanes from being screwed down too tightly.

On release from the plane, an arming wire is withdrawn from the holes in the vanes, allowing the latter to rotate and fall free. On impact, the spindle (12) is forced inward, against the action of the creep spring, to pierce the primer (10) and set off the exploder system. An interesting fuze utilizing a principle not found elsewhere comes under the Japanese B group. This is the B-3(a), a Navy mechanical impact tail fuze used with the Navy 250 Kg. general purpose bomb. The upper body portion (1) houses the arming vane assembly (3), consisting of the vanes, the arming spindle with the striker (4) at its lower end, and the two arms (8) pivoted on a steel pin (12). Six spanner holes are drilled in the body. Two shear wires (5) are present. A sleeve (11) keeps the arms (8) from moving while the fuze is unarmed. A safety pin through hole (6) keeps the vanes from unscrewing until the bomb is released. Another safety pin (9) is removed at the time the bomb is loaded in the plane. The fuze is threaded (10) for the standard Navy gaine. On loading in the plane, the safety pin (9) is removed. On release of the bomb, the safety pin (6) is withdrawn, the vanes unscrew, and the sleeve (11) moves upward relieving the pressure on the arms. On impact, inertia causes the striker (4) to move down and hit the gaine if the inertia is great enough to break the shear wire (5) To assist the shearing of this wire, the arms pivot on pin (12) and exert pressure on the shoulder of the striker. This action is a two-way affair. First, if the bomb strikes a solid target, inertia causes the outer end of the arms (8) to move downward. Second, if the bomb hits a soft target, or water, the penetration causes the outer end of the arms to move upward. In either case, the arms exert pressure on the striker shoulder and help it to function as explained above.

Warning. *After impact, any slight movement of the arms is apt to force the striker into the gaine and detonate the bomb.*

C Type. The three variations of the C type fuze all work on the principle of acetone dissolving a celluloid plug, thus releasing the spring-loaded striker to fire the detonator. These fuzes have been reported to function from a few minutes up to 127 hours after impact; but they might function after a longer time, depending on the temperature, the strength of the acetone, and the thickness of the celluloid plug. Therefore, all precautions should be taken until at least 144 hours after impact. All bombs that are dropped and fail to detonate upon impact should be considered as time fuzes and not as duds.

The first Japanese time delay fuze of which we had any knowledge was the **C-1(a)**. There are several others in use now, but since their general principles are similar and since the C-1(a) is still in use it will be used here for the typical example. The C-1(a) is a Navy chemical time delay tail fuze used principally in the Navy 250 Kg. general purpose bomb. It is made entirely of steel except for the chemical tank, which is copper. It is 6.1 inches long by 2.45 inches in diameter. The Japanese have used a very ingenious method of preventing the withdrawal of the C-1(a) from a bomb. In the external threading of the fuze a slot is cut deeper at one end than at the other. Imprisoned in the slot is a steel ball. As the fuze is screwed into the bomb, the ball retreats, under the action of inertia, to the deep end of the slot and does not interfere with the insertion of the fuze. When an attempt is made to unscrew the fuze, however, the ball rolls to the shallow end of the slot where it jams the threading and very effectively prevents withdrawal of the fuze. This is usually the only fuze found in the bomb, a nose plug filling the cavity intended for a nose fuze.

The outer portion of the body (1) houses the arming vane assembly (3), the inertia weight (11), and the inner body portion (2). Rotation of the inertia weight is prevented by a shear wire (5). At the base of the inertia weight are fastened four plungers (7) and a lug (13), to which is fastened a heavy spring which bears against the striker (4) located in the inner body portion (2). A torus-shaped copper tank (6) is located directly under the plungers (7). Bearing against the concave portion of the firing pin is a chemical composition plug (15), spring-loaded. On release from the plane, the arming wire (14) is withdrawn and the vanes unscrew and fall free, leaving the inertia weight to be held back by the pin (5) which is sheared on impact. The inertia weight, moving down after impact, is locked in the down position by the spring-loaded plunger (12). The acetone from the tank (6) contacts the soluble plug (15). At the moment that the inertia weight (11) moved down and the plungers (7) pierced the tank.

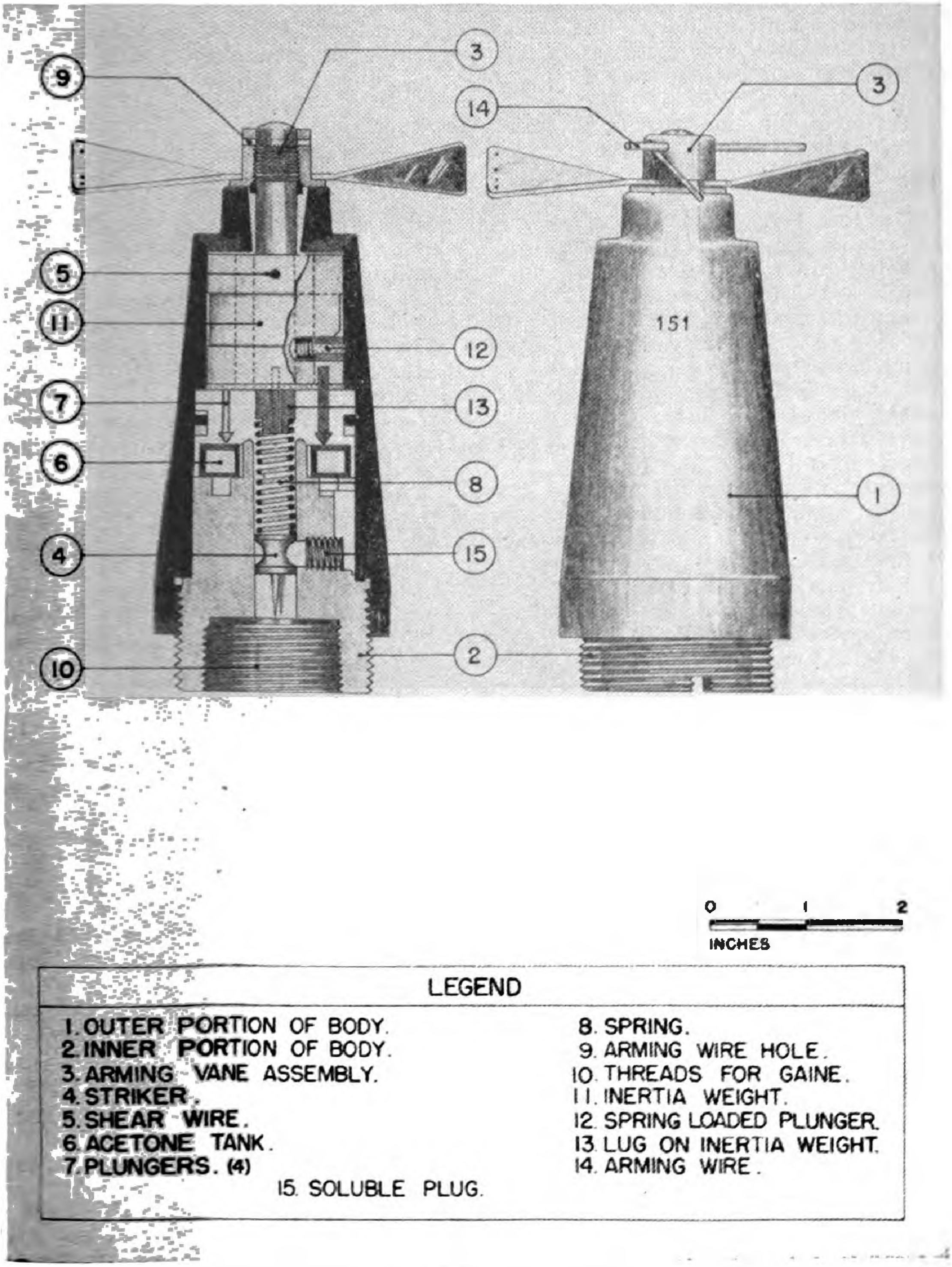


Figure 32. C-1(a) Japanese Navy Long Delay Tail Fuze.

the spring (8) was compressed; the striker (4) is then under pressure. When the plug (15) dissolves, the striker moves forward under spring pressure and pierces the gaine.

D Type Fuzes work on three different principles. The rotation of the vanes on the **D-1(a)** induces a current which fires the detonator after a set atmospheric pressure is built up during the descent of the bomb. The **D-2(a)**, **D-2(b)**, and **D-2(c)** are clockwork fuzes set to function in the air after elapse of a set time. The **D-3(a)** and **D-4(a)** operate after the vanes rotate enough to release a spring-loaded striker.

Typial of the clockwork type aerial burst Japanese tail fuzes is the **D-2(a)** which is used with the 250 Kg. incendiary. Made entirely of brass. except for steel studs in the body and steel studs and springs in the clock, this fuze is 5.75 inches by 2.44 inches wide.

The fuze body consists of a body casing (1), a clockwork retaining ring (2), an arming assembly (3), a clockwork mechanism (17), and a fixed sleeve (13). A safety pin (5) secures the arming vanes and prevents rotation until the bomb is released. The grub-screw (11) holds a fixed sleeve (13) in position with the clockwork retaining ring (2). Six spanner holes (7) are found in the base of the ring (2). A clockwork safety pin (6) passes through an actuator (16) which bears against a safety plate (18) and holds the striker stop-catch (22) in place. The latter is U-shaped and is pivoted on a screw shown in the drawing. The safety pin (6) also holds a centrifugal safety catch (15) which in turn prevents the striker from moving down. A rotation of 1,000 rpm must be reached by this safety-catch (15) or the primer (10) will not be fired. The clockwork is very intricate and delicate and must be carefully handled. The time is set by removing the screw from the timesetting aperture and inserting a special tool. When the body portion (1) is turned to the desired setting, a grub-screw is tightened to hold the setting.

Both pins (5) and (6) are withdrawn as the bomb is released. The arming vanes revolve, raising the safety plate (18) with the actuator (16) moving upward against it as a result of spring action. As the bomb falls it rotates due to the angled fins, and at 1,000 rpm, the centrifugal safety-catch (15) flies out against the action of its spring (14) and is completely free from the striker collar bearing against it. As the clock runs the sliding disc (21) rotates, and at the set time the notch in the plate will be opposite the striker stop-catch (22). The top of the striker is fitted with a knife-edge which bears down on the stop-catch. Previously, the actuator had moved up, allowing the end of the stop-catch to enter a notch in the actuator. The striker, pulling down, forces the stop-catch to pivot and to enter the notch in the sliding plate, thus allowing the striker to move downward and to pierce the primer (10).

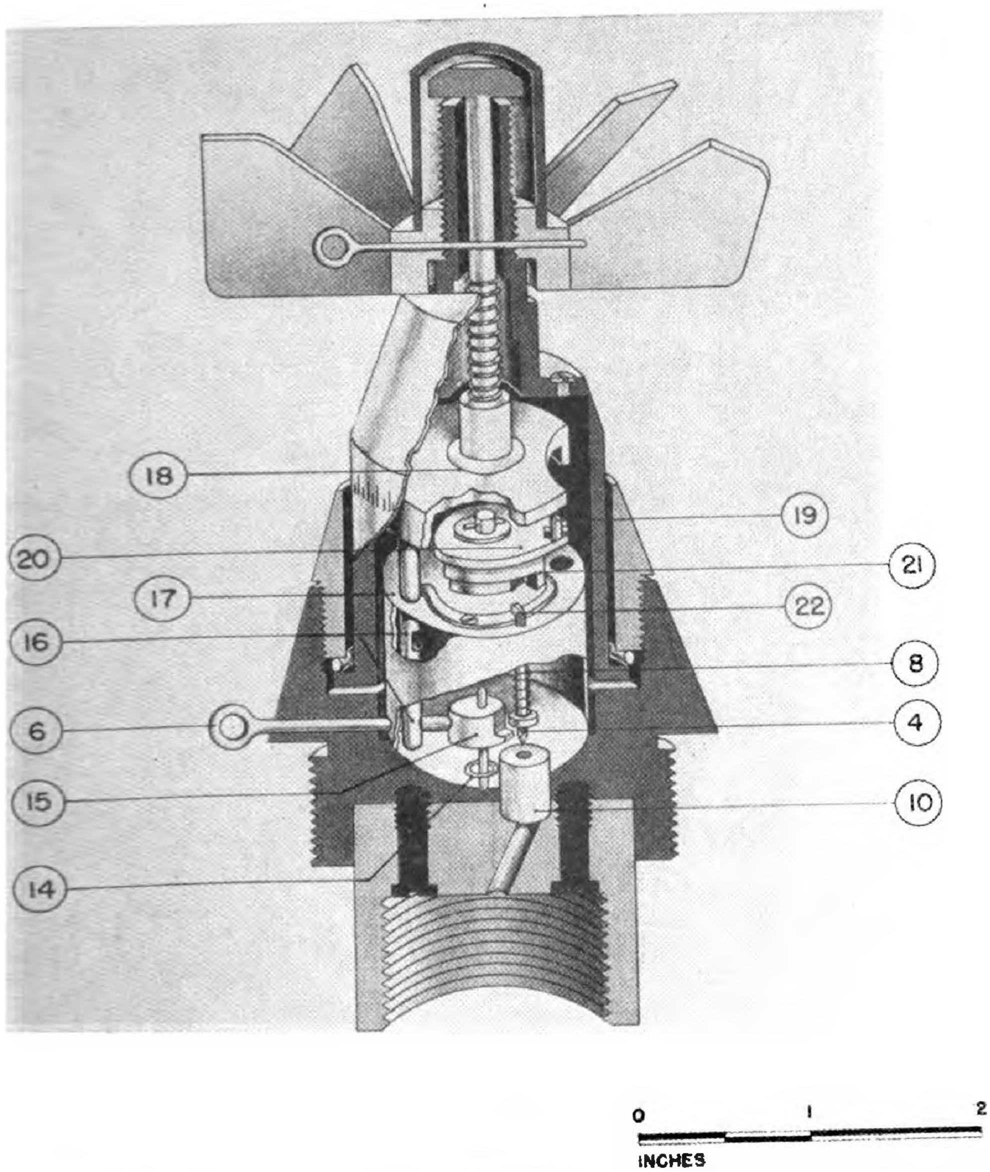
The clock in this fuze starts after 11 turns of the arming vanes. The delay time of the clock can be set from zero to fifty seconds. This time is set before leaving the ground, and the bomb must then be dropped from a specific height above the target. The explosion usually takes place from 100 to 175 feet above the ground.

Warning. *Unexploded bombs may result with this fuze in a very sensitive condition. This is true of all clockwork fuzes.*

Since there are three different types of D fuzes and since three different principles are involved in their operation, all three will be described here.

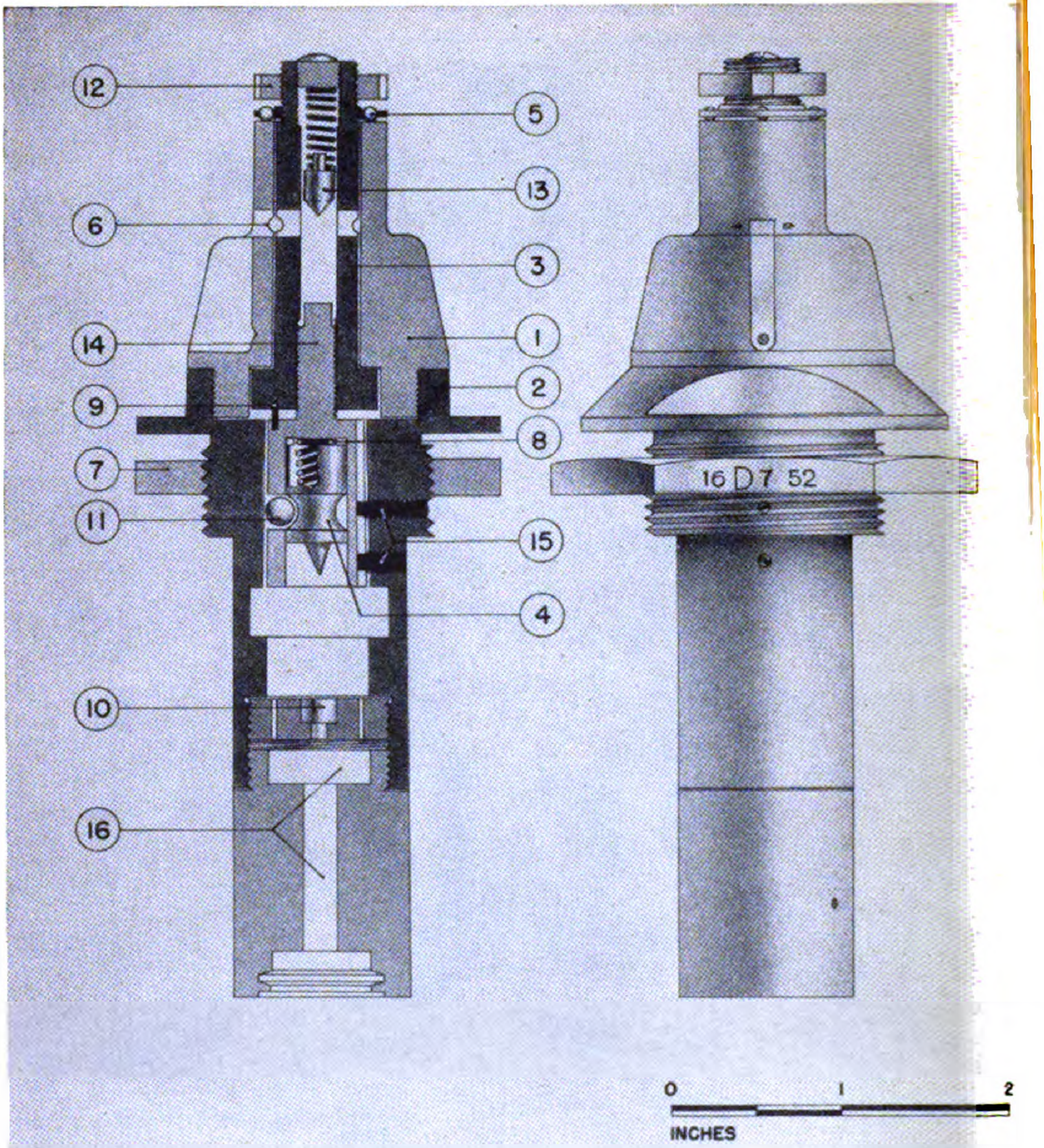
The **D-3(a)** is a Navy mechanical aerial burst nose fuze made entirely of brass except that it has a steel striker (4) and steel locking balls (11). Its overall length is 4.53 inches and its width 1.75 inches. The vanes are not shown in the illustration, but the ball race (5) is provided so that they will operate smoothly.

The lock nut (12) is tightened over the vanes which rest on the ball race (5). On release from the aircraft, the safety wire is withdrawn from its holes (6), allowing the vanes to rotate, thus screwing the arming spindle (14) downward. The arming spindle is prevented from rotating by guide pins (15). The stop stud (9) prevented the arming vane sleeve (3) from being tightened down too far during fuze assembly. As the arming spindle moves downward, the striker (4) and its spring (8) move also until the striker forces the balls (11) to move into the groove cut into the lower body, (the striker is under spring pressure). As



LEGEND	
4 STRIKER	17 CLOCKWORK
6 CLOCKWORK SAFETY PIN	18 SAFETY PLATE
8 STRIKER SPRING	19 TIME SETTING CAM
10 PRIMER	20 TIME SETTING PLATE
14 CENTRIFUGAL SPRING	21 SLIDING PLATE
15 CENTRIFUGAL SPRING SAFETY CATCH	22 STRIKER STOP CATCH
16 ACTUATOR	

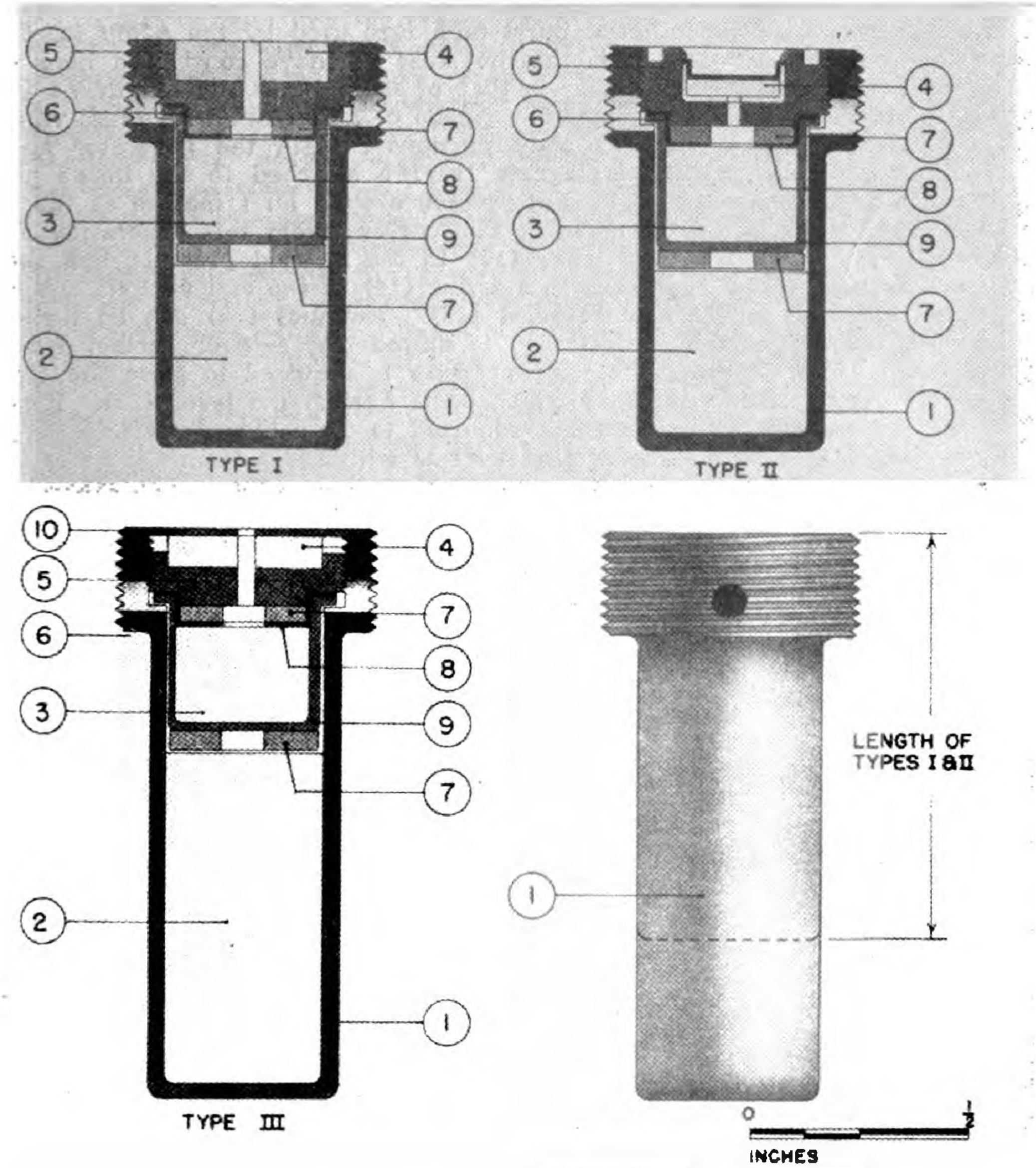
Figure 33. D-2(a) Japanese Navy Aerial Burst Clockwork Fuze.



LEGEND

1. UPPER PORTION OF BODY.
2. LOWER PORTION OF BODY.
3. ARMING VANE ASSEMBLY.
4. SPRING LOADED STRIKER.
5. BALL RACE.
6. HOLES FOR V SHAPED LOCKING WIRE.
7. LOCK NUT.
8. SPRING.
9. STOP STUDS.
10. PRIMER FLASH CAP.
11. STEEL BALLS (3).
12. LOCK NUT.
13. SPRING LOADED PIN.
14. ARMING SLEEVE.
15. GUIDE PINS.
16. POWDER TRAIN.

Figure 34. D-3(a) Japanese Navy Mechanical Aerial Burst Fuze.



LEGEND		
TYPE I	TYPE II	TYPE III
1. CONTAINER.	1. CONTAINER.	1. CONTAINER.
2. TETRYL.	2. TETRYL.	2. TETRYL.
3. FULMINATE OF MERCURY (.6 GR.)	3. FULMINATE OF MERCURY (.6 GR.)	3. FULMINATE OF MERCURY (GR).
4. BLACK POWDER MIXTURE.	4. CAP.	4. BLACK POWDER MIXTURE.
5. COPPER PLUG.	5. COPPER PLUG.	5. COPPER PLUG.
6. COPPER CUP COVER.	6. COPPER CUP COVER.	6. COPPER CUP COVER.
7. FELT WASHER.	7. FELT WASHER.	7. FELT WASHER.
8. TIN FOIL STRIP.	8. TIN FOIL STRIP.	8. TIN FOIL STRIP.
9. COPPER CUP.	9. COPPER CUP.	9. COPPER CUP.
		10. METAL WASHER COVER.

Figure 35. Japanese Army Gaines.

the balls move outward, the striker moves downward, under spring action, and pierces the primer (10) to initiate the explosive train. The lock nut (7) is used for fastening the fuze securely into the body of the bomb.

The **D-1(a)** is an electric aerial burst nose fuze used by the Army for 50 Kg pamphlet container bombs. It is the first fuze we have considered here which is of the generator type. Its color is that of lamp black, its length 7.4 inches its width (of body) 3.05 inches, and it is made of aluminum with brass vanes.

The upper (1) and lower (2) body portions contain the generator and the aneroid pressure box. Several magnets (9) are attached to the inside portion of the arming vane assembly (3) and revolve around an armature as the vanes rotate during the flight of the bomb. The current from this generating system is conducted through the plug leads (15) to the aneroid pressure box through two sockets (13). One wire leads to a screw (14) at the end of a lever and the other is connected with a contact point (16). The dial (18) can be turned by hand. By this means the contact (16) is moved closer to or further from the screw (14). If moved closer less air pressure is required to close the contacts against the action of a spring (17) which bears against the lever (19). If moved further then a greater air pressure is required to close the contacts.

As the bomb is released the arming wire is withdrawn from the holes in the vanes and the latter rotate in downward flight. A current is generated by the revolution of the magnets (9) around the armature (7). The current is conducted through one of the plug leads (15) to one of the sockets (13) to the contact (16). As the bomb continues to fall, the air rushes through the fuze after entering it through the twelve small holes, (4) and, eventually, builds up to the point where the pressure box is sufficiently compressed to allow the strip (19) to recede slightly, thus allowing the lever holding the screw (14) to move upwards under pressure of the spring (17). When the circuit is closed, the current continues from the contact (16) through the screw (14), through the primer-detonator (10), and returns to the generator through the other socket (13). The primer is thus fired and starts the explosive train. The dial (18) serves the purpose of varying the distance above the ground at which the burst will occur.

Gaines. The gaine, as has been explained previously, is a part of the explosive train which is intended to magnify the effect of the primer to such power that the main charge of the bomb, or the booster will detonate. In the Japanese setup there are two gaines, one for the Army and one for the Navy. The principal difference between the two is that the Navy gaine is used to contain practically the entire explosive train except for the main charge, and sometimes an auxiliary booster, while the Army gaine corresponds to the American detonator.

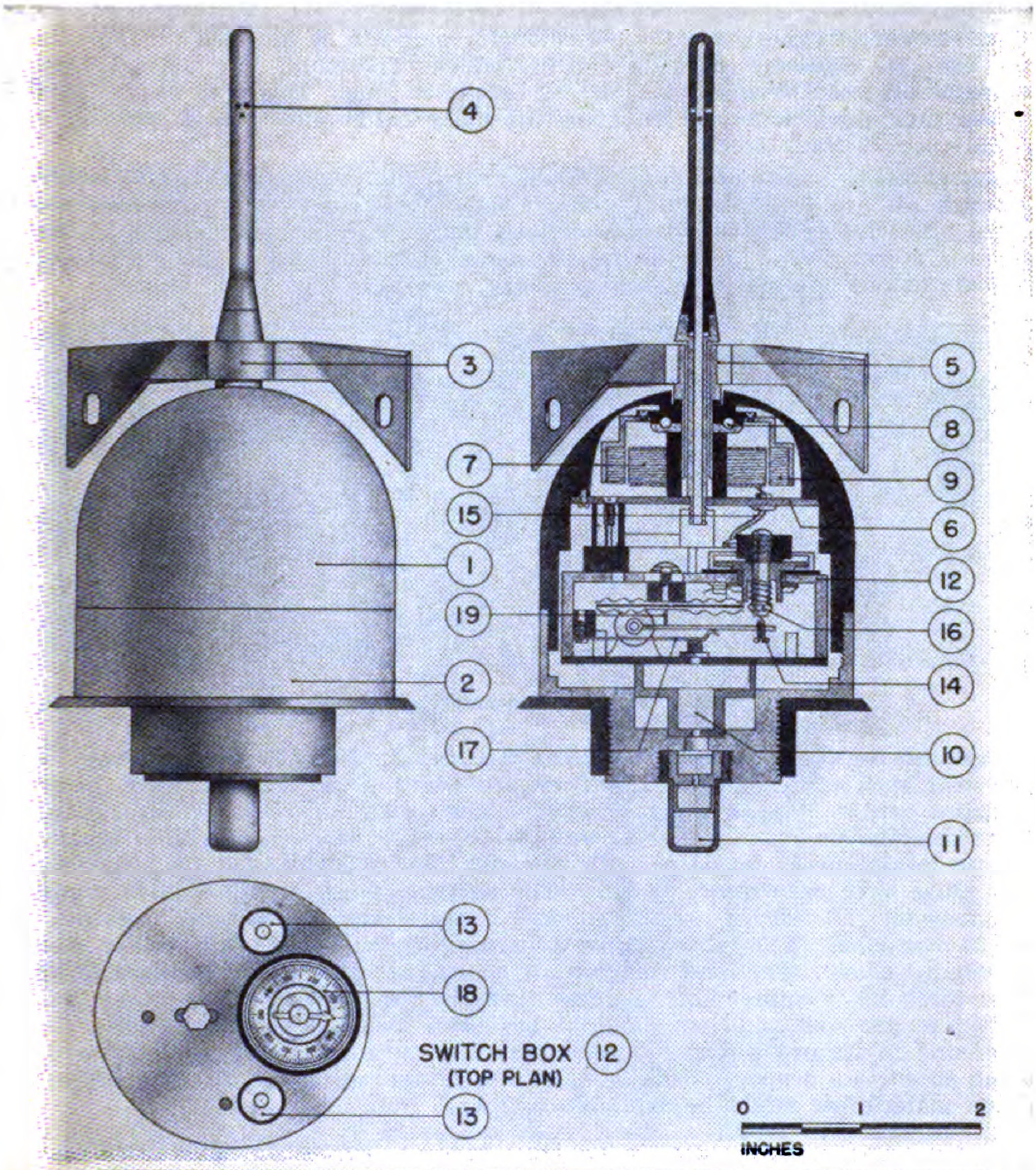
Army Gaines. All Army fuzes use one of the three types of gaine shown in the illustration. Types I and II are used with nose fuzes only, while type III is used only in tail fuzes. The latter type is about twice as long as the first two. Types I and III are ignited by a flash from a primer cap in the fuze, while type II is pierced by the striker. Type I is used by all Army nose fuzes except the A-2 (b), which uses type II. Type II and the A-2 (b) fuze are used only in bombs which do not have HE as the main charge. (15 Kg. anti-personnel is an exception to this rule). These gaines are usually surrounded by a booster.

Navy Gaines. There are four types of gaines used by the Japanese Navy. Types A and D are used for delay action while types B and C are used for instantaneous action. The components of each gaine are illustrated below. Type A has been found with different delay plugs (b-1 or b-2). The detonator plug a-1 may be found in two pieces or as a single piece.

The most recent detonator plug is the a-3 which has been found in the type C gaine. This is a superquick gaine used in the 60 Kg. GPHE Navy bomb, type 97 with the A-3(a) fuze. Type B employs the ordinary instantaneous plug a-2.

Any gaine will fit any Navy fuze which takes a standard gaine. The markings on the gaines refer to the type, date of manufacture, and whether used by the Army or Navy.

Type A has been found with the bottom of the gaine painted red, brown, or green on the outside. These colors have been observed only on type A gaines which always employ a delay. When the b-2 delay plug is used, the tip is red or brown. If a b-1 plug is used, the tip is painted green. The b-2 plug is believed



LEGEND

1. UPPER PORTION OF BODY.
2. LOWER PORTION OF BODY.
3. ARMING VANE ASSEMBLY.
4. TWELVE SMALL HOLES.
5. COLLAR.
6. PLATE.
7. ARMATURE.
8. BALL RACE.
9. MAGNETS.
10. PRIMER-DETONATOR.
11. DETONATOR-BOOSTER.
12. SWITCH BOX.
13. TWO SOCKETS.
14. SCREW.
15. PLUG LEADS (2).
16. CONTACT.
17. SPRING.
18. DIAL.
19. STRIP.

Figure 36. D-1(a) Japanese Army Electric Generator Aerial Burst Fuze.

to be of longer delay than the b-1 which has a delay of 0.034 seconds. In the b-3 plug, the delay may be set for 0.5 second, 1.0 second, or 1.5 seconds.

It is of interest to note that the c-2 detonator plug can be initiated by detonation only, since its explosive charge is entirely tetryl. Therefore, only the a-3 primer detonator plug can be used with the c-2 detonator plug. This may be the reason for the superquick action which gives the daisy cutter effect when used in the 60 Kg. type 97 Navy bomb.

Navy gaines are made of brass, cadmium plated, and finished with a dull lacquer. Although all are equipped with spanner flats, they have been recovered from bombs into which they were screwed hand tight. The booster element in these gaines is a picric acid plug. In larger bombs it is not strong enough to cause complete detonation, and hence an auxiliary booster is used.

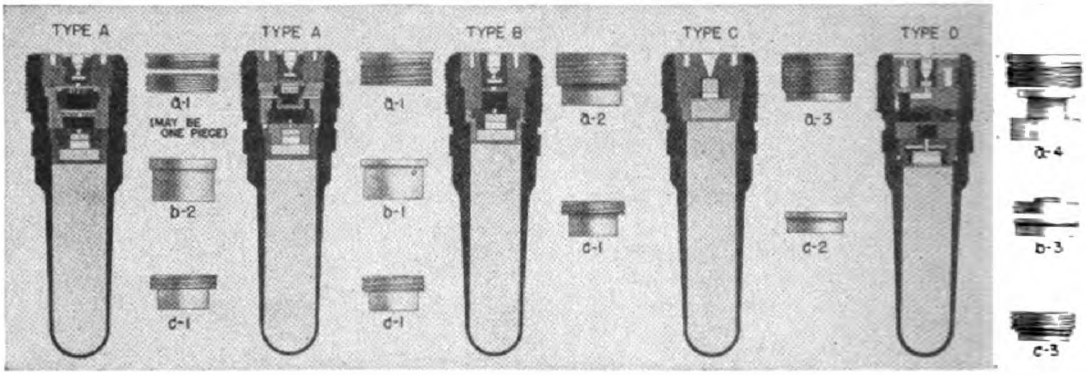


Figure 37. Types of Japanese Navy Gaines.

Magazines for Navy Fuzes. Magazines are used in Navy fuzes to initiate low explosives such as black powder. They are never used with HE filled bombs. Magazines can be fitted to any fuze which takes a standard Navy gaine. Up until the present, however, only A-3(a) and A-3(b) have been used with magazines. Only an instantaneous magazine with two plugs and a slight delay magazine with three plugs have been found to date. The 'd' type plugs contain a large amount of gunpowder and are not used in gaines. Plugs 'a' and 'b' are used in gaines as well as magazines. The magazine explosive is initiated by the fuze striker piercing plug a-1 or a-3. The most common use of magazines is with incendiary bombs.

The foregoing treatment of Japanese fuzes has, of necessity, been very brief, but it is hoped that sufficient material has been included to interest the casual reader and to furnish a firm foundation for the more interested student so that he can go on to a deeper consideration of the subject using FM E9-1983 and such foreign materiel as might be available to him.

BOMB RECONNAISSANCE

Before any bomb can be disposed of it must be located and identified as an unexploded bomb. It has been stated earlier in this chapter that during the early stages of the development of bomb disposal this work was done by anyone who happened to be near the bomb. Such a system led to many false reports with a consequent waste of effort upon the part of highly trained personnel. It may seem almost impossible that anyone could confuse the effects of an unexploded bomb with those of one which has not gone off. Experience, however, proves that such is the case and perhaps the following paragraphs will convince the reader that one must use considerable care in diagnosing any incident before making a positive decision. Let us start with the bomb at the moment of its release from the plane and follow it through its complete history from that time until it either explodes or finally comes to rest.

Bomb Flight, or the travel of the bomb from the time it leaves the carrier plane until it strikes the target area, is important both from the standpoint of the none-too-casual observer of the bombing attack and of the bomb reconnaissance or disposal officer. When the bomb is released from the plane, it does not fall vertically to the ground, but, due to the forward impulse of the plane's motion and the effect of gravity, it follows a curved path or trajectory which closely approximates the figure of a parabola. A bomb dropped from altitudes greater than 10,000 feet at airspeeds in the vicinity of 250 miles per hour, will strike the ground at an angle with the vertical of 15 to 25 degrees. While the bomb falls, the plane, of course, continues its flight in a more or less horizontal

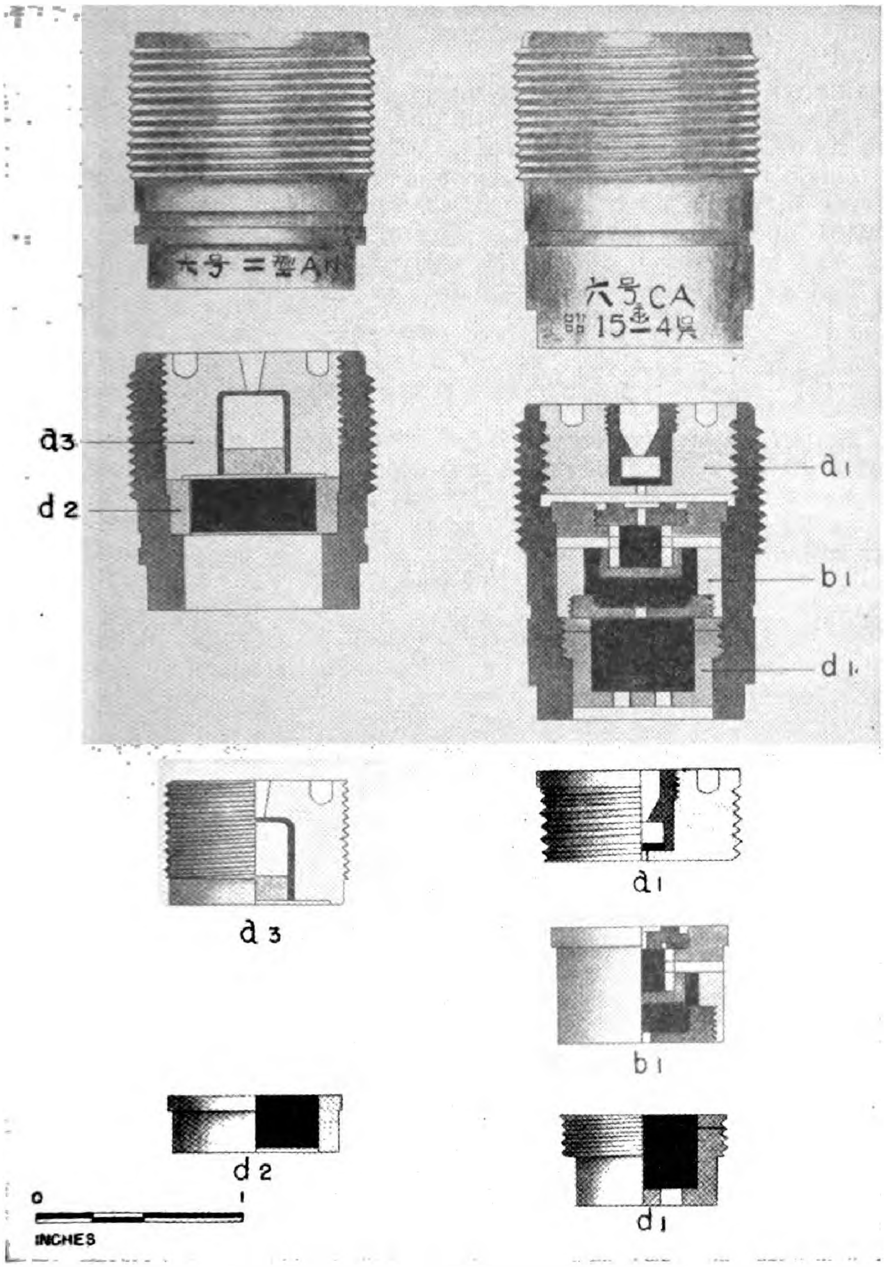


Figure 37A. Magazines for Japanese Navy Fuzes.

plane. Should it continue at the same speed at which it was moving at the moment of release, it may be as much as a mile and one-half beyond the point where the bomb strikes the ground at the time of impact. From this we can safely assume that when the release of a bomb can be observed either directly overhead or nearly so, it will not fall close to the observer, but rather, quite some distance away in the direction of the plane's flight.

Penetration. When the bomb strikes the earth, if the soil is normal, it will continue its downward movement, until detonation occurs or the bomb comes to rest. The path pursued by the bomb is usually fairly straight for about two-thirds of the total depth to which it ultimately will go and then bends quite sharply. This bend frequently makes the location of an unexploded bomb more difficult than it would appear to be. In some instances bombs will curve underground so much that they head upward toward the surface before coming to rest. Others, dropped from fairly low altitudes, have actually come out again on the surface of the ground. Some bombs do not change their direction of penetration but continue to head straight down into the earth until brought to rest by soil resistance.

The maximum depth to which the bomb penetrates is termed *penetration.* The maximum horizontal distance traversed underground from the point of impact is known as its *offset.* Every bomb disposal officer must accumulate as much knowledge as possible regarding penetrations and offsets of bombs of various sizes for the area in which he is stationed, so that he can locate them more quickly when called upon in emergencies. Typical of such figures are the following which applied to England, during the early days of the war:

40% of all UXB's penetrated 15 feet or less;
40% penetrated 15 to 20 feet;
15% penetrated 20 to 25 feet;
4% penetrated 25 to 30 feet;
1% penetrated over 30 feet.

These figures are regardless of bomb size or soil characteristics. Obviously figures of practical value must take into account the soil characteristics, size and shape of bomb, and so on. Or, for instance, an empirical rule may be devised to correlate figures for one type of soil with those of another for bombs of the same size and shape.

The following might be used for this purpose:

If the depth of pentration in normal earth is 1,
Then in chalk or coral penetration it will be 2/3,
And in rock or concrete it will be about 1/3.
For penetration in normal earth of 1,
In dry clay we can expect 2,
And in wet clay .... 3.

Generally speaking it can be said that the finer the soil, the deeper will be the penetration.

Hole of Entry. Frequently a hole will be found in the surface of the earth where the bomb penetrated, although many times it will be filled up with loose earth so as to resemble a spot in which someone has merely turned over a spade full of dirt. If the hole is found it can be used to obtain an estimate of the bomb's size. The following table is a good guide for this purpose although it is not entirely accurate for all bombs. It was made to cover the majority of cases and to be easily memorized for field use.

HOLE OF ENTRY

Diameter of hole (inches)	*Probable type of Projectile*	*Weights*	
		Kilograms	*Pounds*
Up to 8	Artillery or Anti-personnel bomb	....	....
8 to 12	Bomb	50 to 100	110 to 220
14 to 18	Bomb	250	550
18 to 26	Bomb	500	1,100
Over 26	Bomb	1,000 or over	2,200 or over

Holes of entry must be measured at a spot where their true diameter can be obtained rather than at the earth's surface, since the area where the bomb strikes the ground is apt to be beaten in or the loose earth around the hole might slide into the hole giving an opening much larger than the bomb's diameter. This information, when obtained, will enable the bomb disposal officer to plan accurately an excavation to remove the bomb. Very often parts of the bomb will be found in the hole of entry. These pieces may also assist a bomb disposal man in identifying the bomb hidden below and so help him to know the fuzing arrangement he will probably encounter.

Exploded Bombs may also prove valuable in identifying other UXB's in the vicinity. From the fragments and effects of the explosion it is often possible to tell just what kind of bombs were dropped, which tend to prove the presence of others of the same type. Then, since bombs are often dropped in salvos or 'sticks', the reconnaissance agent may be able to find an unexploded bomb by plotting the locations of the explosions and from them judging where other parts of the stick should have fallen. In other words, if a stick of four was loosed, and only three exploded, the fourth can be readily located by spotting the three known bombs on a map and filling in the fourth by measuring the spacing of the three and looking for the blank area on the plot-up to probable location of the fourth.

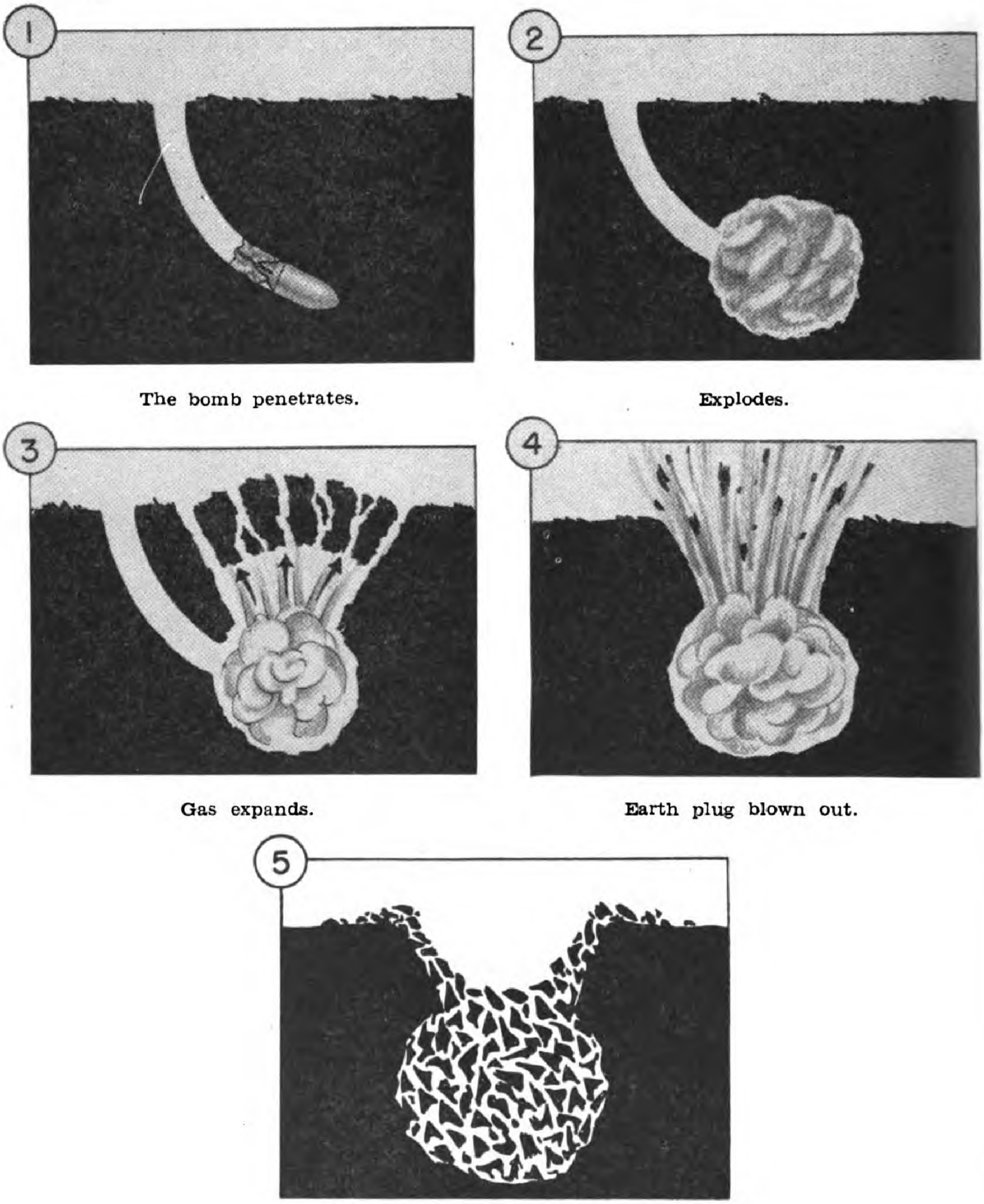
Effects of Exploded Bombs. When a bomb explodes, four major effects may be noticed.

(1) Fragmentation or the throwing of bomb body fragments or splinters in all directions at high velocities from the point of explosion. A demolition or general-purpose bomb case will normally fracture at an angle of 45 degrees, whereas the heavier armor-piercing case fractures perpendicularly. Fragments tend to be projected off at right angles to the long axis of the bomb so that superquick impact fuzes give the greatest fragmentation damage.

Figure 38. Bomb Explosion Near Building.

(2) Blast damage occurs as the result of the rapid transformation of the explosive from a solid to a gas. This transformation sets up a shock wave which radiates from the explosion similarly to ripples caused by the dropping of a pebble in still water. This wave may rebound from surfaces, but does not flow around them. Therefore, personnel and materiel behind a strong wall normally are not injured by the blast wave. The shock wave builds up a pressure in

front of it and creates a decrease in pressure or partial vacuum in its wake. This vacuum or suction phase does not flow radially but air from all directions rushes in to overcome the vacuum. This causes glass, walls, and personnel to be sucked towards the explosion, although the effect of the pressure wave may not have been felt.



The bomb penetrates. Explodes.

Gas expands. Earth plug blown out.

Dirt settles.

Figure 39. The Formation of a Crater From Underground Explosion.

(3) Earth shock occurs from the shock or compression wave from the bomb explosion being transmitted through the earth. The earth near the explosion will usually show a permanent movement, while the earth farther away will be compressed yet will spring back. The earth shock crumples foundations and crushes sewers, water mains, and other structures placed in the earth.

(4) Debris or pieces of earth, structural materials, etc., will also be projected

from the explosion like fragments, but the debris normally does not penetrate objects and will be greater where a bomb penetrates the ground before exploding.

Craters. When a bomb explodes on or under the surface of the earth, it leaves a scar which is known as a crater except where explosion has taken place at such depth that it is completely confined beneath the ground. Craters are different in their characteristics dependent upon conditions at the place where the bomb went off. It is possible here to describe the perfect crater formed by the surface explosion of a bomb, and that formed by an underground explosion; but the reader must remember that the usual case in the field is more apt to present a combination of the characteristics of each rather than a complete array as described herein.

When a bomb detonates the moment it touches the ground, the explosion actually takes place above the earth's surface and the downward force of the blast beats the ground down into a saucer-shaped crater, which has no lip or debris around the edges and the sides and bottom of which are hard packed. In the vicinity of such a crater there will be plenty of signs of blast (such as trees with the leaves blown off and broken windows) and of fragmentation (such as pock marks in walls and tree trunks), and there will be a number of striation marks or grooves in the earth radiating like the spokes of a wheel with the crater as the hub.

The formation of a crater due to an underground explosion is most easily explained by breaking it down into five successive steps: (see Fig. 39.)

In the vicinity of such a crater the observer will find fragment damage and much debris which has fallen and which will be especially noticeable on ledges such as window sills. There will be little blast damage, but the earth shock should be great, causing cracks in foundations and walls and breaks in pipe lines which are in range.

A glance at the sketch illustrating the fifth or final step in this series will show the reader that the crater which is seen after such an explosion is not the true crater. It is called the apparent crater since it is all that is apparent to the observer. The true crater, of course, is the part buried beneath all of the loose earth which fell back into the hole.

The average sizes of apparent craters due to the underground explosion of bombs of normal penetration are shown in the following table:

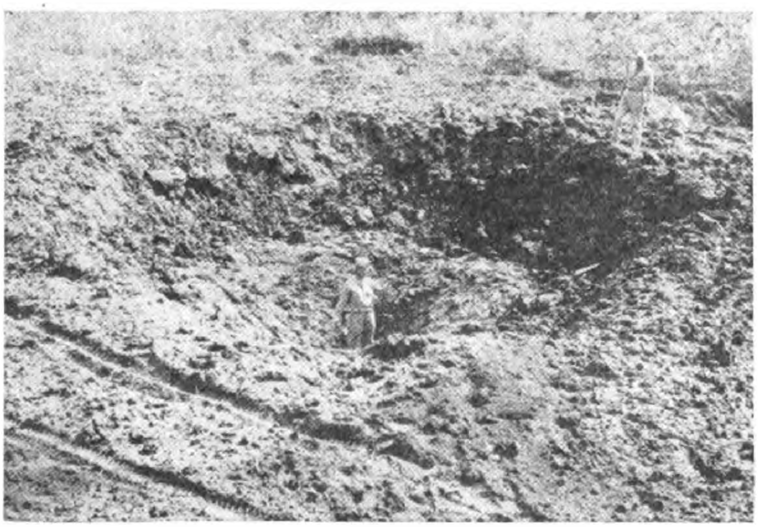
Bomb Size (Kg)	*Crater Diameter (Feet)*
50	10 to 15
250	18 to 25
500	25 to 50
1,000	65 to 75

False Craters. Occasionally a very large bomb which fails to explode will leave, instead of an obvious hole of entry, a crater which resembles that of a small exploded bomb. This is known as a false crater, Figure 40. Since the bomb is still under the ground and may explode at any titme, it is important that the reconnaissance agent be able to identify this crater as the sign of an unexploded bomb. The first step in identifying it is to notice that it does not have any of the outstanding signs we have come to associate with the crater of an exploded bomb: fragmentation damage is missing and blast damage is not apparent, although it is possible that there may be some damage which resembles that due to blast, especially if the bomb has hit a small building. The second step in proving the identity of this type of crater is to check its positive signs: it has very steep sides near the earth's surface, the crater itself is relatively shallow, and, lastly, probing in the bottom of this crater will reveal the presence of a shaft of entry for the bomb. Since this type of crater is only made by bombs of 1,000 Kg. or larger, the shaft of entry will be over two feet in diameter and should be fairly easy to find.

Camouflets. When a bomb explodes underground and lacks the power to create a crater, it forms a chamber such as that described in steps two and three above. This is known as a camouflet. The majority of camouflets are formed by small

Hole of entry 18" across.

False crater.



Crater made by explosion of 2,000-lb. bomb.
Figure 40. Hole of Entry and Types of Craters.

bombs of 50 or 60 kilograms. The amount of surface indication of a camouflet depends upon the depth at which the explosion took place. The danger of a camouflet lies in the fact that the chamber is filled with the gaseous by-products of the explosion, mainly carbon-monoxide. Since the loose surface earth is easily dislodged by a man walking on it, the whole thing is apt to cave in thus precipitating the walker into a chamber full of very deadly gas.

There are three types of camouflet identified as follows:

Type A: A mound of soft earth within a few feet of a hole of entry. The center of the underground chamber in this type is usually about twelve feet underground, and, since the chamber may be as large as twelve feet in diameter, it will extend up to within six feet of the earth's surface and can readily be located by means of a probe rod.

Type B: A mound of cracked, heaved earth within a few feet of a hole of entry. The center of the chamber of this camouflet will be about sixteen feet underground.

Type C: This type camouflet occurs about twenty-one feet underground and is so deep that it leaves no surface indications. Even the most experienced bomb disposal or reconnaissance man will think this an unexploded bomb.

When a camouflet is suspected, its presence can be definitely ascertained by probing and locating the underground chamber.

Warning. The gas from certain types of camouflet is highly explosive. All probing must be done with non-sparking tools. When men are working above a suspected camouflet certain other safety precautions must also be observed. Planks should be laid across the mound to decrease the possibility of a cave-in. The man who stands on the planks to use the probe rod must wear a lifeline so that he can be hauled out quickly should he slip and fall into the camouflet. The difference of a few seconds in pulling a man out of such a hole may mean the difference between life and death to him, because of the high concentration of monoxide gases.

When it has been decided that a camouflet is definitely present, it can be disposed of by using a fire hose to fill the chamber with water. For this purpose the demolition truck of Chemical Warfare units is ideal. Insert the hose nozzle into the hole made by the probe rod remove personnel to a safe distance from the hole and turn on full pressure.

Diagnosis of Unexploded Bombs. In open ground the unexploded bomb is most easily identfied by its hole of entry. Absence of other signs of explosion help, of course, for example when there is such a thing as a false crater present. Occasionally, the debris thrown about by a nearby explosion will toss a rock, or other hard object, so high that in falling it will penetrate the ground and leave a hole which is easily confused with a hole of entry. The bomb reconnaissance agent can avoid reporting such things as unexploded bombs by taking a little more time and investigating just a little more carefully before rushing off to get one of the squads (sep) in action. It will save ordnance officers from being embarrassed, for example, to report an unexploded bomb in, say, the attic of a house and then have someone walk out of the house carrying the rock which made a hole in the roof. This is particularly true in situations where bomb disposal personnel are located considerable distances from the scene, or their services during an emergency may be in great demand.

In pavements the only thing which is apt to deceive the uninitiated is the hole made by the explosion of a fragmentation bomb when it explodes. It sometimes has the appearance of a hole of entry of a larger bomb. However, a little probing (gently, of course) in what seems to be the hole of entry will convince the investigator that the earth is still in its natural state, however torn the pavement may be.

In rivers, lakes, or ponds, there is no way one can tell whether a bomb has not exploded except by seeing it fall. Even then, unless careful observations are taken, it is almost impossible to locate it. The explosion of a bomb in water can frequently be detected because of the way the water may be discolored or because of the presence of a large number of dead fish. The absence of dead fish is obviously not positive proof that the bomb failed to explode.

An unexploded bomb in a building is apt to present the most confusing set of signs to a reconnaissance agent. One example should suffice to prove this point and at the same time to point out the things one must watch for. There is on record the case of a reconnaissance agent who found the hole of entry of a bomb in the roof of an apartment house building in England. It was a 250 Kg. bomb and had passed through several stories of the building. The agent traced its path until he came to a room about four floors down where the bomb had entered and then apparently had exploded. Plaster was liberally scattered about the room, furniture was broken, several panes of glass were smashed and the general effect of devastation was extensive. There was a hole of entry in the ceiling to show where the bomb had entered the room but none in the floor and no bomb in the room. The reconnaissance agent assumed that the bomb exploded and reported it as an exploded 250 kg. bomb. The people were therefore permitted to stay in the building and the incident was closed until the next morning when

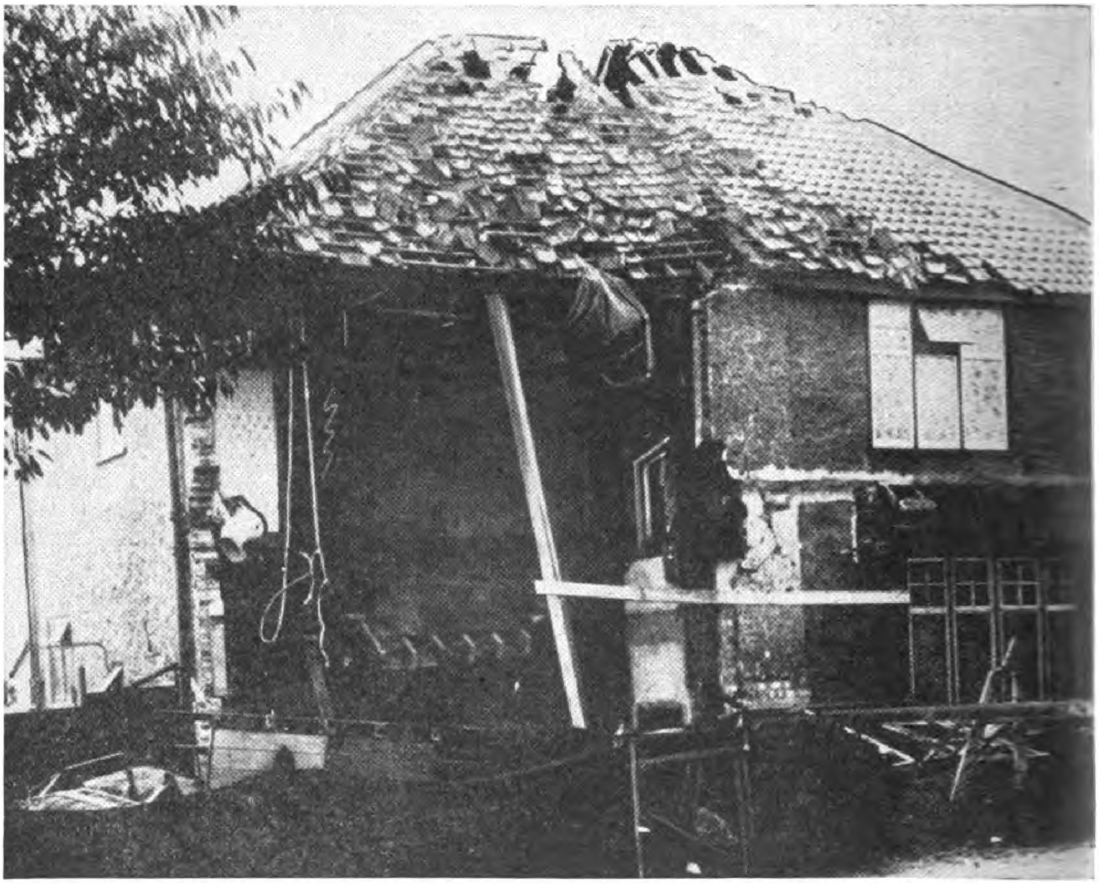


Figure 41. Damage Due to an Unexploded 250 Kg. German Bomb.

the bomb exploded just outside of the building. It had, apparently, glanced off a beam in the floor and bounced out of the window. Had the reconnaissance agent looked for the signs of explosion, fragamentation damage, pulverized plaster (the masonry in that room had been broken up, but not powdered as it would have been in the case of an explosion), blackening of walls and ceiling and floor, blast damage (all windows would have broken, not just a few) and the smell of explosive which would linger a long time in such confined quarters, he would not have turned in such a report. Then, too, a 250 Kg. bomb is a large missile which would have done a tremendously greater amount of damage than would have been contained in a single room. The lesson learned from this incident simply was do not attempt to do too much, get back to the outfit hurriedly before completing the job or to gloss over the facts of the case considering only surface indications. At any rate his mistake was a costly one and an unnecessary one. Do not let it happen to you.

Evacuation. For the purpose of determining evacuation areas, unexploded bombs are divided into two groups—buried bombs and unburied bombs. The distinction is illustrated in the following table:

UNBURIED BOMBS

Bomb Size	*Penetration*
50 Kg.	2 feet or less
100 Kg.	3 feet or less
250 Kg.	4 feet or less
500 Kg.	6 feet or less

All other bombs are to be considered as buried bombs.

In the open, the danger area of a buried bomb is about 100 yards, and for an unburied bomb 300 yards. These figures must be increased fifty percent for bombs known to be 1,000 Kg. or larger. In populated areas the following rules for evacuation should be followed:

(1) For buried bombs—evacuate all buildings within 50 yards; open all doors and windows within 100 yards; allow no wheeled traffic within 50 yards.

(2) For unburied bombs—evacuate all buildings within 100 yards, and the rooms of buildings facing the bomb and within 200 yards of it; allow no wheeled traffic within 150 yards of it.

(3) Parachute mines require an evacuation of personnel and wheeled traffic of 400 yards.

These distances may be decreased or modified by the bomb disposal officer if the bomb can be definitely established as being less than 1,000 pounds.

Protective Works are designed to diminish the effect of an unexploded bomb which later explodes. Because of the difficulty of erecting these works, they are usually reserved for very vital installations. The types and method of employment of protective works are covered in Section III, Chapter 3 of FM 9-40.

Reporting of Unexploded Bombs has always been one of the headaches of bomb disposal personnel. It is only logical that those persons at the scene of a bombing attack or those occupying an area subsequent to such an attack should be the ones who locate the bombs that do not explode. Once an unexploded bomb is suspected, the location should be marked and the incident reported through specific channels for such reports or through command channels. This location and reporting is the essence of bomb reconnaissance which for all its length of title requires only two simple steps—*Locate and Report.* Then, for the safety of all concerned, *Leave the Object Alone.* Many instances have been reported where personnel of the armed forces have courted sudden death through ignorance of the two rules set forth above. For example: an enlisted man in an overseas theater was discovered by a bomb disposal officer hammering his tent pegs with an unexploded, American fragmentation bomb. That he still lives is sheer luck. This is not just an isolated case because the same report mentioned numerous instances of failure to take the simple precautions necessary to safeguard against unexploded bombs. Bomb disposal's only reason for existence is to further the safeguard of personnel and materiel, but it can operate properly only through cooperation of those persons concerned especially from reporting incidents. False alarms are to be expected but this is better than to allow a dud bomb to explode for lack of reporting or want of proper handling. False alarms, however, can be reduced by indoctrinating troops in the knowledge of bombs, the effects of exploding bombs and UXB's.

ORGANIZATION FOR BOMB DISPOSAL

Bomb Disposal originated in England, so it was to England that we looked for much of our early knowledge of disposal methods and the organization and employment of bomb disposal troops.

Bomb Disposal Companies are still the basic units used in England. These British companies and the original U. S. Ordnance bomb disposal companies were organized into a headquarters, headquarters platoon, and four operating platoons. Each platoon was under an officer and was capable of operating as two sections, each working on a separate incident. In the 'tight little isle', with its multitude of vital targets and the static condition of this aerial battleground, this organization proved to be very desirable. The companies had sufficient personnel to transport and utilize the cumbersome equipment necessary to excavate for and render safe the unexploded bombs in a wide area. The section was able, by reason of its manpower, to operate on a twenty-four hour a day basis. However, the company was not sufficiently flexible to fit the needs of an advancing army on a wide front. Therefore, the U. S. Army has reorganized its bomb disposal companies to meet offensive requirements.

Bomb Disposal Squad (Separate). When the Ordnance Department decided that a company was unsuitable for our needs in the field, a study of existing units was undertaken in order to determine the most satisfactory organization for the purpose. The U. S. Navy bomb disposal units consist of two men, an officer and an assistant who is usually a 1st class machinist mate or a seaman 1st class. These men utilize marine or navy enlisted men for the labor part of their work, drawing such labor from the nearest available units. This setup was considered but rejected since it was felt that the Army, being a ground force, would probably be apt to have more simultaneous incidents to handle on some occasions than the Navy and would consequently require more available supervisory men. Eventually it was decided to organize the units so as to have six enlisted men and one officer. This was done under T/O 9-179 and later modified under T/O & E 9-500 which now calls for one captain, one technical sergeant, one sergeant and four T/5's. These men all hold ratings because it is expected that any one of them may be placed in charge of a job and required to carry through all parts of it with the exception of the actual inerting of the bomb fuze. The latter function is officially reserved solely for commissioned officers, although there are cases

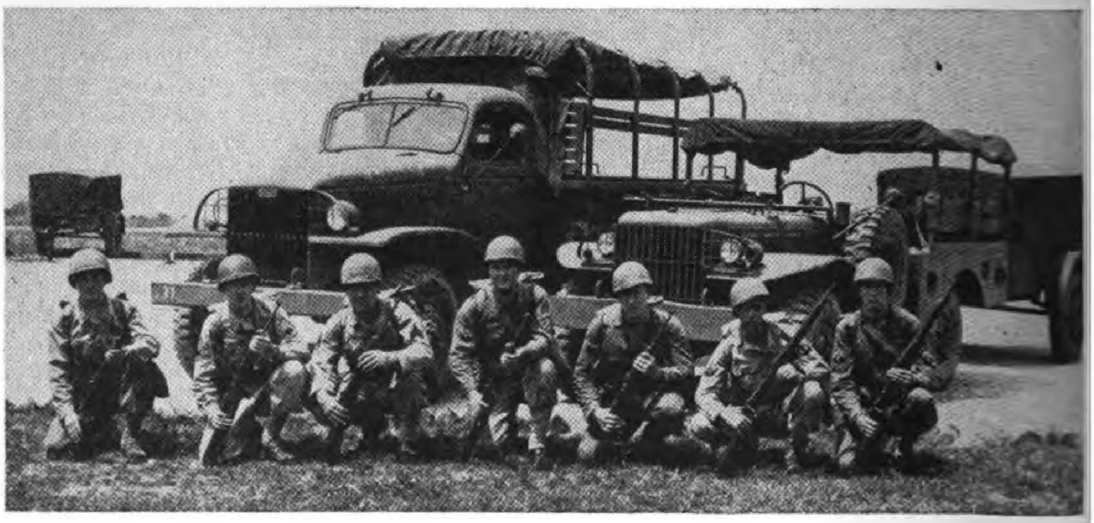


Figure 42. Ordnance Bomb Disposal Squad Separate.

on record where noncommissioned officers have inerted fuzes in the absence of there officers or under the stress of very heavy schedules.

There may be one squad assigned to each infantry division or equivalent organization, one for each Army Air Force group and any number, as required, for the various theater commanders of the Army Service Forces. Such units must be requested by the commander concerned, a point which illustrates another advantage of the squad (sep) over the old company. Any large organization commander might need the services of a bomb disposal unit and yet feel that he did not have sufficient need to warrant the use of a whole company. Under the newer setup such a commanding officer has only to ask for a small seven man unit. The squad (sep) was built for mobility since its mission often requires that it cover considerable territory in a limited amount of time. The squad is easily transported and frequently will move by plane. This is particularly true where fighting is scattered over large areas, as in the Pacific theater. All members of the unit can ride in one vehicle, when necessary, although the T/O allows one three-quarter ton truck, one two and one-half ton truck with winch, and one-ton trailer. The ability to ride as a complete unit in a single vehicle provides speed of mobility for travel in combat areas. Finally, the unit is not burdened with mess equipment, cooks, and rations since it will normally be attached to the nearest available outfit for its mess and quarters.

Despite the small size of the squad, it is large enough to do any job on which it has thus far been detailed. It can, for instance, cover two or three airfields simultaneously, if enemy attacks are not unusually heavy. The squad is also able to handle the bomb disposal work around a railhead or supply base. Under normal conditions it will handle adequately the bomb disposal needs of a small town without outside additional help, or, by utilizing borrowed labor, it can handle the normal bomb disposal needs of a city of moderate size. An appreciable all-around flexibility gain has thus been obtained from organization of bomb disposal service into squads over the company set-up formerly used.

Bomb disposal squads are charged with the following duties:

1. Handle all unexploded bombs in the vicinity where located;
2. Make and forward intelligence reports;
3. Give instructions in bomb reconnaissance;
4. Inert materiel for instructional purposes.

Bomb Disposal Squad equipment is listed in T/O and E 9-500 and in addition to the transportation previously cited, includes;

1 each—Block, ordinary, steel shell for 1 inch rope
3 each—Blocks, snatch, steel shell for 1 inch rope
2 pair —Asbestos mittens, M1942
1 each—Photographic Set PH-261, consisting of
  1 each—camera 35mm, f4.5 lens
  1 each—enlarger
  1 each—G.E. light meter
  Miscellaneous darkroom equipment, film, filters, etc.
1 each—Demolition equipment set No. 1, consisting of
  1 each—blasting machine, 10 cap
  1 each—reel electric cable, 500 feet
  1 each—wire cutter, insulated
  1 each—crimper, non-sparking
  1 each galvanometer
Miscellaneous tape, string, cap box, etc.
1 each—set tools and supplies, Bomb Disposal, consisting of
  10 each—containers for ½ lb. shaped charges
  1 each—fuze deactivator 4-D-20
  1 each—fuze deactivator 4-D-25
  1 each—discharger, fuze
  1 each—set of drills
  1 each—extractor, fuze
  10 lb. —explosive, composition C
  1 each—stethascope
  1 each—set tools, non-sparking, consisting of
    1 crow bar
    1 probe bar
    1 wrecking bar
    1 pick
    2 shovels rd. pt.
    1 shovel sq. pt.
    1 trowel
  1 each—vise, 4½ inch jaw width
  Miscellaneous wrenches, screwdrivers, hammers, etc.

Dependent upon the assigned mission and duties a squad attached to the Air Force should be able to handle our own and allied bombs for 'bombing up' planes. If attached to Ground Forces, it should be able to clear land mines and booby traps in rear areas where called upon to support Engineer troops normally assigned these tasks, especially in captured munition dumps, and it should be able to classify and destroy unserviceable ammunition. Attached to Army Service Forces, the squad should be able to supervise the inspection, classification, storage and shipment of both allied and enemy explosives and to instruct troops in the danger of land mines and booby traps. All of these duties are those which squads in the field have actually been called on to handle and have handled effectively.

Bomb Disposal Staff Officer. In addition to the units mentioned above, there is a staff officer for bomb disposal assigned to the Ordnance officer of theaters of operations staffs, field armies, service commands and defense commands. These men are responsible for advising the Ordnance officer on all matters pertaining to bomb disposal intelligence, requirements, policies, and employment. They are also responsible for the co-ordination of the efforts of all bomb disposal units in their theater.

CHAPTER 2

SHOP THEORY AND PRACTICE

INTRODUCTION

This chapter gives basic information concerning the equipment used in the Service Section of an Ordnance Maintenance Company.

The "machines of war" are our concern. As maintenance units it is our duty to see that after materiel has been manufactured, it is kept operating. It is the machine tool that plays an important part in keeping it operating.

SHOP MATHEMATICS

The following information on Shop Mathematics has been designed to be used primarily as a refresher since the material is condensed. Nevertheless, sufficient information is provided to work all types of problems presented.

FRACTIONS

The greatest part of a machinist's work involves working with fractions and reducing them to lowest terms. If the numerator and denominator of a fraction is divisible by a number, the fraction can be reduced. By the same token, a fraction has been reduced to lowest terms if the numerator and denominator is not divisible by a single number.

EXAMPLES: Fractions reduced to lowest terms:

$$\frac{2}{4} = \frac{2 \div 2}{4 \div 2} = \frac{1}{2} \qquad \frac{9}{12} = \frac{3}{4} \qquad \frac{27}{36} = \frac{3}{4}$$

$$\frac{12}{44} = \frac{12 \div 4}{44 \div 4} = \frac{3}{11} \qquad \frac{14}{32} = \frac{7}{16} \qquad \frac{25}{45} = \frac{5}{9}$$

Lowest Common Denominator. To find the lowest common denominator, place the denominators in a row, separated by commas. This group of denominators is to be divided by a selected number which permits two or more of the group numbers to be divided evenly. Place the quotients of this division process beneath their respective denominators. In the event that a denominator is not divisible by the selected number, that denominator is merely placed below itself and a new selected number is used to repeat the process of division of the denominators. Continue this process until no two of the remaining denominators can be divided by an number except 1. The product of the divisors and the quotients of the last division is the lowest common denominator, or L.C.D.

Given: 8, 5, and 10 are denominators of fractions to be added.

To Find: Lowest common denominator

$$\begin{array}{r|l} 5 & 8,\ 5,\ 10 \\ \hline 2 & 8,\ 1,\ \ 2 \\ \hline & 4,\ 1,\ \ 1 \end{array} = 5 \times 2 \times 4 \times 1 \times 1 = 40 \text{ L.C.D.}$$

Addition. The addition of fractions requires the use of a common denominator since fractions are units of a whole; unlike units cannot be added.

Problem: Select a common denominator. Add

$$\frac{1}{2} + \frac{14}{32} + \frac{27}{36}$$

1. Reduce: $\frac{1}{2} + \frac{7}{16} + \frac{3}{4}$
2. Common Denominator: $\left(\frac{1}{2} \times \frac{8}{8}\right) + \frac{7}{16} + \left(\frac{3}{4} \times \frac{4}{4}\right)$
3. Simplify: $\frac{8}{16} + \frac{7}{16} + \frac{12}{16}$
4. Add Numerators: $\frac{8 + 7 + 12}{16} = \frac{27}{16}$ or $1\frac{11}{16}$

Subtraction. To subtract fractions, establish a common denominator and subtract the minus numerator from the positive numerator.

a. 1/2 — 1/3 =(1/2 × 3/3) — (1/3 × 2/2) = 3/6 — 2/6 = 1/6

b. 11/16 — 3/8 = 11/16 — (3/8 × 2/2) = 11/16 — 6/16 = 5/16

c. 13/16 — 2/3 = (13/16 × 3/3) — (2/3 × 16/16) = 39/48 — 32/48 = 7/48

Multiplication. The result of the multiplication of fractions is the product of the numerators divided by the product of the denominators.

1/2 × 1/2 = 1/4 1/4 × 1/2 = 1/8

Cancellation of Fractions. Cancellation is the process of shortening the multiplication of fractions with respect to reducing the numerators and denominators. Multiplication is simplified by cancellation, since the numerators and denominators are reduced by dividing any numerator and denominator of a series of fractions to be multiplied by a common factor.

1 $$\frac{\overset{1}{\cancel{3}}}{\underset{1}{\cancel{4}}} \times \frac{\overset{2}{\cancel{8}}}{\underset{3}{\cancel{9}}} = \frac{2}{3}$$

2 $$\frac{\overset{1}{\cancel{2}}}{\underset{1}{\cancel{3}}} \times \frac{\overset{1}{\cancel{3}}}{\underset{1}{\cancel{7}}} \times \frac{\overset{1}{\cancel{7}}}{\underset{6}{\cancel{12}}} = \frac{1}{6}$$

3 $$\frac{\overset{1}{\cancel{5}}}{\underset{1}{\cancel{6}}} \times \frac{\overset{1}{\cancel{6}}}{\underset{3}{\cancel{15}}} \times \frac{2}{5} = \frac{2}{15}$$

4 $$\frac{\overset{1}{\cancel{3}}}{\underset{2}{\cancel{8}}} \times \frac{\overset{1}{\cancel{4}}}{11} \times \frac{5}{\underset{2}{\cancel{6}}} = \frac{5}{44}$$

Division. To divide fractions, invert the divisor and multiply. This rule must be adhered to in the strictest sense in order to perform the operation without error.

1. 2/3 ÷ 1/2 = 2/3 × 2/1 = 4/3 or 1 1/3. 2. 3/4 ÷ 4 = 3/4 × 1/4 = 3/16

DECIMALS

Addition. When adding decimals, arrange all decimal points in a single column to avoid errors. It is suggested to add ciphers where necessary.

Add: 3.25 + 72.004 + 8645.0725 + 647.875

$$\begin{array}{r} 3.2500 \\ 72.0040 \\ 8645.0725 \\ 647.8750 \\ \hline 9368.2015 \end{array}$$

Subtraction. In the subtraction of decimals, arrange decimal points in a column and add ciphers to avoid errors.

$$\begin{array}{r} 42.630 \\ -18.275 \\ \hline 24.355 \end{array} \qquad \begin{array}{r} 19.00000 \\ -\ 3.67921 \\ \hline 15.32079 \end{array} \qquad \begin{array}{r} 289.9410 \\ -288.9417 \\ \hline .9993 \end{array}$$

Multiplication. The process of multiplying decimals is the same as with numbers having no decimals except that the product is pointed off from right to left equal to the sum of the decimal places of the multiplier and the multiplicand.

$$\begin{array}{r} 1.5 \\ \times 2 \\ \hline 3.0 \end{array} \qquad \begin{array}{r} 4.5 \\ \times 7.5 \\ \hline 225 \\ 315 \\ \hline 33.75 \end{array} \qquad \begin{array}{r} 2.34 \\ \times .072 \\ \hline 468 \\ 1638 \\ \hline .16848 \end{array} \qquad \begin{array}{r} 5.062 \\ \times\ .374 \\ \hline 20248 \\ 35434 \\ 15186 \\ \hline 1.893188 \end{array}$$

Division. When dividing decimals, the number of decimal places in the quotient is equal to the number of places which the dividend exceeds the divisor.

```
         80.91                        61.00
.964) 78.00000              .002) .12200
        7712                         12
        ----                         --
         8800                          2
         8676                          2
         ----                          -
          1240                         0
           964
          ----
           276
```

Conversion of Fractions to Decimals. To change a fraction to a decimal, divide the numerator by the denominator.

```
              .250                          .875
1. 1/4 = 4) 1.000          2. 7/8 = 8) 7.000
                                          64
                                          --
                                           60
                                           56
                                           --
                                            40
                                            40
                                            --
                                             0
```

Conversion of Decimals to Fractions. In converting decimals to fractions, the numerator is the decimal number, with the denominator as one plus a series of ciphers equal to the number of decimal places of the numerator.

1. $.5 = \frac{.5}{1.0} = \frac{5}{10}$ or $\frac{1}{2}$ 2. $.125 = \frac{.125}{1.000} = \frac{125}{1000}$ or $\frac{1}{8}$

3. $.25 = \frac{.25}{1.00} = \frac{25}{100}$ or $\frac{1}{4}$

SQUARE OF A NUMBER

A square is the product of a number multiplied by itself.

$8 \times 8 = 64$ 64 is the square of 8

$9 \times 9 = 81$ 81 is the square of 9

A number raised to a power is that number multiplied by itself as many times as the exponent indicates.

1. $3^4 = 3 \times 3 \times 3 \times 3$
   $3^4 = 81$
2. $7^2 = 7 \times 7$
   $7^2 = 49$
3. $4^3 = 4 \times 4 \times 4$
   $4^3 = 64$
4. $2^5 = 2 \times 2 \times 2 \times 2 \times 2$
   $2^5 = 32$

SQUARE ROOT OF A NUMBER

To extract the square root of a number means to find that number which multiplied by itself will be the original number. The radical sign $\sqrt{}$ means to extract the square root of that number which is underneath it. A number may be factored into perfect squares beneath the radical sign, and the root extracted from each factor. The roots of those perfect squares are then multiplied together, and the root of the original number is the result.

A. $\sqrt{64} = 8$ $\sqrt{1225} = 35$

$\sqrt{256} = 16$ $\sqrt{2025} = 45$

$\sqrt{25} = 5$ $\sqrt{6400} = 80$

B. $\sqrt{576} = \sqrt{4 \times 144} = \sqrt{4} \times \sqrt{144} = 2 \times 12$ or 24

$\sqrt{1225} = \sqrt{25 \times 49} = \sqrt{25} \times \sqrt{49} = 5 \times 7$ or 35

$\sqrt{484} = \sqrt{4 \times 121} = \sqrt{4} \times \sqrt{121} = 2 \times 11$ or 22

$\sqrt{900} = \sqrt{9 \times 100} = \sqrt{9} \times \sqrt{100} = 3 \times 10$ or 30

Valuable roots to remember for the simplified extraction of the square root by factoring into perfect squares and numbers of which the roots are known:

$$2 = 1.414$$
$$3 = 1.732$$
$$5 = 2.236$$

Extract the square root of the following:

1. $\sqrt{245} = \sqrt{5 \times 49} = 7\sqrt{5}$ or $7 \times 2.236 = 15.652$
2. $\sqrt{768} = \sqrt{3 \times 256} = 16\sqrt{3}$ or $16 \times 1.732 = 27.712$
3. $\sqrt{405} = \sqrt{5 \times 81} = 9\sqrt{5}$ or $9 \times 2.236 = 20.124$

Extract the square root of 178,929

Procedure: $\sqrt{178{,}929}$

(1) 17′ 89′ 29

```
                 4   2   3   0
(2)    4 | 17′ 89′ 29. 00
             16
(3)   82 |  189
            164
(4)  843 |   2529
             2529
                0
```

Step 1. Separate the number 178,929.0 in groups of two numbers to each group starting from the decimal point to the left and right. The result is as follows: 17, 89, 29.

Step 2. Find the largest perfect square in the first set of two numbers, which is 17. The largest perfect square in 17 is 16 with a square root of 4. Place the 4 directly above 17 and also in the first left hand bracket. Multiply 4 by 4 to obtain 16 which is placed beneath 17.

Step 3. Obtain the difference between 17 and 16, and add the second group of figures 89 to 1 which makes 189. Double the root already found and obtain the trial divisor 8. The quotient is 2 plus. The 2 is placed directly above the group 89 and likewise along side of the trial divisor 8 to obtain 82 to complete the divisor. Multiply the divisor 82 by the newest root number 2 obtaining 164, which is then subtracted from 189 with a difference of 25.

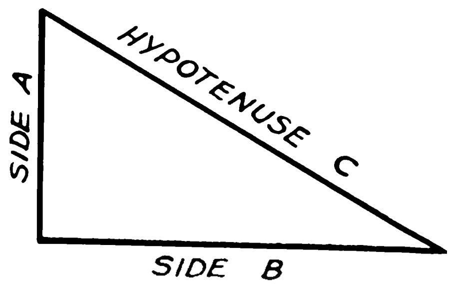
Step 4. Bring down the next group 29 and place the two digits along side of the last remainder making the entire new number 2529. Double the root 42 to obtain 84 and divide the first 3 digits of 2529 by 84 to obtain 3, the next digit of the root. Place the new root digit 3 along side of the trial divisor 84 to obtain 843 which is then multiplied by the new root digit 3. The product of 843 × 3 is 2529, which is placed underneath the first 2529. The difference of these two numbers is 0, indicating that the full root has been found, since the next digits would result in ciphers. The problem can be proved by multiplying the root by itself to get 178,929.

The process of finding the square root is especially useful and necessary in solving the following problems in geometry of the shop.

SHOP GEOMETRY

A triangle is a plane figure bounded by 3 straight sides, whose interior angles total 180°.

1. $a^2 + b^2 = c^2$
2. $a^2 = c^2 - b^2$
3. $b^2 = c^2 - a^2$



Isosceles Triangle. An Isosceles triangle is one with two sides equal and two angles equal. A line dropped from the vertex of an isosceles triangle perpendicular to the base bisects the vertex angle and the base.

Right Triangle. A right triangle is one with a 90° angle in it. Right triangles have sides with definite relationships. Namely, the sum of the squares of the sides of a right triangle is equal to the square of the hypotenuse.

Problem 1	Problem 2	Problem 3
Given: $a = 3$; $b = 4$	Given: $b = 6$; $c = 10$	Given: $a = 9$; $c = 15$
To find: c	To find: a	To find: b
Procedure	Procedure	Procedure
$a^2 + b^2 = c^2$	$a^2 = c^2 - b^2$	$b^2 = c^2 - a^2$
$3^2 + 4^2 = c^2$	$a^2 = 10^2 - 6^2$	$b^2 = 15^2 - 9^2$
$9 + 16 = 25$	$a^2 = 100 - 36$	$b^2 = 225 - 81$
$c^2 = 25$	$a^2 = 64$	$b^2 = 144$
$c = \sqrt{25} = 5$	$a = \sqrt{64} = 8$	$b = \sqrt{144} = 12$

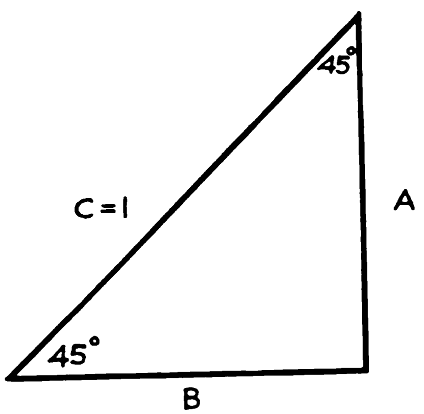
The following special right triangles are used quite frequently in shop work:

A right triangle containing two 45° angles and a right angle has a special relationship between the sides and the hypotenuse.

When two angles of a triangle are equal, the triangle is isosceles, therefore, both sides are equal.

Let the hypotenuse equal 1.

$a = b$, sides being equal, substitute a for b



$$a^2 + b^2 = c^2$$
$$a^2 + a^2 = c^2$$
$$2a^2 = 1^2$$
$$a^2 = \tfrac{1}{2}$$

$$a = \sqrt{\tfrac{1}{2}} = \frac{\sqrt{1}}{\sqrt{2}} \times \frac{\sqrt{2}}{\sqrt{2}} = \frac{\sqrt{2}}{2}$$

$$a = \frac{1.414}{2} \qquad a = .707$$

Given a 45° right triangle with a hypotenuse of 1; therefore, the side equals .707

$$\text{side} = \text{hypotenuse} \times .707 \qquad\qquad \text{Hypotenuse} = \frac{\text{side}}{.707}$$

Problem:

Given a 45° right triangle with a hypotenuse of 5.5 inches.
To find: the sides
Procedure: side = hypotenuse × .707
side = 5.5 × .707
side = 3.8885 or 3.9

Problem:

Given: 45° right triangle with side of 6.2 inches.
To find: hypotenuse

Procedure: $\text{hypotenuse} = \frac{\text{side}}{.707}$

$$\text{hypotenuse} = \frac{6.2}{.707}$$

hypotenuse = 8.769 or 8.8

A 30°, 60°, 90° right triangle is one in which the following relationships exist:

(a) Side opposite 30° angle = ½ hypotenuse.

(b) Hypotenuse = 2 × side opposite 30° angle.

Given: 30°, 60°, 90° right triangle with hypotenuse of 1 side opposite 60°.

Procedure: Let b = side opposite 60° angle

a = side opposite 30° angle

c = hypotenuse

$$b^2 = c^2 - a^2$$

$$b^2 = 1^2 = (\tfrac{1}{2})^2$$

$$b^2 = 1 - \tfrac{1}{4}$$

$$b^2 = \tfrac{3}{4}$$

$$b = \sqrt{\frac{3}{4}} = \frac{\sqrt{3}}{\sqrt{4}} = \frac{1.732}{2} = .866$$

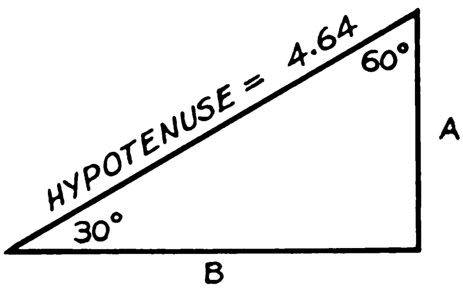
Therefore side opposite 60° angle = .866 × hypotenuse

$$\text{(c) hypotenuse} = \frac{\text{side opposite } 60^\circ \text{ angle}}{.866}$$

Problem: Given 30°, 60°, 90°, right triangle with hypotenuse of 4.64 inches.

To find: Other sides

Procedure: a = side opposite 30° angle



$$a = \tfrac{1}{2} \text{ hypotenuse} = \frac{4.64}{2} = 2.32$$

b = side opposite 60° angle

side opposite 60° angle = .866 × hypote

.866 × 4.64 = 4.018 or 4.02

The following problems are practical applications of the constants .866 and .707:

Computing Sizes of Shapes To Be Cut From Bar Stock. The cutting of regular polygons such as hexagons and squares, is a common practice in shop work.

(a) Problem: Find the largest hexagon which can be cut from a six inch diameter bar of round mild steel.

Procedure: Largest hexagon = diameter of stock × .866

= six inches × .866

= 5.196 inches

(b) Problem: Find the diameter of round bar stock required to cut a hexagon 3.5 inches across flats.

$$\text{Procedure: Diameter of stock} = \frac{\text{distance across flats}}{.866}$$

$$\text{Diameter of stock} = \frac{3.5}{.866}$$

Diameter of stock = 4.042 inches

(c) Problem: Find the largest square which can be cut from a 5 inch diameter bar of round stock.

Procedure: Largest square = diameter of stock × .707

Largest square = 5 inches × .707

Largest square = 3.535 inches

(d) Problem: Find the diameter of round stock required to cut a square of 4 inches.

$$\text{Diameter of stock} = \frac{\text{square}}{.707}$$

$$\text{Diameter of stock} = \frac{4 \text{ inches}}{.707}$$

Diameter of stock = 5.658 inches

CALCULATION OF OPERATING SPEEDS FOR SHOP MACHINES

The calculation of operating speeds in the machine shop is common, and the following formulae are used to determine approximate speeds of operation of the lathe, milling machine, and shaper. Cutting speeds are given in feet per minute and may be found in any machinist's handbook.

Lathe: $\text{Revolutions per minute} = \dfrac{\text{Cutting Speed} \times 4}{\text{Diameter of Stock}}$

$$\text{R.P.M.} = \frac{\text{C.S.} \times 4}{\text{Dia. of Stock}}$$

Milling Machines: $\text{Revolutions per minute} = \dfrac{\text{Cutting Speed} \times 4}{\text{Diameter of Cutter}}$

$$\text{R.P.M.} = \frac{\text{C.S.} \times 4}{\text{Diameter of Cutter}}$$

Shaper: $\text{Strokes per minute} = \dfrac{\text{Cutting Speed} \times 7}{\text{Length of Stroke}}$

$$\text{S.P.M.} = \frac{\text{C.S.} \times 7}{\text{Length of Stroke}}$$

CALCULATION OF SCREW THREAD DIMENSIONS

When working with screw threads it is necessary that the machinist be able to find certain dimensions.

Body size machine screws: To find the major diameter of a machine screw the following formula is used:

Major Diameter = (Body size number × .013") + .060"
M. D. = (B. S. × .013") + .060"
= (10 × .013") + .060"
= .130" + .060"
= .190"

(a) Problem: Find major diameter of a 0-80 machine screw.
Procedure: M. D. = (B. S. × .013") + .060"
= (0 × .013") + .060"
= 0 + .060"
= .060"

Thread Formulae: American National Form Thread. (75% thread).

Single Depth of thread $= \dfrac{.6495}{\text{Threads per inch}}$ or .6495 × pitch.

Double Depth of thread $= \dfrac{2 \times .6495}{\text{Threads per inch}}$

Pitch $= \dfrac{1}{\text{Number of threads per inch}}$

Flat $= \dfrac{\text{Pitch}}{8}$

Pitch Diameter = Major diameter — single depth of thread
Root Diameter = Major diameter — 2 × single depth of thread
Angular depth of cut = 3/4 × pitch
Tap drill size = Major diameter — pitch

TAPER CALCULATIONS

Of the many holding devices in the machine shop, tapered mating parts such as plugs and sockets are used widely. The four major parts or elements of round tapered portions of work pieces are as follows:

Large diameter = L D.
Small diameter = S.D.
Length of taper = Lng. Taper
Taper per inch = T.P.I.

If any three of these elements are given the fourth can be found.

$$\text{T.P.I.} = \frac{\text{L.D.} - \text{S.D.}}{\text{Lng. Taper}} \qquad \text{Lng. Taper} = \frac{\text{L.D.} - \text{S.D.}}{\text{T.P.I.}}$$

$$\text{L.D.} = \text{S.D.} + (\text{Lng. taper} \times \text{T.P.I.}) \qquad \text{S.D.} = \text{L.D.} - (\text{Lng. taper} \times \text{T.P.I.})$$

Tail stock offset for a tapered work piece which is tapered the entire length between centers may be found by one of the following methods.

$$\text{Tailstock offset} = \frac{\text{Total taper}}{2} \qquad \text{Offset} = \frac{\text{L.D.} - \text{S.D.}}{2}$$

$$\text{Offset} = \frac{\text{Lng. taper} \times \text{T.P.I.}}{2}$$

When the entire length between centers is not tapered, the following formula is used to determine tailstock offset.

$$\text{Offset} = \frac{\text{Length between centers} \times \text{T.P.I.}}{2}$$

Conversion factors in tapering problems are as follows:

$$\text{T.P.I.} = \frac{\text{Taper per foot}}{12}$$

$$\text{T.P.F.} = \text{T.P.I.} \times 12$$

INDEX HEAD COMPUTATIONS

Whenever gears, regular, or irregular polygons are cut in shop work, some kind of indexing device must be used. The index head divides the work piece into the desired number of divisions. In the event that the desired number of divisions can not be obtained by the use of the rapid index plate, then the index head must be used.

n = number of divisions desired.

40 = constant or number of complete turns of crank for one full revolution of spindle.

$$\text{Turns of crank} = \frac{\text{40 turns per 1 revolution}}{\text{number of divisions desired}}$$

$$T = \frac{40}{n}$$

Examples:

(a) 10 divisions desired $\frac{40}{n} = \frac{40}{10} = 4$ turns of crank

(b) 8 divisions desired $\frac{40}{n} = \frac{40}{8} = 5$ turns

When 40 is divided by a desired number of divisions and the result is a fraction of a turn, or one or more turns plus a fraction of a turn, index plates are used. These plates have several circles uniformly divided so fractions of a whole turn can be made.

Holes in circles of the plates are as follows:

Plate No. 1: 15, 16, 17, 18, 19, 20 (six circles)
Plate No. 2: 21, 23, 27, 29, 31, 33 (six circles)
Plate No. 3: 37, 39, 41, 43, 47, 49 (six circles)

Example: Index for 43 divisions

(a) $\frac{40}{n} = \frac{40}{43} = \frac{\text{40 holes}}{\text{43 hole plate}}$

Example: Index for 44 divisions

(b) $\frac{40}{N} = \frac{40}{44} = \frac{10}{11}$ Turn or $\frac{\text{10 holes}}{\text{11 hole plate}}$

Since there is no 11 hole circle, the fraction must be raised to higher terms to accomodate one of the given circles.

Therefore: $\frac{10}{11} \times \frac{3}{3} = \frac{\text{30 holes}}{\text{33 hole circle}}$

LAY-OUT

Laying out is a shop term which means the marking of guide lines on the curved or flat surfaces of a piece of work. These markings are, as a rule, taken from the information given on a blueprint or sketch.

The process of laying out is similar to making a mechanical drawing, but differs in that every mark must be absolutely accurate if satisfactory results are to be expected. For the reason of accuracy, a machinist keeps all his measuring and layout tools in good condition and sees that all his scribers, dividers, and prick-punch points are sharp. Particular care of tools is necessary to insure fine accuracy in laying out.

In the machine shop, a blueprint or drawing gives the machinist a clear picture of the part he is to produce and gives all the dimensions necessary to complete it. The machinist must study the drawing to get knowledge and understanding of the part to be machined. Many, and sometimes all, of the operations of a job require it to be worked to a layout.

After the material for the job has been secured, the machinist, in order to make the layout lines more visible, covers the surface to be laid out with layout dope. There are a number of different layout fluids or dope. The most common ones are blue layout fluid and a copper sulphate solution. These dopes, being in liquid form, are applied sparingly with a brush.

When the dope has dried, the machinist proceeds to scribe his lines on the work piece. The slightest error in measurements or in the scribing of the line may make the job worthless.

It must be remembered that the blueprint lines are not accurate; they only serve to illustrate, therefore scale measurements from the print should not be used.

The following is a list of tools that a machinist should have to do layout work:

Dividers	Center Punch
Steel Rule	Prick Punch
Hermaphrodite Calipers	Scribers
Surface Gage	Combination Set
Surface Plate	Bevel Protractor
V-Block	Solid Square
	Vernier Height Gage

We must remember that a machinist's tools help make his job. If he is careless in the way he handles and uses these tools, they will fail to function correctly when he needs them most. There is more than one way to lay out a job, and the machinist who uses a little common sense will turn out a job that will be a credit to his efforts.

HAND TOOLS

The skilled mechanic is recognized by the manner in which he cares for his tools and equipment. The hand tool worker plans his job completely before starting and has all his tools placed neatly before him on a bench or in the racks intended for that purpose.

Screwdriver. The screwdriver is one of the most misused tools in the tool box. It is intended only to loosen or tighten screws; not as a pry or chisel. The blade should always be ground clean to fit the screw slot. Use the proper screwdriver for the job. Never use pliers on a screwdriver. The length of a screwdriver includes the shank and blade but does not include the handle.

Hammer. The hammer probably is the most used of all tools, and there are many types. The flat portion of the head used for hammering is called the "face," and the opposite end is called the "peen." When the peen is ball shaped, it is known as *ballpeen* and this type is most used by machinists. The ballpeen is used principally for riveting. These hammers are classified according to the weight of the hammer head. The hammer handle should always be tight in the head. Always hold the hammer near the end of the handle away from the head. Hammers used on machined surfaces that must not be damaged are called *soft hammers* and may be made of brass, copper, rawhide, plastic, or any similar soft material. Never use the handle for bumping or prying purposes as they are easily broken that way. Hammers should always be kept free from grease and oil as a safety-first measure to prevent them from slipping out of the hand.

Pliers. Pliers should never be used when any other wrench or tool can take its place, as the teeth of the pliers tend to damage the metal surface of the job. Avoid using pliers on hard metals, as the teeth become dull and the pliers loose their grip. Never use pliers on nuts of any kind. *Slip joint* pliers enable them to open wider. *Diagonal* pliers are handy for pulling cotter pins. *Side cutter* pliers are used for wire cutting, etc. *Long nose* pliers are used for recovering nuts or washers that get out of place.

Chisels. *Cold* chisels are used for cutting metal. Most common is the *flat cold* chisel used for cutting rivets, chipping metal, splitting nuts, and cutting thin metal sheets. *Cape* chisels are quite narrow and used for cutting keyways and narrow grooves. The *round nose* chisel cuts a half round or semi-circular groove and is used for cutting inside corners which have a fillet or radius. *Diamond point* chisels cut a V-shaped groove and cut square corners. Ordinary chisels are ground with a 60° included angle. Always use a chisel big enough for the job. Use the proper weight hammer for the chisels used. The cutting edge of the chisel should be watched and not the head of the chisel. Never use a mushroomed chisel, the head should be ground off clean to prevent broken metal from flying around. Don't hold the chisel too tight or too loose. Goggles must be worn when chipping and a chip guard of some sort to prevent chips hitting a passerby. Always chip away from you and toward the solid vise jaw.

Files. A mechanic's tool kit would not be complete without an assortment of files of the chisel-cut variety. These come in two types, *single cut* and *double cut.* Double cut files are for removing excess metal and for rough, heavy work. The chisel cut teeth have a criss-cross pattern. Single cut files are used for a smooth finish and polishing job. It is identified by the single row of teeth on the file. The tapered end that fits into the handle is called the "tang." A file should never be used without a handle. Terms used to indicate the roughness or smoothness of a file are in order as follows: rough, coarse, bastard, second-cut, smooth, and dead smooth. Files are further classified according to their many shapes. Pressure on the file is on the forward stroke only and a long steady stroke is used, wearing the file evenly. Draw filing is a smoothing process, and the pressure is on the stroke towards the body. In filing, use only enough pressure to keep the file cutting. Keep the file clean and free from chips.

MEASURING INSTRUMENTS

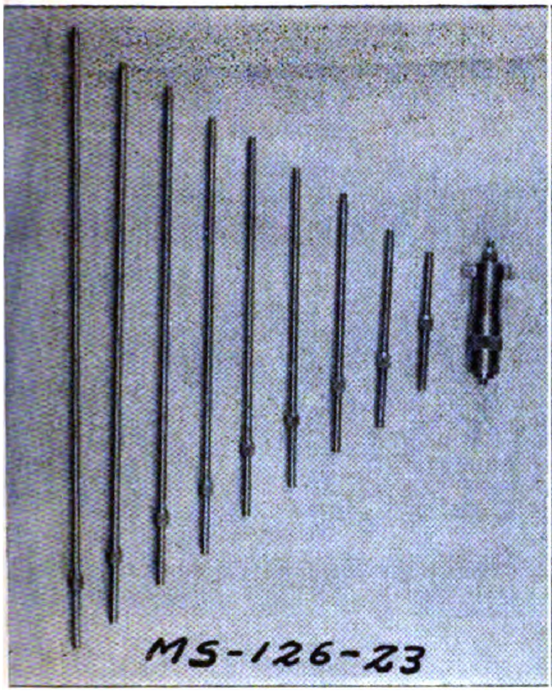
We are going to endeavor to give the reader a more general background of the precision tools it takes to complete small parts which in turn make up the machine of today.

Steel Rule. The steel rule (Figure 1) is the simplest and most common measuring instrument used by the machinist. It may be defined as a strip of hardened steel containing lined graduations etched at intervals of a fraction of a standard unit of length. The steel rule is manufactured in different sizes and styles; it is graduated in subdivisions of every standard of length including the decimal, fractional, and metric systems.

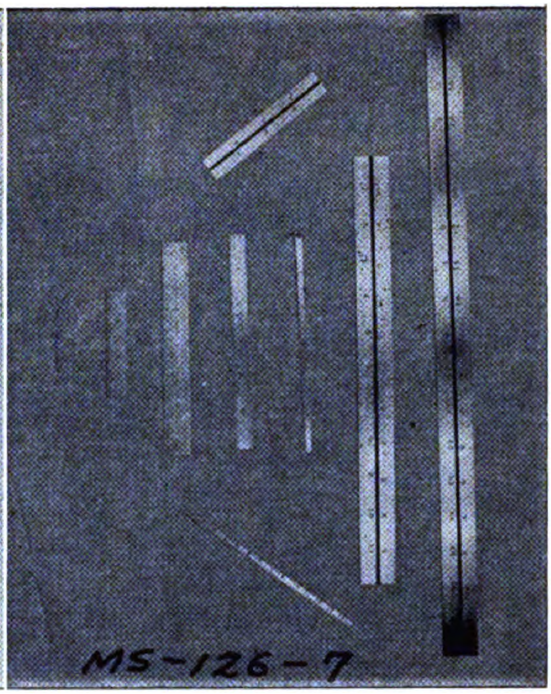
Caliper. In shops, there are times when it is necessary to measure accurately the dimensions of parts which cannot be directly measured by a rule. An example is, when turning a shaft in a lathe, the machinist may want to know when the approximate size has been reached. For this he has a simple measuring tool, the caliper (Figure 1), equipped with gaging legs which contact the part to be measured and preserve the measurement until it can be transferred to a rule. Accuracy in caliper measurement depends upon the sense of touch of the operator. This skill can only be accomplished through practice.

Combination Square. The combination square (Figure 1) consists of a heavy rule which is grooved along its entire length. It is in this groove that the slide head is fitted. The sliding head consists of a locking nut and a scribing point attached to the head. Also it contains an included angle of 45 degrees, which is conveniently used for the layout of dovetails.

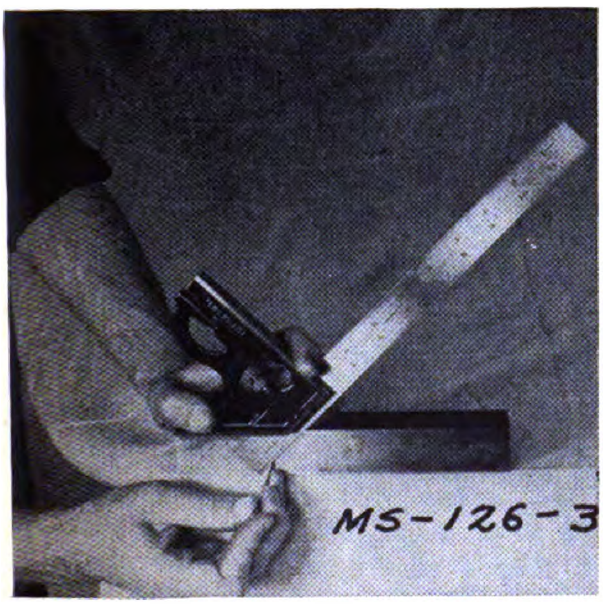
Micrometer Calipers. The micrometer (Figure 1) is based essentially upon the principle of the calibrated screw. If the screw is turned one revolution, it moves a definite distance, which is called the lead. The lead is dependent upon the number of threads in one inch of the screw. Micrometers usually contain forty



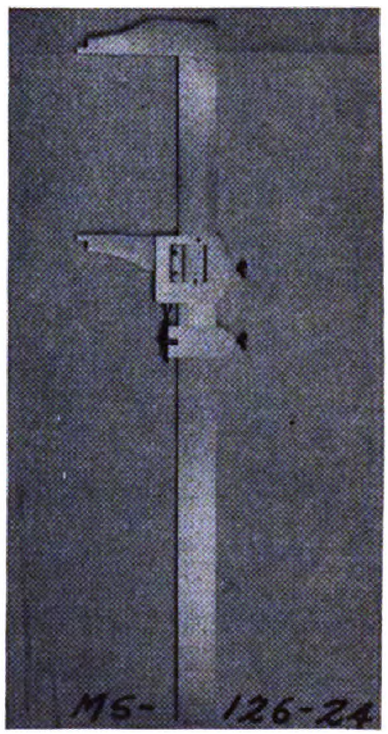
Inside Micrometers.



Steel Rule.

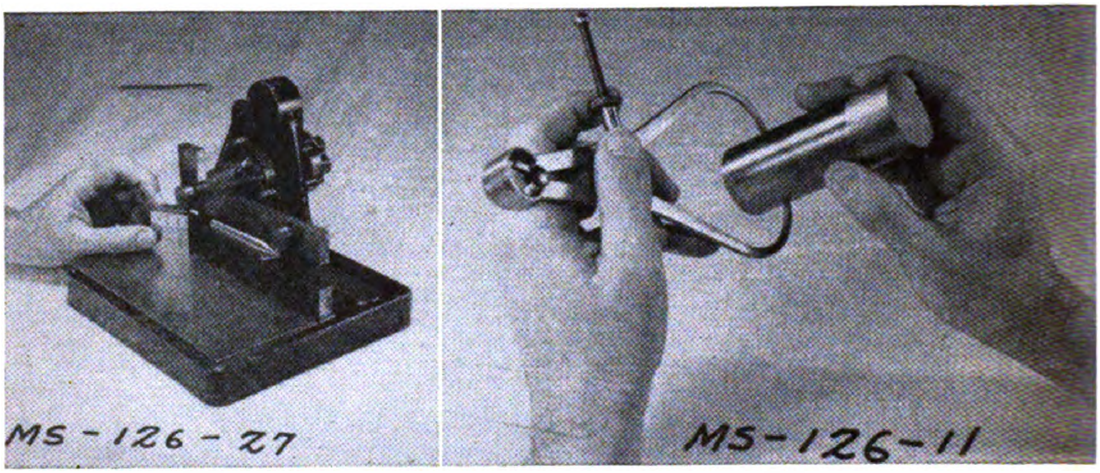


Combination Square.

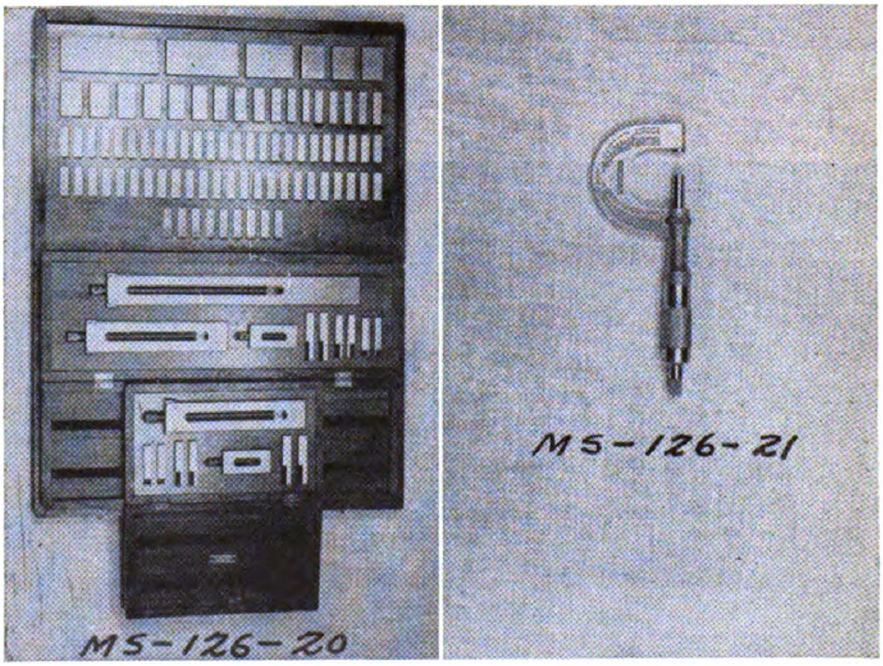


Vernier Calipers.

Figure 1. Precision Tools.



Sine Bar. Calipers.

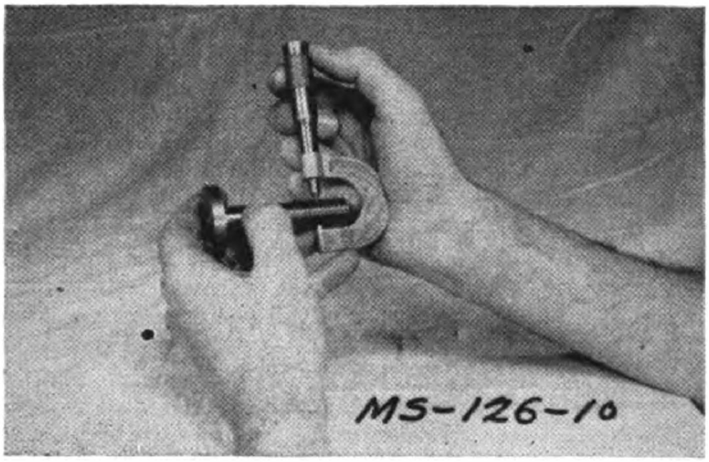


Gage Blocks. Micrometer Calipers.

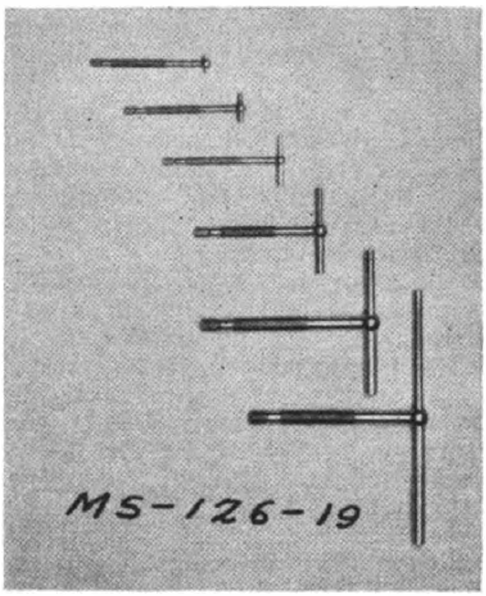
Figure 2. Precision Tools.

threads per inch; so when the screw is turned one revolution it moves 0.025 inch. If a revolution of a thread is divided into twenty-five equal parts, each division will represent 1/25 of 0.025 inch or 0.001 inch.

The *thread micrometer* (Figure 2) is similar to the standard micrometer except that it is equipped with special gaging anvils. In this type of micrometer caliper the spindle end is pointed, and the V-shaped anvil is free to rotate when mated; the spindle and anvil have an allowance for thread clearance. When the caliper is opened, the reading represents the distance between the two pitch lines or the pitch diameter.



Thread Micrometer.



Telescoping Gages.
Figure 2. Precision Tools—(Continued).

Another method commonly used for measuring smaller work where an inside micrometer will not fit conveniently is the use of the *telescoping gage* (Figure 2). This gage should be adjusted in the work until it exactly touches points directly across from each other; after being locked by turning the stem, it is removed and the dimension measured with an outside micrometer.

The *inside micrometer* (Figure 2) is an exceptionally good tool for making inside measurements of a round piece of work, such as the diameter of a gasoline engine cylinder. The inside micrometer is calibrated in the same manner as the outside micrometer. The only difference is that you read from right to left instead of from left to right as you do on the outside micrometer.

Vernier Caliper. In 1631 Pierre Vernier invented a measuring device, the accuracy of which was based upon the relationship between two differently graduated scales. This principle was adopted by manufacturers and has become a basis for precision measurement. It has been applied to height and depth measurement, outside and inside dimension, angle measurement, and accurate scribing work.

The main scale of the vernier caliper (Figure 2) is divided into fortieths of an inch, with every fourth division numbered showing tenths of an inch. The vernier scale contains 25 equal divisions spread over 0.6 inch on the main scale or 24 main scale divisions. Thus one vernier scale division is equal to 1/25 of 0.600 or 0.024 inch. The difference between a vernier division and a division on the main scale is 0.001 inch.

Sine Bar. The sine bar (Figure 2) is a very accurate angle measuring instrument used in the precision inspection of tools, jigs, tapers, dies, and fixtures. The sine bar consists of an accurate steel alloy straight edge and two hardened cylinders. The cylinders are of the same diameter and their center distance must be absolutely accurate. Sine bar surfaces are ground parallel to each other and to the centerline between the two plugs or cylinders. These bars are available in three standard sizes, *i.e.* 5, 10, and 20 inch sine bars.

Gage Blocks. Of all super-precision instruments the gage blocks (Figure 2) are one of the most important. They are the basis of modern interchangeable manufacture. Without them, mass production and the accurate calibration of measuring instruments would be impossible.

Cutting Oil. Since the majority of work in the machine shop involves many kinds of cutting processes on metallic and non-metallic materials, the problems are many and varied. Of these problems the use of cutting oils and compounds is of major importance to ease stock removal. Extensive reasearch has shown that the removal of stock is not the action of splitting the work ahead of the tool as in wood, but an actual forcing of the material back into the body of the work and also onto the tool surface. The machine forces the work against a tool as in the case of the lathe operation, and the tool must be able to overcome the tenacity or the resistance to withstand being pulled apart. As this cutting process goes on, it can easily be understood that a great amount of heat is generated from the friction between the tool and material being removed. Some kind of lubrication must therefore be used to overcome most of the friction and also cool the work, since it is utterly impossible to reduce the friction completely. Parts being worked on expand from the heat generated and surfaces are found to be inaccurately finished when the work contracts with cooling.

Cutting oils are used for chip removal in the following operations: drilling, reaming, boring, milling, threading, and tapping. If chips are accumulated within tool spaces such as flutes and secondary clearances, the tool will bind within its confining hole as in the case of a tap or reamer and crack off or produce a severely marred finish. Cutting oils are also used in a sense similar to the previously mentioned one, but chips are washed away, and the work is therefore kept clean enough to permit necessary observation of the cutting performance with respect to the tool and work in confined spaces. Cutting oils reduce the power required to cut which is particularly noticeable in the hand threading operations with taps and dies. An important use of cutting oils is to prevent build up, or the accumulation of tiny particles which pile up in cone fashion on the tool edge, thereby reducing cutting efficiency and increasing friction. Cutting oils and compounds must be rust preventive and are used to produce fine finishes on machined surfaces.

The kinds of cutting oils are many indeed, and the use of a specific oil or compound is dependent upon the type of cutting operation and the material worked on.

Lard oil is perhaps the most widely known, and it is used primarily as a lubricant. Lard oil is hydraulicly pressed from lard, and first grade lard oil is usually colorless or has a greenish tinge. Since it is expensive, lard oil is usually mixed with one of the following oils: cottonseed, mineral, vegetable, or hydrogenated oils.

Cutting compounds are made of mixtures of oils and greases with disinfectants such as creosol or carbolic acid added to them.

Soda water mixtures are composed of carbonate of soda (sal soda) and water with oil or soap added for lubrication purposes.

Operations which produce short chips such as grinding, milling, and drilling usually require a good coolant such as the so called soluble oil which is mixed with water to produce a milky emulsion.

Machining operations on very hard steels require cutting oils and aids of solvent proportions such as carbon tetrachloride, kerosene, or turpentine.

General tapping operations require the use of lard oil, mineral oil, white lead and oil; while precision tapping is accomplished with carbon tetrachloride, turpentine, or kerosene.

Thread cutting operations require the use of a cutting aid which will get under the chip and produce a smooth surface. Some of these are white lead and oil, white lead and turpentine, lard oil, mineral oil, kerosene, turpentine, and carbon tetrachloride. Reaming operations require the use of good lubricant, such as white lead and oil, mineral oil, sperm oil, or lard oil.

SHAPERS

Types and Uses of Shapers. The primary function of the shaper (Figure 3) is to produce flat surfaces. The work is held in a vise on a movable work table. On some shapers the table is universal. It utilizes a reciprocating motion to carry the cutting tool and peels off a chip on the forward stroke. The work table feeds on the backward movement of the ram.

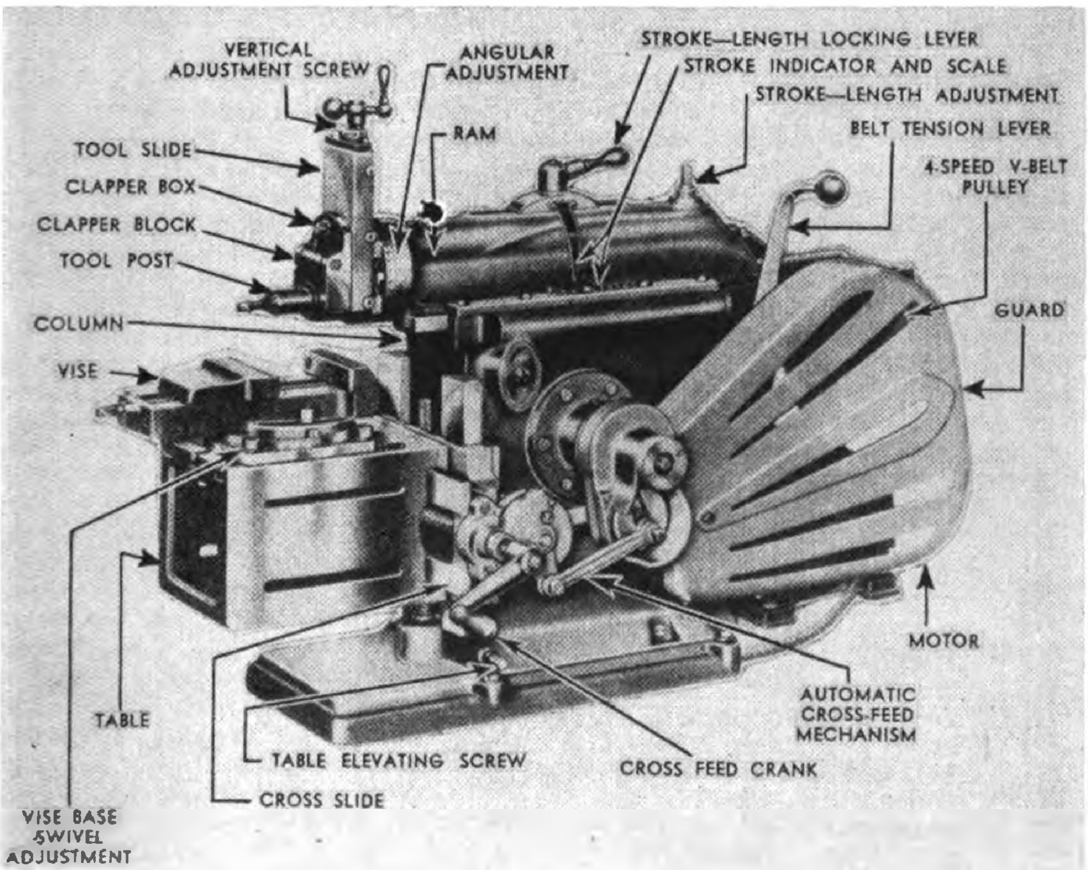


Figure 3. Bench Shaper.

Shapers are classified as to size and type. The size refers to the maximum length of cut that may be taken, 14, 16, 20 inches, etc.; and a standard shaper of a given size will hold and plane a cube of that size.

As to types of shapers, there is the *crank* type and the *hydraulic*. The crank type is more commonly in use in the shop trucks. On the crank shaper the ram is driven forward and backward by an oscillating arm operated by a crank-pin in the main driving gear and in which the feed is transmitted to the work table by a ratchet and pawl mechanism.

The shaper is especially adapted to small work which may be held in a vise bolted to the work table. The toolhead is so constructed as to permit horizontal, vertical, or angular cuts to be taken. For toolroom work such as punch and die work, jig and fixture parts, and on short work for other special tools or machines, the shaper is practically indispensable.

Shaper Operation and Adjustment. The shaper is one of the easier machines in a shop to learn to operate. All the operator has to do is to adjust the length of stroke and to place his work in position with the stroke of the ram. To get the various lengths of stroke, it is necessary to change the position of the crankpin from "on center," which will give no movement, to the limit of "off center," the maximum length of stroke. The crankpin then must be carried on a block that may be moved toward, or away from, the center of the bull wheel.

After having set the length of stroke correctly, sometimes the stroke will not completely cover the work. In this case the ram must be slid either backward or forward to seat itself properly over the work. The position should be such that when the ram is in its rearmost position, there is at least ¾ inch clearance between the tool and the back of the work. And when the ram is in its farthest forward position, there is approximately ⅛ inch clearance between the tool and end of work. This provides enough clearance in the back for the clapper box to seat itself properly before starting on the forward stroke. The front clearance allows the tool to break the chip before its return stroke.

Due to the fact that the rocker arm is in an angular position at the point of reversal, the ram travels with greater speed on the return stroke than on the cutting or forward stroke. The average ratio in most shapers is approximately 2 to 3. This ratio will vary slightly with the length of stroke.

By running the bull gear, or driving gear, at different speeds, a varying number of strokes per minute can be produced. However, for each speed of the driving gear the number of strokes per minute will be constant no matter what the length of stroke. In order to set the ram at these various speeds, a cone pulley or a speed change gearbox is used. The one commonly used for shapers in the shop trucks is the cone pulley system. Here the speed changes may be obtained by changing the belt on the various steps of the pulley, and in this manner four different speeds can be obtained. To correctly set the number of strokes per minute, the cutting speed of the material being cut may be multiplied by seven, and that product divided by the length of stroke. The cutting speed is the number of surface feet per minute that the tool can safely pass over the work.

Cutting. Below are listed cutting speeds of various materials:

Material	*Cutting Speed in Feet/Min.*
Cast Iron	50-60
Cast Steel	60
Malleable Iron	70
Machine Steel Forgings	60-70
Machine Steel Bar Stock	60-70
Tool Steel Forgings	35-40
Steels Containing Nickel and Chromium	30-50
Yellow Brass	150-200
Composition Brass	120-150
Bronze	30-80
Aluminum	150-300

The above speeds are for high speed steel tools only. For high carbon steel tools divide speeds by two (2). These cutting speeds will remain constant no matter what machine is used to cut the metal. The following is an example of figuring the number of strokes per minute—shaping malleable iron and using a seven (7) inch stroke. The C.S. for malleable iron is 70, so using the aforementioned procedure:

$$\text{S.P.M.} = \frac{\text{C.S.} \times 7}{\text{Length of Stroke}} = \frac{70 \times 7}{7} = 70 \text{ strokes per minute.}$$

If the machine cannot be set at 70 S.P.M., then set it on the nearest number of strokes *under 70* that the shaper will produce. It is not recommended that the higher speed be used.

The work table may be fed horizontally either by hand or by power, and may be adjusted for work of different heights by moving the table up and down. The table is bolted to a saddle, and the saddle is gibbed to the crossrail, which provides a suitable bearing surface for the horizontal movement of the work table when the feed screw is turned. The front face of the column of the shaper is finished to form a suitable bearing surface for the vertical adjustment of the crossrail. Clamping bolts are provided on both sides of the shaper to securely bind the crossrail to the column. Whenever the vertical adjustment of the table is made, these bolts should first be loosened, then the adjustment made, and the bolts again tightened to give rigidity to the work.

The work table is provided with T-slots on both sides and on the top so that bolts can be inserted for clamping the work.

Manual and Automatic Feeds. All shapers are equipped with a feeding mechanism for the purpose of moving the table in a horizontal direction. This mechanism consists of a feed screw and a large nut fastened to the table. The feed screw is held in a fixed position as far as moving laterally is concerned, but it may be revolved. This feed screw can be turned either by hand or power feed causing the table to move in a horizontal direction. The automatic feed is obtained by causing the feed screw to make part of a revolution, and the amount it moves is governed by the action of a pawl which engages a ratchet wheel fastened to the screw. The pawl operates once during each revolution of the bullwheel, that is, it indexes and falls back over the teeth just indexed. This is caused by the oscillating motion of the pawl carrier which receives its motion from an eccentric on the bullwheel hub.

It is important that the set up should be made so the table is always indexing on the return stroke of the ram. If, when starting the automatic feed, the index is on the forward stroke, it can be changed simply by sliding the eccentric to the opposite side.

The toolhead is so constructed as to hold the tool and also to allow the tool to be adjusted for the desired cut. The downfeed screw has a graduated collar in thousandths of an inch to indicate the movement of the slide. The slide and screw have a fairly wide range of movement, and, because of the swivel construction between the head and ram, the feed may be vertical or at any angle in the plane of the swivel. In this way a vertical cut of considerable depth or a medium bevel cut may be taken by use of the down feed. The swivel head plate is usually graduated in degrees, and is adjusted by loosening and tightening the binding bolts.

The cutting tool is held in the tool head securely against the clapper block. This block is held by a hinge pin snugly against the back and the sides of the clapper box. On the forward or cutting stroke, the tool is braced against this clapper box giving the tool its support. On the return stroke, the block is hinged outward and allows the tool to clear the work. This prevents the severe drag of the tool over the work eliminating the ruin of the cutting edge of the tool.

The downfeed is used for vertical cuts such as cutting dovetails, squaring ends, finishing the sides of tongues and grooves, cutting keyways, and occasionally for cutting off. In all cases, except for cutting off or cutting keyways, it is very necessary to swivel the clapper box when using the downfeed. This is based on the fact that when the top of the clapper box is moved in a direction away from the surface of the cut, the tool will hinge in a direction up and away from the work on the return stroke.

It is not good practice to use the head with the slide run down much below the swivel plate, because in this position it is not as rigid as when backed up by the ram. Be careful also when making the setup for an angular cut to have the ram positioned such that the tool head will not strike the column on the return stroke.

Shaper Cutting Tools. Due to the variety of cuts that can be made on a shaper, it is necessary to have various sizes and shapes of tools. These tools are very similar in form to those of the lathe, but differ slightly in their clearance angles. The front clearance angle should be approximately three degrees, and a side clearance of two or three degrees is ample. Too much front clearance will cause the cutting edge to crumble away and dull quickly. Too little front clearance will keep the cutting edge from getting under the chip, thus producing a rough surface. The same applies to side clearance. A side rake angle of ten degrees or more is usually given the shaper tool. The angle will vary slightly with the hardness of the metal to be machined and the type of tool used. There will be no front rake except in the finishing tools.

The tool holder and high speed steel bits have in most places taken the duties of the forged tool for shaper work. The bits may be ground to practically any shape that is required to accomplish the job. When mounting the bit in the toolholder, do not extend it too far from the holder or unnecessary spring will result. A lathe toolholder and bit may be used provided the tool bit is not given too much clearance. The newer shapers are fairly rugged machines and accurately built, so when a considerable amount of metal is to be removed, the shaper should be made to work during its roughing cut, the cutting speed should be suitable. and the depth of cut and feed should be set to remove as big a chip as the shaper will drive and the strength of the tool will permit. It is difficult to give a definite rule for the correct amount of feed and depth of cut, but a safe rule to follow is to give as much feed as is consistent with the surface desired, and all the depth of cut the machine and tool will stand.

Shaper Work Aids and Their Uses. There are several different methods of holding the work for machining. The most common method employed on the shaper is the vise. However, other methods such as angle plates, shaper centers, and just plain clamping the work to the table are used extensively.

Angle plates come in a number of different sizes and are usually made of cast iron. The work is held by clamping it to one wing of the angle plate and clamping the other wing to the table.

Shaper centers are used especially for certain curved surfaces that have some flat portions protruding. With these centers the work may also be mounted on a mandrel if it is more advantageous to do the work in that manner. The head is so designed as to permit numerous indexing operations.

There are also numerous aids to permit the correct seating of the work when using the vise. For instance, parallels are used to raise the work to the required height in the vise or to level it with the ram. And then hold-downs are used sometimes to hold thin pieces in the vise. These hold-downs have a slight angle from the perpendicular and upon applying pressure will force down on the work.

Before setting up the work in the vise, the vise should be aligned with the ram. This is necessary to insure the cutting surface to be square with the jaws of the ram. Some vises cannot be aligned with the ram, and in this case it is necessary to use paper shims to bring the work in line.

Do's and Don't's in Using the Shaper. Many more important and interesting things could be written on the use of the shaper; we have touched upon only the more important aspects, and in closing this subject we present a few "Do's and Don't's":

Keep the machine clean and well oiled.

Use the proper wrench or handle and when not in use keep them where they belong.

A vise jaw that is scored and dented and out of true is a disgrace in any shop. A real mechanic is careful. Use brass, copper, or cardboard to protect the jaw when clamping the rough surfaces of bar stock, castings, or forgings.

Parallels should be kept clean, free from burrs, straight, parallel, and square. Examine them before using, and be sure they are at least clean and free from burrs. Do not hammer a rough piece down on a parallel. Be sure there are no chips on the seating surfaces or the clamping surfaces of the vise, parallels, and work. Carefully remove the burr caused by any previous cut if it will interfere with the proper seating or clamping of the work.

Select the proper tool, grind it carefully, and oilstone it. A workman is often judged by the tools he uses.

To seat the work, use a babbitt hammer or a babbitt ball. Do not use a wrench.

Do not hammer the work with the babbitt, tap it just hard enough to seat it. Do not tighten the vise again after seating the work as this is likely to lift the work slightly.

Tissue paper "feelers" between the parallels and the work are often very useful to determine if the work is properly seated.

Do not pinch a thin piece of work too tight or it will buckle more or less and be out of true when the pressure is released. Be sure the top of the table and the bottom of the vise plate are clean and also free from burrs before resetting a vise that has been removed from the work table.

When setting the tool to a surface already finished, be sure the tool block is firmly seated, place a piece of tissue paper under the cutting edge and then feed the tool down to pinch the paper lightly.

When setting up irregular work, be sure the head and also the bottom of the ram will clear the work during the whole length of stroke and the whole width of the cut.

Be sure, at all times, that the tool block works freely and seats properly. Failure to do this has caused a lot of spoiled work.

Do not hammer the side of the apron to swivel it. If the edge of the seating surface of the apron is dented and burred, it will cause the tool block to bind in the box.

DOALL SAW

Probably the newest and most versatile machine tool found in the army machine shops and mobile shop trucks is the "Doall" saw known in SNL's as "SAW, band, metal cutting, Doall, model ML."

Characteristics. The Doall Saw (Figure 4) has found its fixed place among metal working machine tools. It is one of the fastest semi-precision methods of removing metal. Metal cutting band saws have been in general use since 1900. Through the recent perfection and development of molybdenum and other alloys which make possible a narrow saw band, the Doall contour machine was developed a few years ago. This machine also incorporates the band file using a flexible steel tape as a carrier for the file segments.

Job Selector. The job selector is a large movable dial found on the upper left door of the machine. Its use is to determine the correct size and speed of the saw band depending on the material being cut. It is also the source of information concerning the file type and file cut to be used plus the file velocity in feet per minute. The correct saw set and temper can also be found on the selector. The above data is given for fifty-five different materials.

Speed Indicator. The speed indicator, a dial gage reading in FPM, should be held at the proper speed determined by the job selector. An important precaution is stated on the face of the dial, "the speed should only be changed while the machine is in operation."

Work Table. The work table is mounted on a double trunnion providing tilting adjustment forward, backward, and to either side. The backward and forward tilt of the table is a maximum of ten degrees. The lateral tilt to the left is ten degrees also, while to the right there is a maximum of forty-five degrees. Degree segments are attached directly to the trunnions indicating the angle at which the table is set.

Butt Welder. Mounted on the left side of the machine is the butt welder panel assembly. The arrangement of this panel is viewed from the operator's position. The tension control dial regulates the tension of the moving jaw for each width of saw to be welded. To the right of the tension selector is the adjusting switch used to control the amount of heat generated at the weld. The welding lever located below the switch should not be depressed while the operator is in contact with the welder jaws. The annealing switch, a red bakelite button, is not a snap switch, it should be depressed fully and held there during the annealing process. Directly above the grinding wheel is found a weld thickness gage, used to check the blades after welding and grinding to insure free passage through the guides.

The Band Saw. Twenty different sizes of band saws are supplied with model ML Doall. These bands are cut to a maximum length and can be shortened within the range of the saw carrier wheel adjustment. In welding the blade, it is necessary that the ends be square before clamping them in the jaws of the butt welder. For internal sawing, a hole is first drilled through the job, and one end of the blade is inserted with the teeth pointing in the proper direction.

The ends of the saw are ready to be clamped in the terminals of the butt welder. It is extremely important that the junction is not made at an old weld as proper annealing cannot be obtained. The width of the blade should be determined by two factors, first the feed, and second the curvature to be cut. It is advisable to use the widest blade possible. The accompanying table shows the selection of proper widths for the minimum radii to be cut.

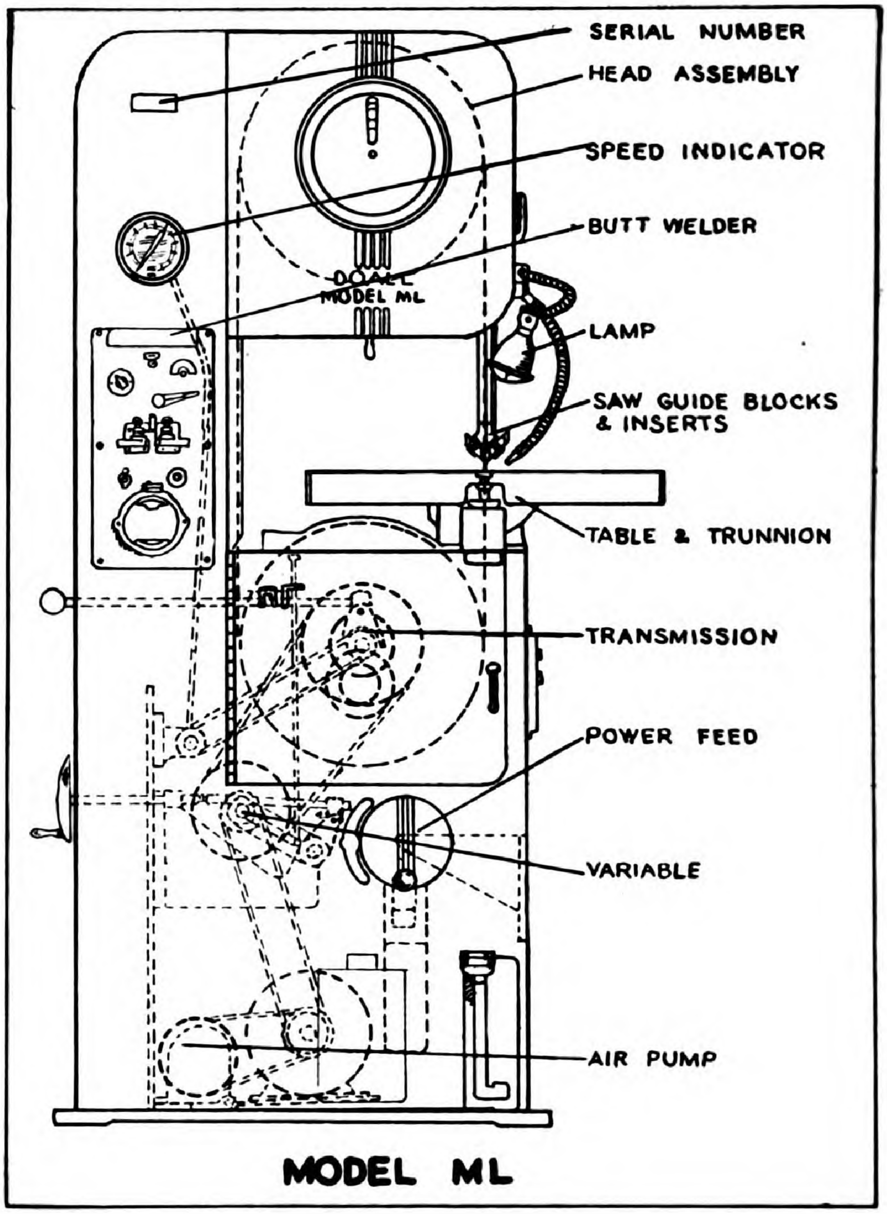


Figure 4. The Doall Saw.

Width of Saw	*Minimum Radii Cut* (Heavy Set Saws)*
1/16	90°
3/32	1/16 inch
1/8	1/8 inch
3/16	5/16 inch
1/4	5/8 inch
3/8	1-7/16 inch
1/2	2-1/2 inch

(The thickness of the blade material back of the set is .025)

* 1. Light set saws are .32 at the teeth.
  2. Heavy set saws are .042 at the teeth.

File Bands. File bands for the model ML are continuous lengths of fine spring steel. The bands are made in two sections, each joined with regular snap lock joints. These joining portions are painted yellow for quick location of the joint. It is important that files be kept clean, as clogged teeth will scratch or tear the finished surface.

Polishing Bands. Polishing bands are much the same as file bands, with the exception that emery cloth is used in place of teeth. The bands are available in the following grades to permit a variety of finishes.

Application	*Cutting speed*	*Grit*
Grinding	275-700	50
Polishing (Coarse)	500-1000	80
Polishing (Fine)	800-1500	150

Feeds. The machines are equipped with both a hand screw and a power feed. The screw feed merely uses a ½-inch acme thread. The screw is used to force the work against the moving saw blade. The screw feed should be used where hand feeding of the work is likely to be tiring. The power feed is seldom used on a Doall in shop trucks as the set up time is not justified for single pieces. For proper saw guide set up, select the correct set of inserts corresponding to the width of blade to be used. The gage rather than the blade itself is inserted in the slot while the inserts are being clamped.

Operating Speeds. An essential factor in the success of precision contour sawing is the use of correct operating speeds for the individual jobs. The saw may travel at the rate of fifty feet per minute when cutting high chrome or at 1500 feet per minute when cutting aluminum, this wide range of speed is made possible by the variable speed pulley. The pulley faces are solid black bakelite of high impact strength and wear resistant qualities. Pulley faces are mounted on a ground steel bearing tube. The pulley alignment is perfect at all times as the assembly floats on the stub shaft. The change of speed is accomplished by moving the V-belt in or out of the floating pulley faces by means of the speed change hand wheel. The variable pulley should be checked and lubricated once a month with a good grade of spindle oil.

General Features. The Doall machine incorporates six important features. Three of these functions are sawing, filing, and polishing. The fourth is the compact welding and annealing unit used to join the ends of the saw band. The job selector, fifth in line, determines the proper speeds for the first three functions based on the material being cut. Last is the variable speed control, a unique device which permits a very fluid adjustment of operating speeds.

Time and time again the Doall saw has proved its worth to the Ordnance machinist by the accuracy and ease obtainable on the great variety of jobs. In most cases, working with hand tools constitutes a long and laborious job, with the accuracy entirely dependent on the skill of the machinist. Using a Doall saw with a reasonable amount of skill and experience, the average machinist can turn out an accurate job in a fraction of the time required with hand tools, thus eliminating the necessity for a highly skilled craftsman.

Proper care and lubrication are essential to insure long life and accurate work from the coveted Doall machine.

LATHES

The screw cutting engine lathe is the oldest and most important of machine tools, and from it all other machine tools were developed. It is to the lathe that we owe the development of our modern machines. The steam boat, locomotive, electric motor, airplane, and automobile were all possible because of the lathe. Our great industrial progress of the last century would have been impossible were it not for the lathe.

Types and Uses of Lathes. The lathe is principally used for removing material from the inside or outside of straight or tapered cylindrical objects. Facing or radial turning is also performed with the lathe, and by use of the proper attachments and accessories, threads of various pitches may be cut, radii turned, and cylinders of irregular outline machined. The removal of material is accomplished by the use of cutting knives, known as tool bits, which are ground to the proper shapes for various operations.

Lathes for general shop work may be divided into two classes: *engine lathes* and *tool-room lathes*. The tool-room lathe is ordinarily more accurately constructed and is provided with more attachments than the engine lathe. Therefore, work of a better grade and of a more complete nature may be acomplished on the tool-room lathe.

Lathes are made in various sizes, the size being determined by the diameter of work that it can turn and the length of the bed. The swing and length are measured in inches. Lathes of European manufacture measure swing as being the radius of work that can be handled rather than the diameter as in American practice. Some makes of lathes measure length as being total bed length, while others list length as being the length of work accommodated between centers.

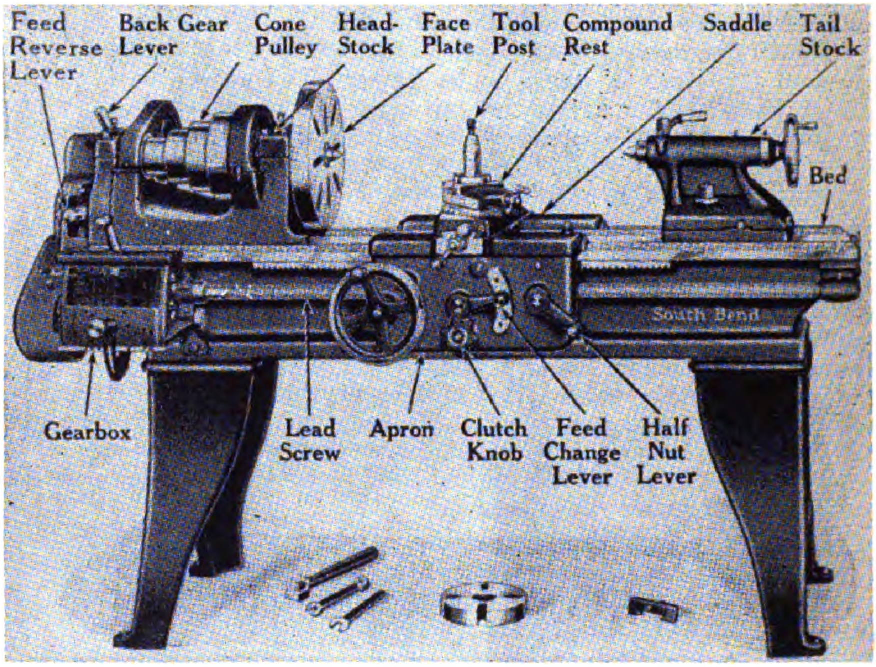


Figure 5. Engine Lathe.

The lathe is composed of five essential features: bed, head stock, tail stock, carriage, and feeding and threading mechanisms.

The *bed* is the main body of the lathe upon which are machined the ribbed portions known as ways. These ways afford alignment and bearing surface for the headstock, carriage, and tailstock.

The *headstock* is made up of the headstock casting, main spindle and bearings, the necessary mechanism for obtaining various spindle speeds, and a series of gears used to transmit motion from the spindle to the feeding or thread cutting mechanism.

The *tailstock* is mounted on the ways and is designed to be clamped at any point on the bed. It is provided with a sliding spindle operated by a hand wheel. The tail spindle is also fitted with a center called the "dead center." The tailstock may be adjusted laterally (toward or away from the operator) by means of adjusting screws.

The *carriage* consists of the saddle, which can be made to slide along the ways by hand or power feed, and the apron fastened to the saddle at the front of the bed. The function of the carriage is to carry the cutting tool. The cross-slide which is fitted to the saddle may be moved by hand or power feed at 90° to the axis of the lathe. On the cross slide is mounted the compound rest, which can be swiveled and clamped at any angle. On its upper side is a T-slot which carries the tool post. The carriage is moved along the ways by means of a pinion gear traveling in a rack at the front of the bed. The apron contains the gears and clutches used to transmit motion from the feed rod or lead screw to the carriage.

The *feeding and threading mechanism* are power fed from the spindle by means of a gear train. All modern lathes are provided with a quick change gear box so that various feeds may be obtained easily and quickly. Power is transmitted through the feed rod to the carriage in normal cutting and from the lead screw to the carriage in threading.

Lathe Mounting and Adjustment. In order that a lathe may operate efficiently, it must be properly mounted and adjusted. Primarily, the lathe must be set up and maintained in a level position. It should be mounted on a solid concrete foundation if possible; however, it may be mounted on a substantial wood floor, in which case it may be necessary to brace the floor to prevent sagging.

If the lathe is not level, it will not rest evenly on all four legs. The weight of the lathe will cause the bed to be twisted, throwing the headstock out of alignment with the ways of the bed causing it to turn or bore tapers. There are several approved methods of leveling and securing a lathe. Leveling screws, shims, or hardwood wedges may be used under the legs, adjusting them so that the bed is level in both longitudinal and lateral positions. A precision level, that is at least twelve inches long and sufficiently sensitive to show a distinct movement of the bubble when a .003 inch shim is placed under one end, may be used in leveling the lathe. A check must be made across the lathe bed at both the headstock and tailstock end. A lathe should be anchored to the floor by means of lag screws and the leveling rechecked after the screws have been drawn down.

The proper adjustment of the various clutches, bearings, and mating members of the lathe are most important in producing accurate work. Some of the common adjustments are listed here in the order of the frequency in which they will probably occur:

(1) Gibs on cross feed, compound and carriage.
(2) Longitude and cross feed clutches.
(3) Thrust bearing on lathe spindle.
(4) Headstock motor drive clutch.
(5) Spindle bearings.
(6) Thrust collar on lathe lead screw.

Care of the Lathe. Keeping the lathe well oiled will greatly influence its operating efficiency as well as its life. Only a good grade of machine oil, SAE No. 10, should be used, and all bearings and bearing surfaces should be oiled progressively so that none will be omitted. When oiling the sliding surfaces, such as the ways, cross slide, etc., it is best to rub the oil in with the hands so as to make sure that the oil is well distributed. It is not necessary to use an excess of oil, a few drops being sufficient. In general, the principles of caring for engine lathes apply to other types of machines found in the shop.

Lathe Cutting Tools. In order to machine materials efficiently, it is necessary to have the correct type of tool with a keen cutting edge. The tool must be well supported and in proper relation to the work and center line of the lathe.

Primarily, cutting tools may be considered as wedges which are forced into the material to cause compression with a resultant rupture or plastic flow of the material. This rupture or plastic flow is usually called cutting. If the wedge is of thin section, it will cut more easily, but will not have the strength to resist the load applied when machining steel or other hard and tenacious metals. This wedge will show the best results when its angle is approximately sixty-one degrees for the machining of soft steels. For the harder materials, this angle is increased to give the cutting edge support.

In order for the tool bit to cut effectively, the side and end are ground so as to leave a projecting edge. This is known as side and end relief. If the amount of relief is not sufficient, the tool bit has a tendency to rub against the work, causing excessive heat and leaving a surface of rough appearance. If the amount of relief is too great, the cutting edge will be weak and will break due to insufficient support.

Rake. The top of the tool bit should slope away from the cutting edge so that the tool bit may be forced into the metal with less resistance, and the chip of metal being removed will not be greatly distorted, thus reducing the power required. This sloping of the top of the tool bit is known as rake.

For the simple removal of metal, it is best to have a large radius at the cutting edge of the tool bit. This shape distributes the cutting pressure and also gives more surface through which to radiate heat. It will wear better and last longer than a tool which is pointed or has sharp corners, although it is sometimes necessary to use a tool that is pointed for machining operations, such as squaring a shoulder, cutting a thread, etc. When using this type of tool care must be exercised due to its inherent weakness.

Beyond proper rake and relief, there are no definite rules to govern the shape of cutting tools. They may be square, pointed, of small or large radii, or of irregular shape, and for certain types of work the cutting edge may be shaped to fit gages of various kinds. Tools which are shaped to fit gages are generally known as "forming tools" and can be used to advantage when making knobs, balls, machine handles, radius grooves, etc.

Tool Grinding. The ordinary means of shaping cutting tools is by the use of grinding wheels. The wet grinder is preferred and should be used with a heavy flood of water so there is no danger of drawing the temper from the tool as it is ground. If a dry wheel is used, the tool bit should be cooled frequently by dipping in water.

It is also necessary to see that the wheel is dressed properly, the grinding pressure is not too heavy, and the tool bit is not held against the wheel too long without being cooled. The relief and rake surfaces of the finished tool should be clean and smooth and should not have a number af facets. Considerable practice is necessary before this can be accomplished by the average person. The cutting edge should be sharp and keen and can be greatly improved by hand stoning the tool after grinding, with a hard, medium grain stone. This is not a remedy for a tool that has become dulled in use (in which case it should be reground), but it is for the purpose of improving its condition after it has been ground on the grinding wheel.

Tool Selection. The majority of tool bits used at this time are of high speed steel and are considerably more efficient than the carbon steel tools. They are capable of retaining their hardness at higher temperatures and therefore can be used at higher speeds. In view of the numerous steels used in the manufacture of cutting and turning tools, it is difficult to give a definite rule for their selection. Steels for this purpose may be generally classified as *carbon steel* and *high speed steel* and are marketed under various trade names, such as Rex A, Rex AA, Rex AAA, Super Dreadnaught, Dreadnaught, etc., in the high speed steel class; and Ketos, Black Diamond, Crescent, Sanderson, etc., in the carbon steel class. Generally, high speed steels are an alloy of tungsten with various proportions of chromium and vanadium. When selecting steel for the manufacture of tools, the cutting speed must be considered. For low speed turning and for hand tools, such as taps, reamers, chisels, and punches, carbon steel gives satisfactory results and is more economical. For high speeds, the high speed steels should be used.

There has been a gradual decline in the use of hand forged tools for lathe work. These have been replaced by tool bit holders of various types. Many varieties of holders are on the market and care should be used in their selection so that proper tool efficiency may be obtained. Tool bits are available in different sizes to fit the various holders and are furnished hardened and cut to standard lengths. Tool holders for the average line of lathe work are described as follows:

The *straight, right,* or *left hand turning tool* holders are for the majority of external turning and machine operations.

The *cut-off tool holder* is made either offset or straight. It is shaped to hold flat, thin-sectioned tool bits and is used to separate pieces in the lathe.

The *boring tool holders* are standardized commercial types. Boring tool holders can be locally manufactured by slotting the ends of rods and brazing high speed tool bits in these slots. Another way of making boring tool holders is to broach a hole in a bar or rod of proper size to hold the tool bit. A set screw or other suitable device is used for holding the tool bit firmly in place.

Cutting Speeds and Feeds. In order to machine metals successfully, careful attention must be given to the speed at which the work revolves, and the distance the tool advances during each revolution. These are known as cutting speeds and feeds. Cutting speed, which is usually given in feet per minute, is equal to the number of feet at the outside surface or periphery of the material that pass the tool bit point in one minute.

There are five factors that should be considered in regulating the cutting speed:

(1) *Hardness of metal* being cut. Hard metals require a lower cutting speed than softer metals, because they are cut with a tool having a blunt angle which will heat more rapidly than the sharper edge used for softer metals. A lower speed is therefore necessary in order that the tool bit may last for a reasonable length of time.

(2) *Tool bit material.* High speed tool bits have the ability to withstand high temperatures, and therefore higher speeds may be used with this type of tool bit. The usual procedure, when using a carbon steel bit, is to reduce the speed to one-half of that used when operating with the high speed tool.

(3) *Feed and depth of cut.* Both feed and depth of cut are determining factors in the selection of cutting speed, and any increase in the depth of cut or coarseness of feed at a given speed will result in a proportional increase in heat generated. Heat is one of the main considerations in tool bit life.

(4) *Diameter and length of work.* When the diameter of the work is small and its length is great enough to set up vibrations due to speed (thereby causing poor finish), it is necessary to reduce the cutting speed.

(5) *Coolant.* The cutting speed can be increased about forty per cent if a large stream of coolant is directed upon the chip at the point of contact of the tool.

On the lathe, the cutting speed must be transposed to revolutions per minute of the lathe spindle by the following formula:

$$\text{R.P.M.} = \frac{\text{C. S.} \times 4}{\text{Dia. of work}}$$

C. S. = Cutting Speed of material.

Feed, or the distance the tool advances during each revolution, controls to a certain extent the speed at which the metal is removed and finish produced. For the roughing cut (fast removal of stock), it is ordinarily advisable to use a comparatively shallow cut and a coarse feed.

For example, in the case of a fourteen inch by six foot lathe, using a tool bit of the proper size and shape, a depth of cut of ¼ inch and a feed of large diameter, a depth of 0.010 inch and feed of 0.005 inch or less might be considered a finishing cut for best results, assuming that the set-up and machining conditions are the best.

The correct depth of cut in relation to the feed depends upon the kind, size, and type of machine tool and tool bit, as well as the nature of the work being machined. A depth of cut of one inch and feed of 0.125 inch for some classes of work on the large turning lathes would not be excessive, while a cut of 0.125 inch and a feed of 0.004 inch might be considered heavy cutting on some of the smaller bench lathes.

Lathe work is held either in chucks on face plates or between centers and may be supported by such attachments as the center and follower rests.

Chucks. A great amount of lathe work involves the use of chucks, and the following description includes the ones which apply to general machine shop operations.

Independent chucks are used more than any other type for general lathe work, due to the fact that they will take work of practically any shape, have great holding power, and can be adjusted very accurately. In mounting this chuck or any attachment that screws on the lathe spindle, the threads and bearing surfaces of both the spindle and the chuck should be cleaned and oiled. In cleaning these threads a spring thread cleaner is very desirable. To align work in the independent chuck, it is placed between the chuck jaws and adjusted to approximate central position by the use of the concentric rings on the chuck face. When this is done, the work is revolved and a piece of chalk held lightly against it until a mark shows. The spindle of the lathe is then stopped, and the jaw or jaws opposite the chalk mark are loosened while the jaws on the chalk-marked side are tightened. This operation is repeated until the desired accuracy is attained. Before cutting ail chuck jaws must be tight.

Test Indicator. When centering smooth-surfaced work to a high degree of accuracy, a test indicator may be used. To do this, the indicator is placed on the lathe with the indicator point in contact with the surface to be aligned. The chuck is then rotated by hand, and the concentricity is shown by the indicator pointer movement. Adjustment may be made on the jaws until the desired accuracy is attained. To remove chucks or face plates that are screwed on the lathe spindle, a chuck-removing wrench should be used, although if not available a block of wood placed between the ways of the lathe and one chuck jaw is satisfactory if the lathe spindle is placed in reverse and started in low gear. Caution: A wood plate should always be placed on the lathe bed below the chuck during this operation to protect both chuck and lathe from damage.

The *universal chuck* is used in holding round and hexagonal work and can be adjusted to centralize the work quickly. Two sets of jaws are usually required on a universal chuck; one set for internal work, and one set for external work.

Collet chucks are small, accurately made, and of the split shell type. They are used to hold work that has smooth, round, external surfaces and should be used only for light machining operations on work that fits them accurately. Collets may also be obtained for holding square, hexagonal, and octagonal work.

The *combination chuck* is made with either three or four jaws which can be moved either independently or in unison.

The *drill chuck* is a small universal chuck that can be mounted in either the headstock or tailstock spindle and is used to hold drills, reamers, as well as work of small diameter.

Face Plates and Centers. The face plate is a flat, round plate provided with T-slots and is especially valuable in machining holes that are to be accurately located in thin work. It screws onto the lathe spindle and is used for holding work to be machined. Angle plates may be bolted to the face plate and the work mounted thereon. The accuracy of the bearing surface of a face plate is most important. Any unevenness of this surface should be removed by taking a facing out. Care should be exercised in clamping work to the face plate so neither the work nor the face plate will be sprung. To eliminate any spring or vibration caused by having work offset on the face plate, balance weights should be used. Paper placed between the face plate and the work when the set-up is made will reduce the possibility of slippage. The various types of centers have many applications in general lathe work. The standard *plain or male centers* are the most common and are used in pairs to support work that has center holes drilled in its ends. The *pipe center* has a conical point which revolves on a bearing. It is used for holding pipe, tubing, etc. The *self-driving or square center* has a point made in the shape of a pyramid. It is used on small work where a light complete cut from end to end is desired without interference from a driving dog. The shape of the center hole in the work is made to correspond to the driving center. The *female center* is conically bored at the tip and used to support work that is pointed on the end. The *drill pad center* is used to drill flat stock in the lathe and is an ordinary center shank terminating in a disk or pad, against which the work is held by friction. The *crotch center* is used to hold round work at right angles to its axis, for such operations as drilling or reaming the wrist pin hole in a piston. The *half center* is a plain center having a portion of the 60° end cut away. It is used for completely facing the ends of work held between centers.

Mandrels. The purpose of the mandrel is to hold work that has been previously bored or reamed so that its outside surface may be machined in relation to that bore or ream. The *standard mandrel* is generally made of tool steel, hardened and ground on the surface that supports the work. This surface is usually tapered 0.008 inch per foot, and the average or standard size is near the middle of the bearing surface. This taper allows the work to be pressed tightly upon the bearing surface or the mandrel where it is held by friction. Mandrels that operate on lathe centers should have center holes as large as possible to provide ample bearing surface. It should always be lubricated before work is pressed upon it to prevent galling. The size of a mandrel is usually marked on the large end.

The *expansion mandrel* is used to hold work that is reamed or bored to non-standard sizes. An expansion mandrel is composed of two parts, consisting of an inner arbor which has a taper of approximately 1/16 inch for each inch of length and an outer split shell that is tapered to fit the arbor. The split shell is placed in the work and the tapered arbor forced into the shell, causing it to expand the necessary amount. *Expanding jaw mandrels* are also in common use and are similar in construction to expansion reamers. The *nut mandrel* is a mandrel that is threaded to a shoulder at one end. Nuts are screwed onto the threaded portion until flush with the shoulder and held in this manner so that they may be machined in proper relation to their threaded bore. The *eccentric mandrel* has two or more center holes at each end. One pair is located in the center of the mandrel, and the other pair is at a predetermined distance off center. By mounting the mandrel between the offset centers, the outside diameter of work may be machined eccentric to its bore. The *gang mandrel* is used for holding several duplicate pieces such as gear blanks. The pieces are held tightly against a shoulder by means of a nut at the tailstock end. *Special mandrels* which are held in chucks may be made locally when a mandrel of the proper size or shape is not available. Mandrels of this type may also be made for special applications, such as the holding of a tapered sleeve upon its internal taper or the machining of nuts which are not bored completely through.

Center Rest. The center rest consists of a frame carrying three adjustable jaws and is used to support work that may spring or distort while being machined. It may be used to an advantage on work held either in the chuck or between centers. It is necessary first to machine a concentric bearing surface on the work at the point at which the jaws are to be applied. After the work has been mounted and the center rest clamped firmly to the lathe bed, the jaws must be carefully adjusted to this bearing surface and locked in position by means of the attached set screws. An overarm is provided on the center rest so that work may be removed and replaced without disturbing the jaw adjustment. This feature also allows the machining of duplicate pieces. To prevent marring of work which has ground surfaces, the use of copper shim stock between the center rest jaws and the work is advisable. Center rest bearing surfaces must be kept lubricated with a mixture such as white lead and lubricating oil to prevent scoring.

Follower Rest. The follower rest is also used to support work that may spring or distort while being machined. It is clamped to the saddle of the lathe, and the two jaws are adjusted and locked upon a surface of the work which has previously been cut. The tool is usually mounted a short distance to the left of the follower rest jaws; and as the carriage and tool move along the work, the rest gives support almost directly behind the cut. A follower rest is essential in threading long work of small diameter and is very useful in many other similar operations.

Work Set Up and Operation. The job to be machined in the lathe is usually referred to as the work or work piece. When the word "work" is used it is understood to have reference to the job.

In machining work on the lathe, the shape, size, and nature of the job to be done governs the way it is to be mounted.

For turning and facing one end of a piece of stock, the three or four jaw chuck may be used. Most work that is to be machined accurately is mounted between centers. To mount work in this manner the pieces of stock are checked for size with the drawing. All burrs are removed, and the stock is faced to the approximate length. The work is then removed from the lathe, layed out, and center punched for the center holes. A drill chuck with the proper size center drill is placed in the tailstock spindle. The tailstock is now moved towards the headstock leaving enough space for the work. Lock the tailstock in the position. The work is held by hand in the lathe, seating one center punch mark against the hard tailstock center. Start the lathe and turn the tailstock hand wheel. Feed the work in this manner into the center drill being very careful that the center drill meets the center punch mark. Continue feeding with the tailstock hand wheel until the proper depth is reached. Remove the work and repeat the operation on the other end of the work. Mount a driving plate on the spindle and insert a soft center in the headstock spindle. The center holes must be clean and a white lead and oil mixture applied to the point of the hard (tailstock) center. A lathe dog (driving clamp) is placed on one end of the work. The tail of the dog is inserted in the slot in the driving plate and the work is mounted between the headstock and tailstock centers. Be sure to tighten the set screw on the dog against the work. A facing tool is mounted in the proper holder and set at the "center" of the axis of rotation. The tool is moved either into the work, or it may be moved out from the center. For finish facing a half-center is usually used.

Plain Turning. For plain turning, the work is mounted on centers as previously mentioned, but a turning tool is used in place of the facing tool. The tool bit is caused to move longitudinally either by hand or power feed. Allow the tool to travel about half way, move the carriage back to the tailstock, but be careful not to move the cross-feed screw. Turn the piece end for end and engage the feed until the cut has reached the previous cut.

Cutting. For cutting a groove, such as a run-out groove, on a piece of stock a parting tool is used. When a piece of stock is to be parted in the lathe it is important that the work is not mounted between centers. The work would become weak and pinch or bind on the parting pool, resulting in a broken parting tool damaging the work. It is essential that the parting tool be set on dead center, and, that when actually cutting, a sufficient amount of cutting oil should be applied. The spindle speed should be reduced to approximately one-quarter (¼) of the turning speed.

Some important things to remember when turning are: proper feeds, speeds, depth of cut, properly ground tool bit, sharp tools, correct height of tool, and proper alignment of centers. The importance of cleaning the spindle tapers when inserting centers, etc., cannot be overstressed.

Thread Cutting. When chasing threads on a lathe, there are a number of things to take into consideration. Our first step is to set up our machine to cut the required number of threads per inch. This is done by operating the quick change gear box. The compound rest is set at 29½ or 30 degrees when cutting national form standard threads. Adjust the gibs of the cross slide and compound rest to a snug position. The speed of the lathe should be approximately 1/3 of the turning speed. The tool bit is of primary importance and must be ground properly. The included angle of the tool bit for national form standard threads is 60 degrees. This angle is ground to a special gage called a "center gage." After the tool is properly ground it is set up in the tool post and adjusted so that the top of the tool is on dead center with the machine. The center gage is used to align the tool so that the center line of the 60 degree angle is set at 90 degrees with the work to be threaded. The feed change lever is put in the neutral position. The machine is now set up for cutting National form threads. Before the actual cutting is started a reference point must be established. The dial on the compound is moved to zero, and at the same time one should make sure that the back-lash is taken out. The cross-feed screw is then turned until the tool touches the work. With the tool in this position, loosen the set screw on the collar of the cross-feed dial and move it to zero. Move the tool to the extreme right of the portion to be threaded or to the starting position. Move the compound one graduation, and engage the half-nut lever at designated mark. (On most lathes the half-nut is engaged at any line for even numbered threads: every quarter turn for uneven threads, every half turn for ½ threads, and every full turn for ¼ threads.) When the tool reaches the end of the portion to be threaded, disengage the half-nut lever and back out the tool with the cross-feed. Move the carriage back to the starting position and move the cross-feed lever back to zero. Check the cut just taken with a rule to make sure the set-up is for the number of threads required. If your set-up is correct, proceed in the same manner. Move the compound dial within about five thousandths of an inch, apply sufficient cutting oil, and engage the half nut lever. The first few cuts may be about five thousandths, but as the cut is deepened, the amount of feed must be reduced. The finishing cuts should be no more than one thousandth of an inch. The thread should be checked with a thread or pitch micrometer. or its mating part.

Taper Turning. Taper turning can be done on the lathe in practically the same manner as straight turning. Tapers may be turned on a lathe in several ways depending on the length and amount of tapers.

The amount of tapers is generally given in degrees or taper per foot. The compound is used for most short, steep tapers, such as the sixty degree angle on a lathe center, although, in some cases a wide-nose tool may be used by setting the cutting edge with a bevel protractor at the required angle and feeding in with the cross slide and moving the carriage into the work. A simple formula for changing taper per inch into degrees is $\frac{TPI}{2}$ = tangent of the angle. Of course, a table of tangents has to be available to complete this formula.

The taper attachment or the tailstock offset method is used for long tapers such as are found on the body of lathe centers (Morse, Brown and Sharpe, and Jarno). The taper attachment is an attachment for machining tapers of all types, both external and internal. The length of travel is considerably longer than the compound rest. This attachment is graduated in degree on one end and in inches per foot on the other end. A sliding block is set on the ways of the taper attachment guide bar, which in turn is fastened to the lathe cross-slide by a link and connecting screw. As the lathe carriage is moved the guide block is caused to move along the guide bar, which is set at the required angle to the axis of the lathe. This in turn causes the lathe cross-slide to move back and forth at right angles to the axis of the lathe, according to the direction in which the carriage is traversed. The lathe cross-slide must be released from its feed screw during this operation so that it may be free to follow the taper set on the guide bar. Taper attachments are usually of two types, telescoping and plain. There is only a slight difference between the two. When the *plain taper* attachment is to be used, it is necessary to disconnect the cross-feed screw by removing the bolt. This bolt locks the cross-feed nut to the compound rest base of the lathe. Removing this bolt leaves the compound rest base free to slide so that it may be controlled by the taper attachment. This is not necessary with a *telescoping type* because of the telescopic cross-feed screw. There is always some play or lost motion with either one of these attachments, therefore, the tool should be moved beyond the start of the actual cut to allow the slack or back lash to be taken up before the tool begins to cut. If this is not done, the finished job will have a straight portion at the beginning of the taper. Some important things to remember are: centers in alignment (if turning between centers), tool set exactly at center, and be sure to take out back lash.

If no taper attachment is available, external tapers may be turned by the tail stock offset method. By this method, the tail stock is moved off the true center line. The amount the tail stock is offset is dependent on the following information: total length of piece held between centers and the amount of taper desired. The taper is calculated in thousandths of an inch. The moving of the tail stock one way or the other (towards or away from the operator) governs whether small or large diameter is formed at the tailstock. For instance, if the tailstock is set off in the direction of the operator, the diameter at that end of the work will be smaller, and if moved in the opposite direction, the diameter will be larger. Some important things to remember are that the tool bit cutting edge should be on center, and that one should loosen clamp screw before attempting to offset tailstock. Internal tapers cannot be cut by the offset method.

Knurling. Knurling is an operation of rolling depressions into the surface of the work by means of small wheels or rollers with helical teeth. Most knurling tools produce a diamond pattern and are so arranged as to be interchangeable with rollers for coarse, medium, and fine work.

For knurling, the lathe should be run at approximately half the normal cutting speed with the knurling tool pressed hard against the work. The longitudinal feed of the lathe may be used with a coarse feed. Use plenty of lard oil during knurling so as to float away the small particles of metal which appear during knurling. About three to five passes over the same surface should result in a good knurled surface. In order to produce a good knurl, have the knurling tool set firmly so that both wheels rest against the work.

The different kinds of operations, set-ups, and types of work that can be done on a lathe are almost unlimited. Outside of the operations mentioned, there are drilling, boring, reaming, radius turning, polishing, filing, etc. Milling attachments, tool post grinding, and many other attachments make the lathe useful to a much greater extent. The versatility of the lathe rests entirely on the operator.

MILLING MACHINE

Column and Knee Types. The most common type of milling machine used in the machine shop is the "column & knee" type. This machine is so named because of its design. The main casting consists of a high column to which is fastened a bracket or "knee," which supports the table. The knee is adjustable on the column so that the table can be raised or lowered to accomodate jobs of various sizes. Vertical cuts may be taken by feeding the table up or down. The table may be moved in the horizontal plane in two directions, either at right angles to the axis of the spindle (longitudinal feed), or parallel to the axis of the spindle (transverse feed).

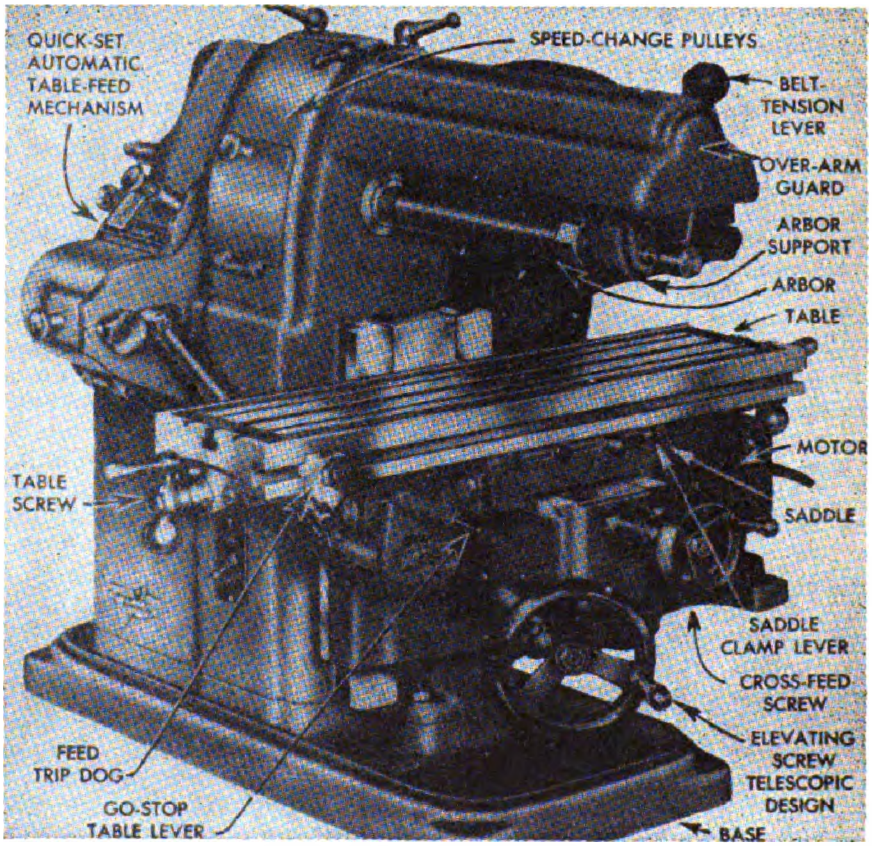


Figure 6. Milling Machine.

The advantage of the column and knee type lies in the fact that only in this type of milling machine are these three movements combined. For this reason, the column and knee machine is superior to the manufacturing or planer type for general milling purposes. The column and knee type may be divided into three classes: the plain milling machine, universal milling machine, and vertical spindle milling machine.

Plain Milling Machine. The plain milling machine is one in which the longitudinal travel of the table is fixed at right angles to the spindle. In this machine the table has three movements: Longitudinal (at right angels to the spindle), transverse (parallel to the spindle), and vertical (up and down). It is the practice to make cuts at fast speeds, and to make coarse feeds in this class of work for which the medium and larger sizes of plain milling machines are adapted. The rigid construction of the machine enables this to be done successfully, and it is this ability that is the chief value of the plain miller.

Universal Milling Machine. The universal milling machine is a development that embodies all the principle features of the other types of milling machines. It is designed to handle practically all types of milling machine work. The table has the same movement as the plain milling machine, but in addition it can be swiveled on the saddle so that it moves at an angle to the spindle in the horizontal plane. When fitted with an attachment known as an index head, angular, spiral, and helical cuts may be made. The universal type of milling machine is used to cut helical gears, twist drills, milling cutters, and various kinds of straight and taper work. The universal milling machine is regarded as one of the most important machines in the machine shop.

Vertical Spindle Milling Machine. The vertical spindle milling machine embodies the principle of the drill machine. The spindle and table are similarly located, and the cutter is mounted on the spindle. The spindle has a vertical movement, and the table has vertical, longitudinal, and transverse movement. The vertical spindle milling machine is used for face milling, profiling, die sinking, and for various odd-shaped jobs. Owing to the position of the spindle, this type of machine can be used advantageously in boring holes. In order to increase the range of work that can be done on a milling machine, many mechanisms known as attachments are used.

Milling Machine Attachments. The *Compound Vertical* milling attachment is particularly applicable to a large variety of milling, because it can be set in two planes. It is especially advantageous when it is desired to set the spindle at an angle to the table, as in milling angular strips, table ways, etc. With the spindle in this position, the full length of the table travel is available, and an ordinary end mill, instead of an angular cutter, can be used for milling the angle.

The *Universal Milling* attachment, as the name implies, is fully universal in regards to setting the spindle. Its range of work is very much the same as is covered by the preceding attachment, and in addition it can do many unusual jobs beause its spindle may be set at any angle in both planes.

Rotary attachments are used on a variety of circular milling jobs, such as circular T-slots, segment outlines, etc., and on a great deal of tool and die making jobs that require splining, slotting, or irregular form milling.

The *Slotting* attachment is largely used in tool making, such as in forming box tools for screw machines, making templates, splining keyways, and work of a similar character. The working parts consist of a tool slide that is driven from the machine spindle by an adjustable crank that allows the stroke to be set for different lengths. The attachment can be set at any angle between 0° and 90° either side of the center line, the position being indicated by graduation on the circumference of the head.

The *Rack Milling* attachment is used for cutting teeth in racks. It can also be used in connection with the universal spiral index cutters for cutting worms. on universal milling machine, and for other miscellaneous operations. The cutter is mounted on the end of a spindle that extends through the attachment case parallel to the table T-slots. This spindle is driven from the machine spindle by a train of hardened steel bevel and spur gears.

The *High Speed* attachment consists of a pair of gears for increasing the speed. and an auxiliary spindle that drives the cutter. It is used in order to obtain the correct speed for small milling cutters, which should be run more rapidly than the fastest spindle speed when cutting keyways and slots.

The *Tilted Table* is designed primarily for use in connection with index centers and fluting taper reamers, taps, etc. In addition to this work, many other kinds of taper pieces can be accurately reproduced.

The *Plain Vise* is used in light milling operations. The bed and sides are made of cast iron, and the jaws are made of tool steel, hardened and ground. It is fastened to the table by means of a screw that passes through the bed and threads into a nut inserted in the table T-slot.

The *Flanged Vise* which differs very little from the plain vise, except that a slotted flange is provided at each end so that a T-slot bolt and nut can be used to fasten the vise to the surface of the table.

The *Swivel Vise* is the same as the flanged vise, but the base is held to the table with a swivel, allowing the vise to be turned or swiveled at any angle. The entire circumference of the base is graduated in degrees.

The *Toolmakers' Universal Vise* enables a job to be set at any angle in the horizontal or vertical plane.

The *Spring Chucks* more commonly called *Collets* are convenient for holding wire, small rods, straight shank drills, mills, etc. The collet holder is made of steel ground to fit a standard tapered hole and has a hole through its entire length. The spring collet is held in place by a cap nut that forces it against the tapered seat and closes the chuck concentrically.

Milling machine spindles prior to 1927 did not have a standard spindle that made arbors interchangeable. The National Machine Tool Builders Association adopted a standard taper spindle having a taper of three and one-half inches per foot. Arbors of this nature are interchangeable from one make milling machine to another.

The Index Center consisting of the index head and foot stock is one of the most versatile accessories of the milling machine. It is used for obtaining equally spaced divisions on the periphery of work such as gears, drills, reamers, cutters, etc., and also for helical and spiral milling. The most essential parts of the index head are the worm and worm wheel, index plates, sector arms, and change gears.

The Worm Wheel. The worm wheel has forty teeth and the worm has a single thread. The worm wheel is keyed to the spindle. The index crank turns the worm forty times, while the spindle is revolved once. Fractional parts of a turn are obtained by means of the index plates which are furnished with each head.

The sector arms are used to mark off the number of holes on the index plate which are required to make a fractional part of a turn of the index crank without counting them each time the index crank is moved. The change gears control the movement of the index plates and the spindle in differential indexing and helical milling. Rapid, plain, and differential indexing are the three methods most commonly used.

Rapid Indexing. In rapid indexing, the worm and worm wheel are disengaged and the spindle is moved by hand. The required number of divisions on the work is made by means of the rapid index plate located on the nose of the spindle. The plate usually has twenty-four equally spaced holes, and only the numbers which will divide evenly into twenty-four can be indexed (that is: 2, 3, 4, 6, 8, 12, and 24). An index pin placed in one of the holes of the rapid index plate locates the spindle in the proper position and a clamping devise locks it while the cut is being made. This method is used when a large number of duplicate parts is being milled.

Plain Indexing. Plain indexing is a method of indexing for a number beyond the range of rapid indexing. In this operation, the index head spindle is moved by turning an index crank attached to a worm which meshes with the worm wheel. The worm wheel has forty teeth and the worm has a single thread. For each turn of the index crank, the worm wheel moves one tooth, or one-fortieth of a revolution. To cause the spindle to make one turn, the index crank must make forty turns, in other words the ratio between the revolutions of the index crank and those of the spindle is forty to one. A wide range of divisions may be indexed by using this method.

Differential Indexing. The differential method of indexing is used when indexing for numbers beyond the range of plain indexing. This is accomplished by connecting the index plate to the spindle by means of a gear train, so that the index plate can rotate in relationship to the movement of the spindle. By a proper arrangement of the gearing, the index plate can be moved faster or slower and in the same direction (positive) or in the opposite direction (negative) to the index crank. This causes the movement of the index crank. Before differential indexing is attempted, gearing and the forming of gear ratios should be understood.

MILLING MACHINE CUTTERS

A milling machine operator should be familiar with the different types of milling machine cutters. These cutters are generally made from carbon steel, high speed steel, stellite or cemented carbide, and are classified according to their relationship to the axis of the spindle of the milling machine. There are four different types of milling operations.

Plain milling, or *slab* milling, produced by plain milling cutters, produces flat surfaces parallel to the axis of the spindle of the milling machine.

Face milling, produced by face or side cutters; produces flat surfaces at right angles to the axis of the spindle of the milling machine.

Angular milling, produced by angular cutters, produces flat surfaces at an inclination to the axis of the spindle of the milling machine.

Form milling, produced by any cutter pertaining to a form, produces surfaces having an irregular outline. Since there are four classes of milling operations, the milling operator knows that there are four classes of cutters: Plain, side or face, angular, and form. An example of each is:

Plain—plain mill, inserted (nicked) tooth, interlocking, slitting saw.

Side or face—side mill, end mill, shell mill, face mill.

Angular—single angle (45°), double angle (90°) spiral mill cutter, hobs.

Formed—convex, concave, irregular form, involute gear cutter, epicycloidal gear cutter.

In all milling machine work, the speed in which the cutter is rotated and the rate in which the work is fed into the cutter are probably the most important factors in regard to cutter life and speed in which the job can be done.

Selection of Speed and Feed. In selecting the proper speed and feed there are many variables; therefore, one set rule cannot be followed, but in all cases the full advantage of the cutter must be considered. Generally speaking, a cutting speed should be selected that will give the best compromise between the maximum production and the longest life of the cutter. Several factors determine the speed and feed in any operation.

The harder and tougher the metal, the slower the speed and cutting, since the frictional heat is greater on harder materials. The depth of cut and type of finish being produced must be considered, as the amount of frictional heat generated is directly proportional to the amount of material being removed. All finish cuts can be made at a speed forty to eighty percent higher than that used for roughing.

Speed in which the cutter can be run depends upon its structure and size. High speed cutters due to heat resistant properties may be operated at from fifty to one hundred percent faster than carbon steel cutters.

Sharp cutters may be operated at a much higher rate of speed than dull ones.

Feeds depend not only on material, but on the size of the work and the way it is held. Thin frail pieces require small cuts and feeds because they cannot be held securely. A heavy piece securely held can stand a heavy feed.

The physical strength of cutters is seldom a limiting factor except for small end mills, saws, and special cutters. For small cutters a conservative feed rate should be used.

A plentiful supply of cutting lubricant on most materials will assist in cooling the cutter, so that it will not overheat at relatively high speeds. To calculate the approximate cutter speed, the cutting speed in feet per minute of the material is multiplied by twelve, dividing this sum by the circumference of the cutter. Thus establishing the formula

$$\frac{\text{C.S. x 4}}{\text{Dia. of Cutter}} = \text{RPM}$$

The variation in speed is very slight and in many cases the exact RPM's cannot be set on a machine therefore the lowest, closest figure should always be selected.

When using high carbon cutters, the rate of speed at which the work passes the cutter determines the time required for the cutting job. In selecting the feed there are several factors to be considered. Forces are extered against the work, the cutter, and their holding devices during the cutting process. The forces exerted vary directly with the amount of metal removed and can be regulated by the feed and depth of cut. Therefore, the correct amount of feed and depth of cut are interrelated, and in turn are dependent upon the rigidity and power of the machine. Machines are limited by the power they can develop to turn the cutter and the amount of vibration they can resist when using coarse feeds and deep cuts.

The feed and depth of cut also depend upon the type of cutter being used, for example, deep cuts or coarse feeds should not be attempted when using a small diameter end mill, as such an attempt would spring or break the cutter. Coarse cutters with strong teeth can be fed at faster rate of feed because the chips may be washed out more easily by the cutting lubricant.

A coarse feed and a deep cut should not be used on a frail piece of work or on work mounted in such a way that its holding device is not able to prevent springing or bending.

The degree of finish desired regulates the amount of feed. When a coarse feed is used the metal is removed more rapidly, but the appearance and the accuracy of the surface being cut may not reach the standard desired for the finished product. Because of this fact finer feeds and increased speed are used for finer, more accurate finishes; while for roughing it is good practice to use a comparatively low speed and a heavy feed. More mistakes are made on the side of overspeeding than overfeeding. Overspeeding may be detected by the occurrence of a squeaking, scraping sound. If vibration (referred to as "chattering") occurs in the milling machine during the cutting process, the speed should be reduced and the feed increased. Too much cutter clearance, poorly supported work, or a machine gear that is badly worn are common causes of chattering.

The feed of a milling machine may be designated either in "inches per minute" or "thousandths of an inch per revolution of the spindle."

The "inches per minute" system is used in the newer machines in which the feed and spindle speed work independently of each other. Good finishes may usually be obtained with a feed of four to six inches per minute, while using a high speed cutter on steel. A good cutting oil for coolant purposes should be employed in either case.

The "thousandths of an inch per revolution of the spindle" system is used on the cone drive machine on which speed and feed are interdependent, and a change in speed causes a similar change in feed.

The formula for calculating the proper amount of feed is as follows: Chip Thickness x Number of Teeth on Cutter x RPM= Feed in Inches per Minute.

Here again the chip thickness is selected by the operator. The type cutter, amount to be removed, type of material, and setup should be considered as important factors. In general machine shop work, a conservative chip thickness of from .001 inch to .002 inch is selected.

Example.

Chip Thickness	.002 inch
No. of Teeth	20
RPM	120

.002 x 20 x 120=4.8 or 4-4/5 inches per minute.

Holding the Work. The proper method of holding work for milling is governed by the size of work, its shape, and the nature of the milling operation. The number of duplicate parts required should also be taken into consideration. Some pieces are clamped directly to the machine table which has T-slots for receiving the clamping bolts. Vises are frequently used for holding small pieces but are not suitable for many classes of work. When large quantities of duplicate pieces are to be milled, they are usually held in special fixtures which are so designed that the work can quickly be clamped in the correct position for milling. The arrangement or form of a fixture depends upon the milling operation. The work must be held securely enough to prevent its shifting when a cut is being taken. It is equally important to support the part so as to overcome any springing action due either to the pressure of the cut or its own weight. Some parts are sprung out of shape by applying the clamps improperly or by omitting to place supports under some weak or flexible section as a result the milling surface is not true after clamps are removed, and the casting springs back to its natural shape.

Mounting Cutters. There are two methods of mounting the milling machining cutters on the arbor. One method is when the part being machined feeds against the direction of cutter rotation and the second method is to have the machine feed with the cutter rotation.

In the first case, the cutter tends to push the work away, and in the second case, the cutter tends to draw the part forward. If there is any backlash or lost motion between the table feed screw and nut, which is true when starting a cut, the cutter teeth which are engaged take deeper cuts than they should, which may result in breaking the cutter or damaging the work. As a general rule the work should feed against the cutter rotation. In other words, the feeding movement and cutting movement are in opposite directions. This is known as the "normal" or "conventional" method of milling.

Climb Cut Milling. The term "climb cut" or "climb milling" means that the work feeds with the cutter rotation. Several advantages are claimed for climb cut milling, assuming that conditions are favorable to its application. One important advantage cited is that the cutter life is increased and at the same time higher speeds and feeds may be employed.

Climb cut milling has another important advantage in that it enables pieces, that are difficult to clamp securely in a fixture or on the machine table, to be milled efficiently. The downward action of the cutter teeth in climb milling such pieces tends to seat them firmly in the holding devices. Cutters used in the conventional manner would tend to lift the pieces from their seats and might make the operation impractical. It is evident that a machine used for climb cut milling must be in good condition and be so constructed that the machine table will resist the cutting forces in either direction. Any play or lost motion which would permit the cutter to climb into the work faster than intended would of course be objectionable. In conclusion, we again must say that the products turned out by the machine are dependent upon the ability of the operator.

AUTOMOTIVE MACHINING

Engine Tear-Down and Rebuilding Operations. When engine cylinders become worn or scored in excess of .010" it is necessary to rebore them and to fit them with new pistons and piston rings in order to restore the original efficiency of the engine.

Boring. Before actual reboring operation is begun, the engine should be completely disassembled and thoroughly cleaned. The engine block then should be checked for cracks or broken studs. These should be repaired or removed before any machine work is begun, as by doing them later serious distortion of the cylinder walls would result. The studs should be removed from the top of the block and the top surface should be filed to remove all the burrs, after which it should be checked with a straight edge for flatness. If the top of the block varies over .002 inch from being flat, it should be filed till it comes within that tolerance.

All cylinders of an engine block should be the same size and they should all be bored to a standard oversize. In order to determine the size of the new bore, it is necessary to "mike" all the cylinders to find the maximum size of the cylinder that is worn the most and select a size that will clear that cylinder. Both finished pistons and piston rings are available in standard oversizes which are multiples of ten over the original cylinder diameter, starting from .010 inch and usually ranging on up to .040 inch oversize. In selecting the correct cylinder bore size, consideration should be given to the accuracy of the centering device used on the boring bar. It is usually considered safe to allow from .004 inch to .005 inch for centering over the cylinder.

To produce a good tool finish with a boring bar, it is advisable to first take a roughing cut out of the cylinder and follow through with a .005 inch finishing cut. An alternate method of finishing cylinders after boring is by the use of a cylinder hone with fine polishing stones. Since the hone has no guided path to follow, one should not allow over .0005 inch for maximum accuracy. After the boring or honing job has been completed, it should again be cleaned and washed thoroughly with soap and water.

For the actual operation of cylinder boring or honing equipment, one should refer to the manufacturer's instruction manual as different makes of machines vary greatly.

Crankshaft Grinding. This is a delicate precision operation, so the utmost care should be exercised throughout the entire operation. There are different types of crankshaft grinding machines available, ranging from a portable grinder used as a lathe attachment to grinders weighing many tons. The latter of course are the

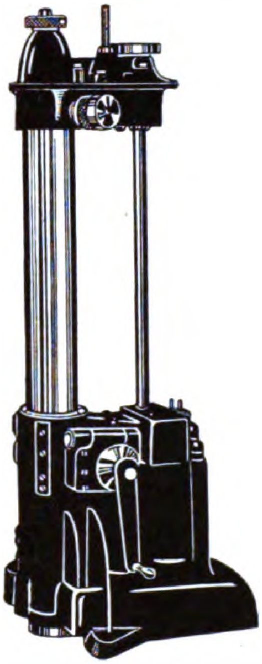


Figure 7. Boring Bar.

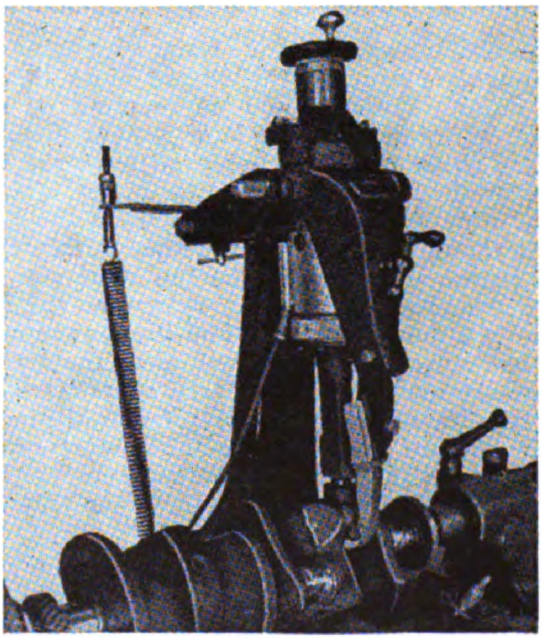


Figure 8. Crankshaft Grinding.

most desirable, but due to their size and to the fact that they require a highly skilled operator, they are seldom found anywhere other than a base shop. The portable type grinder is a very efficient unit, and with careful operation can produce satisfactory results, though not quite as accurate as the large grinders.

Regardless of which type crankshaft grinder is used, the crankshaft must be checked and prepared for grinding. The crankshaft should be first cleaned and the burrs removed from around the center holes. It should then be placed between centers in a lathe and checked with a dial indicator first for run out at the centers and then for possible spring in the shaft. The back end of the crankshaft should be indicated on the flywheel flange, and if run out is noted, the shaft should be chucked by the front end while the flywheel flange runs in the lathe steady rest. The center should be rebored by setting the compound rest at 30° to the lathe axis. The front end of the crankshaft should be checked on centers, indicating on the extreme front end of the crankshaft if a keyway does not exist there. If a keyway does exist, however, the indicator should be used on the end of the front main bearing journal. If run out is noted, that part of the shaft should be run in the lathe steady rest, using the same procedure as with the other end of the shaft. It must be observed in recentering the crankshaft that an unworn portion of the shaft should be worked from the flywheel flange or the unworn end of the front main bearing journal. After the centers have been trued up, the crankshaft should again be placed between centers in the lathe and checked for run out at the center or intermediate bearing journals. If run out exists, it should be straightened in a press and the shaft again checked as before.

The crankshaft is now ready to be placed in the lathe or crankshart grinder for the grinding operation. The original bearing journal diameters should be determined from a specification manual in order to figure a standard undersize for the crankshaft. In most cases, crankshaft bearing journals are ground in multiples of ten under the original diameter, but this may vary with different bearing types. In order to grind all of the bearing journals to the same undersize, it is necessary to "mike" all the journals to find the one that is worn the most, and figure a size that will clear it.

When the crankshaft has been completely ground, it should be thoroughly cleaned, paying particular attention to the oil holes. A properly reground crankshaft will give the same results in an engine as a new one.

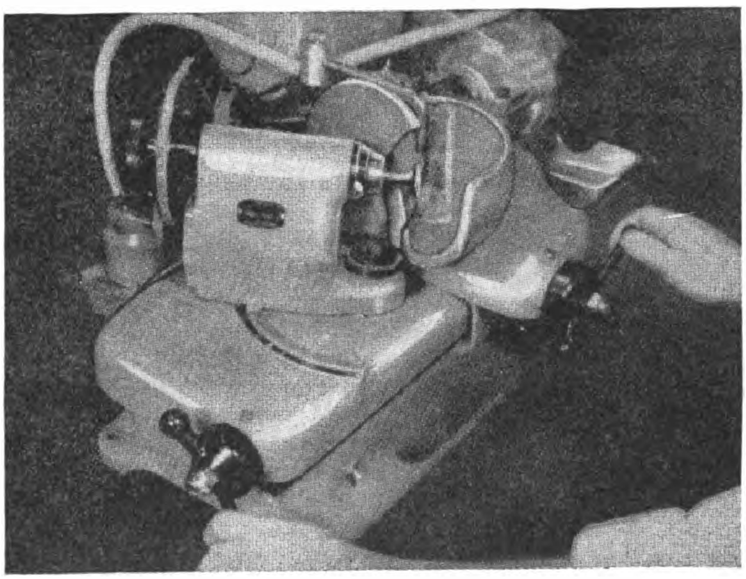


Figure 9. Valve Refacing.

Valve Refacing. Proper valve performance plays a most important role in the operation of a four stroke cycle engine. When the valves become burned, pitted, or warped they cannot properly seal the compression chamber and a great loss of power will result.

The valves should be cleaned with a wire brush removing all carbon and rust from them. They then should be ground in a valve refacing machine set to the proper angle. As little stock as possible should be removed from the valve in grinding, just enough to obtain a true surface. The constant bumping of the valve tappet on the valve stem during its operation in the engine will pit or hollow out the end of the valve stem, making its adjustment with a thickness gage impossible. The valve stem end should be trued up on the fixture provided for that purpose on the valve refacing machine.

Valve Seat Grinding. Equally as important as refacing the valve is the grinding of the valve seats. Before grinding the valve seats, the engine block or head should be cleaned and the valve guides cleaned with a special brush or a valve guide reamer. All worm valve guides should be replaced before grinding the valve seats in order to maintain the alignment between the guide and the seat. With this done,

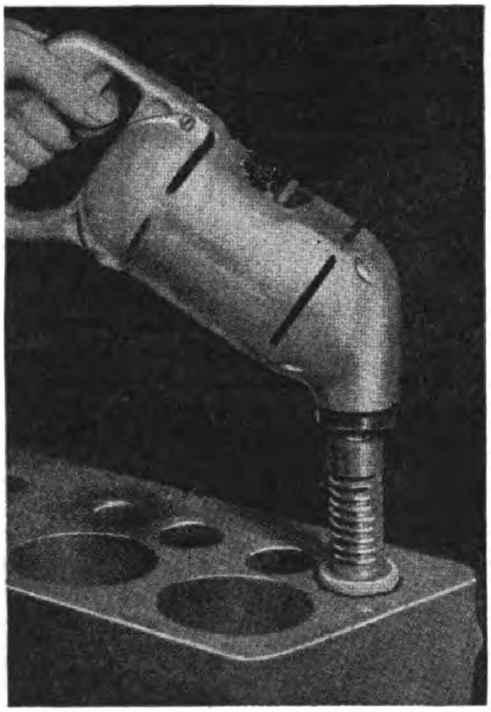


Figure 10. Valve Seat Grinding.

the valve seat grinder pilot should be inserted and expanded in the valve guide ready for the grinding operation. Since some valve seats are made of hard alloys and others of cast iron, it is necessary to select a grinding wheel of the proper grade for the job. The grinding wheel should be kept trued to the angle at all times in order to insure an accurately ground valve seat. The grinding operation should continue only till the seat is completely reground, removing as little stock as possible. When valve seats become too wide due to excessive grinding, they should be narrowed to between one-sixteenth (1/16) and one-eighth (⅛) of an inch in width. They can be narrowed by using from the top a grinding wheel of a lesser angle, or by using a wheel of a greater angle from the inside. It is preferable to lower a valve seat from the top where possible, though in some cases it may be necessary to use both methods.

When valves are refaced and valve seats ground in the proper manner, it is not considered necessary to lap the valve and seat, however, if they are lapped, assurance will be given of having a very satisfactory job.

In-Line Boring. Since engine blocks are not always properly normalized, it is difficult to produce a good main bearing job by installing prefit insert bearings. In line boring in the engine block a set of semi-finished insert bearings corrects for all the inaccuracy that may exist in the alignment of the bearing bores, and an accurate job will result.

In preparing a block for in-line boring, it should first be properly cleaned and the bearing bores should be checked for burrs. These should be moved with a scraper. To facilitate cleaning the oil lines after the completion of the job, the oil line in the bearing bores should be plugged with small cotton rags before the bearings are inserted. The line boring machine should then be assembled on the engine block, using the centering devices in the front and rear bearing bores before the insert bearings are installed. With the line boring assembly completed, the semi-finished insert bearings should be installed in all the bearing bores using a torque wrench in order to tighten all the bearing cap bolts to conform with the manufacturer's specifications. The bearing caps should be checked for fit with shim stock and shims should be used where recommended by the engine manufacturer.

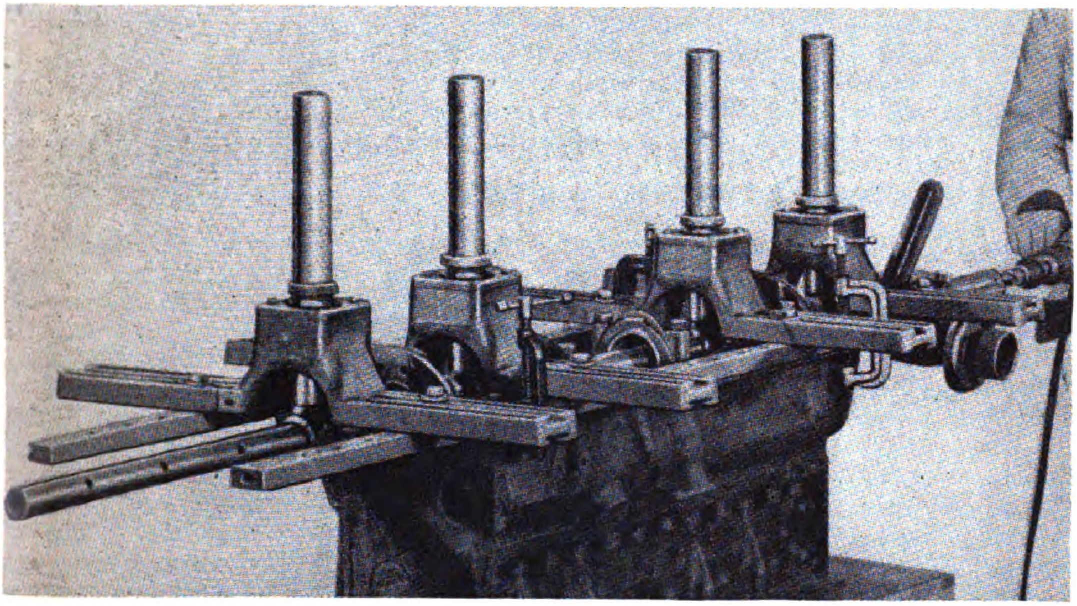


Figure 11. In-Line Boring.

With the bearing inserts properly installed, they should be bored to the diameters of the crankshaft bearing journal plus clearance. The clearances recommended by the manufacturer of the engine should be used if possible, but in their absence .001 inch should be added for every inch of bearing journal diameter for clearance. The side flanges of the thrust bearing should be faced leaving .007 inch clearance for crankshaft and play.

After the boring job has been completed, the line boring machine should be removed from the engine block, the bearings removed in sets as they were bored, and cleaned. The engine block should now again be cleaned, and particular attention should be paid to removing the rags from the oil holes and cleaning the oil line properly. The bearings can now be placed in the engine block. Apply a thin coat of SAE 10 engine oil to the bearing surfaces and install the crankshaft. If shims were used in boring, they should be used in the same place in assembling the bearing caps. The bearing cap bolt should again be tightened by using a torque wrench to insure proper fit. This time the bolts should be locked, if such locks are provided, and the bearing job is complete.

A properly in-line bored set of bearings requires no scraping or fitting and in most cases will last much longer than a prefit set of bearings in an engine.

Machining Brake Drums. When brake drums become worn out round or scored, it is impossible to have proper braking efficiency which is so necessary on heavy and fast vehicles. In most cases, replacement of brake drums is out of the question, so it is necessary to remachine the old drums.

Most brake drum lathes are made to accommodate the drums, tires, and wheels as a unit for re-machining, thus saving much time that would be required for disassembly. The bearings should be removed from the wheel hubs and the proper adapter selected that will fit into the bearing cup. By centering the drums in the bearing cup, proper concentricity can be assured. The largest mandrel that will fit the hub should be used to insure a rigid set up. It is advisable to wrap a belt or pull a spring around the drum during the machining operation in order to prevent the drum from vibrating, which would cause chatter. The tool bit should be kept sharp at all times to insure a uniform finish. The amount of stock that should be removed varies of course with the wear of the brake drum. As little stock as possible should be removed to prevent unnecessary weakening of the drum, yet enough to remove all ridges and irregularities. After the drum has been machined, it should be polished with a fine grade emery cloth in order to remove tool marks. A brake drum cone can be employed for the same purpose with equal results.

In most cases a tool finish is sufficient, but occasionally cast iron drums that have developed hard spots from severe service are found; in those cases the drums will have to be ground. Most brake drum lathes have grinding attachments that can be used with the same set-up as for turning. Grinding a brake drum is a slow operation and is seldom considered necessary on average brake drums.

Properly machined brake drums will restore the original braking efficiency to the vehicle.

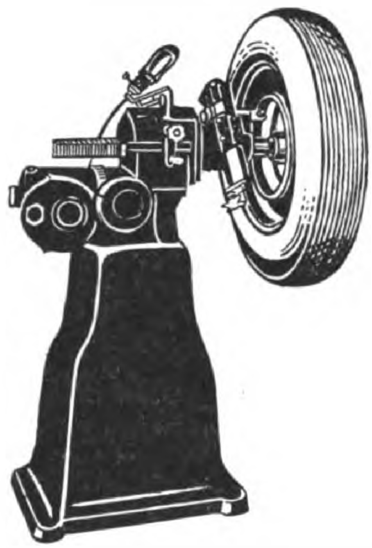


Figure 12. Brake Drum Machining.

Machining Pistons. In order to maintain a low inventory and yet have a complete coverage of piston sizes, pistons are frequently stocked in semi-finished sizes with the facilities to turn or grind them to the sizes desired. Pistons are usually finished in a piston grinder that is capable of cam grinding, though they may be finished in a lathe with the suitable attachments.

Since pistons are not all of the same design or material, it is always advisable where possible to use the clearances recommended by the piston manufacturer. In their absence, however, good results can be obtained by allowing from .00075 inch to .001 inch clearance at the skirt for every inch of piston diameter. The upper part of the piston is subjected to more heat and is a heavier mass of metal; so it is important that the piston lands be sufficiently relieved, so that there be no possibility of them touching the cylinder wall when expanded under high temperature operation. The top land should have from .005 inch to .007 inch clearance for every inch of piston skirt diameter, the second and third land should have .005 inch clearance for every inch of piston diameter. Five or ten thousandths too much clearance on the lands will do absolutely no harm, whereas one or two thousandths too little clearance may ruin an entire job.

Grinding is a slow operation and it is always advisable to turn the piston to within .008 or .010 inch with a turning tool before grinding. By so doing a good finish can be obtained with a minimum of wheel wear.

After the grinding operation has been completed, all burns should be removed and the piston is ready for use.

SHOP TRUCKS

The machine shop trucks are found in the service section of a maintenance unit. The T/O's allot one truck to a medium maintenance company and four to a heavy maintenance company. With these trucks and good workmen with an able section leader, the service section can be of invaluable assistance to the rest of the company and the using units they serve. The facilities of the trucks' equipment are limited only by the imagination of the machinists.

Three types of vehicles will be found in the field. The M4 type (SNL G-57, Vols. I, II, III, IV, and V), the M16 type (SNL G-146, Vols. I, II, III, IV, and V) and the regular 2½ ton 6 x 6 Cargo (SNL N-21) with machine tools mounted.

The M4 truck is a cab-over-engine 4 x 4. The equipment on this vehicle gets its power from a 5 KW generator, which is driven through a power takeoff from the motor of the vehicle. The body is a special all-steel type and the windows are blacked out with snap-on curtains. It has a hot water heating system.

The M16 has a standard 2½ ton 6 x 6 chassis. This chassis also mounts a special all-steel body with wood floors and large rear double doors. It has a total of fifteen windows, thirteen of which can be opened. All windows are equipped with a fine mesh screen to protect the glass and keep bugs out at night. The windows are also provided with blackout curtains on the inside of the truck. These curtains are along the same style as an ordinary window shade in a home. This vehicle has a combination heater and ventilation system to make working conditions as normal as possible in any weather.

The M4 and M16 carry the same equipment known as loads. These loads are designated as loads "A", "B", "C", "D", and "F". Every truck except load "F" has a four cylinder gasoline motor coupled direct to a five kilowat generator for electric power. The electrical power may be transmitted to other vehicles through a connector box located on the outside right front of the body by means of cables.

Standard equipment with these trucks is two hundred feet of heavy rubber covered connector cable which is broken down into three fifty foot and two twenty-five foot lengths. At the end of each cable is a waterproof connection so that line may be strung on the ground during wet weather without inflicting any damage. Care must be taken with these connections to see that they are not placed in the paths of vehicles traveling through the area, because they will rupture easily. There is no method available in the organization to repair these cables so that they again will be weatherproof.

Our first of this series of machine shop trucks is load "A", both the M16 and M4 body styles. It is the basic machine shop truck of a medium and heavy maintenance company. For equipment it has a ten-inch engine lathe with a complete line of accessories which include a three jaw universal and a four jaw independent chuck, collets ranging from one-sixteenth to one inch, follower rest, steady rest, micrometer carriage stop, taper turning attachment, globe milling attachment, complete set of tool holders, tool post grinder, and a set of transposing gears for the cutting of metric threads. Another machine tool contained in this load is a seven-inch crank type shaper with vise and dividing head. This load also has a ¼-inch column drill press equipped with a combination universal table and vise. Drills up to ½-inch diameter can be accommodated in the chuck. Additional equipment is comprised of a bench grinder, ten ton hydraulic ram complete with attachments for body, fender, and frame work, and two bench vises. Hand tools included are files, cold chisels, brass drifts, pin punches, one set of SAE taps and dies, one set of US standard taps and dies, one set of metric taps and dies, straight shank drills from one-sixteenth to one-half inch, letter drills from A to Z—and tapered shank drills from one-half to one inch, nine sets of counterbores, one set straight reamers from one-quarter to three-eighths inches, one set of expansion reamers from three-eighths to one and one-eights inches, one set of expansion reamers from three-eights to one and one-half inches. Precision tools include one set inside micrometers two to twelve inches, twelve inch vernier calipers, surface gage, dial indicator, outside and inside calipers and pitch gages. Three outside micrometer calipers cover a range from 0 to 4 inches. With this assortment of machines and tools, it is possible to complete in this one truck many small jobs.

Next in our series of trucks is the load "B", both M4 and M16 body types. This truck carries a heavy duty lathe equipped with attachments similar to the load "A" ten inch lathe and is capable of handling heavy work. The load "B" will carry one of two types of lathes which may be either a 16 x 22 inch gap lathe or a regular 16 inch lathe. Both machines serve the same purpose. The truck's equipment also includes a one and one-half inch portable drill, which has a stand in the truck so that it may be converted to a modified type of drill press. Along with this we have a bench vise, and a drill grinder whose range is one-quarter to five-eighths of an inch. This truck also has a very good assortment of drills. Numbered drills from one to sixty, a complete set of letter drills, and taper shank drills from one-half inch to one and one-half inch. This truck is designed for heavy work.

The load "C" truck is equipped with a number "12A" Van Norman modified column and knee, swivel head, moveable ram milling machine, Doall saw, end mill grinder, and a quarter inch bench type sensitive drill press. Attachments for the milling machine include a dividing head, footstocks, table stops, and a good selection of cutters. The Doall saw is an ordinary stock model with blades and file bands. This truck is also equipped with inside and outside micrometers.

Load "D" incorporates a two-hundred and twenty volt snagging grinder, seven inch shaper (which is exactly the same as the crank shaper in the load "A" truck), arbor press, and a twenty inch floor model column drill press with a one inch drill capacity. Also included are various hand tools and a set of inside and outside micrometers. This load is for heavy rough work and is not intended for fine precision work.

Load "F" is a very important truck. It can be used for demolition work. Its hand tools are few, but the two main pieces of equipment are the fifty ton hydraulic press and the air compressor with its accompanying tools. The tools consists of two air drills, one one-half inch and the other of one inch capacity, a nut runner and air screwdriver, a portable air grinder, a complete set of air chisels, and punches and rivet buckers. It can be seen that these tools can be effectively used to destroy equipment.

The load "F" truck does not have a generator of its own. None of the equipment on it depends upon electricity for power. However, it is necessary to run a line from this vehicle to another with electrical power so that it can have lights for night operation.

The new trucks that have been just made up are the maintenance set "G" and "H." These trucks have a *standard* 6 x 6 chassis with wooden floors and tarpaulins instead of a steel body. The main idea is to have all trucks look similar from the air so that the enemy cannot pick out special purpose trucks for bombing and strafing. Set "G" has a Van Norman mill and an end mill grinder like load "C", Set "H" has a Doall saw, one 20-inch floor model column drill press with a one inch drill capacity and a brake drum lathe. Two disadvantages of these trucks are that blackout working conditions are very poor, and dirt filters through the tarpaulins and will quickly damage the machinery if not properly taken care of. Great care must be taken in cleaning the machine prior to operation to remove the dust, otherwise the dust mixing with oil will form an abrasive.

With this set of machine shop trucks, nearly all maintenance jobs can be handled quickly and efficiently. If the machinery and tools are properly taken care of they will last indefinitely. Tool breakage should be very low if the workmen are careful, because the tools are of highest quality.

SOLDERING

Solder is a lead and tin alloy used to join metallic surfaces.

When a metal is soldered the surface molecules of that metal and the solder blend to form a new alloy consisting of the lead and tin of the solder and the components of the soldered metal. If copper is soldered to copper, a new alloy is formed which contains copper, lead, and tin. Excessive solder between joints does not make a stronger joint, since the maximum strength is formed by the new alloy and not the orignal lead and tin of the solder.

The soldering process requires the complete dioxidation of the metals to be joined, otherwise, they cannot be soldered. When a metal is prepared for the soldering operation, all foreign materials such as paint, scale, oxides, and dirt must be removed by some mechanical means.

The second step is to remove only oxides and to prevent any further oxidation of the metal by using a chemical flux. An oxide is the chemical combination of an element with oxygen. Raw metals will oxide immediately when subjected to the oxygen of the atmosphere. Therefore, it is necessary to keep these raw metals coated with flux to prevent the oxygen from attacking them.

Commercial solder for general soldering jobs is composed of two metallic elements: lead and tin. In the strange phenomenon of alloying, it has been found that two or more metals joined to become an alloy acquire a complete new set of physical properties.

Pure lead melts at 620° Fahrenheit. Yet a mixture of 66 percent tin, and 34 percent lead melts at a temperature of 356°.

This new melting point is 264° less than the melting point of lead and 94° less than the melting point of tin. This is also a part of the strange phenomenon of alloying. Solder will not flow until it is several degrees higher than its melting point.

Perhaps the handiest tool for scraping off rough and foreign matter is one made of an old power saw blade converted by grinding the teeth half off. An old file can be used by grinding it to any desired shape which the job may require. Emery cloth is useful in removing oxides; a wire, scratch wheel, or brush serves well in cleaning pitted surfaces. Acid of any kind is also good for cleaning.

Many of the deoxidizing agents are very active chemicals, which cause corrosion and must be neutralized by washing with a cyanide solution, followed by a hot water wipe. Solvents are best reduced with an alcohol wash. Some common fluxes used are listed below:

1. Sal Ammoniac
2. Commercial Soldering Paste
3. Muriatic or Hydrochloric Acid
4. Zinc Chloride
5. Rosin
6. Naphthalene
7. Borax
8. Tetrachloride

Method. Solder is applied to the work by one or more of the following methods: soldering copper, blow torch, blow pipe, natural gas torch, and heat. Soldering coppers should be heated so the tips are never held in direct contact with a flame. This can be accomplished by letting the tip extend beneath the flame and allowing the major portion of the flame to heat the rear of the copper. The heat will be conducted to the tip. Direct excessive heat on the point of the copper will cause oxidation and a resultant pitting of the tool. The copper should be kept clean, pointed, and the sides filed smooth. A copper must be tinned so that the solder can be applied to work directly from it. Too much heat on the copper will cause the lead and tin of the solder to oxidize and form a powder. A soldering copper may be kept clean and always tinned by heating it in a bath of molten solder.

The blow torch is very useful in heating and spreading solder over large surfaces as in body work. Solder can be made to flow freely along seams and around piping with a blow torch.

The torch is equipped with a hook on top to hold a soldering copper below the flame. The torch is put into operation by first filling a well, located under the torch tube, with whatever inflammable fluid is used. The fuel in the well is ignited and permitted to burn up completely at which time the torch tube will be heated sufficiently to convert the liquid fuel to a gas. The fuel is forced into the combustion chamber by air pressure and is regulated by a needle valve, which should be checked and cleaned periodically.

When two metals are tinned, squeezed together, and then heated, the process is called *sweating*. Too much heat will cause the metal to warp, expand, and parts to buckle.

Maximum strength is obtained by a minimum amount of solder, cleaning the joint to be soldered carefully, and setting the job together properly.

WELDING

The general opinion of welding is that it is nothing more than simply melting together the edges of metal. Actually only a very small percentage of welding is as simple as this, for welding today is a science as well as an art, and a person must spend months and sometimes years to become a good welder.

Let us take a look at some of the problems that a welder encounters. First, we know that all metal will expand when heated and contract when cooled, and if some means are not used to control expansion and contraction, the material will either warp and buckle, or there will be stresses set up in and around the weld, which will cause the metal to crack on cooling or fail when put into use. Second, we know that if certain metals such as tool steels, cast iron, malleable iron, etc., are heated and allowed to cool too fast, they will become very hard and brittle. On the other hand, there are certain metals which we must cool fast to obtain the desired physical properties.

The first thing the welder must do is to analyze his job. What is the application of the part, will too high heat ruin it, is it likely to warp when heated and cooled, is it a metal that will become hard and brittle if it cools too fast, what type of joint will give the best strength and require the least amount of time, etc.?

It must be kept in mind that very few of the welding jobs which are done in the field will be alike, and each one should be figured out very thoroughly before it is begun.

There are many different kinds of welding, but the ordnance repairman is interested mainly in two types: electric arc and oxyacetylene. We may also divide these processes under fusion welding, a joining together of metals while they are in the plastic or molten state, and brazing, which is the joining together of metals by a bonding process, wherein a rod having a lower melting point than the base metal is used, and the base metal is not actually melted. Both fusion welding and brazing will be discussed in detail later.

Almost all metal can be joined by one of the processes mentioned above, but some metals which have been specially processed by heat treating or drop forging for example, will be adversely affected as a result of the heat of welding: therefore, special welding materials and techniques must be used to enable the welder to do a good job on these metals.

OXYACETYLENE WELDING

Equipment. In the oxyacetylene process of welding, a torch or blowpipe is used to mix equal proportions of oxygen and acetylene gases to produce a flame at a temperature of approximately 6,000°F. Pure oxygen is used rather than air as it will produce a much hotter flame and will not cause impurities to form in the weld.

Handling and Use of Welding Gases. Oxygen for welding is compressed into seamless steel cylinders which have a capacity of 220 cubic feet of gas at a pressure of 2,000 pounds per square inch at a temperature of 70°F. A typical oxygen cylinder is 51 inches high, 9 inches in diameter, with a 1/4 inch wall.

The storage of acetylene gas is not qnite as simple as that of oxygen. Acetylene, when stored in a free state under pressure greater than 15 pounds per square inch, can be made to dissociate or break down by heat or shock and possibly explode. When under a pressure of 29.4 pounds per square inch, it becomes self-explosive, and a slight shock is likely to cause it to explode even in the absence of oxygen or air.

To overcome this danger, the acetylene is dissolved in a solution of acetone. This solution is absorbed in a porous filler consisting of such materials as balsa wood, charcoal, finely shredded asbestos, infusorial earth, corn pith, and portland cement. These filler materials are porous and act as a sponge to absorb the liquid acetone, which in turn absorbs the acetylene gas. Acetone has a very high absorption for acetylene. One volume of acetone will dissolve or absorb 24 volumes of acetylene at 15 pounds per square inch pressure, and about 420 volumes at 250 psi pressure. When acetylene is compressed in this manner it can be safely stored at pressures up to 250 psi.

Because of this method of storage, *the acetylene cylinder should always be used and stored in an upright position* so there will be no chance of the liquid acetone coming out of the cylinder into the hose and torch. Not only will acetone in the acetylene gas (wet gas) cause a very poor weld, but it creates danger of a flashback, which is a penetration of the flame through the torch into the handle

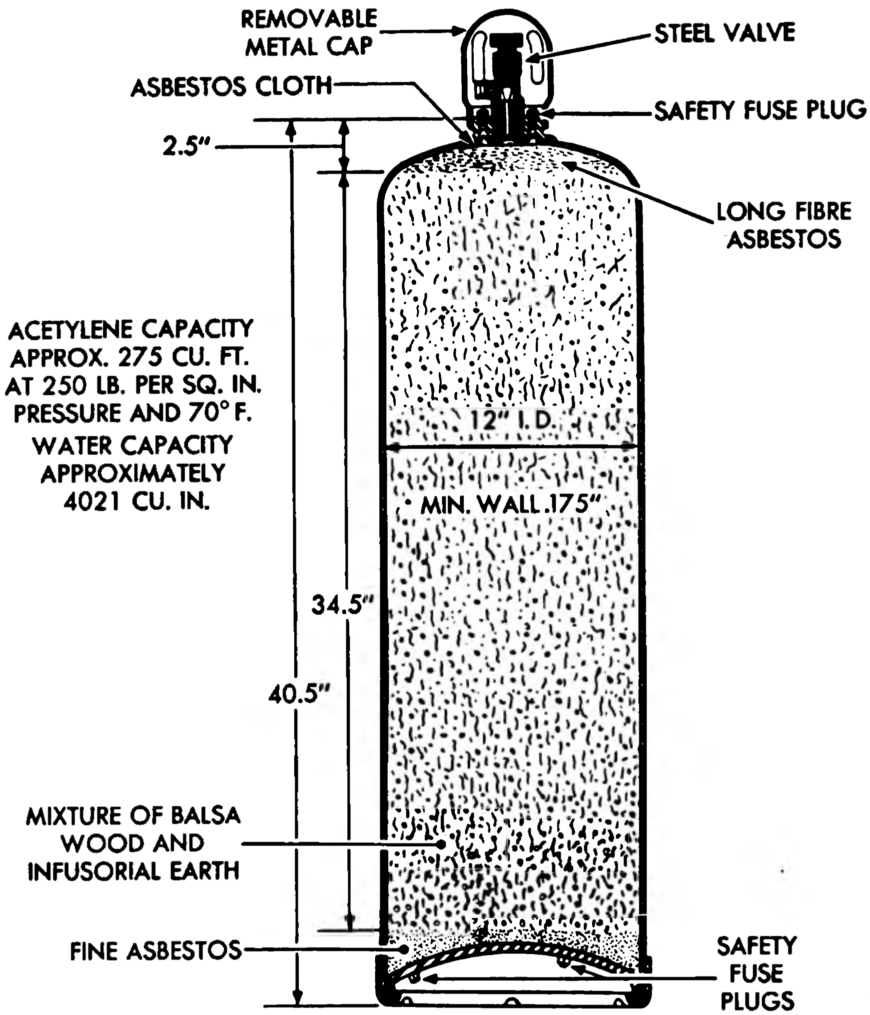


Figure 13. Acetylene Cylinder.

and hose, and on up into the pressure regulator. The sizes and shapes of cylinders used by other countries may be quite different from those used by the United States, and at times it may be difficult to determine by appearance an acetylene cylinder from an oxygen cylinder. A very good way to identify the cylinders is by tapping them with a metallic object. The acetylene cylinder will have a dull sound as it contains filler material, but the oxygen cylinder will have a hollow ring. It will also be necessary to have adaptors made to connect the regulators to many of these cylinders.

Regulators. The high pressure of the gases in the cylinder must be reduced to a much lower pressure at the torch. This is known as the working pressure, and it is essential that this working pressure be accurately controlled. These functions are performed by the oxygen and the acetylene regulators.

These regulators operate on essentially the same principle as any other gas regulator. The mechanism consists of a nozzle through which the high pressure gases pass, a seat to close off the nozzle like a valve, and a diaphragm and balancing spring all enclosed in a suitable housing. At the top is a pressure adjusting screw, which exerts pressure on the adjusting spring to control the working pressure.

Regulators are of two types; *single-stage* and *two-stage*. The single-stage regulator reduces the cylinder pressure to the working pressure in one stage. The two-stage performs the work in two stages, which gives a more accurate regulation of pressure with less fluctuation.

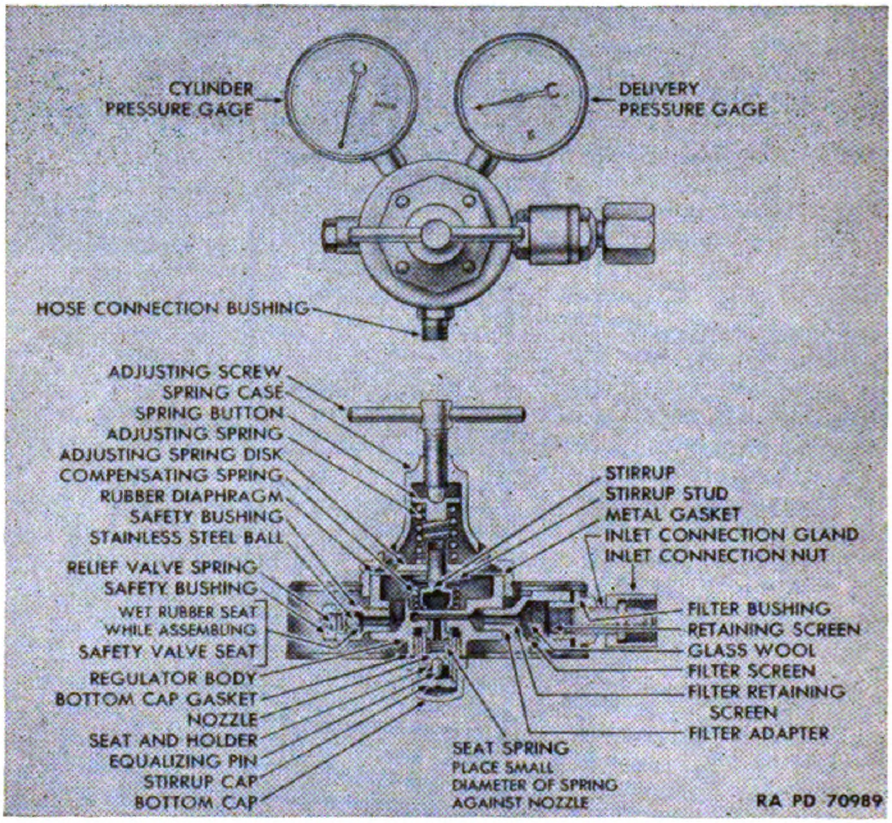


Figure 14. Single-Stage Regulator.

Both oxygen and acetylene regulators are equipped with two gauges. One of the gauges is to indicate the pressure of the gas in the cylinder; the other shows the working pressure being delivered to the torch. The size and graduations of these gauges will depend on the type and the services for which they are intended.

Hose. The hose used for oxyacetylene welding is specially manufactured for this purpose, and is usually supplied in 12½ foot lengths. The *Oxygen Hose is Green* and the connections have right hand threads. The *Acetylene Hose is Red* and the connections have left hand threads.

The Welding Torch. The most commonly used torch today is known as a medium-pressure torch, which operates on pressures from 1 to 15 psi. The torch is fitted with interchangeable tips, which enable the welder to adapt the size of the flame to the thickness and to the type of metal to be welded. The torch has two tubes, one for oxygen and one for acetylene, a mixing chamber, and needle valves for control and adjustment of the flame.

Equipment Assembly and Tear-down. Connecting the regulators to the cylinders and hose, connecting hose to the torch, turning on the gases, and lighting the torch are operations that should be performed systematically to avoid mistakes. The following are the steps in order of their performances:

Crack the cylinder valve by opening each valve for an instant to blow out dirt, Attach regulators to their respective cylinders.

Connect each hose to its regulator. (Acetylene hose has left hand threads on connections.)

To open cylinder valves *release regulator adjusting screws* (turn counter-clockwise), and open cylinder valves slowly. Open oxygen cylinder valves fully, but open acetylene cylinder valves only one-quarter to one-half turn so that it may be shut off quickly in emergency.

To blow out hose, open each regulator by screwing in pressure adjusting screw.

Connect hose to torch.

To adjust working pressure, open acetylene torch valve and adjust acetylene regulators to pressure corresponding to number of tip, *e.g.*, for a number 5 tip use 5 pounds acetylene pressure. Adjust oxygen pressure in same manner.

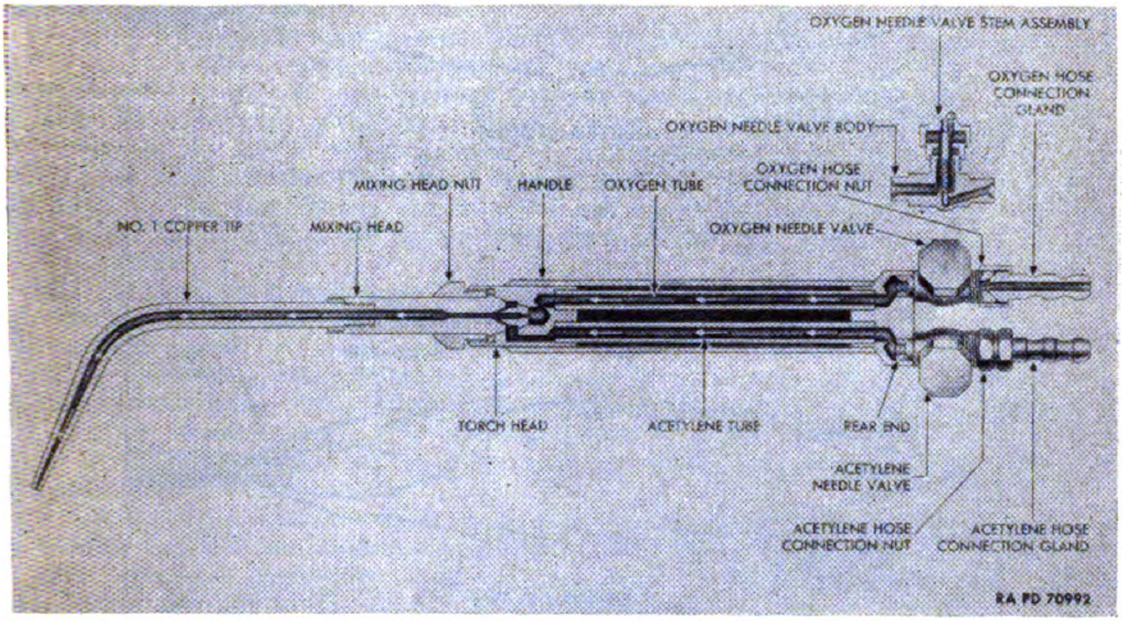


Figure 15. Equal-Pressure, General Purpose Welding Torch.

To light the torch, open acetylene needle valve on torch and light gas with spark lighter. Increase the acetylene pressure by opening the needle valve until the flame leaves the end of the tip, and the base of the flame is approximately 1/16 inch to 1/8 inch away from the tip face. As the oxygen valve is opened, the flame will become shorter and will be bluish-white in color with a bright inner cone. See figure 16 for types of oxyacetylene flames.

Equipment should be shut down in the following manner:

Close acetylene needle valve on torch.

Close oxygen needle valve on torch.

Close acetylene cylinder valve.

Close oxygen cylinder valve.

Open acetylene needle valve on torch, and allow gas to drain from lines.

Close needle valve and release regulator pressure adjusting screw.

Open oxygen needle valve on torch and allow gas to drain from lines.

Close needle valve and release regulator pressure adjusting screw.

FUSION WELDING

For fusion welding the torch is held so that the tip forms an angle of approximately 60 degrees with the plates being welded. The inner cone of the flame should be just about 1/8 inch above the plate as this is the hottest zone of the flame (approximately 6,000°F.). When the edges of the plate become molten and begin to flow together, move the torch along the edges in a semi-circular motion. This motion will melt down the side walls of the plates. For most joints, it is necessary to add additional metal to the weld for reinforcement.

This is done by placing the end of the welding rod under the flame and in the molten pool of metal. The molten base metal and filler rod will flow together until the edges are completely fused. After the metal has cooled, there is a single continuous piece of metal with no seam at all. In fusion welding, the base metal and the welding rod usually have essentially the same composition.

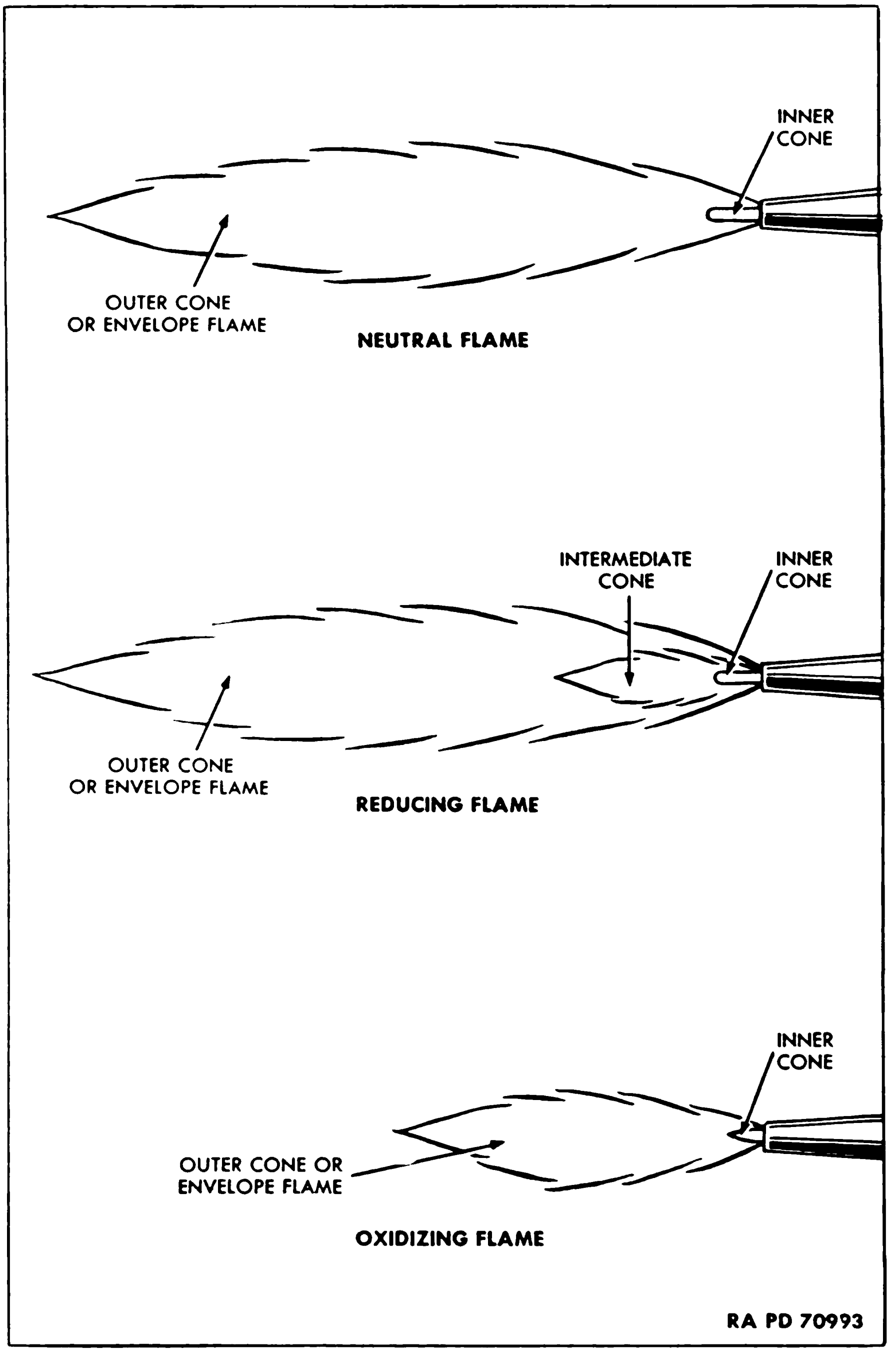


Figure 16. Oxyacetylene Flames.

BRAZING

Brazing may be defined as a group of metal joining processes, wherein a non-ferrous filler metal is used which has a lower melting point than the base metal. The difference being in excess of 50 degrees, and the melting point of the base metal above 1,000 degrees. In other words, it is the joining of cast iron, steel, nickel, copper, brass, and other metals without fusion or melting of the base metal.

Bronze Welding. Bronze welding is the most common of the different types of brazing. This type of brazing is done very similarly to fusion welding, using the same type of joint and applying the filler metal in much the same manner. It must be kept in mind that the term "bronze welding" is a brazing process and should not be confused with the process of bronze fusion welding, which is welding of bronze base metal by the fusion process.

In the bronze welding process, the edges to be joined are heated to a dull red. With the base metal at the proper temperature (1,600 to 1,700 degrees) and with the aid of a suitable flux, the bronze filler rod applied to the joint will unite with the base metal to form a strong bond which will have high strength and toughness, comparable to that of a fusion weld. The purpose of the flux is to protect the base metal and filler rod from oxidation during the heating and cooling stage, and to dissolve any oxides that may be formed on the base metal or rod while it is molten.

Bronze welding is a convenient method of joining dissimilar metals, such as cast iron to steel, copper to steel or cast iron, etc. It is usually better to bronze-weld grey cast iron castings than to fusion-weld them, so the metal will retain its grey iron structure. Metals whose properties are either destroyed or impaired by fusion welding, such as malleable iron or high carbon and tool steel, are satisfactorily repaired by bronze welding. Another advantage of bronze welding is that less stresses are set up in the metal due to the lower temperature used, and the fact that the bronze used in the filler rod is very soft and ductile while cooling.

Bronze welding should never be used where the repaired part will be subject to temperature higher than 500°F. since the strength of bronze greatly decreases above this point.

Silver Soldering. Silver soldering is also a type of brazing, and finds application in joining close fitting parts and parts which will be adversely affected by higher temperatures. The melting point of silver solder will range from 1175 to 1600°F., which is not high enough ordinarily to impair the physical properties of most metals.

In preparing a joint for silver soldering, it should be made as close fitting as possible. It has been found that maximum strength is derived from a "sweat joint".

The technique for silver soldering is similar to that used in ordinary soft soldering with the torch. The joint should first be covered with a special silver solder flux. A carburizing flame should be used and held so that only the outer envelope contacts the piece being heated. When the base metal reaches the proper temperature indicated by the melting of the flux, the silver soldering wire should be applied. The heat of the base metal will melt the solder into the joint. A very strong joint is formed by means of the thin film of silver solder which penetrates into the base metal making reinforcement unnecessary.

ELECTRIC ARC WELDING

In electric arc welding the heat for fusion is produced by an arc, which is established between a metal electrode or wire and the work to be welded. This arc is produced in much the same manner as the spark made by striking a pair of pliers across the terminal post of a storage battery. In the case of arc welding, the electric current is usually produced by a generator. The current may be either DC (direct current) or AC (alternating current), the former being used for most maintenance work.

Arc Circuit. In DC welding the current leaves the generator at the positive terminal (+) and returns at the negative terminal (—). If the negative cable is attached to the electrode holder (an insulated device for holding the electrode) and the positive cable is connected to the work, the hook-up is known as *straight polarity;* that is, in straight polarity the electrode is always negative (—). The current, therefore, leaves the generator at the positive (+) terminal, passes through a cable into the work, through the arc, the electrode, the electrode holder, and returns to the generator through the negative (—) cable. *Reverse polarity* is the opposite of straight polarity. The negative cable is connected to the work and the positive cable to the electrode holder, and the current flows from the electrode to the work.

The metal electrode is used as one of the terminals of the arc circuit, and at the same time the melting metal from the electrode is carried through the arc and deposited in the melting metal of the work, making the weld. Metallic electrodes may be divided into three groups: (1) bare electrodes, (2) lightly coated, and (3) heavy coated or shielded arc electrodes.

Electrodes. Bare electrodes are made of steel wire of a definite composition without any special coating other than those materials which are left on the wire by the drawing operations. The slight, stabilizing action on the arc is only incidental.

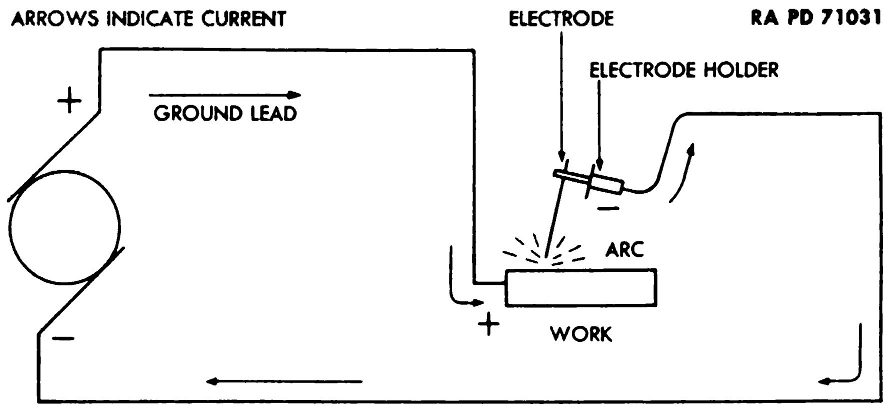


Figure 17. Straight Polarity.

Lightly coated electrodes are made of wire of a definite composition and a thin coating is applied. This coating acts as a flux to dissolve or reduce impurities in the weld and to increase arc stability.

Heavy coated or shielded arc electrodes are the most commonly used of the three types. These are made in the same form as the other types except that the coating is of appreciable thickness. This coating produces a gaseous shield around the arc which prevents contamination of the molten metal by the oxygen

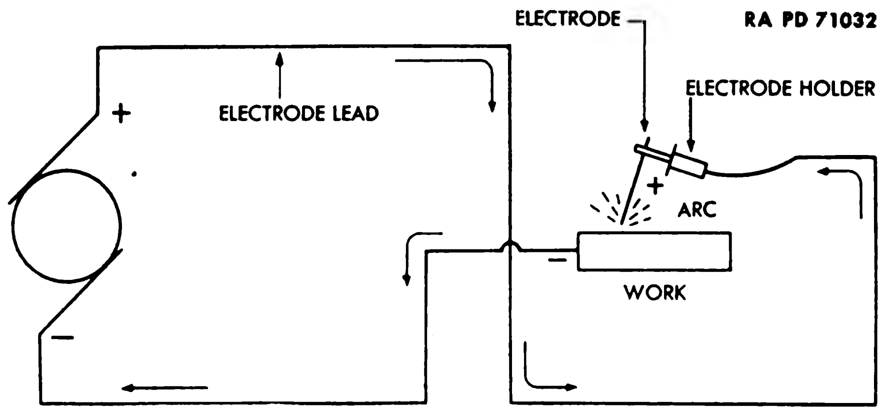


Figure 18. Reverse Polarity.

and nitrogen of the atmosphere. The coating also forms a heavy slag over the molten metal, which holds the heat in and allows the weld to cool slowly. This slow cooling allows gases to escape and permits impurities to float to the surface. The removal of impurities is also aided by the fluxing action of the coating.

One of the most recent advantages found in the heavy coated electrode is that the physical characteristics of the weld deposit can be improved by introducing materials through the coating which will alloy with the weld metal deposited. An example of this is the modified 18-8 stainless steel electrode, which is used for armor plate welding. Wire containing 18 per cent chromium and 8 per cent nickel is used and small percentages of either manganese, or molybdenum, or both, are added into the coating to give the weld metal the desired properties.

There is no hard and fast rule as to the polarity to use on different electrodes, but as a general rule straight polarity is used for bare or lightly coated electrodes. When these electrodes are used on straight polarity, more heat is developed at the positive side of the circuit, which is the one located at the work. When heavy coated electrodes are used, the gases given off may alter the heat conditions and less heat will be developed at the work. In general, coating on electrodes affects heat conditions differently, depending upon their composition. Straight polarity may be desirable for one type of coating and reverse polarity for another. Manufacturers of electrodes are required to specify on a label, pasted on each box of electrodes, the correct polarity to use. See the comparative electrode chart in Table I, for uses of various electrodes.

When proper current adjustments have been made, the exposed end of the electrode should be gripped in the electrode holder, so that the entire electrode may be deposited without breaking the arc.

Striking the Arc. There are two methods used for starting the arc: the *brushing or striking,* and the *tapping* method. When struck by either method, the arc is formed by short-circuiting the welding current between the electrode and the work. The surge of high current at the arc causes the end of the electrode and a spot on the base metal, beneath the electrode, to melt instantly.

In starting the arc by the brushing or striking method, the end of the electrode is struck on the base metal similar to the action of striking a match and then raised a short distance to establish the arc. The arc length or gap between the end of the electrode and the work should be approximately equal to the diameter of the electrode being used.

In the tapping method, the electrode is held just above the spot at which the arc is to be established, tapped or bounced on the surface of the base metal, and slowly raised to the correct arc length.

After the arc is struck, particles of metal will melt off the end of the electrode and deposit themselves in the molten crater of the base metal. As the electrode is carried along the surface of the work, it must be fed down so as to maintain the correct arc length. If the electrode is fed down to the work and along the surface at a constant rate, a uniform bead of metal will be deposited on the surface of the base metal.

EXPANSION AND CONTRACTION

The failure of a welder to take into consideration the effects of expansion and contraction, which inevitably result when metals are heated and cooled, may cause warping, cracking, and failure of the part in use, even though all other factors have been properly accounted for.

Expansion is the increase in dimension of a metal due to an increase in temperature. Expansion increases directly with temperature in a relation known as the coefficient of expansion. Contraction is the decrease in dimension as the metal cools.

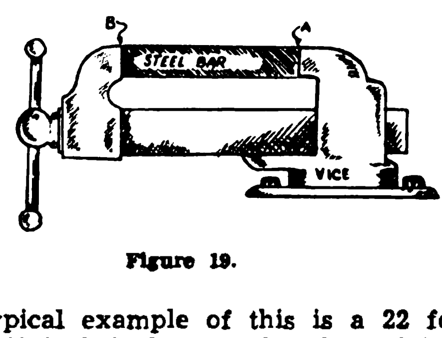


Figure 19.

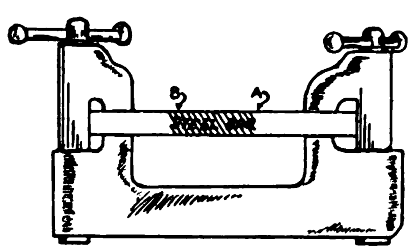


Figure 20.

A typical example of this is a 22 foot railroad track section which will increase ¼ inch in length when heated from 70°F to 120°F, and return to its initial length on cooling back to 70°F. This accounts for the gap between the sections of track. which allows the sections to expand without any restrictions.

TABLE I
Comparative Electrode Chart

Manufacturer	Trade Name	All Position Mild Steel	Poor Fit-Up All Position Mild Steel	All Position AC or DC Mild Steel	High Speed Downhand Mild Steel	Finish Pass Downhand Mild Steel	High Speed Horizontal Fillet or Downhand Mild Steel	High Tensile Carbon Moly 40-80% MO All Position	High Tensile Carbon Moly 40-80% MO All Position	High Tensile 70,000-80,000 PSI Downhand	High Tensile 90,000-100,000 PSI All Position
AO SMITH CORPORATION	SMITH	SW 10	SW 11	SW 15	SW 20 SW 21	SW 25	SW 35	SW 73	SW 75	SW 76	SW 85
METAL & THERMIT CORP.	MUREX	Vertex	Genex	Alternex	Cresta F. H. P.		Fillex & Type F	Carbon Moly 50	Molex	Carbon Moly 70	
HOLLUP CORPORATION	SUREWELD	B	N	C	A		A&F		Mly		H. S. V.
LINCOLN ELECTRIC CO.	FLEETWELD	No. 5	No. 7	Transweld & Readyweld	No. 9	No. 10	No. 8		No. 85	9-H. T.	No. 100
AIR REDUCTION SALES CO.	AIRCO	78, 79, 78E	87, 62, 67	No. 90	No. 83		No. 81	No. 94	No. 93		
UNA WELDING INC.	UNA	No. 3100	Nos. 2100 & 2500	No. 1500	No. 3200		No. 3300	No. 3825			No. 3185
CHAMPION RIVET CO.	CHAMPION	Blue Devil	Gray Devil	A. C.	Red Devil		Black Devil	Red Devil 75	Blue Devil 85	Red Devil 85	
GENERAL ELECTRIC CO.	G. E.	Type W22	Type W20	Type W25	Type W23		Type W24	Type W54	Type W52		
WESTINGHOUSE MFG. CO.	FLEXARC	A. P.	F. P.	S. W.	D. H.		D. H.				
WILSON WELDER & METALS	WILSON	No. 98	Nos. 520 & 107	No. 520	Nos. 851 & 105		No. 851 No. 105	No. 901	No. 9		
HARNISCFEGER CORP.	SMOOTHARC	A. P.	P. F.		D. H. 3		D. H. 2, F. W., F. R.		C. M. 50		
PAGE STEEL & WIRE CO.	PAGE HI-TENSILE	C&A	F	A. C.	H.		G.				
STEEL SALES CORP.	SUPERWELD	No. 66	No. 77	A. C.	No. 55						
REID AVERY CO.	RACO	H. D. 7	H. D. 8		H. D. 5		H. D. 6				
McKAY CO.	McKAY	Nos. 15 & 150	No. 17	Nos. 116, 117 & 120	No. 18	No. 16H	No. 16				

Note: Other Smith High Tensile Electrodes are:
SW—85—80,000 to 90,000 Psi Downhand
SW—100—100,000 to 110,000 Psi Downhand
SW—101—110,000 to 120,000 Psi Downhand
SW—96—130,000 to 140,000 Psi Downhand

We will go into a little more detail on expansion and contraction in relation to welding where the part being heated will not be free to move.

Let us imagine that a steel bar, 10 inches long and 2 inches in diameter, is placed between immovable objects so that it cannot expand in length. (The coefficient of expansion of steel is 1 per cent at 1,200°F.) When it is heated to

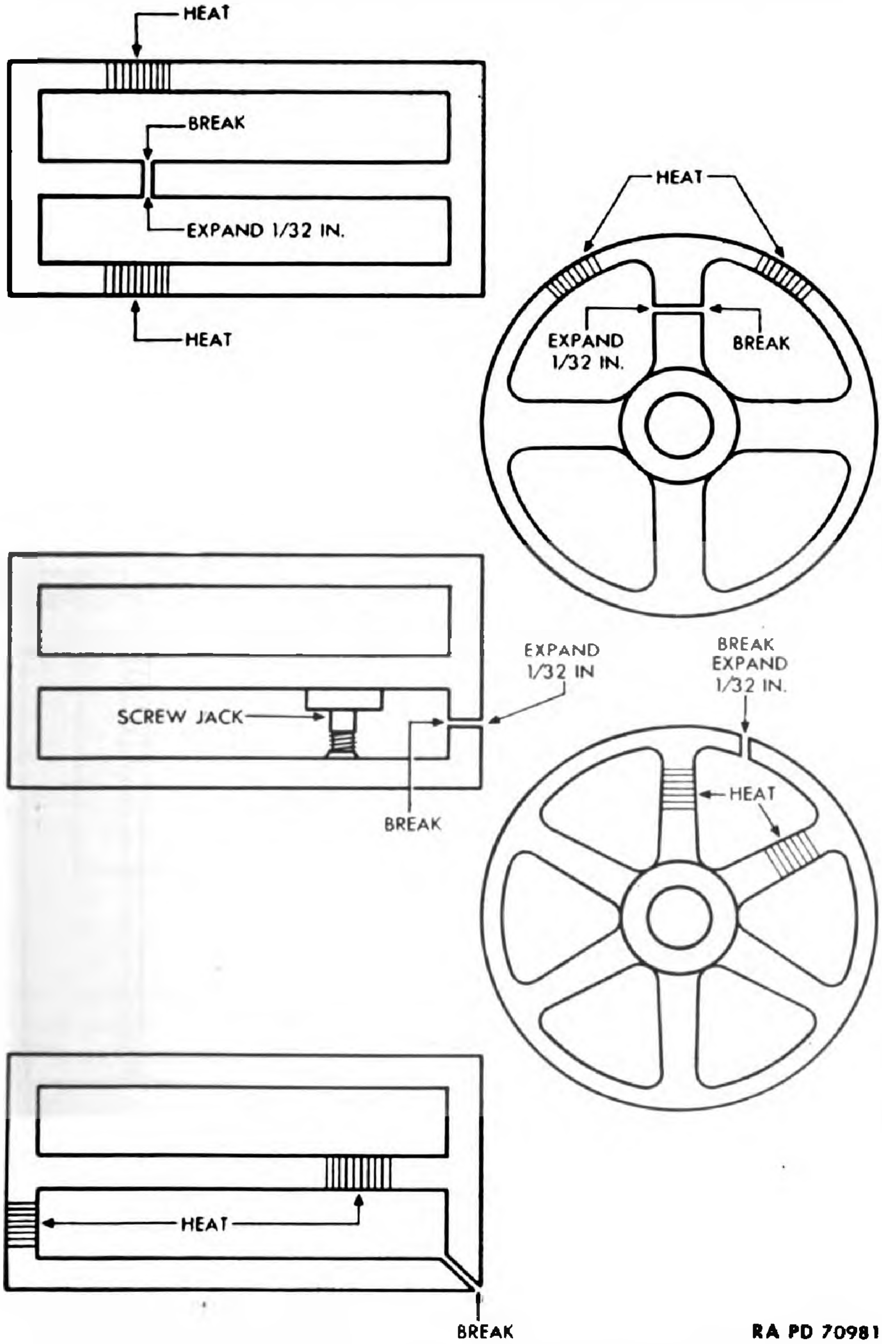


Figure 21. Spot Preheating of Castings for Controlling Expansion.

1,200°F, we know that there will be a great force exerted at points A and B (figure 19) as the bar is attempting to expand to 10.1 inches in a 10 inch space. At first thought, we might think that the bar would buckle. This would be true if the diameter were not so large, but as the mass of metal will prevent the bar from buckling it must "upset" itself. Up-setting simply means that, although the volume of the metal remains the same, the length is decreased and the diameter is increased. When a blacksmith wishes to up-set a piece of metal, he heats it to red heat, places one end on the anvil, and hammers the other end. This is the same process as has happened in our example. When the bar cools, we will find that the diameter is larger and the length is less than the original. By this experiment we see that it is possible to make a piece of metal change its size or its shape by heating, if its normal directional movement is restricted.

If we carry the experiment further, we will see how expansion and contraction may cause stresses and cracks. Referring to figure 20, let us assume that the bar is fastened so that the ends cannot move in either direction. When the shaded section is heated, it will not be possible for this section to expand in length as it is restricted by the rigid metal. Therefore the heated section will be up-set in the same manner as the bar in the first example. As this section cools and attempts to contract, there is going to be a tendency for the grains of the metal to pull apart at points A and B. (Figure 20) This drawing action produces residual or shrinkage stresses, which remain in the metal after it has cooled. If this drawing action in the metal becomes too great, or if the metal is one which is non-ductile, such as cast iron, it will crack on cooling.

In the upper left corner of figure 21 we have a welding job where a problem of expansion and contraction, very similar to the one described above, has to be controlled. Here a cast iron grate is cracked through the center section. If we attempt to weld this crack without taking any precautions, the area which is heated during the welding will be likely to recrack on cooling as described above. If we were to heat the shaded areas to a dull red heat before beginning the weld and allow all three sections to cool and to contract together after the welding operation, the stresses would be considerably reduced. All sections would then expand and contracts at the same time and no restricting forces would be produced. This shows the application of preheat in reducing stresses.

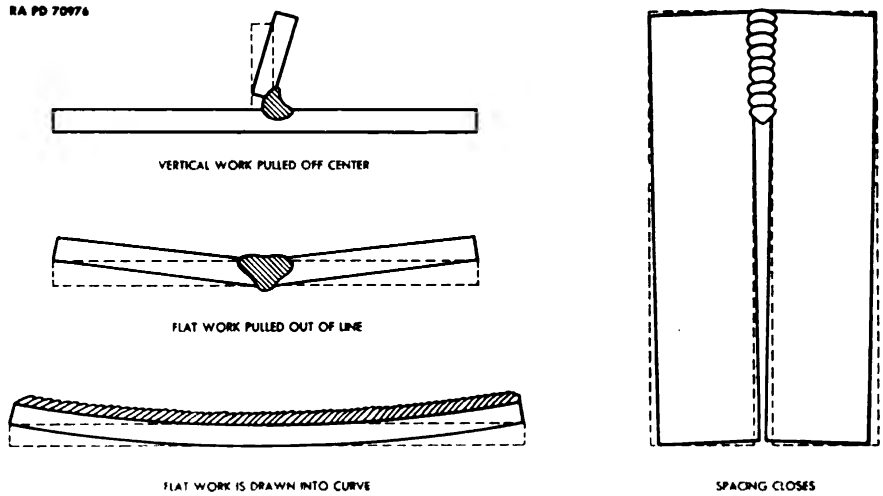


Figure 22. Results of Weld Shrinkage.

Referring to the welded joints in figure 22, we can see how contraction of the weld metal may cause warpage, stresses, or cracks. If the welds were made with the plates free to move, the weld metal on contracting would cause the plates to warp or pull out of line. If the plates were rigid, stresses or cracks would form in and next to the weld as it cooled. In the latter case, the contracting forces can be partly off-set by "peening," or hammering, the weld metal as it cools. This forging action forces the metal in the opposite direction.

In welding long seams, the contraction of the weld metal will cause the edges to draw together and actually to overlap. To allow for this, the plates should be offset so that, as the weld progresses, the separation between the plates will remain the same.

Another way of preventing warping and buckling in sheet metal is by the use of chill bars, wet rags, wet sand, or wet asbestos placed next to the weld zone to draw off the heat.

In welding long seams it is usually good practice to use the backstep method. This is done by welding a few inches, skipping to another spot on the seam, and welding back toward the first weld. The purpose of this method is to minimize the heat put into the weld.

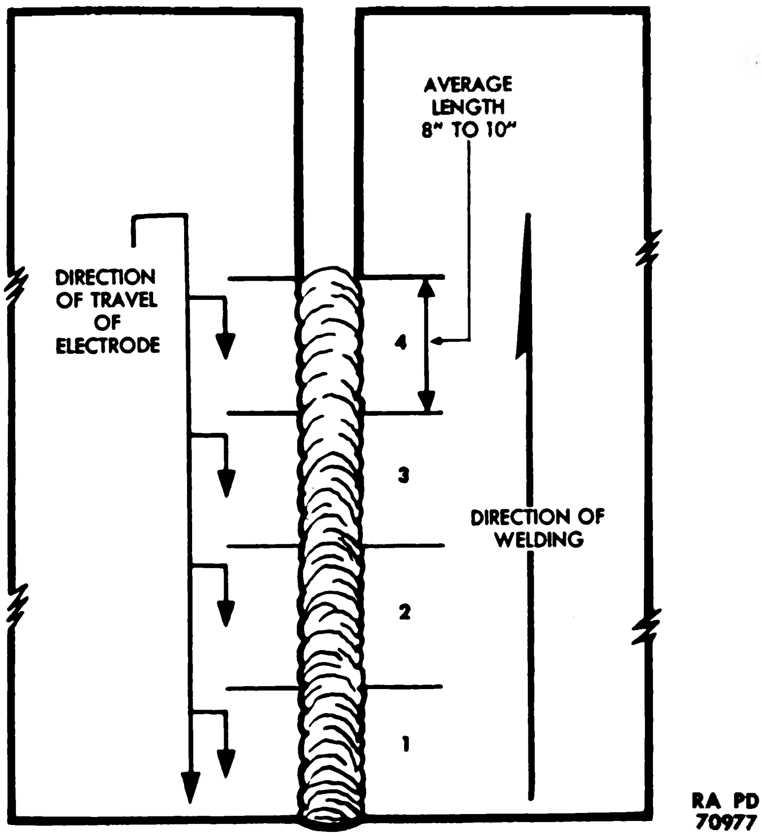


Figure 23. Back Step Method to Counteract Contraction.

Expansion and contraction is a tough problem for the welder, but he can do a lot toward controlling its effect if he will analyze his job and figure out the best welding process and the method, or methods, of expansion and contraction control.

WELDABILITY

Definition. Weldability is defined as the ability of a steel to pass through the thermal cycle of a particular welding process without the production of hard and brittle zones in the welded joint, as zones tend to produce cracks during the welding of a particular structure or the failure of the welded joint under service-loading of the structure.

Weldability can be maintained by keeping to a minimum the elements which confer a pronounced tendency to harden with the accompanying loss of ductility. As carbon is the element which confers the hardness to steel and iron, it can be seen that the lower the carbon content the better will be the weldability of the metal. The same is true of the alloy steels where, even though the carbon content may be quite low, the alloying elements will decrease the weldability.

Quenching. Before going further, it may be well to discuss the term "quench." Quenching is done by rapidly cooling a metal by immersion in liquids, gases, or by contact with metal. The term is usually applied to the operation where a medium carbon, high carbon, or hardenable alloy steel is heated above the upper critical temperature and immersed in a quenching medium in order to cool it to, or below, room temperature. Low carbon steel, which forms the bulk of tonnage for welding application, imposes no limitations as to be rate of cooling In other words, a *low* carbon steel with the usual amounts of manganese cannot be cooled fast enough by ordinary quenching to cause it to obtain any appreciable amount of hardness.

It is easy to see that if a piece of tool steel, let us say about ¼ inch round, were heated just above the critical temperature (bright red heat) and plunged into a bucket of water, it would become very hard and brittle. Actually the same thing occurs when a weld is made of a similar piece of steel.

If the electric arc having a temperature of approximately 10,000°F were struck on a heavy plate of high carbon steel and a weld bead run down the plate, the heat from the weld would be drawn off into the cold surrounding metal so fast that the portion of metal which had been heated would be given a quench just as fast, and in some cases faster, than if the heated portion had been quenched in water. This may be a little hard to realize at first, but when we stop to consider how much faster metal will conduct heat than water, we can see that the heat will be drawn from the weld very rapidly. This is known as a *quench by the mass of metal* or *an auto-quench.*

If the same weld had been made with oxyacetylene torch, the auto-quench would not have been nearly as fast; first, because the temperature of the oxyacetylene flame is only about half that of the electric arc, and second, because the oxyacetylene process is slower, thereby heating more the surrounding metal as the weld is made and thus decreasing the quench effect.

In welding any hardenable metal the flow of heat from the weld zone to the cold surrounding metal should be as slow as possible to prevent a loss of ductility. The rate of cooling after welding may, of course, be retarded by applying heat immediately after welding or wrapping the part in asbestos to prevent the rapid cooling. Slower cooling is also accomplished by making the weld in numerous passes. For example, when welding ¼ inch plate, rather than filling the vee groove with one heavy weld bead, use three or four smaller beads. This way, less heat is put into the plate at one time and the heat from each bead helps retard the cooling of the previous bead. This is referred to as *multi-pass welding.*

The most convenient and the most used method is to preheat the parts before welding. Preheat, of course, will have to be used more frequently with electric arc welding because of its extremely localized heating. Preheat temperatures will range anywhere from 100°F to 600°F depending upon the type of the mass of the metal being welded. In the field preheating is usually accomplished with the oxyacetylene torch. One convenient method of determining preheat temperature is by touching the heated metal with 50-50 solder, *i.e.*, 50 per cent lead, 50 per cent tin. The melting point of this solder is about 450°F, which is the approximate preheat for welding most hardenable steels.

CUTTING

If a wire is heated bright red and placed in pure oxygen, it will burn with dazzling brilliancy. This is the principle of cutting with the oxyacetylene cutting torch.

The cutting torch is similar in appearance to the welding torch, except that it has an additional tube for high pressure oxygen and the tip has a number of holes. (Fig. 24)

The tip usually has one hole in the center through which passes the pure oxygen for cutting. Four holes surround this center jet and through these passes a mixture of oxygen and acetylene to form the preheating flames. The torch is furnished with various size tips for cutting different thicknesses of metal. The cutting oxygen is controlled by a trigger-operated valve.

For cutting steel, after the preheat flames have been adjusted to neutral, the torch is held so that the preheating flames are just above the point at which the cut is to start. (Fig. 25) The angle of the torch tip should be 90 degrees to the work. When the metal reaches the kindling temperature of 1,400° to 1,600°F, the trigger-operated valve, which controls the cutting oxygen, is opened and a high pressure stream of oxygen is directed on the heated area. The torch is then moved

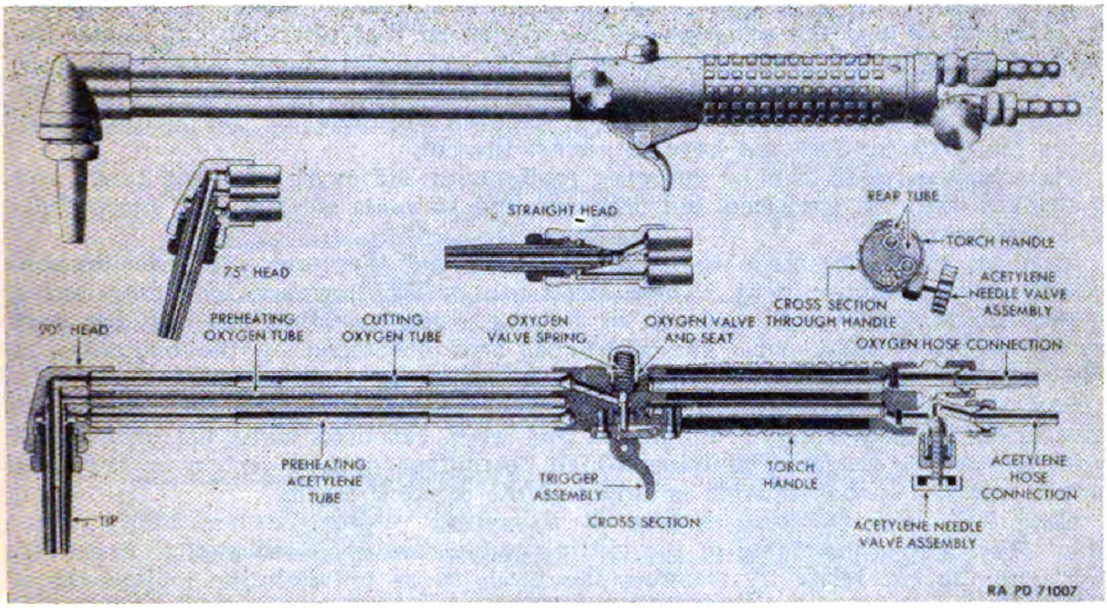


Figure 24. Oxyacetylene Cutting Torch.

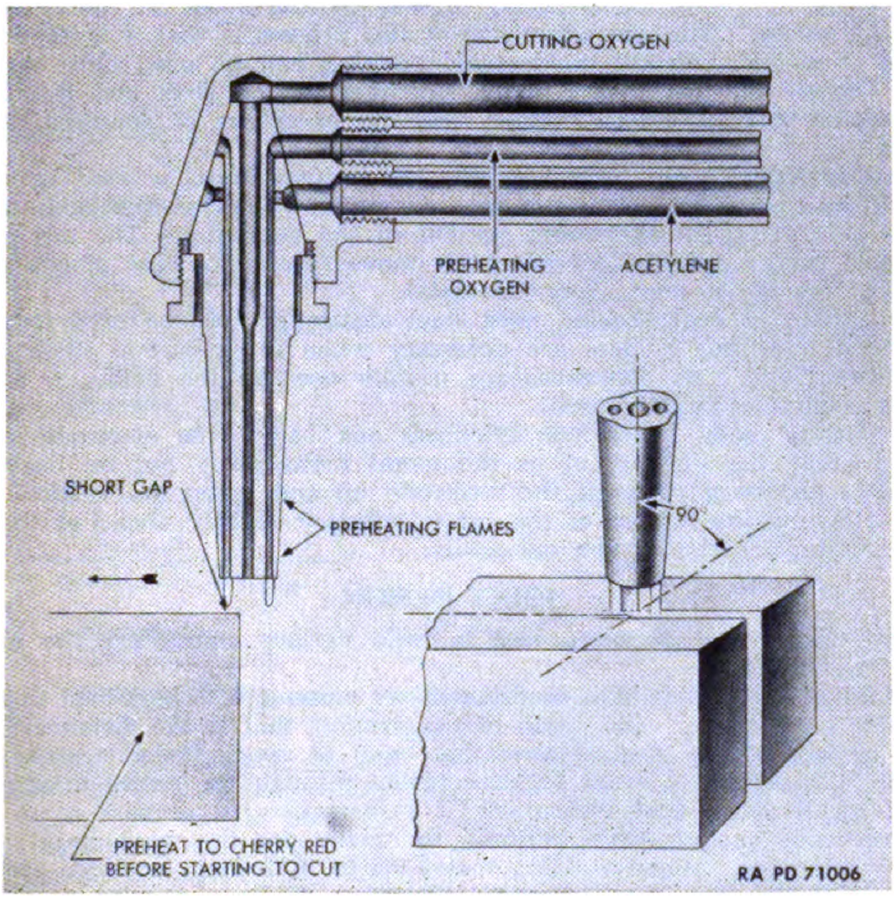


Figure 25. Starting a Cut and Cutting with a Cutting Torch.

steadily along the line of the cut at a speed which completely severs the metal, but will not cause the edges of the metal to melt.

Theoretically, the heat generated by the rapid oxidation of the steel would be sufficient to heat the adjacent metal red hot, so that after the cut is started the preheating flames could be shut off and the cut could be continued with only the oxygen. But in practice, the preheating flames do continue to burn as the operation is often interrupted by dirt or scale on the metal or the operator may move his torch too fast and have to restart the cut.

Plain carbon steels can be cut very easily with the oxygen cutting torch and a straight even cut produced, but cast iron and stainless steel present more difficult problems.

Stainless steels are made to resist oxidation, and therefore offer considerable resistance to oxygen cutting. These steels can be cut, however, by either laying a steel plate along the line of cut, or feeding a steel welding rod into the kerf as the metal is being cut. The additional heat developed by the oxidation of the steel rod or plate is sufficient to melt a slot in the stainless steel.

Cast iron is more difficult to cut than steel because, first, the cast iron melts at a lower temperature than its oxides, and when cast iron melts the oxides mix with it; second, cast iron contains a high percentage of free carbon or graphite, which causes a carbon dioxide pollution of the oxygen stream.

Cast iron and stainless cutting is a melting process rather than oxidation. The preheating flame of the cutting torch should be adjusted to carburizing, and the cut made by weaving the torch so as to wash the molten metal from the cut.

Oxygen cutting is used in the field for preparation of joints for welding, cutting pipes, cutting round and flat stock, piercing holes, salvaging equipment, destruction of abandoned equipment, and many other uses.

The process of arc cutting is purely that of melting away the metal along the desired line of cut. The one advantage of this process is that it is applicable to all types of metals, whereas oxyacetylene cutting can be used only on ferrous metals. Oxygen cutting gives a much smoother cut on steel and is much less expensive for cutting ferrous metals with the exception of stainless steel and cast iron.

In cutting with the arc, very high current settings must be used to melt the metal. In most cases arc cutting is done on straight polarity (electrode negative, see page 117) using the maximum current of the generator. The arc is struck at the start of the cut, and the electrode moved along the line of cut allowing the heat of the arc to melt away the metal.

Either carbon or heavy-coated mild steel electrodes may be used for cutting Since special electrode holders are necessary when using carbon electrodes, the heavy coated mild steel electrodes are usually used in the field. A 3/16 inch electrode is most commonly used.

When cutting metal of ¼ inch thickness and below, the electrode is simply advanced along the line of cut as the metal melts away but on heavier materials it is necessary to work the electrode up and down the vertical face of the cut, allowing the bottom of the cut to advance slightly ahead of the top so that the molten metal may run out easily.

JOINT DESIGN

The five basic types of joints used to weld various metals are the butt, lap, corner, tee, and edge.

Butt Joint. The butt joint is used when two pieces are to be joined in approximately the same plane. The depth of penetration, that is the distance from the original surface of the base metal to that point at which fusion ceases, is about 3/32 inch. Therefore, in order to have fusion through the entire thickness of a piece of metal above 3/32 inch thick, it is necessary to prepare some type of groove or leave enough space between the plates for the weld metal to penetrate the thickness. When welding metal up to 3/32 inch, no edge-preparation or spacing of the plates is necessary other than to have a good fit-up and to have the edges of the plates clean. If both sides are accessible, metal up to ⅛ inch may be welded without any edge-preparation or spacing.

The *flange butt joint* shown in A, Figure 27, is made by bending the edges at right angles and placing them together. This joint can be welded without the use of additional filled metal by melting down the flange. It is used on light gage metal.

The *Plan Butt Joint*, B, Figure 27, may be used on metal from $\frac{3}{32}$ inch to $\frac{3}{16}$ inch when welded from only one side, or it may be used up to a thickness of ¼ inch when welding can be done from both sides.

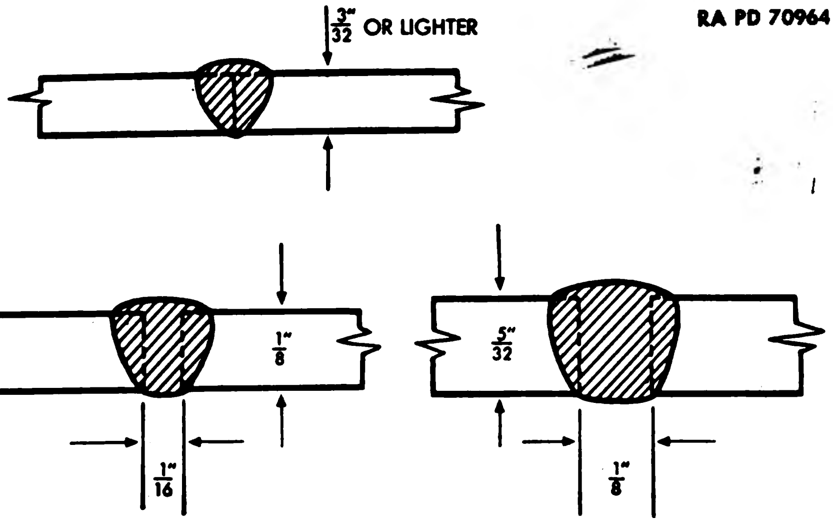


Figure 26. Plain Butt Joints.

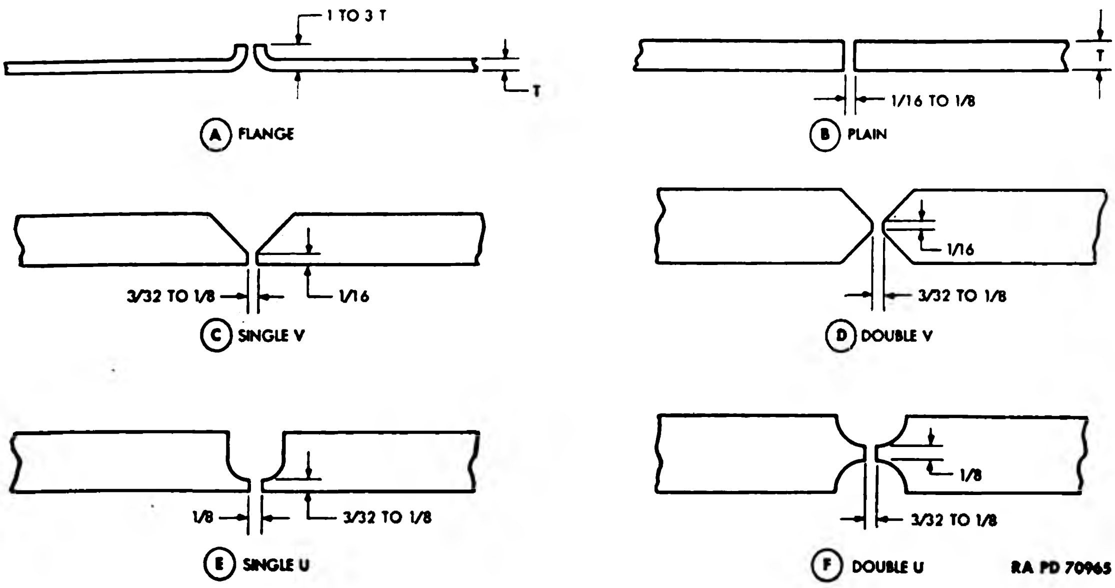


Figure 27. Preparation of Metals for Welding Butt Joints.

When welding metal above $\frac{3}{16}$ inch, a *single vee joint*, C, Figure 27, should always be used, or if possible to weld from both sides on metal above ⅝ inch, a double vee groove should be made. The included angle of bevel for grooves of the vee butt joints will range from 60 to 75 degrees for arc welding, and from 75 to 90 degrees for oxyacetylene welding. The bevels of these joints are usually cut with the oxygen cutting torch.

The *Double Vee Joint* requires approximately half the amount of filler metal that the single vee requires and allows the welder to get complete penetration

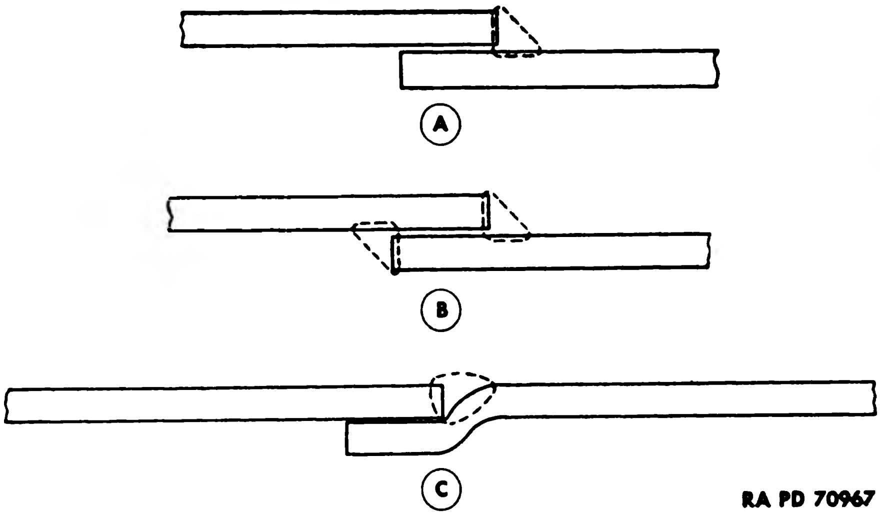


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Figure 28. Preparation of Metal Sheets for Lap Joints.

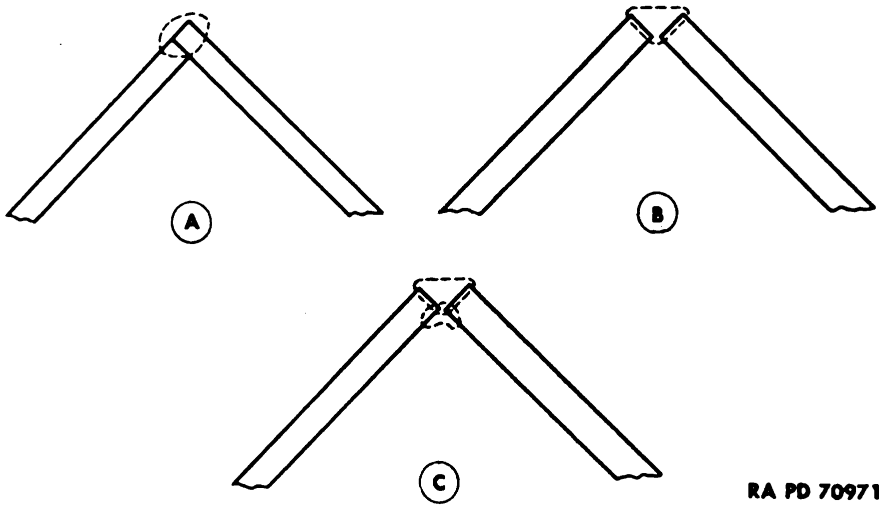

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Figure 29. Corner Joints for Sheet and Plate.

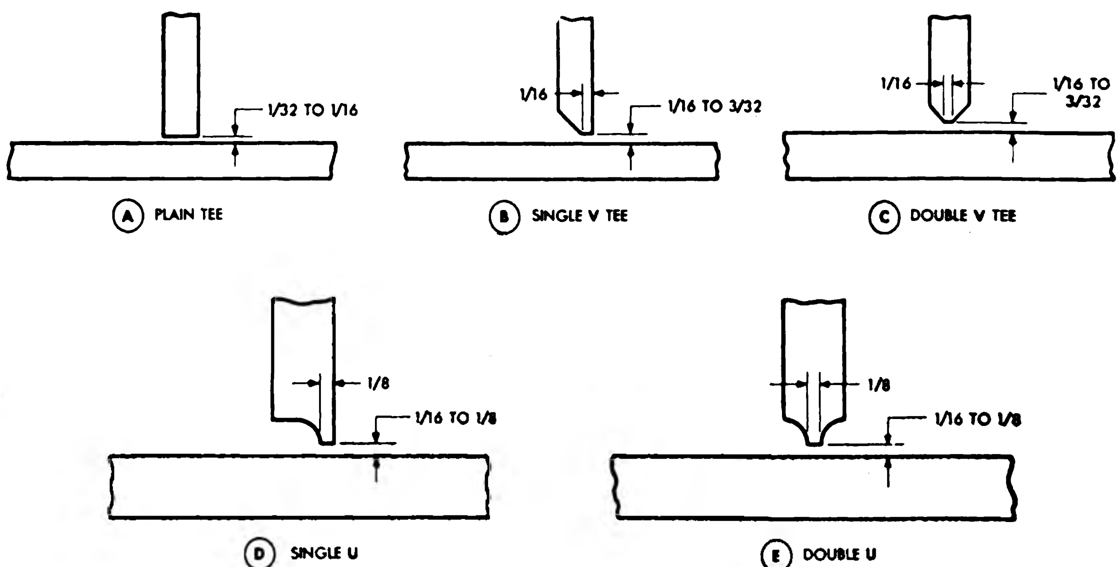

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Figure 30. Preparation of Metals for Welding Tee Joints.

much easier. The U-shaped type of joint requires less filler metal than the vee type, but takes much more time in preparation.

Lap Joint. The lap joint, shown in figure 28, is used where two plates overlap. When welding is possible from only one side, the joint may be made as shown in A, although when so made the full strength of it is not developed. The lap is stronger than a butt joint for some applications such as frames or tubing which telescope or overlap each other.

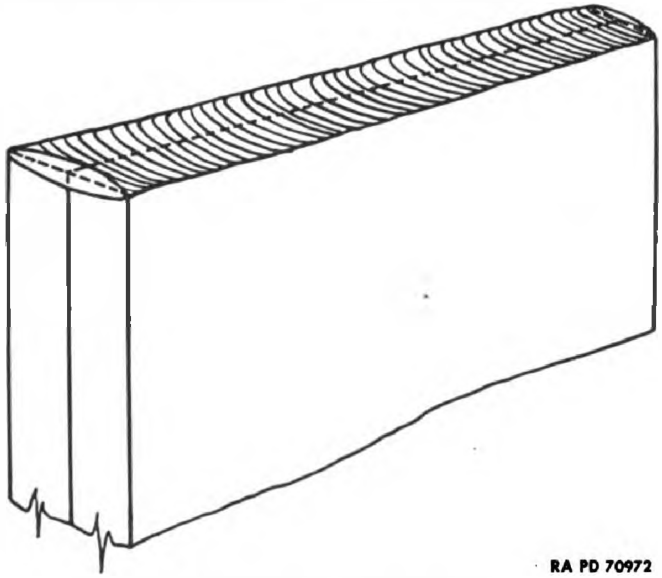


Figure 31. Edge Joint.

Corner Joint. Corner joints are also used for joining the edges of plates whose surfaces are at approximately 90 degrees to each other. This joint is shown in figure 29 and is used in the construction of box frames, pans, tanks, etc.

Tee Joint. Tee joints, figure 30, are used for welding plates at approximately 90 degrees to each other. The included angle of bevel for the heavier plates will vary according to the separation between the plates, but will usually be about half the included angle used for butt welds.

Edge Joint. Parallel plates are joined together with the edge joint, figure 31. This joint is used to join sheet metal edges and to weld reinforcing plates on flanges of I-beams or edges of angle iron.

ARMOR PLATES*

Properties, Identification and Welding Electrodes

Armor plate is a heat-treated alloy steel designed to resist penetration and shock from shells and shell fragments. There are two different types of armor plate used on combat vehicles; one is the homogeneous type, the other is the face-hardened.

Homogeneous Armor. Homogeneous armor is a heat treated alloy steel that is uniform in hardness, composition, and structure throughout, and may be cut or welded from either side. The heat treatment of homogeneous armor develops good shock or impact resisting properties. Homogeneous armor will be found in two forms; *cast* and *rolled*. The cast is easily determined by its appearance, having a rough surface and usually used on rounded sections, such as tank turrets, cast doors, etc., where the complicated design makes casting necessary. The *Rolled* is in flat smooth surfaces, having an appearance like any other rolled plate of the same thickness. There is no appreciable difference between the rolled and cast; they are of the same composition and may be welded together.

Face-hardened Armor. Face-hardened armor is different from the homogeneous type and must not be treated as homogeneous under any circumstances. Face-hardened armor has one extremely hard surface layer, which will extend to a

* For further information on Armor Plate see Chapter 5, Volume II.

depth of approximately 25% of the thickness of the armor. This hardened layer faces outward on the vehicle to provide good resistance to penetration. The inner side or remaining portion is comparatively soft and has properties similar to those of the homogeneous type. Face-hardened armor will be in rolled plate only. Due to the carburizing process by which it is made, face-hardened armor is actually two different steels, one of a high carbon content (25% of the plate thickness), the other similar to the homogeneous type. Face-hardened armor must always be cut from the soft side to avoid excessive heat on the face or hardened side. High cutting or welding temperatures soften the face, making it less resistant to penetration. Face-hardened armor plate will usually be found on light-armored vehicles, scout cars, half-tracks, artillery shields, etc.

Identification. It is essential that the armor plate be definitely identified before any attempt is made toward repair. It can be seen from the above that the two armor plates are different, and the welding procedures for each are distinctly different and cannot be interchanged.

One of the most accurate methods of identification is with the use of a file. Both sides of the homogeneous type will file readily, but only the soft side of the face-hardened will file. The face side being extremely hard, the file will not cut in, but will slide over it and break off teeth. Armor plate can also be identified by the appearance of the holes made by projectiles. The homogeneous type will bend or give under impact; the edges of the holes are torn and irregular and are bent and drifted in the direction the projectile was traveling; and the inside of the hole is usually smooth and of the same size as the projectile which made it. The metal around shell holes or penetrations on the face-hardened type will be clean-cut and sharp, and the plates will not bend or drift with the projectile, but will crack before bending very far. The face-hardened type can also be identified by examining the edges of a fresh break. The face side, or hardened layer, is of a fine grain structure and is brighter than the coarser grain structure of the soft side.

Welding Armor Plate. Armor plate is an air-hardened steel; that is, heating the metal slightly above its critical temperature range and allowing it to cool in air will cause it to become very hard. This property of the armor makes it difficult when either welding or cutting to keep the hardened zones to a minimum.

The welding of armor plate by the oxyacetylene process is not recommended. The task that would be present when welding large sections of heavy armor by oxyacetylene welding can easily be understood. The large amount of preheat necessary and the time spent in preheating and welding are but two of the factors against the oxyacetylene method of welding armor plate. The large amount of preheat would also destroy the properties engendered by heat treatment. The armor upon cooling would have a variety of different properties, depending upon the length of quenching time.

Arc welding of armor plate is the more satisfactory method. It can be done in the least amount of time, with the least cost, and with a minimum of heat-affected areas in the armor.

Electrodes. Carbon steel or mild steel electrodes are of little value when welding armor. They produce a brittleness in the fusion zone, which very often cracks before the weld is complete or as it cools. The strength of the weld metal deposited by mild steel electrodes is also considerably less than the strength of the armor plate.

Armor plate can only be satisfactorily repaired with a chrome-nickel stainless steel electrode of the austenetic type. When using the austenetic chrome-nickel electrodes, no preheat (above 100°F) or post heat is required. A chrome-nickel deposit is austenetic only if the alloy content is high—24% or above. If the alloy content drops lower than 24%, the metal moves further away from the austenetic form and loses its ductility. A weld deposit is lower in alloy than the original electrode due to alloy losses in transferring across the arc and weld-metal dilution with the armor. Until recently, armor plate was welded with a 25-20 stainless steel electrode (25% chrome and 20% nickel). This electrode was high in alloy content and could withstand the losses in arc transfer and also weld dilution. Because of the scarcity of chrome and nickel, a need arose for an electrode that would do the same job, but with less chrome and nickel content. As a result, the modified 18-8 (18% Cr. 8% Ni.) stainless steel electrode was developed. To accomplish this, other alloys had to be added in the electrode and in the coating. Most common are manganese and molybdenum used separately or together, either in the lime-type coating or in the titania coating.

It must be remembered that when using an electrode of the modified 18-8 type, the current settings must be as low as is consistent with good welding, so as not to have excessive losses in arc transfer and weld dilution.

CUTTING ARMOR PLATE

Oxyacetylene Method. Due to the alloys in armor plate and stainless steels, they are more difficult to cut than the carbon steels. The oxyacetylene cutting procedures outlined for the cutting of carbon steels will hold true for the cutting of armor plate with a few additional precautions.

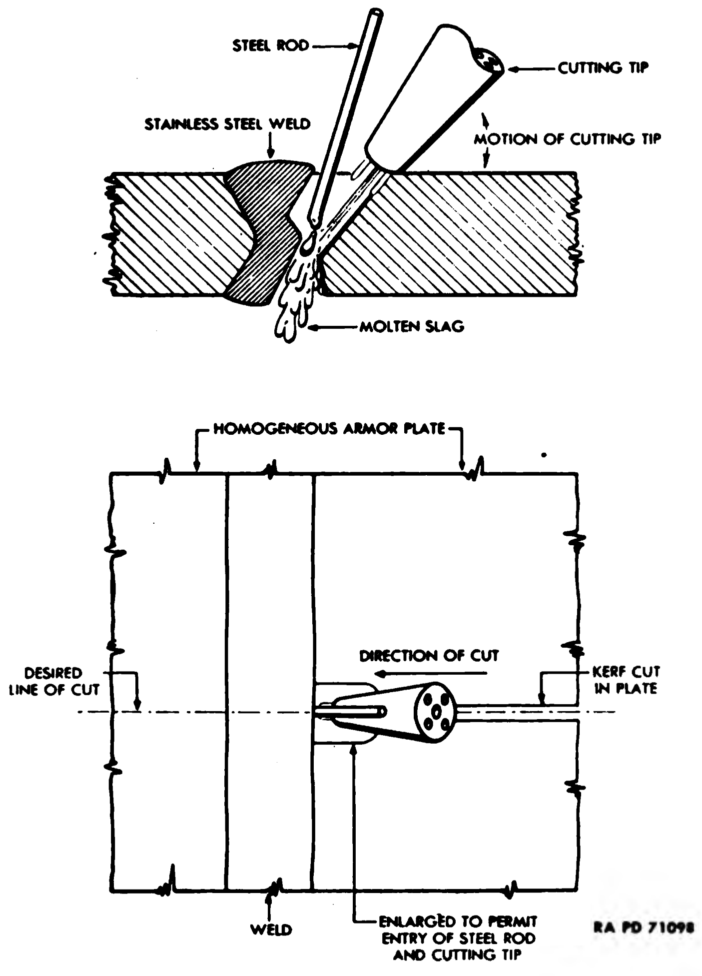


Figure 32. Method of Cutting Stainless Steel Welds.

The ratio of oxygen and acetylene pressures should be kept as low as is consistent with good cutting procedures. The preheating flames should be soft neutral flames. The tip sizes should also be the smallest possible to give quality cuts. These precautions are necessary to prevent overheating of the armor plate. Before starting a cut on armor plate, it is necessary that the armor be preheated along the line of cut. The preheat temperatures should be at least 100°F, at which temperature the metal will feel warm to the hand, but at no time should the preheat exceed 370°F. Preheating before cutting is important as cold armor will crack when heated locally to high temperatures.

Stainless steel cannot be cut as described above, as oxygen cutting is a process of rapid oxidation, and stainless steels are made to resist oxidation. To cut stainless steels a mild steel rod must be used to assist the cut. The cut is started by heating the metal to a cherry red color and holding a steel rod against the stainless steel as shown in figure 32.

The resulting heat of the oxidizing steel rod melts the stainless steel and washes it out of the kerf with the molten slag. The steel rod must be fed into the kerf as the cut progresses, keeping it as close as possible to the melting metal.

This method of cutting stainless steel is slow and costly, both in materials and time. Cutting stainless steel by the arc method is much faster than with the torch and should be used when possible.

Arc Method. Armor plate and stainless steel can then be cut equally well by either the *carbon arc* or *metallic arc* method. Carbon arc is not generally used because of side wall shortening, the need for special electrode holders and larger machines to supply the necessary high current. The *metallic arc* method is the preferred method for cutting stainless steels. Electrodes of the heavy-coated shielded arc type give the best results and are most generally used on straight polarity. The recommended current settings for the electrodes are: 5/32 inch—300 Amps, 3/16 inch—400 Amps.

The cutting procedure is to start the cut at the top of the plate, with the electrode at a 60 degree angle to the plate, and then to cut from top to bottom. By cutting with this procedure, the molten metal is pushed down by the arc pressure when moving down the plate. Metal arc cutting leaves the plates covered with slag and spatter which must be removed by chipping or grinding. Armor plate is usually cut with the oxyacetylene cutting torch, and the stainless steel weld is usually cut by the metallic arc method.

WELDING HOMOGENEOUS ARMOR PLATE

In order to make sound welds on armor plate with the modified 18-8 stainless steel electrodes, there are certain welding procedures that must be followed. The procedures are definite and must be followed to avoid overheating of the armor plate and to keep weld-metal dilution to a minimum. As stated before, these factors are of great importance if the repair is to withstand shock or impact.

The first step in the repair of any shell hole, crack, or bulge, is to identify the armor correctly. Having once identified the armor, the proper joint can be selected. The joint selection is of great importance. Double vee type joints should be used on homogeneous armor when over ⅝ inch in thickness, and if the armor is accessible from both sides. If not accessible from both sides, the single vee type joint will have to be used. Great care should be exercised to control the warpage as much as possible when using single vee joints. Warpage may be controlled by heavily peening the weld after each pass and by heat control. In other words, use the lowest possible welding current consistent with good welding.

The preparation of armor plate joints must be done correctly. The plate preparation cannot be stressed too much. When preparing a joint, the correct cutting procedures, as stated before, must be followed.

The welding procedures for the welding of carbon or mild steels cannot be used on armor plate as there will be excessive weld-metal dilution at the root of the weld. The resulting mixture will be a harder and more brittle metal than the base or weld metal, and it will be more likely to crack under impact.

The included angle on all armor plate joints is a 45 degree angle. This has been found to be the most satisfactory angle from the standpoint of the economy in welding materials, time involved in welding operations, and ease of welding. All sharp corners on beveled plates should be rounded off to minimize the weld dilution at these points.

The correct joint preparation is shown in figure 33.

The correct spacing on each side of the backup rod should not be less than 1/16 inch and the total spacing between the plates at the root should be from 5/16 to ⅜ inch.

A 3/16 inch stainless steel eletcrode with flux removed is used as a backup rod

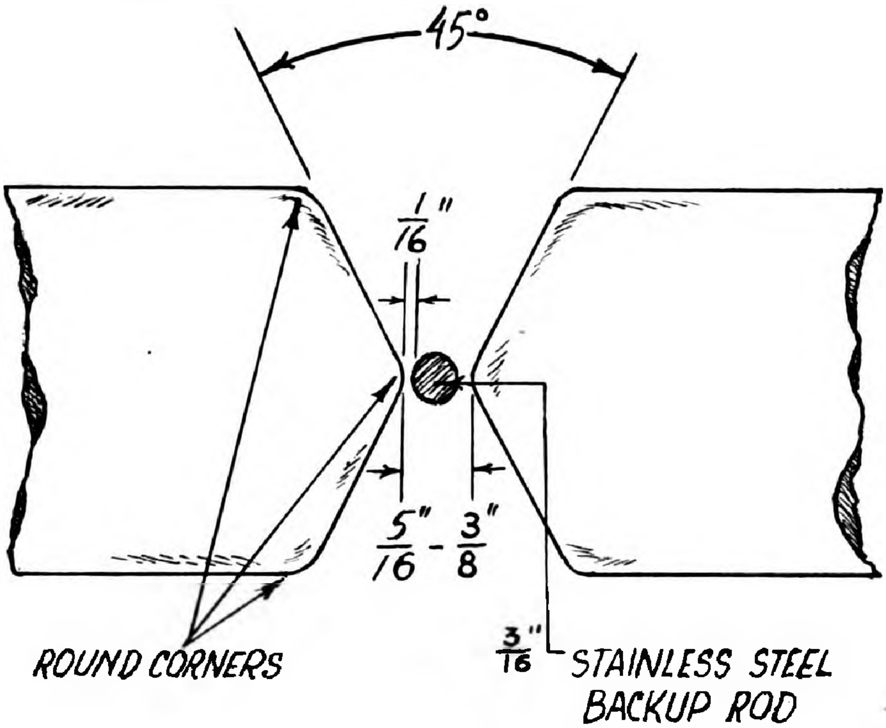


Figure 33. Double Vee Butt Weld Preparation on Homogeneous Armor Plate.

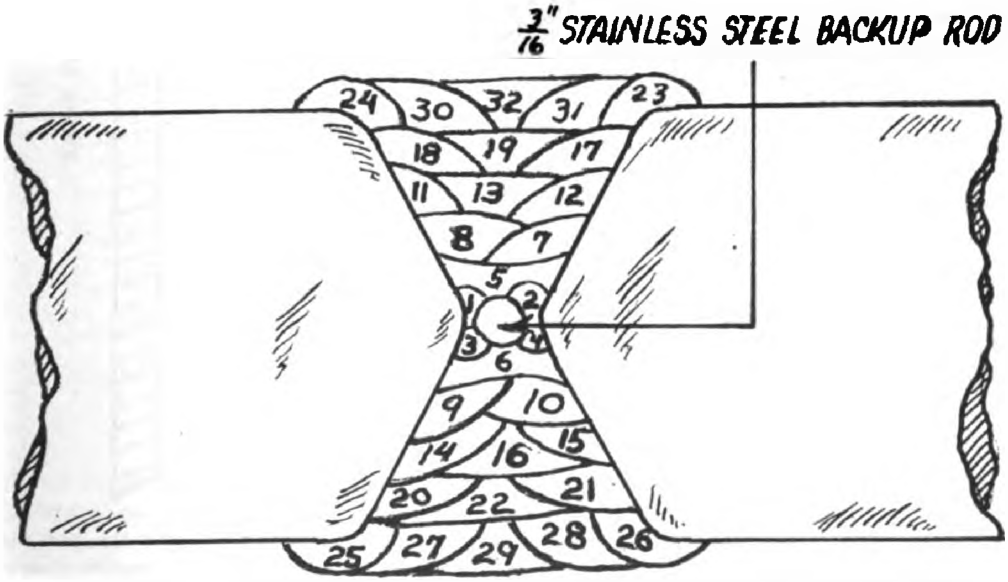


Figure 34. Sequence of Passes on Double Vee Butt in Homogeneous Armor Plate.

to aid in getting complete penetration with as little fusion with the base metal as possible.

Care must be taken when welding at the root of the joint to avoid slag inclusion. Root beads should be run with ⅛-inch electrodes, weaving the electrode only to control the puddle. Root beads 1 and 2 are laid in first as shown in figure 34. Work must be thoroughly clean, and all slag removed before laying beads 3 and 4. Beads 1 and 2 should penetrate half-way through or slightly more, so that beads 3 and 4 can be properly fused into them.

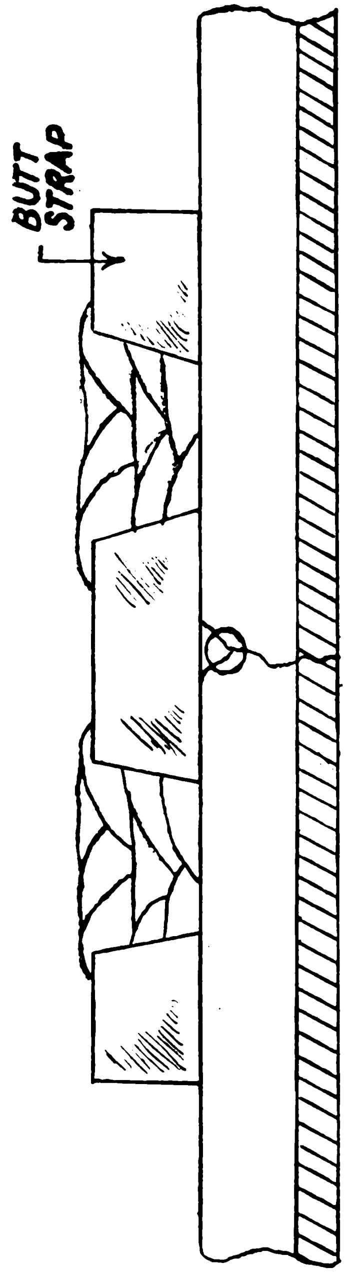


Figure 35. Plug Welded Butt Strap.

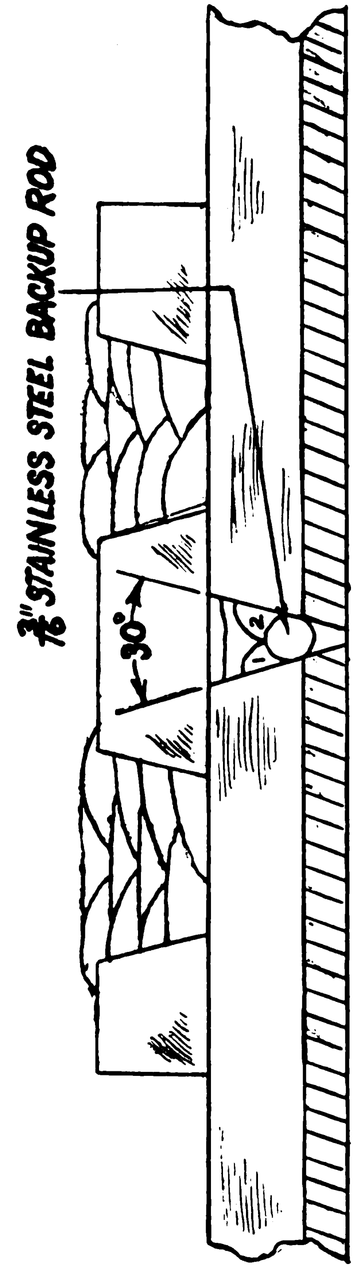


Figure 36. Plug Welded Butt Strap (Poor Fit-Up).

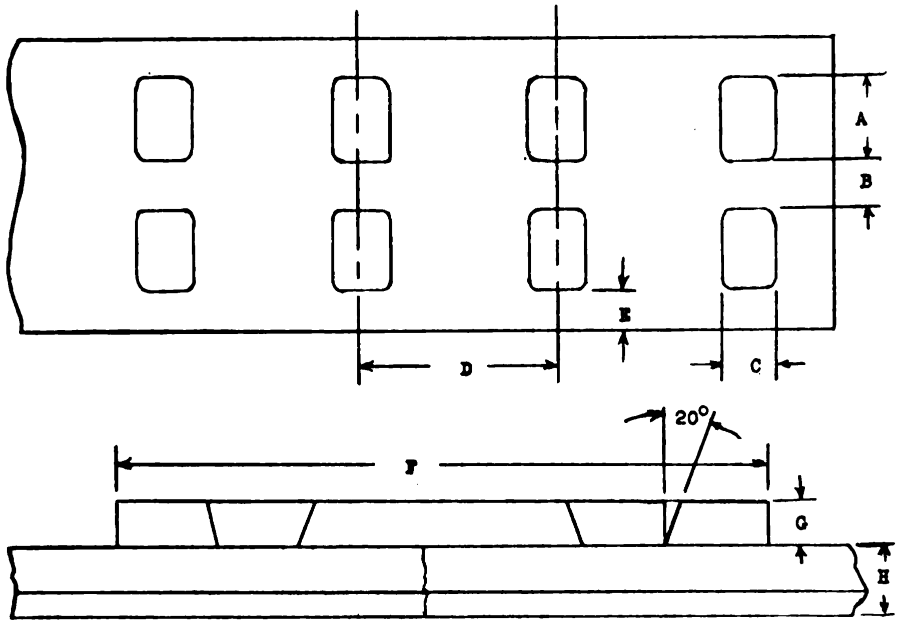
The succeeding beads are all weave beads and should be no more than ½ inch wide. Weaves of not more than ½ inch in width are used to minimize the slag inclusions and stresses. All weaves when laying these beads must be held long enough on the sides of the groove to allow the weld metal to flow up on the bevel. This will prevent deep vees between welds or along bevels, as slag inclusions will invariably result when laying beads over deep grooves.

This method of alternating passes from one side to the other, as shown in figure 34, helps keep the plates in alignment and equalizes the stresses. Each pass laid serves partly to stress-relieve the pass below it and partly tempers the hardened zone in the armor caused by the quench effect of the surrounding metal.

Passes 23, 24, 25, and 26 are annealing passes or beads. These beads are laid before the cover passes and are narrow in width, approximately 5/16 inch. By laying these narrow beads on the toe of the weld, the small area it hardens can easily be tempered by the cover beads, thus relieving the danger of the fusion zone cracking under impact at the toe of the weld. The weld reinforcement is determined by the height of the annealing beads, which should be from 1/16 inch to ⅛ inch above the plate surface. Cover beads should then be flat and flush with the annealing beads.

TABLE II.

Butt Strap Sizes to be Used for Different Sizes of Armor Plate



H	G	A	B	C	D	E(MIN)	F(MIN)
1/4"	3/16"	3/4"	1"	7/16"	3"	1/4"	3"
3/8"	1/4"	1-1/8"	1"	1/2"	3"	3/8"	4"
1/2"	3/8"	1-1/4"	1"	5/8"	3"	3/8"	4-1/4"
5/8"	3/8"	1-1/4"	1"	5/8"	3"	3/8"	4-1/4"
3/4"	1/2"	1-1/4"	1"	5/8"	2"	7/16"	4-1/2"
1"	5/8"	1-3/8"	1"	3/4"	2"	1/2"	4-3/4"

WELDING FACE-HARDENED ARMOR PLATE

Face hardened armor can be satisfactorily welded with the modified 18-8 stainless steel electrodes if the proper procedures are followed. Face-hardened armor is welded by plug welding a butt strap to the soft side of the armor as shown in figure 35.

The butt strap is a strip of either homogeneous armor, mild steel, or low carbon structural steel (in order of their preference) cut to dimensions given in the table of butt strap size (Table II) for the thickness of the face hardened armor being repaired. The strength of the repair will depend upon the soundness of the plug welds. A joint of this type can be made water tight by veeing the plate slightly as shown and running a sealer bead in the vee. It must be then ground flush with the plate to allow the butt strap to fit closely to the armor. This type of repair is usually employed on light armor when the armor is only cracked, or on armor plate having only a slight opening.

For heavier plate thicknesses with larger openings, or when replacing a section of face-hardened armor, the method of repair shown in figure 36 is preferred. Plates are beveled to a 30 degree included angle, and a 3/16 inch stainless steel electrode with the flux removed is placed in the vee so that it is above the face side and fits snugly to the bevel. The purpose of the backup rod is to keep seal beads 1 and 2 from penetrating to the face side. After the vee has been filled, the butt straps are welded to the soft side as described before. The butt strap method of repair can be used on all thicknesses of face-hardened armor up to 1 inch but it is usually used up to and including ⅝ inch plate. Whenever using two or more butt straps that join each other, weld them together.

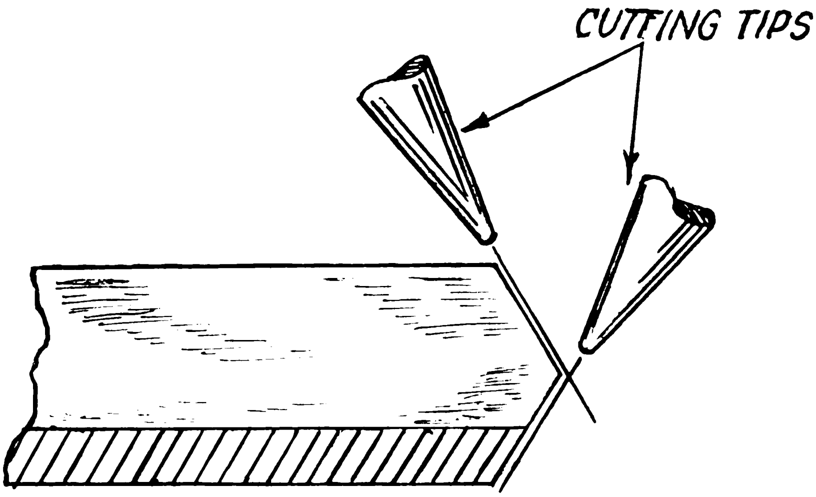


Figure 37. Method of Cutting Double Vee Butt on Face-Hardened Armor.

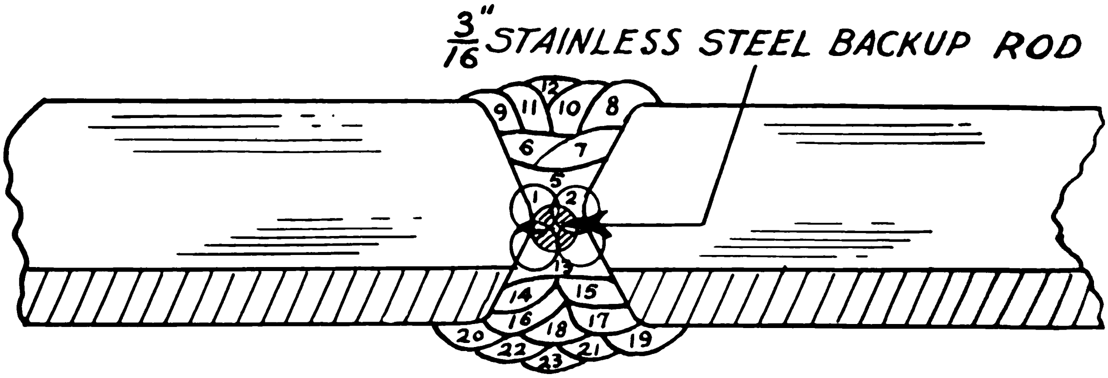


Figure 38. Sequence of Passes on Double Vee Butt in Face-Hardened Armor.

Face-hardened armor over ⅝ inch can be satisfactorily welded using the double vee butt weld. The plate preparation and set up is the same as for the homogeneous type, with the exception that all cutting must be done from the soft side as shown in figure 37.

The same procedures are used for laying each bead as are used on homogeneous armor, but the soft side is welded first as shown in figure 38.

WELDING TRUCKS

The welding trucks used by maintenance units in the field are equipped with the necessary apparatus for oxyacetylene, electric arc welding, and small forging operations.

TABLE III
Procedure Guide for Welding

Base Metal	Welding Process	Flame Adjustment	*Welding Rod or Electrode	Flux (Gas)	Recommended Preheat—Deg. F.
Low Carbon Steel	G.F.W.	Neutral	Low Carbon		
(.06% to .30%)	M.A.W.		Low Carbon		
	B.W.	Sl. Oxidizing	Bronze	Brazing	
Med. Carbon Steel	G.F.W.	Sl. Carburizing	Low Carbon		300-500
(.30% to .50%)	M.A.W.		High Strength Stainless or Low Carbon		300-500
High Carbon Steel	G.F.W.	Sl. Carburizing	High Carbon		500-800
(.50% to .90%)	B.W.	Sl. Oxidizing	Bronze	Brazing	300-500
Tool Steel	B.W.	Sl. Oxidizing	Bronze	Brazing	300-500
(.90% to 1:50%)	S.S.	Carburizing	Silver Solder	Silver Solder	
Low Alloy, High Tensile Strength (General)	G.F.W.	Neutral to Sl. Carburizing	Stainless or Low Carbon		300-500
	M.A.W.		High Strength, Stainless or Low Carbon		300-500
High Manganese (12% to 14%)	M.A.W.		Nickel-Manganese or Stainless		
Stainless Steel (General)	G.F.W.	Neutral to Sl. Carburizing	Stainless Steel		
	M.A.W.		Stainless Steel		
Copper [1] (Deoxidized)	G.F.W.	Neutral	Deoxidized Copper		500-800
	B.W.	Sl. Oxidizing	Bronze [2]	Brazing	300-500
	M.A.W.		Copper or Bronze		400-600
Brass or Bronze	G.F.W.	Oxidizing	Brass or Bronze	Brazing	200-300
	B.W.	Sl. Oxidizing	Brass or Bronze [2]	Brazing	200-300
	M.A.W.		Copper or Bronze		200-300
Aluminum	G.F.W.	Sl. Carburizing	Aluminum	Aluminum	500-800
	M.A.W.		Aluminum		500-800
Lead	G.F.W.	Sl. Carburizing	Lead	Soldering Acid	
Gray Cast Iron	G.F.W.	Neutral	Cast Iron	Cast Iron	700-800
	B.W.	Sl. Oxidizing	Bronze	Brazing	300-500
	M.A.W. [3]		Cast Iron, Stainless Steel Low Carbon Steel		500-800
Malleable Iron	B.W. [4]	Sl. Oxidizing	Bronze	Brazing	500
White Metal (Pot Metal)	G.F.W.	Carburizing	White Metal		

Note: This is only a guide and the procedures will not prove to be the best in all cases.

KEY:

G.F.W. Gas Fusion Welding (Oxyacetylene)
M.A.W. Metallic Arc Welding
B.W. Bronze Welding (Brazing)
S.S. Silver Soldering

* Electrodes are listed in order of preference.

[1] Only copper of the deoxidized type can be fusion welded. Its weldability may be tested by heating to a bright red heat and hammering on an anvil. If it breaks, it is not weldable.

[2] Rod must have a melding point at least 50 degrees below that of the base metal.

[3] Will give a very hard and brittle weld. Nonmachinable.

[4] Must always be brazed if the physical properties of the metal are to be retained.

There are, in general, three types of welding trucks. All of these trucks carry essentially the same equipment and accessories, the difference being in the type of body and the installation of the electric arc welding generator. The older of the welding trucks, the M3, is a cab-over-engine bus body vehicle with the welding generator driven through a power take-off. The M12 is a 6x6, special body truck, as shown in figure 39. The generator in this truck is a 300-ampere machine, driven by a separate gasoline engine. Both of these special body trucks are being replaced by standard 6 x 6 cargo trucks in which the maintenance sets are the same as those in the M12 and are mounted in a similar manner.

METAL SPRAYING

Today metal is sprayed onto surfaces very much in the same manner as paint. The process, frequently called metallizing, employs a portable spray gun into which is automatically fed a metal wire. The wire is melted by an oxygen-gas flame as it emerges from the nozzle at the end of the gun. A strong jet of compressed air atomizes the molten metal and blows it out of the nozzle in a fine dense spray. The sprayed metal chills almost instantly on reaching the surfaces of the material being sprayed.

In operation, the wire is fed through the gun between two knurled rolls, which are driven by a small air turbine, geared down by reduction gears. The wire feed rate may be increased or decreased according to the kind of metal being used. The wire, usually on spools or in coils, is fed from a turntable-type reel stand.

A compressed air supply of approximately 35 cubic feet per minute at 60 to 65 pounds per square inch pressure is required to drive the air turbine and spray the molten metal.

Acetylene, propane, manufactured gas, natural gas, or hydrogen gas may be used as the fuel gas. Acetylene is by far the most widely used gas, although propane is frequently used.

In comparing the physical properties of sprayed metal with the original metal, the tensile strength and ductility are very low, but the hardness, compressive strength, wear resistance, corrosion resistance, and heat and electrical conductivity are just about equal to the original wire. Wear resistance is often improved to a considerable extent.

The bond formed between the sprayed metal and the base metal is purely mechanical as the sprayed metal is neither a weld or a braze; therefore, it is very important that the proper preparation be given to the base metal. It is essential that the surface be clean and free from all rust, oil, and moisture. To secure a good mechanical bond the preparation of the base metal should produce a multiplicity of minute keys or locks to hold the sprayed metal firmly to its furface. The preparation may be made by sand or grit blasting, rough threading in a lathe, or by the use of a special shaft-preparing tool which is used in a lathe. Recently several manufacturers have put on the market an electrical bonder. This bonder prepares the surface by depositing small particles of metal from a metallic electrode and can be used on most any type of surface.

Metal spraying can be used for building up worn surfaces of bearings and undersized parts, altering shapes of castings, providing a metallic surface on wood, glass, fabrics or paper, providing protection against corrosion, repairing holes and cracks in castings; balancing equipment for high speed rotation, and many other mechanical and corrosion resistance operations.

IDENTIFICATION OF METALS

The material presented in this discussion is intended to acquaint the reader with the various major characteristics of metals in common use in the machine shop.

Of prime importance to the soldier-machinist is the ability to identify metals. It is often necessary for him to choose his raw material from a scrap pile, and he must be able to choose the correct material by sight, weight, or some other simple means. Metals are classified into two groups; *ferrous* and *non-ferrous*. Ferrous metals are those which contain iron as the principal element. Metals, either ferrous or non-ferrous, are rarely used in their pure form, but are most generally alloyed or mixed with some other metallic or non-metallic substance. What is an alloy? Chemically speaking it is a solid solution of two or more metals. Commercially, an alloy is not limited to being a solid solution, but can also be a mechanical mixture.

Copper Alloys. Of the non-ferrous metals, two major groups are in common use: copper-base alloys and aluminum alloys. Copper-base alloys are those which have copper as their principal element. Copper is frequently found in nature in the free state. It is red in color and is heavier than iron or steel, weighing 556 pounds per cubic foot, as compared to 450 for cast iron and 490 for

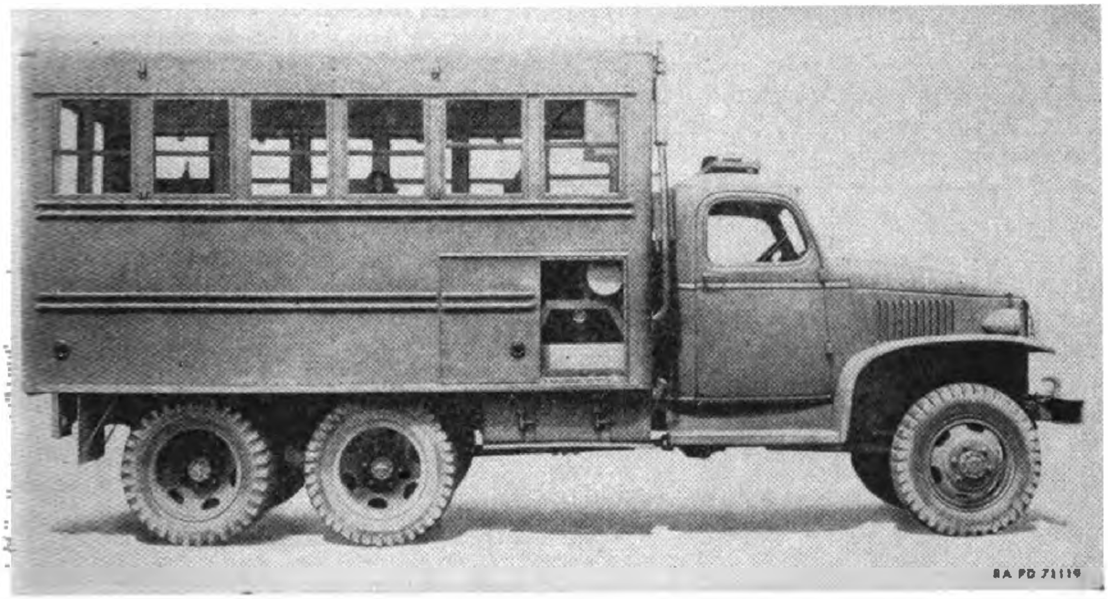


Figure 39. Welding Truck, M12.

steel. The alloying elements usually used with copper are tin to make bronze; zinc to make brass; and lead, for either or both, depending upon the properties required. The amounts of these alloying elements can be varied to obtain the required physical properties of tensile strength, hardness, wear resistance, and machinability. Bronze varies in color depending upon composition, but the usual color is deeper than brass, tending toward an orange or gold.

Aluminum Alloys. Aluminum, another non-ferrous metal, is among the few used to any extent in the commercially pure form. It is a bluish-white color and is mined in the form of the mineral, bauxite. The two outstanding properties of aluminum that make it commercially valuable are its resistance to corrosion and its light weight. It weighs only 165 pounds per cubic foot, 1/3 the weight of steel. In the pure form it is used where light weight and resistance to corrosion are required, but where strength is not important. To give aluminum strength, it is alloyed with copper and zinc. Alloys of these metals provide aluminum with its wide range of uses.

Ferrous Alloys. Ferrous metals are those which contain iron as the principal element and are considered the most important for several reasons. First, they are used more widely than any other metal. Second, their physical structure is more complicated than any other. Third, they are produced in a wider range of compositions than any other metal. Each composition produced finds important uses, and each one has particular physical properties which often vary considerably from the other compositions. Therefore, it is these metals, namely iron and steel, to which the balance of this discussion will be devoted.

Iron. Iron is a metal which when refined has remarkable properties of strength, hardness, ductility, malleability, etc., depending upon the refinement. In the earth's crust it occurs as iron ore, a chemical combination of iron, oxygen, and impurities. It is of no commercial value as such, so it must be 'reduced' or separated. This is done in a blast furnace. The iron ore is charged into the furnace with limestone as a flux and carbon in the form of charcoal, coke, or anthracite coal. By blowing hot air up through the charge, the ore is melted down and the carbon combines with the oxygen in the ore. The product is a metal whose composition is approximately 93 per cent pure iron, with 3 to 5 per cent carbon. This known as pig iron. Pig iron can be used in foundries for the manufacture of iron castings by remelting and casting it in molds without materially changing its chemical composition. However, it is extremely brittle, so it is often refined by the addition of steel and iron scrap to lower the carbon content and improve its strength and machinability qualities. This is usually done in a cupola, a furnace resembling the blast furnace in shape, but almost always smaller in size. The process carried on in the cupola is merely one of melting down the ingredients and not one of chemical reduction as in the blast furnace. The product of the cupola is not referred to as pig iron, but as cast iron. It is gray in color, brittle and quite weak, but easy to machine. It contains free carbon in the form of graphite.

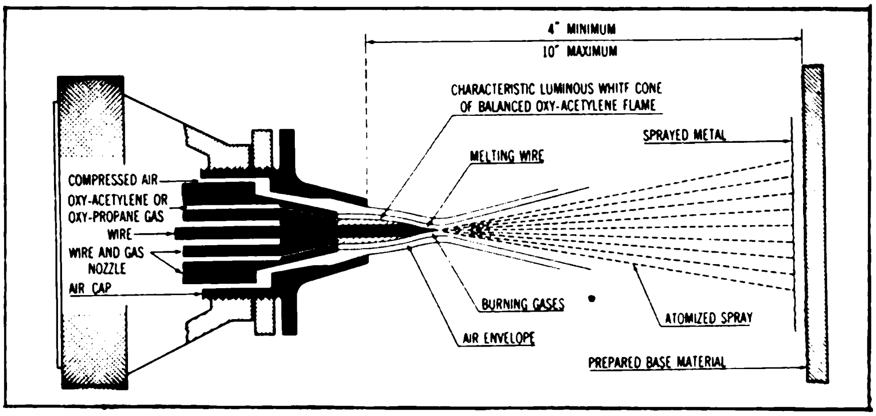


Figure 40. Metalizing Gun, Wire Nozzle and Air Gap, Cross-Section.

Steel. In order to make steel, cast iron or pig iron must be further refined. Cast iron, as was mentioned above, contains 3 to 5 per cent carbon, much of it in the free state, and comparatively large amounts of other impurities such as sulphur, phosphorous, silicon, etc. Steel contains no carbon in the free state. All carbon in steel is chemically combined with iron in the form of carbide. The above impurities must be held to a minimum, since they contribute undesirable properties if present in large amounts. Therefore, the iron must be processed to remove these impurities and to remove some of the carbon. This is done by several methods, which vary with the type of product desired.

It has been previously stated that iron and steel composition could be controlled at will in the making to vary its physical properties. The carbon content of steel influences most of these properties more than any other single constituent. Steel, as was said, contains carbon only in the chemically combined form. It is possible for steel to have from no carbon at all (where it is nothing more than plain iron) to 1.7 per cent carbon. Low carbon content makes the metal very easy to machine, ductile and tough. However, without carbon or with only small quantities present, it is not possible to harden the steel. As the carbon content increases, the steel becomes increasingly difficult to machine or forge, less ductile and stronger. It becomes more responsive to heat treatment and harder after such treatment. With the maximum possible carbon content, the steel in the heat-treated state is very hard and brittle, approaching the hardness and brittleness of glass.

Steel is often alloyed with other metals to produce desirable properties such as increased strength, increased hardness without brittleness, wear resistance, corrosion resistance, strength at high temperature, machinability, etc. The motor common alloying elements are nickel, chromium, molybdenum, tungsten, vanadium, silicon, and manganese.

Steel Identification. It is virtually impossible to distinguish between steels by sight or weight alone. The machinist in the field oftentimes will find it necessary to determine the carbon content in a steel before he can use it. The hardness of a steel can be tested with a file or cutting tool, but a high carbon steel does not have to be hard to have hardening properties. In order to approximate the carbon content we divide carbon roughly into three (3) groups. Low carbon, or .10% to .30%; medium carbon, or .30% to .60%; and high carbon, or .60% to 1.20%. One of the oldest and simplest methods of approximation is the spark test. This is performed by holding the metal in question against an abrasive wheel. Each minute cutting edge on the abrasive wheel will remove a chip from the piece, but it is done at such high speed that the chip will come off glowing hot. This glowing chip is the spark seen shooting off from the point of contact of the wheel and metal. Carbon in this chip at high temperatures demands release from its union with iron and explodes the chip to get free. The explosion, or 'burst' as it is called, is plainly visible to the eye. A piece of low carbon steel will have a large number of bright yellow streamers caused by the flowing chips, but very few bursts because of the lack of carbon. Conversely, high carbon steel will have very few streamers and nearly all burst, because the high carbon content causes the glowing chips to explode before they have traveled very far from the wheel. Medium carbon steel would have the long streamers, but with a fair amount of bursts interspersed.

Classification of Steel. With the large number of carbon and alloy steels in use, it becomes very necessary to have some simple means of classifying them as to alloying elements and carbon content. There are several methods in existence, but the system adopted by the Society of Automotive Engineers, Inc., seems to be the most popular. This is a numerical index system which gives to each steel a four or five digit number, such as "SAE 4640." This number is made up as follows: reading from left to right, the first digit indicates the class to which the steel belongs, such as nickel steel, carbon steel, chrome steel, etc. The second digit indicates the approximate percentage of the predominant alloying element. The last two figures indicate the average carbon content in hundredths of a per cent. The basic numerals for the various classes of steels are:

1	Carbon	Ex. 1112
2	Nickel	Ex. 2345
3	Nickel Chrome	Ex. 3450
4	Molybdenum	Ex. 4130
5	Chromium	Ex. 52100
6	Chrome Vanadium	Ex. 6115
7	Tungsten	Ex. 71360
9	Silico-Manganese	Ex. 9255

Thus we see that a SAE 4640 steel would be a molybdenum steel with approximately 6% molybdenum and an average of 0.40% carbon. Likewise, SAE 1045 steel would be a carbon steel with no other alloy and 0.45% average carbon content.

CHAPTER 3

AMMUNITION AND TERMINAL BALLISTICS

It is prerequisite that an Ordnance officer have a wide and complete knowledge of the many types of ammunition found during training exercises and in field operations, for he will be called upon to pass judgment on the various technical phases of ammunition and will have to furnish information pertinent to the success of entire operations.

Ammunition is potentially dangerous since it is manufactured with intent to destroy or kill, but if you handle it always with respect and caution there is little danger. Accidents with ammunition can all be traced to carelessness and ignorance.

Since most branches of the Army are concerned with ammunition, the proper terms and nomenclature peculiar to ammunition must be used at all times to eliminate errors in understanding. Certain types of ammunition are so nearly alike that only proper terminology can distinguish one from another. The habit of using proper nomenclature must be formed early in the study of ammunition.

When an ammunition model is classified as an adopted type, it is assigned a model designation to distinguish its particular design. The model designation becomes an essential part of the standard nomenclature and is included in the marking on the item.

Prior to World War I, the model designation was always composed of the letter 'M' followed by the year in which the design was adopted, for example: M1906. From the World War until July 1, 1925 it was the practice to assign 'mark' numbers. The word 'Mark', abbreviated 'Mk', was followed by a roman numeral; for example, Shell, HE, Mk II. The first modification of a model was indicated by the addition of MI to the mark number, the second by MII, etc. The present system of model designations consists of the letter M followed by an arabic numeral. Modifications of a definite nature are indicated by adding the letter 'A', and the appropriate arabic numerals. Thus M2A1 indicates the first modification of an item for which the original model designation was M2. In addition to the 'A' modifications, there are also 'B' modifications. These may be either a change in the method of manufacture of an item or a change in the material used. An example of this is the M18B1 steel cartridge case; the 'B' designation in this instance denoting a steel cartridge case. Certain items standardized for use by the Army and Navy are designated by the letters 'AN' preceding the model designation, for example, AN M100A1, AN Mk19. These two designations indicate that the item is of Army design in the first case and in the latter the designation indicates the item is of Navy design. In recent years the Navy designations have consisted of arabic numerals, whereas previously they were roman numerals. Some of the latter type designations may still be found. The M designation system for ammunition items is also used for major ordnance items such as artillery and small arms.

As new ammunition items were designed and old types became obsolete, it became necessary to initiate a system of classification to completely define the different types of items. Standard items are the most advanced of their type and are considered satisfactory for the service intended. They are those that have been adopted by the War Department. In this connection refer to the description in the Ordnance Book of Standards chapter 10, volume I. Standards are preferred for procurement and in meeting supply demands. Substitute standard articles are those which do not have completely satisfactory military characteristics, but are usable substitutes. They are not normally used, nor are they available for issue to meet supply demands. They may, however, be procured to supplement the supply of standard articles. Limited standard items are those which do not have as satisfactory military characteristics as standard articles. They are either in use or are available for issue to meet supply demands. In making use of the Standard Nomenclature Lists, the status of the ammunition may be found marked as 'S' or 'S & M'. In this instance, the 'S' indicates that the item is standard for issue and is currently being manufactured, Ammunition is further classified as to its use and to type filler. Service ammunition is that which is used for effect. It usually has high-explosive or chemical filler except in the case of small arms ammunition. Practice ammunition is provided for training in marksmanship. This type may have a small quantity of low explosive filler to serve as a spotting charge or the filler may be inert. Blank ammunition is provided for saluting purposes and for simulated fire. Blank ammunition does not incorporate the use of a projectile. Drill or dummy ammunition is used for training purposes and for practice in the handling and loading of weapons. It is completely inert and can be used until worn components require replacements as in large caliber and trench mortar ammunition, or until worn out as in the case of small caliber rounds.

In manufacture, ammunition is produced in lots. Each lot is assigned a 'lot number', which is designated according to pertinent specifications and thereafter remains an essential part of the ammunition marking. The lot number is stamped or marked on every piece of ammunition unless the item is too small to permit marking. A group of two or more lots which for both engineering and statistical reasons can be considered to be of the same standard quality is called a 'grand lot'. In addition to the foregoing there is a lot number that is assigned to each complete round of fixed and semi-fixed ammunition (except where the item is too small as in the case of small arms ammunition) and on all packing containers. This information is required for all purposes of record including reports on condition, functioning, and accidents in which the ammunition is involved. In order to provide for uniform functioning, all the components in any one lot are manufactured under as nearly identical conditions as practical. For example, components requiring uniform performance quality are as follows:

a. All projectiles of one lot.
b. All fuzes of one lot.
c. Primers of one lot.
d. Propellants of one lot.

DEFINITION OF TERMS

Ammunition. Ammunition is defined as any or all materials used to charge weapons of war, including pyrotechnics in all its forms. The soldier himself may function as a 'weapon of war'; for example, in throwing hand grenades.

Caliber. Caliber is the diameter of the bore of the weapon between opposite lands. While it is a unit of measure and is expressed in inches, centimeters, and millimeters, in itself it has no unit. To be of use, caliber must refer to a specific weapon.

Complete Round. A complete round of ammunition is *all* the necessary components required to fire a weapon one time and to function that round of ammunition at the target. For example, a complete round of high explosive shell would be made up of a projectile, an explosive filler, a fuze, a booster, a cartridge case (or powder bags), a primer, and a propelling charge. These are all the components necessary to bring about the desired function of the shell.

A most important dividing line in ammunition is that between small arms and artillery ammunition. Small arms ammunition is defined as ammunition fired in weapons whose bores are 0.60 inches or less in diameter, while artillery ammunition is defined as ammunition fired in weapons over 0.60 inches in diameter.

The various types of ammunition and ammunition components are marked in a way providing positive identification for all purposes. Primarily, projectiles are painted to prevent corrosion from exposure. Various colors of paint are used for the different types of projectiles and the color affords a basic means for identification. An explanation of the color scheme follows:

Projectiles filled with high explosive such as amatol, explosive D, TNT, etc., are painted olive-drab with marking in yellow. The presence of a smoke producer in high-explosive shell is indicated by the letter 'S' stenciled just above the bourrelet.

Shells containing a chemical filler are painted gray. In addition to the caliber and mark number, chemical shells listed herein are marked for identification as follows:

Chemical Filler	*Marking on Shell*
H persistent gas	H—GAS and 2 bands (all in green).
NC persistent gas	NC—Gas and 2 bands (all in green).
FM smoke	FM—Smoke and 1 band (all in yellow).
WP smoke	WP—Smoke and 1 band (all in yellow).
FS smoke	FS—Smoke and 1 band (all in yellow).

Loaded shrapnel and low-explosive shell are painted red.

Armor-piercing projectiles which contain no explosive or only a tracer, assembled in fixed ammunition, are painted black.

Projectiles assembled in fixed or semifixed rounds of practice ammunition are painted blue. These, including the fuze, may be completely inert or they may contain a live fuze with a bursting charge of black powder.

Individual fiber or tin containers in which ammunition is packed are marked with the caliber, type, and the ammunition lot number. Color bands are painted on these containers or adhesive sealing strips and are colored as follows:

Type of Ammunition	*Color*
High explosive or armor-piercing w/explosive filler	Yellow
Armor-piercing, w/o explosive filler	Black
Practice	Blue
Shrapnel	Red
Chemical (See Fig. 71, page 238)	Gray with superimposed narrow green (gas) or yellow (smoke) bands.

Small arms ammunition cartridges are painted only on the tips. However, the packing boxes are stained and have yellow markings which completely identify the contents. This will be covered in more detail in subsequent sections.

Since the action of all ammunition is quite important it is necessary that specifications be rigorous and rigidly maintained. Ammunition is, therefore, thoroughly inspected and tested before acceptance. In accordance with the results of these tests, each lot of ammunition is assigned a grade. In the case of small arms ammunition, the grade determines the principal use in a particular class of small-arms weapons for which a definite lot may be employed. Grade designations used for ammunition other than small arms refer to the result of surveillance tests.

Ammunition is packed and marked in accordance with pertinent specifications and drawings. These packings are designed to withstand all conditions ordinarily encountered in handling, storage, and transportation under Interstate Commerce Commission regulations and in tactical operations. Further information concerning packing and marking is contained below.

MILITARY EXPLOSIVES

Introduction. There are many known explosives, each having different characteristics, and each being equally essential to ammunition make-up. It is therefore necessary to classify them so that proper employment can be made for military purposes and thus afford control of the final uses of each type.

Explosive Train. With ammunition, the proper functioning at the proper time is of prime importance. What enables us always to obtain this action? It is the explosive train. This train is a series of explosives arranged to provide the control necessary to give the desired results.

Military explosives, classified according to use, fall into three general groups:

1. Propellants;
2. Bursting charges;
3. Initiators.

The initiator can be closely allied with the first two classes since both propellants and bursting charges require an initiating explosive to ignite them. Since the propellants begin the job and the bursting charges finish it, both activated by certain initiators, there must be a definite arrangement of the explosives used in the round. It follows that there are both propelling charge explosive trains and bursting charge explosive trains.

Propelling Charge Train. Propelling charge explosions are utilized to force the projectile from the weapon. This operation is accomplished by (1) a primer which receives the action, stab, or flame, transmitted by the firing mechanism of the weapon and (2) the propelling charge itself. With some types of ammunition this alone is sufficient, but with others an auxiliary charge is added to insure proper ignition of the propellant.

Bursting Charge Train. The bursting charge explosive train brings about the action of the projectile at the target. Here, also, we find certain necessary components, these being (1) a detonator, (2) a booster, and (3) the bursting charge. The small sensitive detonator receives the initial shock of the firing pin and transmits the explosive waves to a larger quantity of less sensitive booster explosive which increases the power sufficiently to set off the bursting charge. Projectiles constructed with the above arrangement of explosives are considered to function by means of a 'high-explosive bursting charge train'.

In obtaining specific functional properties, additional elements are added where needed, *i.e.*, powder time trains or pellets for delay and additional detonators to insure instantaneous transmittal of detonating action.

Low explosive bursting charge trains are used in some types of ammunition and usually require primers, delays, and igniters to initiate the low explosive bursting charge.

Explanation of Ammunition Terms. We know that an explosive upon being detonated gives off large quantities of gas and heat. But certain conditions have to be satisfied with any explosive that we use. First, we want the reaction to take place when the initial impulse is applied. Second, we want the reaction to occur rapidly; and finally, we want as nearly a complete conversion into gaseous products as possible, wherein heat will be given off, without application of additional energy except that of the initiating action.

The only way in which explosives can be classified is by their relative speeds of decomposition. Even then it is difficult to draw a line of distinction. So it becomes necessary to state that all relatively slow burning compounds (with a rate of from 1mm/sec. to 1 meter/sec.) are LOW EXPLOSIVES, and those having a very rapid rate of decomposition (1,000 meters/sec. and up) are HIGH EXPLOSIVES and are recognized by their detonation.

Definitions. The following terms are used in connection with explosives.

Stability—The property of an explosive to remain in its original condition even though subjected to long storage periods, and to changing temperature and pressure.

Sensitivity—The capability of the explosive to withstand shock imparted during loading processes and transportation handling, and in firing. It can also be thought of as the 'ease of detonation'.

Brisance—The shattering capacity of an explosive or its capacity to shatter its confining medium.

Detonation—The rate or velocity of the reaction or transformation.

a. A 'high order' detonation is complete detonation with maximum brisance being attained.

b. A 'low order' detonation is an incomplete detonation in which maximum brisance is not attained.

Power—The ability of the explosive to accomplish work or the ability to displace the surrounding medium. Power is related to the effect of the detonation.

Deflagration—A slow change with rapid combustion (rather than detonation).

Hygroscopicity—The absorption of moisture.

Properties of Various Types of Explosives. To provide uniformity and meet rigid military requirements, certain well-defined properties are demanded of military explosives. In general these properties are as follows:

1. Primers, detonators, initiators:
   a. Sensitive to shock
   b. Sensitive to heat
   c. High brisance.
2. Propellants:
   a. Insensitive to shock
   b. Easily ignited by heat
   c. Evolves gas at a controllable rate.
3. Bursting charges (high explosives):

a. Insensitive to shock
b. Insensitive to heat
c. High brisance.

CLASSIFICATION

Low Explosives

Low explosives are generally used as propellant charges, although some forms of ammunition employ them for other purposes. In a study of explosives it should be recognized that the various kinds of low explosives are not necessarily used as propellants.

Black Powder. Black powder is our oldest known explosive. Prior to the latter part of the 19th century it was used for all military explosive purposes, and even today it is used much in the same composition as when originally developed.

It is a mechanical mixture composed of 75% potassium nitrate (salt petre), 15% charcoal, and 10% sulphur. The charcoal serves as the fuel, the potassium nitrate supplies the oxygen, and the sulphur lowers the ignition point and serves also as fuel. It is a black, shiny, granular powder which may have varying grain sizes depending upon the specific purpose for which it is manufactured. If not properly protected black powder may undergo a reduction in rate of burning from moisture absorption.

Propellants. Deterioration is the main difficulty encountered with the propellant class of low explosives. Due to quantities of volatile solvents present, extreme care must be exercised in order to prevent a change in the properties. Once started, gases liberated increase the rate of deterioration, and the heat built up will often cause spontaneous ignition. Thus it is most important to maintain proper storage conditions, use air-tight containers, and control temperature and humidity.

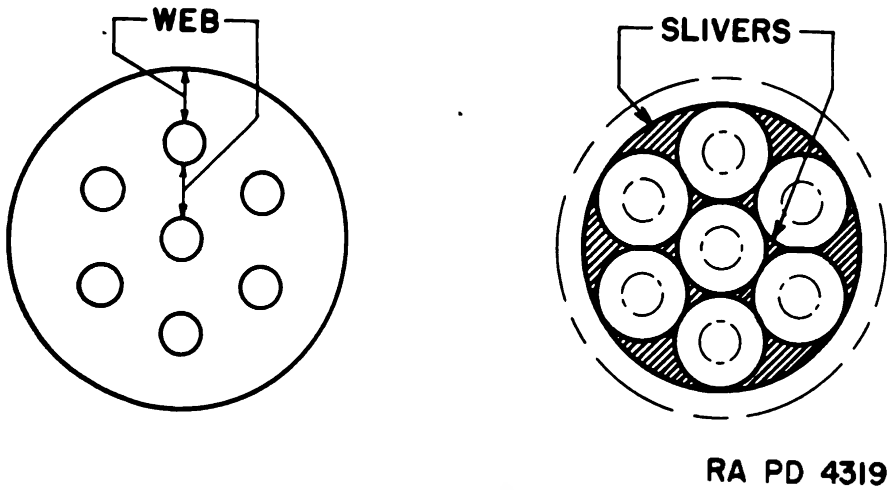


Figure 1. Burning of Powder Grains.

Smokeless Powder—The following are types of smokeless powder:

Nitrocellulose Powders. Straight nitrated cotton, or nitrocellulose (guncotton or pyrocotton), was first used as the standard propellant when smokeless powder replaced black powder. It had some disadvantages in that it required special storage conditions to keep it from losing volatility and absorbing moisture. Ballistics were materially affected. Too much muzzle flash caused by the slow burning of the powder in the weapon, was also a drawback.

NH (non-hygroscopic) and FNH (flashless NH) powders are the result of a need for propellants which would not have the drawbacks encountered with straight nitrocellulose. The rate of burning is controlled by special grain designs and by the size of granulation and web thickness, *i.e.*, the mean measurements of the least burning thickness of the grain. With proper granulation, the combustion takes place very rapidly and the gases lose most of their heat while forcing the projectile from the gun tube. This eliminates the chance of ignition at the muzzle of the piece, since the gases are cooled below their ignition point before escaping from the weapon.

Our two types of granulation are progressive and degressive forms. When the burning surface of the grain increases as it burns itself out we have 'progressive' burning. Examples of this are multi-perforated cylindrical and rosette grains.

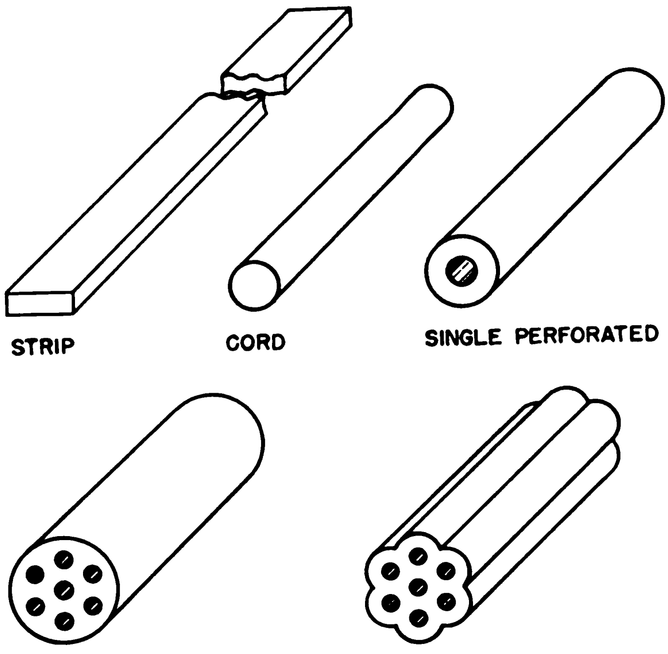


Figure 2. Types of Powder Grains.

When multi-perforated cylindrical grains are used with some weapons, unburned portions or slivers remain after firing. The rosette type powder grain was developed to eliminate this condition. But when the burning surface of the grain becomes less as it consumes itself we have a 'degressive' action. Strip, cord, and single perforated grains exhibit this type burning. Powder burning is also discussed at the end of chapter 2, vol. II, under Interior Ballistics.

As compared to control of muzzle flash through the rate of burning, another method is the addition of cooling agents into the powder to reduce gas temperatures. Some cooling agents aid in stabilizing the powder by reducing hygroscopicity; others stabilize by reducing the rate of deterioration.

Double Base Powders. Smaller weights of double base powder can be used to give the same potential energy as larger quantities of single base types. Ballistite is one of the most important military double base compound propellants. It is composed basically of 60 percent nitrocellulose and 40 percent nitroglycerine. It is manufactured usually in single perforated cords or in flat sheets. Ballistite is principally used in propellant charges for trench mortar shells and rockets.

Cordite is a double base powder used by the British as their standard propellant for many types of ammunition. In the typical form it is in most cases composed of 70 percent nitrocellulose and 30 percent nitroglycerine.

E. C. Blank Powder is perhaps the most important single base compound powder in use today. It is a granular mixture of nitrocellulose and small quantities of inorganic nitrates (principally potassium and barium nitrates). It is of pinkish color due to the addition of a dye and also contains a stabilizer. Its principal uses are in blank cartridge loads and as the bursting charge for fragmentation hand grenades.

High Explosives

A high-explosive compound may be defined as a substance which decomposes at a rate so rapid that the action is a detonation, and which is so disruptive that it could not be used as a propellant.

There are many reasons for selecting any one type of high explosive for military uses, probably the most important being its suitability for accomplishing the desired purpose. Other reasons are availability of raw materials, cost of manufacture, stability in storage, hygroscopicity, reaction with metals, sensitivity to shock during handling and setback action of firing, and brisance.

TNT is our most important military high explosive. It fulfills practically all requirements to the utmost. It is normally used as a standard, and the performance of all other high explosives are based upon it.

General data pertaining to the various types of high explosive in common use is furnished in the adjoining table I.

CHEMICAL FILLERS

General. Munitions filled with chemical agents will enable such diversified functions as: reaching enemy personnel and material in buildings, pillboxes, foxholes, and other types of emplacements; hindering or delaying enemy attack through area neutralization; or rendering enemy personnel helpless to perform combat duty by reacting upon the human body.

Chemical agents, in respect to military matters, are substances useful in war, which by their ordinary and direct chemical action produce a toxic or an irritating (harassing) effect, a screening smoke, an incendiary action, or any combination of these.

Types of Chemical Agents

Casualty Agents. An agent used against personnel for the primary purpose of producing casualties. These chemicals are highly toxic in relatively low concentrations. In general, casualty agents when effective may be expected to render personnel helpless for periods varying from a few days to in excess of a month.

Harassing Agents. Chemical agents used against personnel primarily to force masking and thus retard military operations. They are generally toxic, but are of such a nature that it is not possible to produce a death dealing concentration under field conditions.

Screening Agents. Agents used principally for their screening properties, such as screening or blanketing to prevent observation.

Incendiary Agents. Agents employed primarily to ignite combustible substances. There are two general types of incendiaries; one is the scatter type, which disperses a large number of small burning pieces over a relatively large area in order to initiate fires at many places simultaneously; the other is the intensive type, which concentrates its heat and flame within a limited space in order to set fire to heavy constructions and targets generally more difficult to ignite.

Physiological Classification. Chemical agents may be classified according to their effect on the body. Although one agent may produce more than one reaction, the agent is classified according to the principal action it has upon the body. The physiological effect of any toxic agent is dependent upon the time of exposure and the concentration. Some agents act rapidly, the effect being almost instantaneous, while others have a delayed action.

Vesicants produce large watery blisters upon contact with the body. They inflame the eyes and cause inflammation of the lungs. The severity of the effect is dependent upon the period of exposure and the vapor concentration in the air, or, the amount of liquid in contact with the skin. Vesicant action is delayed from 30 minutes to several hours after exposure.

Lung Irritants when breathed cause irritation and inflammation of the lungs.

Lacrimators cause intense but temporary irritation of the eyes and copious flow of tears.

Sternutators or *Irritant Smokes* are in a solid or liquid form and cause sneezing, intense irritation of the nose, headache, nervous depression, and nausea.

TABLE I. TABLE O

Name	Form and Color	Use
TNT (Trinitrotoluene)	Honey or straw-colored when pure Crystalline.	Standard bursting charge. For demolition work also. Very brisant.
AMATOL (Ammonium nitrate + TNT) 50/50 to 80/20	50/50—yellowish 80/20—brown	Bursting charges. 50/50 almost as powerful as TNT. 80/20 less than TNT.
EXPLOSIVE "D" (Ammonium picrate)	Crystalline, yellow to reddish-brown.	Bursting charge for AP projectiles. Less brisant than TNT.
PETN (Pentaerythrite-tetranitrate)	White	Used in Primacord. Used in pentolite manufacture. Much more brisant than TNT; one of the highest.
PENTOLITE (PETN + TNT) 50/50 or 10/90	Yellow, waxy substance.	Bursting charges in rockets, rifle grenades.
RDX (Cyclotrimethlene-trinitramine) RDX COMPOUNDS: Composition A Composition B Composition C Composition C2 Torpex (RDX, TNT, Aluminum powder)	RDX—White Compounds vary with plasticizers and binders used. Usually tan to reddish yellow or brown. Torpex—grey	RDX used only in manufacturing explosive compounds. It is too sensitive alone. Compounds manufactured by addition of waxes, desensitizers and TNT. Used as bursting charges for shells, bombs, for demolition, mines, torpedoes and depth bombs.
NITROSTARCH (Nitrated starch)	Metallic-gray, powdery.	Substitute demolition for TNT.

NOTE: (p) pressed (c) cast

F HIGH EXPLOSIVES

Velocity of Detonation Meters/sec.	Sensitivity (Comparative)	Remarks: Packing, Storage, Safety, etc.
6,700 (p) to 7,030 (c)	To extreme heat or tetryl blast only. Very insensitive to shock or friction. Rifle bullet will not normally detonate it unless in metal container.	Other names: triton, trotyl, tolite, tritolo. Very safe to handle. Very stable, non-hygroscopic. Store in bullet-proof magazine.
50/50-7,000 80/20-5,100	Insensitive to friction. Severe impact will detonate it.	Greater TNT content used with smaller calibres. Hygroscopic, forms compounds with copper but not with other metals.
6,700	Most insensitive of all explosives.	Loaded by pressing. Highly inflammable and detonates prior to melting. Becomes more sensitive with age. Stored in wooden containers because of reaction with metals. It is hygroscopic.
8,300	One of the most sensitive; more than tetryl, less than mercury fulminate. Rifle bullet will detonate it but not Primacord.	Very safe when in Primacord form. Denotates HE's in contact with them. Packed wet (40% water) in bags within barrels or kegs.
50/50-7,700 10/90-7,500	More sensitive to shock and friction than TNT. Will detonate with bullet impact.	Not too stable due to TNT separating out. Must be stored cool and dry. It is cast loaded.
9,300	Same as tetryl. Extremely sensitive.	Stability very good and does not react with metals.
All compounds—8,500	All compounds insensitive.	Compounds do not react with metals and their plasticity varies with addition products and temperatures.
7,500	Torpex more sensitive than TNT. Bullet will detonate it.	Torpex 50% greater efficiency under water than TNT.
7,100	More sensitive to impact than TNT. No. 6 Detonator will set it off.	Inflammable with explosive violence. Slightly hygroscopic. Less stable than TNT.

TETRYL (Trinitrophenylmethylnitramine)	Canary yellow crystals.	Standard booster. Charge for 37mm AA shells. Very high brisance.
LEAD AZIDE (Lead and Nitrogen)	White to buff. Powdery crystals.	Primer and detonator element. Low brisance.
MERCURY FULMINATE (Nitric acid, ethyl alcohol and metallic mercury)	White with occasional brownish tinge. Crystalline.	Primer and detonators. Low brisance about same as lead azide. Will not detonate cast TNT and Explosive "D."

7,400	More than TNT. Less than lead azide. Can be used in small quantities safely. Will detonate easily.	Very stable Non-hygroscopic. Keep dry and store in bullet-proof magazine.
5,300	Very sensitive to flame. Less sensitive to impact than mercury fulminate.	More stable than mercury fulminate. Non-hygroscopic. Always stored under water.
5,400	Most sensitive. Sensitive to shock, friction, heat.	Non-hygroscopic. Always stored under water. Unstable. Reacts with metals. Decomposes at high temperatures.

Incendiaries produce serious burns when they come in contact with personnel.

Systemic Poisons directly affect the heart action, nerve reflexes, or interfere with absorption and assimilation of oxygen by the body.

Persistency. The effectiveness of all chemical agents continues for some time after their release. The length of time that an agent remains effective at the point of release is called the persistency of that agent. Persistency is affected by the tendency of the agent to vaporize due to temperature, wind velocity, and other weather conditions; and by the munitions from which the agent is disseminated. The persistency of the agent may be varied by altering the explosive force of the bursting charge of a chemical shell; and by terrain, soil, and vegetation.

Chemical agents which evaporate within ten minutes, or which form a smoke cloud upon release, are called *non-persistent* agents. Those that remain at the point of release as a liquid or solid for 10 minutes or longer in dangerous amounts are called *persistent* agents.

Painting & Markings for Chemical-Filled Ammunition. Chemical munitions are painted a characteristic blue-gray. The particular agent used as a chemical filler is indicated by the markings that appear on the ammunition.

Casualty producing agents are identified by the C.W.S. (Chemical Warfare Symbol) and the word GAS stenciled in green.

Agents which produce casualties as well as being persistent are marked with two green bands stenciled on the ammunition.

Non-persistent agents have only one green band stenciled on the ammunition.

Harassing Agents are identified by CWS, the word "GAS", and one band—all stenciled in red.

Screening Agents are identified by CWS, the word "SMOKE", and one band—all stenciled in yellow.

Incendiary Agents are identified by the CWS, the word "INCENDIARY," and one band—all stenciled in purple.

Types of Chemical Fillers

Mustard (H). The king of the war of gases is mustard. It is a dark brown liquid which slowly evaporates into a colorless gas, giving off the odor of garlic. It is persistent from 3 days to several weeks. The principal physiological effect of the gas is that of a vesicant, although the blistering does not ordinarily appear for several hours. Mustard is used to neutralize areas, contaminate materiel, cause casualties, and harass enemy personnel. It will also render food and water unfit for use.

Lewisite (L). A dark brown liquid which evaporates as a colorless gas. It has the odor of geraniums. Lewisite in the pure form is odorless. In addition to being a vesicant and lung-irritant, lewisite is a systemic poison. It is persistent from 24 hours to a week. The tactical use of L is the same as that for H. It renders food and water permanently unfit for use.

Chlorpicrin (PS). An oily liquid which changes slowly in the open to a colorless gas with the odor of flypaper. It is persistent from 1 hour to 1 week. Chlorpicrin is a lung irritant. In addition it causes nausea, vomiting, and some lacrimation. For this reason it has sometimes been called "vomiting gas." Tactically it is used in heavy concentrations as a casualty agent and in lighter concentrations as a harassing agent. Contaminated food and water may be rendered fit for use under the direction of a medical officer.

NC. A mixture of chlorpicrin and stannic chloride. Its odor is that of chlorpicrin, and in addition it may be detected by the fumes or smoke produced when it is exposed to air. Its tactical use and physiological effect are similar to PS. NC is slightly corrosive to the skin; contact should be avoided.

Phosgene (CG). Normally a colorless liquid with an odor resembling ensilage or fresh-cut hay. It is non-persistent. CG is a casualty producing lung irritant. In high concentrations it produces immediate injury to the lungs manifested by gasping, painful breathing, and weakness. In low concentrations phosgene is not irritant, but when breathed for some time may produce a type of chemical pneumonia. The effect is often delayed several hours, after which time the victim suddenly collapses. The effect of phosgene in low concentrations is greatly intensified if the individual is called upon to work, to march, or is exposed to cold after breathing in the gas.

SYMBOL	AGENT	TACTICAL CLASSIFICATION AND MARKINGS					Physiological Classification						AMMUNITION EMPLOYING CHEMICAL FILLERS								
		Casualty	Harassing	Screening	Signalling	Incendiary	Lung Injurant	Vesicant	Lacrimator	Irritant Smoke	Incendiary	Systemic	75 mm G	75 mm How	105 mm How	155 mm How	155 mm Gun	Mortar Shells	Grenades	Rockets	Bombs
H	Mustard	H GAS	H GAS					√					M64 Mk. II	M64	M60	Mk. II Mk. II A1 Mk. II A1-Mod M105 M110	Mk. VII Mk. VIIA1 M104	81 mm M57 4.2" M2			100 lb. M47A2 115 lb. M70
L	Lewisite	L GAS	L GAS					√													115 lb. M70
NC	Chloropicrin and Stannic Chloride	NC GAS					√						Mk. II								
CG	Phosgene	CG GAS					√											4.2" M2			500 lb. AN M78 1000 lb AN M79
AC	Hydrocyanic Acid	AC GAS										√									500 lb. AN M78 1000 lb. AN M79
CN	Tear Gas Chloracetophenone		CN GAS						√										M7		
CNS	Tear gas solution CN - Chloropicrin - Chloroform		CNS GAS						√				M64	M64		Mk. IIA1 Mod I M110		4.2" M2			
CNB	Tear gas solution CN - benzene - carbon tetrachloride		CNB GAS						√									4.2" M2			
DM	Adamsite		DM GAS							√									M6		
FS	Smoke Sulfur trioxide solution			FS SMOKE									Mk. II	M64	M60	Mk. II Mk. IIA1 M110 M105	Mk. VIIA1 M104	81 mm M57 4.2" M2			100 lb. T8
HC	Smoke			HC SMOKE	HC SMOKE								M89		M84	M115 M116		60 mm T8	AN M8 M15	T27E1	
WP	Smoke	WP SMOKE		WP SMOKE		WP SMOKE					√		Mk. II M64	M64	M60	Mk. II Mk. IIA1 M110 M105	Mk. VII Mk. VIIA1 M104	81 mm M57 60 mm T6 4.2" M2		T26E1	100 lb. M47A1 100 lb. M47A2 10 lb. M67
FM	Smoke			FM SMOKE									Mk. II					4.2" M2			
TH	Thermit					TH INCENDIARY					√										4 lb. AN-M54 2 lb. AN-M52 4 lb. AN M50A1
IM	Gelatinized Gasoline					IM INCENDIARY					√								M3		100 lb. M47A2
NP	Gelatinized Gasoline					NP INCENDIARY					√								M3		6 lb. M69

Primary Classification   Additional Classification

Figure 3. Chemical Fillers of Ammunition.

Hydrocyanic Acid (AC). A non-persistent, casualty producing systemic poison with an odor of bitter almonds or crushed peach kernels. It is a liquid which boils at 80° F, which means that AC would automatically become a gas on warm summer days. In large concentrations it has a fishy odor. It poisons the nerves and causes death from paralysis of the central nervous system. The gas is much lighter than air and therefore rises very rapidly. For this reason, hydrocyanic acid would be effective only in closed places, such as dug-outs, pill boxes, and tanks.

Tear Gas (CN), Chloracetophenone. A solid substance with a faint fragrant odor, which resembles that of apple or locust blossoms. Its physiological reaction is extreme irritation of the eyes. It imparts only a disagreeable taste to food and water.

Tear Gas Solution (CNS). A mixture of CN, PS, and Chloroform with a faint odor of fly paper. CNS is persistent from 1 hour to 1 week. It is a typical lacrimator and is used as harassing agent.

Tear Gas Solution (CNB). A mixture of CN, carbon tetrachloride, and benzene, with a benezene odor. It is a lacrimator less severe than CNS.

Adamsite (DM). A solid which is dispersed by burning type munitions and appears as a yellow smoke with an odor somewhat resembling coal smoke. It is a typical sternutator causing lacrimation, violent sneezing, intense headache, nausea, and temporary physical infirmity. Its tactical use is as a harassing agent and it may only be used from burning type munitions. It renders food and water permanently unfit for use.

Smoke (FS). A sulfur trioxide-chlorsulfonic acid. It is a liquid, which when dispersed into a humid atmosphere, produces a dense white smoke. The smoke is harmless to personnel except in heavy concentrations. Liquid FS renders food and water unfit for use; the smoke merely imparts an unpleasant taste.

Smoke (HC). Hexachlorethane-Zinc. A mixture which has no harmful physiological effects and which can be used only in burning types of ammunition.

Smoke (WP). White Phosphorus is a yellow waxy substance which ignites spontaneously and produces a dense white smoke. Its principal use is to produce smoke, although it is an incendiary and casualty agent as well. WP is used only in explosive type ammunition. When a projectile filled with WP explodes it scatters small pieces of Phosphorus which ignite spontaneously. These particles continue to burn even when embedded in the flesh. The 4.2" Chemical Mortar Shell M2 filled with WP was used very effectively recently in the Italian Campaign for routing the enemy out of fox-holes and dug-outs. Phosphorus smoke is uncomfortable to breath, but harmless; however, the particles will poison food and water.

Smoke (FM). Titanium Tetrachloride which is similar to FS in appearance, properties and use.

Thermit (TH). An intimate mixture of iron oxide and finely powdered Aluminum. It is in the form of a dark gray granular mass. When ignited, it burns with great rapidity with the evolution of extreme heat, the iron oxide being reduced to boiling molten iron. This material is colorless. The average Thermit has a persistency of about 5 minutes. There is no physiological effect derived from Thermit other than that of burns from the hot metal. If any of the material gets on skin or clothing it will cause severe burns.

Gelatinized Gasoline (IM), (NP). Gasoline thickened to gels and used as incendiary mixtures.

SMALL ARMS AMMUNITION

Small arms ammunition is defined as "ammunition fired in weapons whose bore is 0.60 inches or less in diameter." This classification refers to individual weapons normally accompanying foot troops and will include caliber .22, .30, .45, .50, and .60.

One exception to this definition is shotgun ammunition. The diameter of the bore of a 12-gage shotgun is approximately 0.785 inches. However, since the shotgun is similar to the other small arms weapons, it is included in that category.

Complete Rounds

A round of small arms ammunition is known as a cartridge. In general, it consists of a bullet, a propelling charge, a primer, and a cartridge case assembled into one unit.

Bullets for service use generally have a metal core and a gilding metal jacket. Propelling charges consist of smokeless powder. Single perforated grains glazed

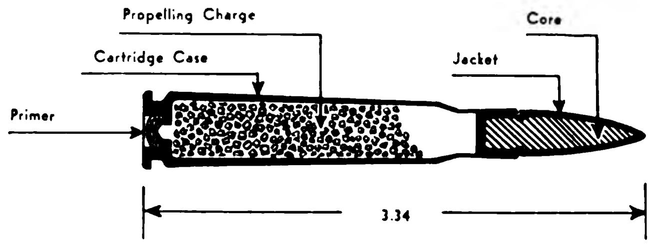


Figure 4. Complete Round.

with graphite are normally used. The powder charge is loaded loosely in the cartridge case. The primer is made of a soft metal cup containing a sensitive priming composition which will produce a flame at the shock of the firing pin. The cartridge case is either brass or steel and prevents the escape of gases to the rear. It also holds the other components together.

Classification

Small arms ammunition is classified according to its purposes. The rounds which are used in actual combat are called "service" rounds, and those designated for some particular use are called "special purpose." The service rounds are ball, armor piercing, tracer, incendiary, rifle grenade, and armor piercing incendiary. The special purpose rounds are blank, dummy, guard, high pressure test, and subcaliber. Shot gun shells must be classed separately.

SERVICE ROUNDS CALIBERS .30 AND .50. Since the service rounds are the ones most commonly encountered they are the only types which will be discussed in detail.

Ball ammunition is effective against personnel or light materiel. The bullet contains a slug of hardened lead. In the case of the cal .50 type, the core is of soft steel, which gives it ballistic properties similar to the armor-piercing bullet.

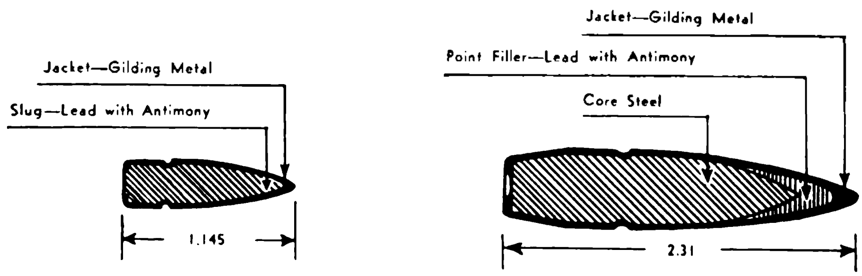


Figure 5. Bullet, Ball, Cal .30 M2. Bullet, Ball, Cal .50 M2.

Armor-piercing ammunition has a bullet containing a hardened steel core. It is to be used against armored aircraft, vehicles, concrete shelters, and other bullet resisting targets. Depending upon the type considered, point or base fillers of lead or aluminum are used for filling in the spaces between the steel core and jacket.

Tracer ammunition has a bullet containing a chemical composition in the rear which is ignited by the propelling charge and which burns in flight. It is used for observation of fire, for incendiary purposes, and for signaling. The forward half of the bullet contains a lead slug.

Incendiary bullets contain a composition which gives off a great amount of heat upon impact, thereby setting fire to inflammable objects.

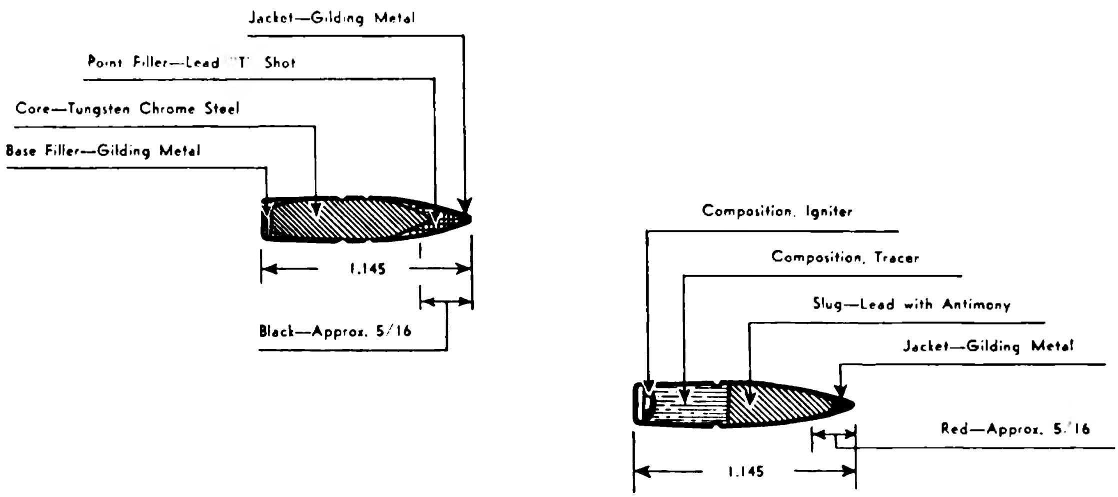


Figure 6. Bullet, Armor Piercing, Cal .30 M2. Bullet, Tracer, Cal .30 M1.

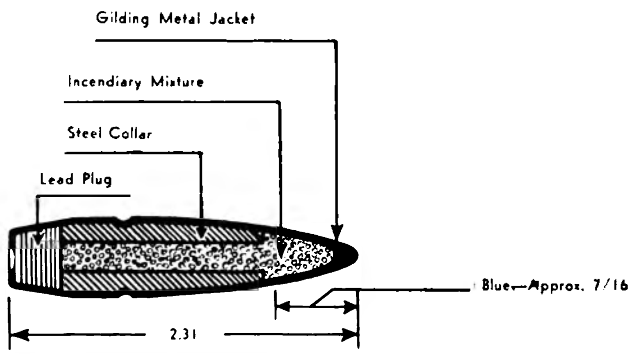


Figure 6A. Bullet, Incendiary, Cal .50 M1.

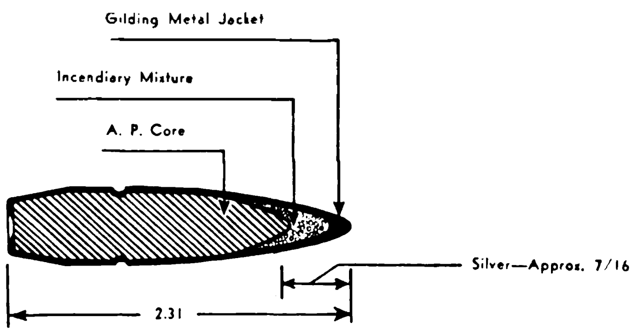


Figure 6B. Bullet, API, Cal .50 M8.

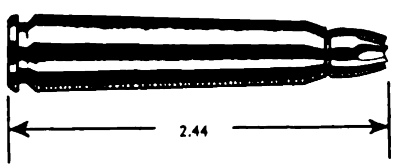


Figure 6C. Cartridge, Rifle Grenade. Cal .30 M3.

Armor piercing incendiary bullets penetrate armor plate and then act as an incendiary round.

The rifle grenade cartridge has no bullet. It contains a large charge of fast burning powder and is used to project rifle grenades from the rifle or carbine.

SPECIAL PURPOSE ROUNDS, CALIBERS .30 AND .50. *Blank* rounds contain no bullet. They contain a charge of EC Powder and are used for simulated fire, signaling, and salutes.

Dummy ammunition has no propelling charge or primer. It is used for training.

Guard type has a reduced propelling charge. It is used for guard purposes.

High-pressure test has an augmented propelling charge. It is used only in proof firing.

Subcaliber type has a rimmed cartridge case. It is used in subcaliber tubes and mounts in cannon. Subcaliber weapons are discussed in chapter 2, entitled Artillery.

CARBINE. Carbine ammunition cannot be fired in the other .30 caliber weapons. The cartridge case is smaller and tapers slightly along its entire length in place of having a definite shoulder. The bullet has a rounded nose. The service rounds are ball, tracer, and rifle grenade cartridges. Special purpose rounds include dummy and high pressure test.

CALIBER .45. Cal .45 ammunition is limited in service rounds to three standard types. One of these is the ball round which, except for size and weight, parallels the cal .30 ball. Another round is called a "chilled shot." It contains a large quantity of no. 7½ chilled shot and will be used for hunting purposes only. Tracer ammunition is the third type but is used only in submachine guns.

The special purpose cal .45 rounds used are blank, dummy, and high-pressure test.

SHOT GUN AMMUNITION. Shot gun shells differ depending upon whether they are intended for guard and combat use, or for hunting and trap shooting. The former have a brass head extending at least 1 inch along the case. The latter have a head extending only ½ inch along the case. The shell body is made of paper and waterproofed. The brass head is attached to the body by crimping.

The size of the leadshot for each type is as follows:

Guard or Combat	*Hunting or Trap Shooting*
No. 00 Buck Shot	No. 7½ Chilled Shot
No. 4 Chilled Shot	No. 9 Chilled Shot

Characteristic data for the various types of small arms ammunition are listed in Table II.

GRADING. Various types of weapons, rifles, ground machine guns, aircraft machine guns, etc., have different ammunition requirements and tolerances for reliable operation. Ammunition may differ in dimensions and characteristics due to variations in manufacture which are the results of mass production. Consequently, each lot of ammunition must be graded in accordance with acceptance test to designate its use in the different types of weapons.

Current grades of all existing lots of small arms ammunition are established by the Chief of Ordnance as a result of inspection and are published in SB 9-AMM 4. Grades are not marked on or in the packing box.

Calibers .30 and .50 Ammunition

The following grades have been established for calibers .30 and .50 ammunition as most appropriate for use in the specific type of weapon:

Aircraft machine gun	AC.
Aircraft machine gun or rifle	AC or R.
Rifle	R.
Ground machine gun	MG.
Unserviceable	3.

The following grade of calibers .30 and .50 ammunition may be used in the weapons specified below. They are listed in order of priority of issue and use:

For Caliber .30.

Grade AC; AC or R	for AC machine gun.
Grade AC, AC or R; MG; R	for AA machine gun.
Grade R; AC or R	for rifles, semi-auto and auto.
Grade MG; R; AC or R; AC	for ground MG.
Grade 3	not to be issued or used.

For Caliber .50

Grade AC	for AC machine guns.
Grade AC; MG	for AA machine guns.
Grade MG; AC	for ground machine guns.
Grade 3	not to be issued or used.

Caliber .45 Ammunition

The following grades have been established for Cal .45 ammunition:

Grade 1—For cal .45 revolvers, pistols, and submachine guns.
Grade 2—For cal .45 pistols and submachine guns only.
Grade 3—Not to be issued or used.

Priority of Issue.

In order to provide a sequence for the issuance of small arms ammunition, the following priorities of issue have been established.

1. Those lots marked with an asterisk in SB 9-AMM 4.
2. Lots containing less than 20,000 rds.
3. Lots marked "Repacked Liners not Sealed."
4. Lowest or oldest numbered lots.

Defects found on Visual Examination.

The following defects may be found in cartridges on visual examination before firing.

Name of defect	How to recognize	Common causes—precautions
(1) Body or shoulder splits.	Pressing with the thumb on cartridge case, near neck.	Improper annealing, weak structure and strain. Should not be fired.
(2) Corrosion	Coloring of cases (green, blue, yellow, or white colors). Also appearance of chemical deposit. Not to be confused with true discoloration; blackening of case.	Metal eaten into and weakened; will cause rupture when cartridge is fired. Deposit interferes with chambering. Cartridges showing advanced corrosion should not be fired.
(3) Crease	Similar to a fold in case neck or shoulder.	Thin metal at crease spot.
(4) Draw scratch	Longitudinal scratch on case.	Caused by grit in the final draw die. Deep scratch will open up on firing.
(5) Folded neck	Overlapping of metal in case and neck indicated by longitudinal protuberance.	Metal thinner on one side; insufficient annealing.
(6) Indent and bur	Indentations and burring.	Rough handling during manufacturing process. Dangerous pressure only if dent is large.
(7) Inset primer	Primer set too deep in pocket.	Likely to misfire. Should not be used.
(8) Loose rounds	Bullet loose in case	Should not be fired.
(9) Mouth pulldown	Mouth of case shoved to one side by bullet when seated in case.	Mouth annealed very soft.
(10) Oil dent	Smooth surface indent in or near shoulder or neck of case.	Excess of oil used in tapering operation. Negligible defect unless extremely large.
(11) Round head	Head of cartridge case beveled on outer edge so that it is practically round.	Too little metal in head to form properly; also a thick-headed cartridge appears as a round head. Causes trouble in extraction.
(12) Scale	Inclusions of impurities in the metal, sometimes observable to the eye, sometimes hidden.	Causes irregular break in cartridge case and loss of velocity due to escape of gas when fired.
(13) Season crack	Split in the neck of case. Definite longitudinal cracking when exposed to severe weathering conditions or certain reagents.	Due to the distortion of the normal crystalline structure of the metal as result of drawing and tapering operations (not to be confused with split necks occurring after firing.)
(14) Short rounds	Bullet seated too deep	Not serious unless it is so deep as to affect density of charge.
(15) Shoulder bulge	Pucker at the junction of shoulder and body.	Metal too soft or thin at this point. Also by forceful seating of bullet.
(16) Split bullets (tracer)	Longitudinal cracks in the bullet.	Ruptures neck of cartridge case. Free mercury from tracer mixture amalgamates with metal of bullet causing the split. Serious defect; to be reported when found.
(17) Split mouth	Split in edge of case	Often result of plugging operation.
(18) Thick head	Head of case has a thickness of metal greater than the maximum allowed.	Extractor may not be able to function.
(19) Thin head	Head of case has a thickness of metal less than minimum allowed.	Extractor may pull through thin metal of the head.

Table II

Type	Cart. Case	Jacket	Bullet Core	MV ft/sec	Approx. max. range (Yds)	Remarks
Cal .30						
Ball M1	Brass	Gilding metal	Lead antimony	2647	5500	CC has numerals "25" and above on head.
Ball M2	Brass	Gilding metal	Lead antimony	2805	3500	CC has numerals 38 and above on head (38-40 jacket tinned, 40 up not tinned)
Tracer M1	Brass	Gilding metal	Lead antimony Tracer mixture	2715	3450	Tip of bullet painted red. Range of trace 750 yards from weapon.
AP M2	Brass	Gilding metal	Lead point Tungsten chrome steel	2775	3500	Tip of bullet painted black.
Incendiary M1	Brass	Gilding metal	Incendiary mixture	*	*	Tip of bullet painted blue.
Rifle Grenade M3	Brass	....	....	....	....	Mouth of CC rose crimped.
Blank M1909	Brass	....	....	....	....	Mouth of CC roll cumped.
Guard M1906	Brass (6 flutes)	Cupro-nickel	Lead antimony	1200	2000	6 short corrugations below neck of CC.
Guard M1	Brass	....	Lead	1200	2500	Formerly gallery practice M1919.
Dummy (corrugated) M1906 prior to 15 Jan 40	Brass (tinned) 6 corrugations 3 holes	Cupro-nickel	Lead antimony	....	....	....
Dummy corrugated M1906 (after 15 Jan 40)	Brass (tinned) 6 corrugations No holes	....	....	....	....	May use M1906 M1 or M2 bullets.
Dummy slotted M1	Brass 1 slot near head	Gilding metal	Lead antimony	....	....	Range dummy.
Dummy M2	Brass (tinned) no slot	Gilding metal	Lead antimony	....	....	Used in inspection of weapon, not issued to troops.
High Pressure Test M1	Brass (tinned) "Test" on head	Gilding metal	....	....	....	Used to test for breech pressure, not issued to troops.
Subcaliber M1925	Brass extracting rim	Gilding metal	Lead	1990	4300	Used only in "Krag" type rifle barrel chambers.

Table II—Continued

Type	Cart. Case	Jacket	Bullet Core	MV ft/sec	Approx. max. range (Yds)	Remarks
Cal .50						
Ball M2	Brass	Gilding metal	Soft steel w/lead antimony point filler	2935	7200	....
Tracer M1	Brass	Gilding metal	Lead antimony Tracer mixture	2865	3500	Tip of bullet painted red. Range of trace 1600 yards from weapon.
Tracer M10	Brass	Gilding metal	Lead antimony Tracer mixture	*	*	Tip of bullet painted orange. Range of trace 1600 yards from weapon.
Armor-piercing M2	Brass	Gilding metal	Lead antimony Tungsten chrome steel	2935	7200	Tip of bullet painted black.
Incendiary M1	Brass	Gilding metal	Incendiary mixture	*	*	Tip of bullet painted blue.
Armor-piercing Incendiary M8	Brass	Gilding metal	Tungsten chrome steel Incendiary mixture	*	*	Tip of bullet painted silver.
Dummy M2	Brass (tinned) 3 holes	Gilding metal	Soft steel w/lead antimony point filler	....	....	....
Blank M1	Brass	....	....	....	....	Mouth of Cart C roll crimped.
High Pressure Test M1	Brass (tinned) "Test" on head	Gilding metal	Lead slug in two parts	....	....	Used to test for breech pressure. Not issued to troops.
Cal .45						
Ball M1911	Brass gilding metal primer cup	Gilding metal	Lead antimony	Pistol 825 Submachine gun 990	Pistol 1600 Sub-MG 1700	Old jackets cupro nickel. Next jacket gilding metal-tinned. Present jacket gilding metal.
Shot M15	Brass	....	....	*	40 ft	CC is elongated w/approx 130 no 7½ chilled shot.
Dummy M1921	Brass Inert Primer - 3 holes. No Primer- No holes	Gilding metal	Lead antimony	....	....	Used in Sub-MG.
Blank M1	Brass has extracting flange	....	....	....	....	Fired in revolvers only.
High Pressure Test M1	Brass (tinned) "Test" on head	Gilding metal	Lead antimony	....	....	Used to test for breech pressure. Not issued to troops.

Armor Penetration

It is the purpose of this section to provide information pertaining to the performance of armor-piercing projectiles against homogeneous and face-hardened armor plate. The various theories and analyses of the mechanics of armor penetration will not be dealt with in this discussion, although such knowledge is necessary for better evaluation of results obtained from test firings of projectiles against armor plate. It also allows these findings to be interpreted more easily and accurately. It is from the test firing that data are obtained and compiled as a basis for determining penetrations.

Armor Penetration and Striking Velocity Curves. Penetration data have been compiled for all standard projectiles when fired against armor plate at various angles of impact. Striking velocity and penetration curves have been prepared for each projectile against homogeneous and face-hardened plate. From the charts, the thickness of armor plate which can be penetrated, together with corresponding range and striking velocity, can be determined for each projectile. It will be noted that certain portions of the penetration curves are shown by broken lines. These represent an estimated performance for which actual firing data have not been obtained. The penetration curves represent average values for an intact projectile completely penetrating the plate.

Illustrative Examples on Use of Curves. The following examples and chart are given to illustrate the use of the striking velocity and armor penetration curves. The range scale in yards and the penetration scale in inches are shown along the bottom of the chart and the striking velocity in feet per second is shown along the left-hand border. The striking velocity curve is designated by showing the muzzle velocity upon which it is based. The penetration curves are designated as to the obliquity upon which they are based.

Example I:

Given—3 in. plate thickness.

Required—The striking velocity and maximum range at which penetration at 20° obliquity can be achieved.

Solution—(1) Enter the penetration scale at point "A" which represents 3-in. plate thickness. (2) Proceed upward along the vertical line until the intersection with the 20° obliquity penetration curve is reached at "B." (3) From "B" proceed left along a line until the intersection with the striking velocity curve at "C" is reached. (4) From "C" continue left along the horizontal line to "E" where the striking velocity of 2,160 f/s can be read; then proceed downward from "C" along the vertical line to "D" where the range of 1,430 yd. is found. Thus a striking velocity of 2,160 f/s is needed to penetrate 3-in. of plate and the maximum range at which the projectile will penetrate the plate is 1,430 yd.

Example II:

Given—1,430 yd. range.

Required—The maximum thickness of armor plate which can be penetrated at 20° obliquity and the corresponding striking velocity required.

Solution—(1) Enter the range scale at 1,430 yd. "D" and proceed upward on a vertical line to point "C" where the striking velocity curve is intersected. (2) Proceed right from "C" along a horizontal line to "B" where the penetration curve for 20° obliquity is intersected. (3) Then proceed downward along a vertical line to "A" where a thickness of 3 in. is read. (4) From point "C" proceed left along horizontal line to "E" where a striking velocity of 2,160 f/s is read.

Example III:

Given—2,160 f/s striking velocity.

Required—The range and thickness of 20° obliquity armor plate which can be penetrated.

Solution—(1) Enter the striking velocity scale at point "E" which represents 2,160 f/s. (2) Proceed right to point "C" and then downward along the vertical line to "D" where the range of 1,430 yd. can be read. (3) From point "C" proceed right to "B" and then downward along the vertical line to "A" where the thickness of 3 in. can be read.

ARTILLERY ATTACK ON CONCRETE

Penetration and Perforation. The following considerations, as used in discussion, tables, and charts, apply to attack on concrete targets. *Perforation* of a concrete target, wall or roof, means making a hole all the way through. *Penetration* means making a crater which does not go all the way through. *Depth of penetration* is measured perpendicular to the face of the wall.

Edge Effect. In cases when the target is sufficiently close to have small dispersion of fire the artilleryman can make use of the edge effect under some conditions. Projectiles striking closer than 15 calibers from the edge of a wall (an embrasure usually) penetrate more deeply and remove more concrete than if striking in the center. The effect is marked at 10 calibers from the edge, and best at about 8 calibers. Up to double the normal volume of concrete may be removed by the use of edge effect.

Tables. The tables in this section are based on the following hypotheses:

(a) That data shown are based on firing against the center of a wall, without consideration of edge effect.

(b) Although the penetration decreases with the obliquity of the target, the crater produced is wider than that produced by normal impact. The actual volume of concrete removed per round may even increase for oblique impact. For prolonged fire the obliquity probably does not greatly influence the number of rounds necessary to obtain perforation, up to obliquities of 20° to 30°.

(c) Heavier targets must, in general, be defeated by repeated fire, perforation finally being obtained by having several rounds hit in approximately the same small area. The number of hits necessary in the same crater for perforation increases with range, and the chance of obtaining multiple hits in the same small area decreases with range; therefore the total number of rounds which must be fired to have a high probability of performation increases very rapidly with range to enormous values at the higher ranges.

(d) Data in the tables are calculated by estimating, at the given range, the number of consecutive hits in one small crater necessary to perforate and, from the range table probable errors, the number of rounds which must be fired to obtain this number of hits in this crater. The tables should be of value in determining approximately, at least, the ranges at which various weapons will be effective, and for obtaining some comparison between the different weapons. The absolute numbers must be accepted with some caution.

(e) Especially when the table entry is large (100 or over) there should be a fair fraction of perforations from all subsequent hits. In short, the entries in the table should not be far below the number of rounds necessary to obtain complete destruction of the target, except in the case of the smaller calibers at close range.

(f) The data for the H.E. shell with C.P., T105, Fuze is probably pessimistic, as the H.E. shell with this fuze removes greater volumes of concrete than the A.P. projectiles. For multiple hits, all other factors being equal, the destructive effect of the H.E. shell with this fuze are greater than that produced by A.P. projectiles.

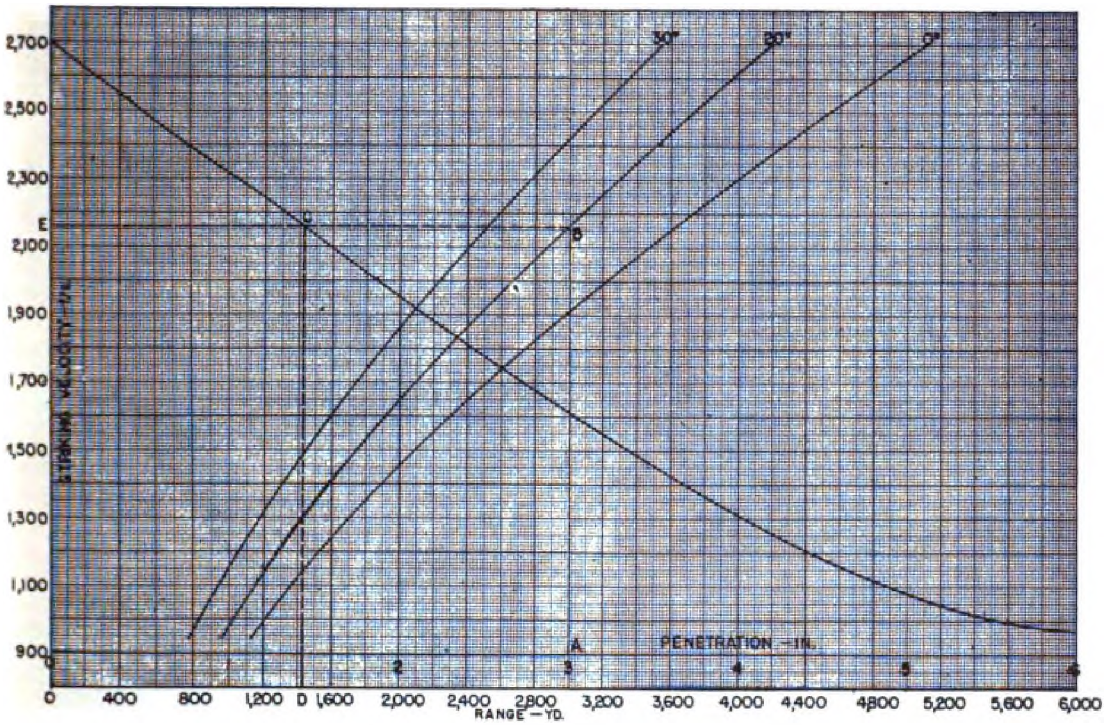


Figure 99. Illustrative Example on Use of Curves.

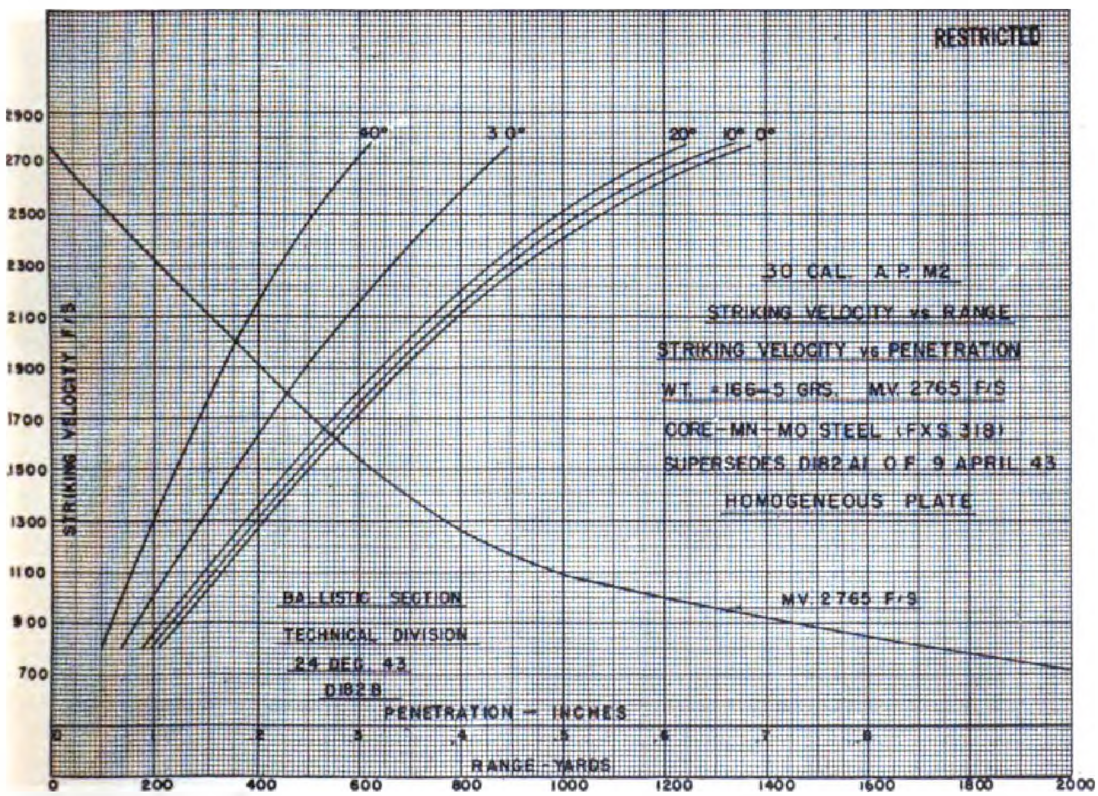


Figure 100. Armor Penetration of Cal .30 A.P. M2—Homogeneous Plate.

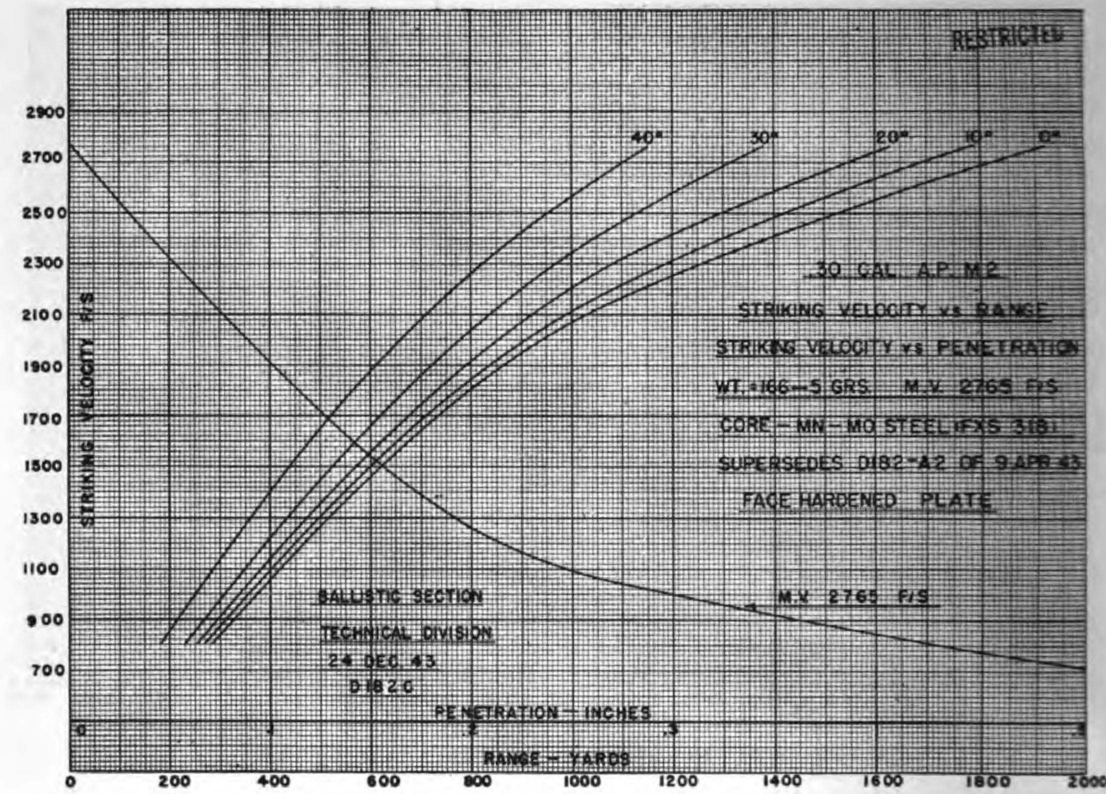


Figure 101. Armor Penetration of Cal .30 A.P. M2—Face Hardened Plate.

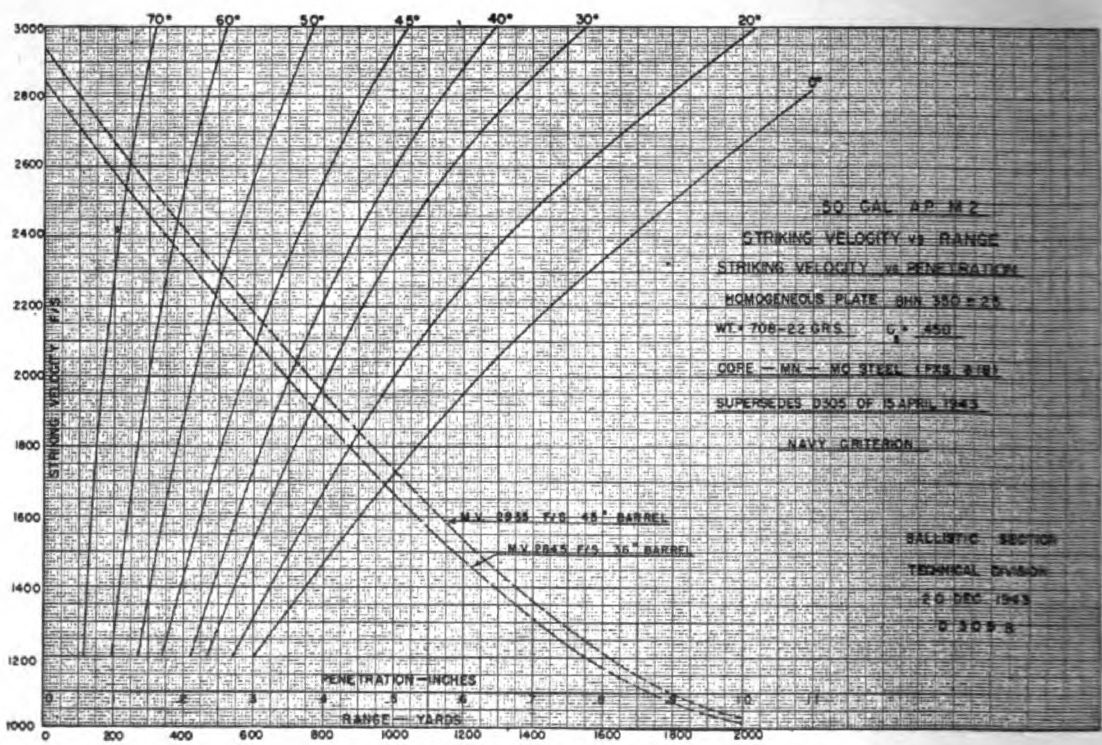


Figure 102. Armor Penetration of Cal .50 A.P. M2—Homogeneous Plate.

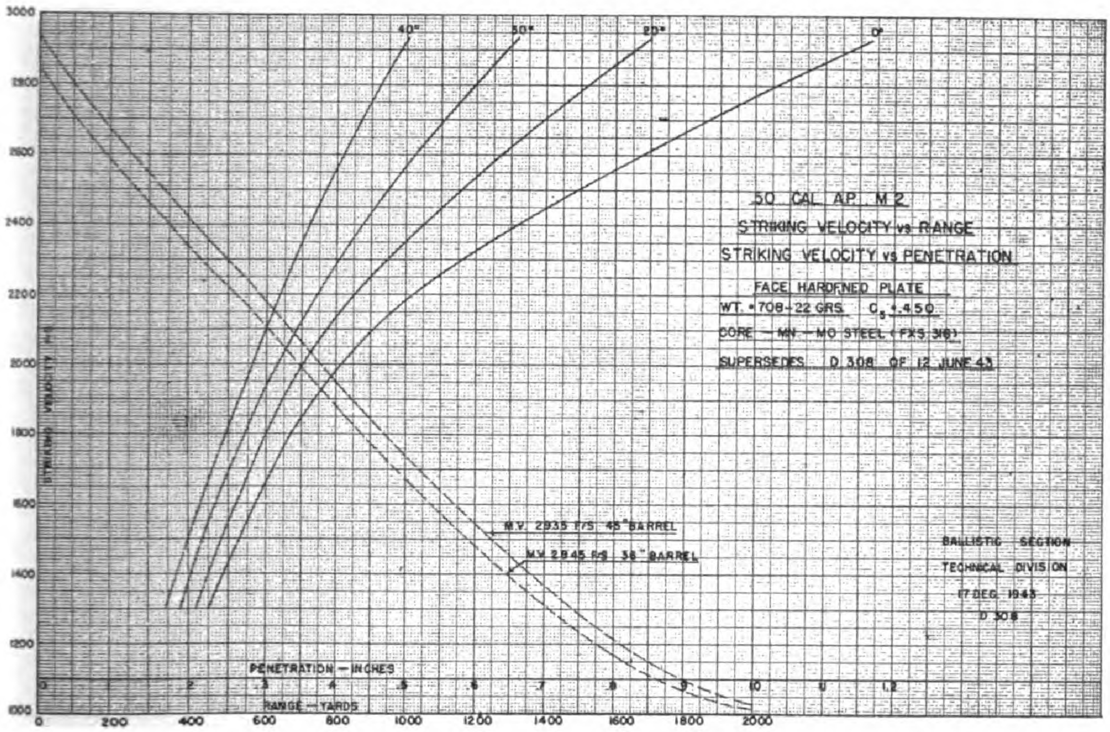


Figure 103. Armor Penetration of Cal .50 A.P. M2—Face Hardened Plate.

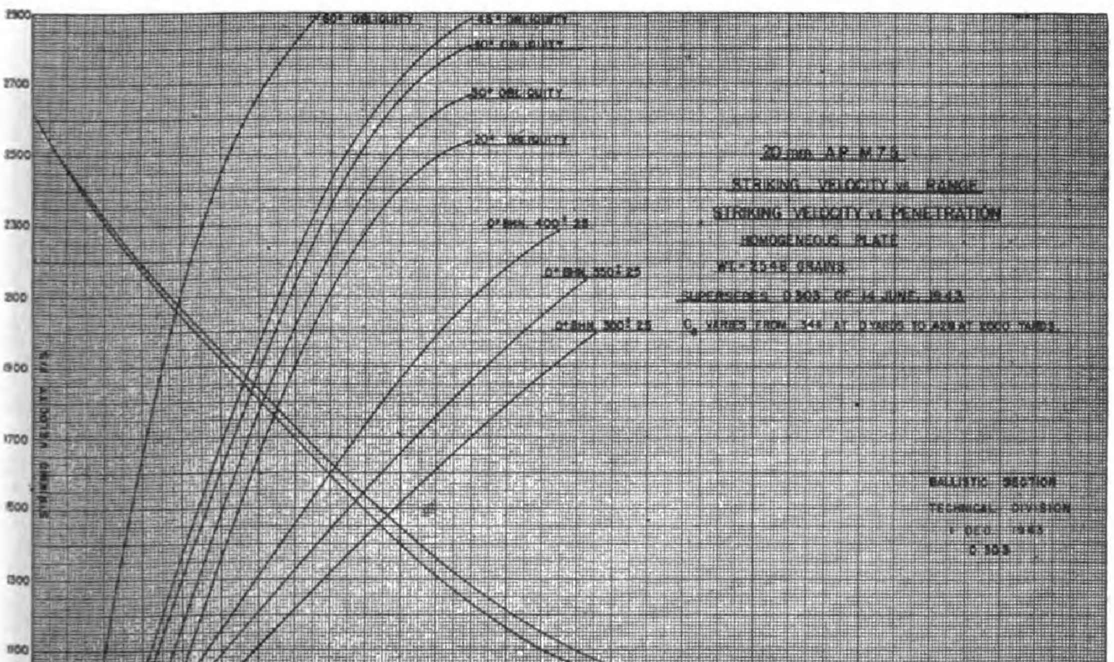


Figure 104. Armor Penetration of 20mm A.P. M75—Homogeneous Plate.

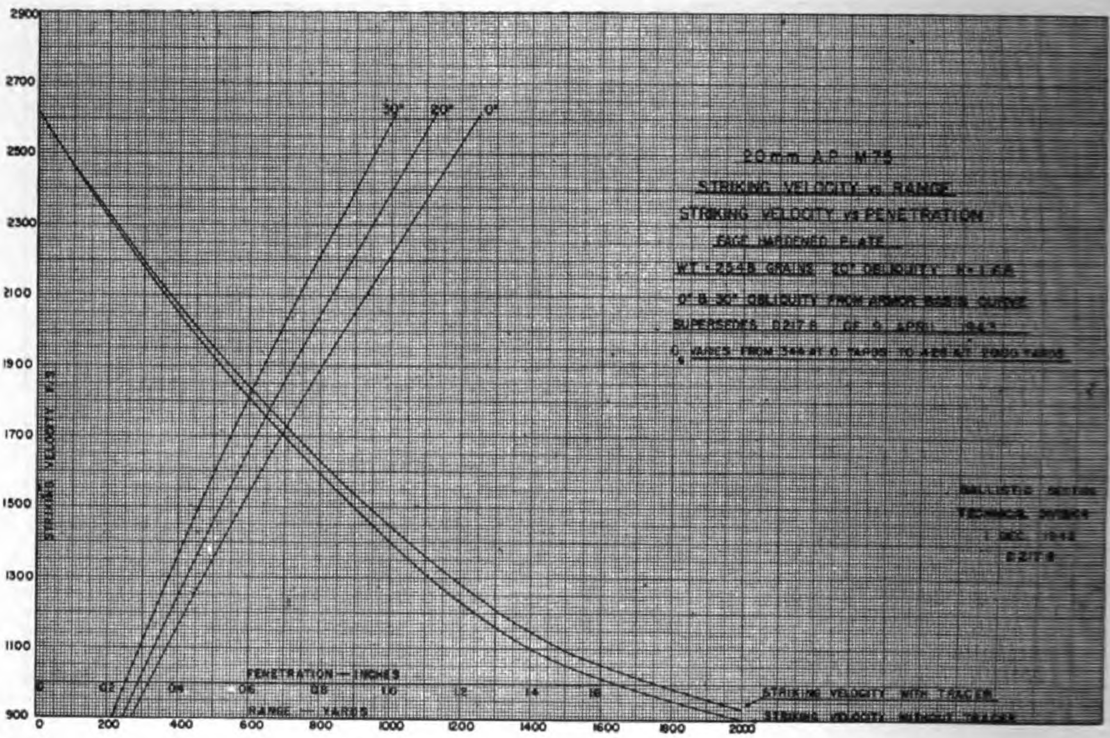


Figure 105. Armor Penetration of 20mm A.P. M75—Face Hardened Plate.

Figure 106. Armor Penetration of 20mm A.P. M95—Homogeneous Plate.

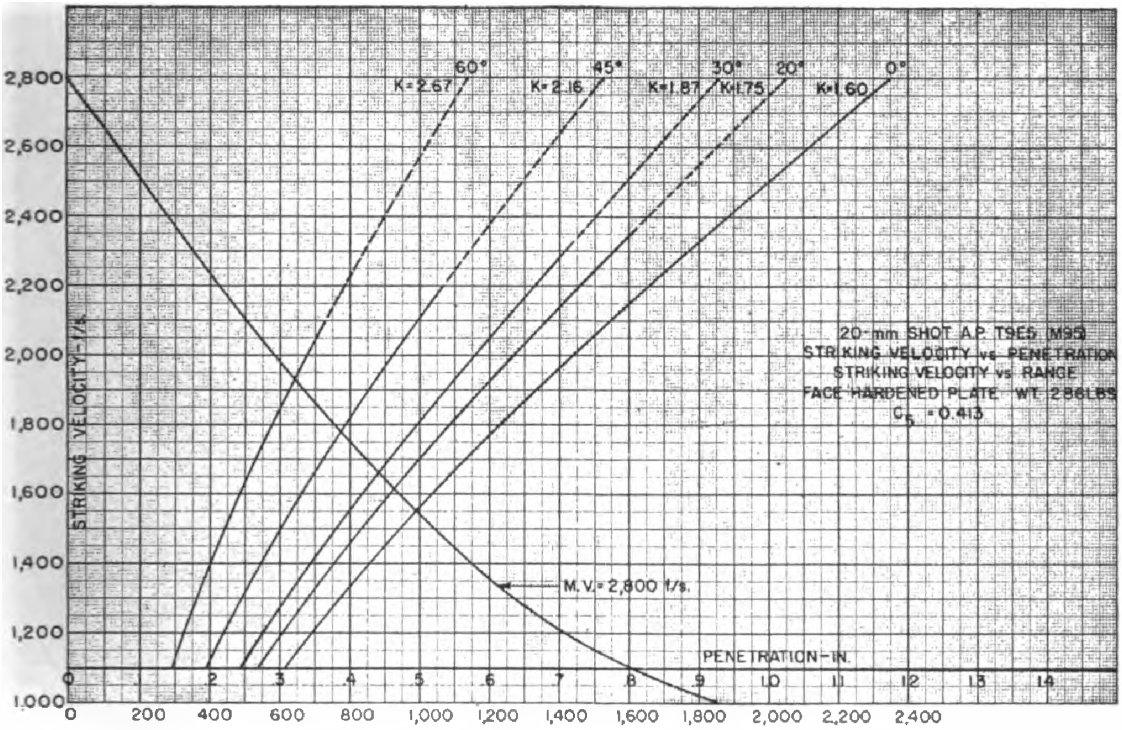


Figure 107. Armor Penetration of 20mm A.P. M95—Face Hardened Plate.

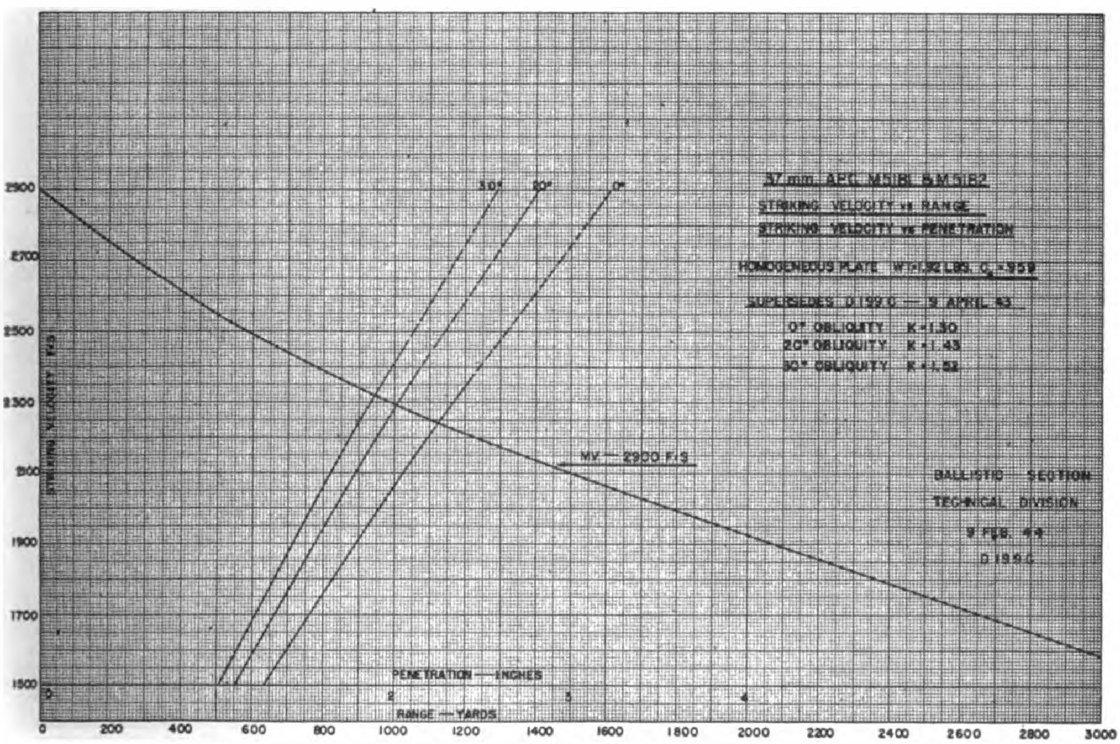


Figure 108. Armor Penetration of 37mm A.P.C. M51B1 and M51B2—Homogeneous Plate.

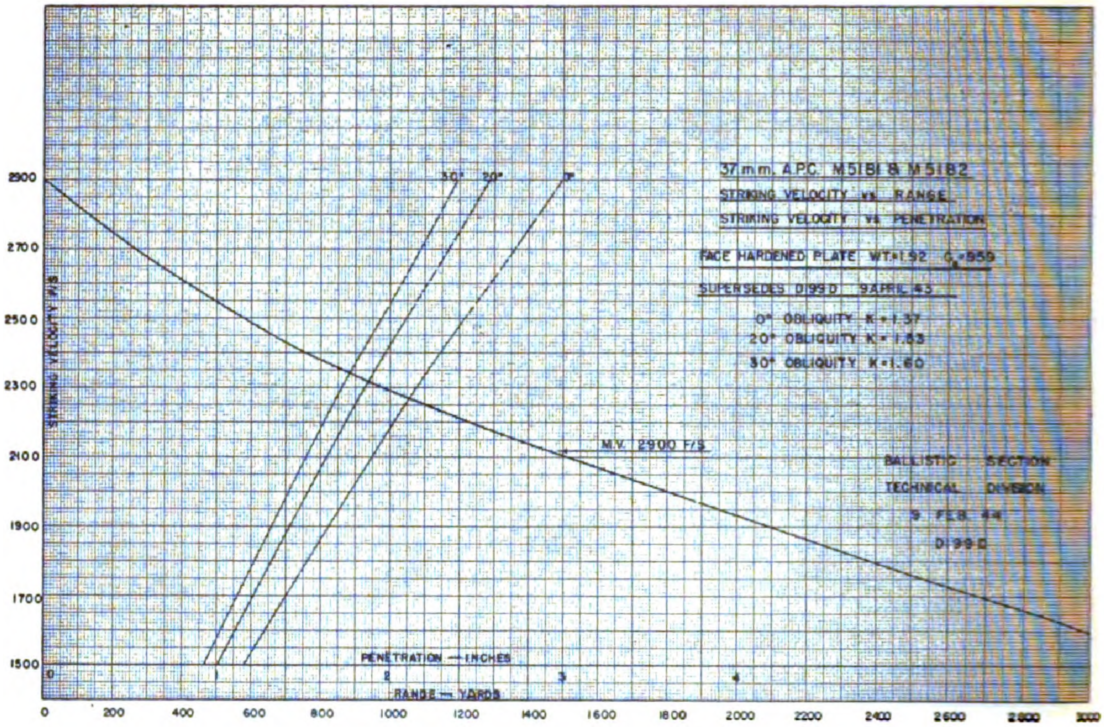


Figure 109. Armor Penetration of 37mm A.P.C. M51B1 and M51B2—Face Hardened Plate.

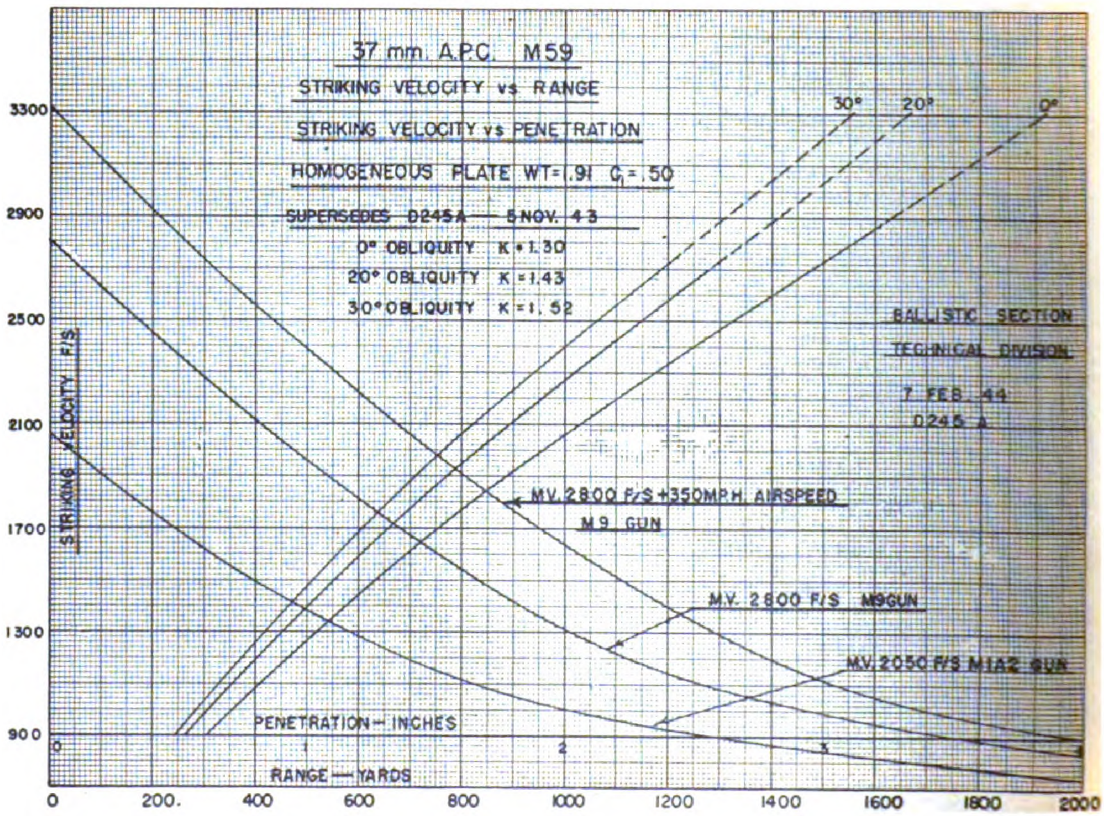


Figure 110. Armor Penetration of 37mm A.P.C. M59—Homogeneous Plate.

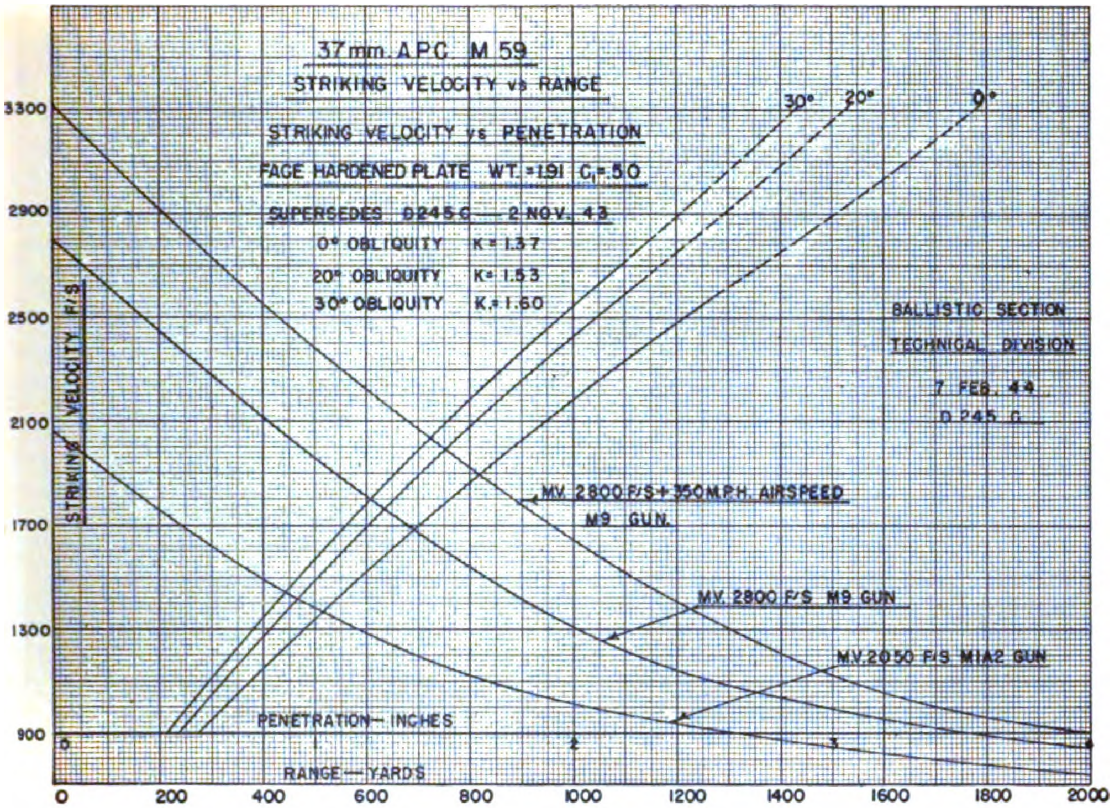


Figure 111. Armor Penetration of 37mm A.P.C. M59—Face Hardened Plate.

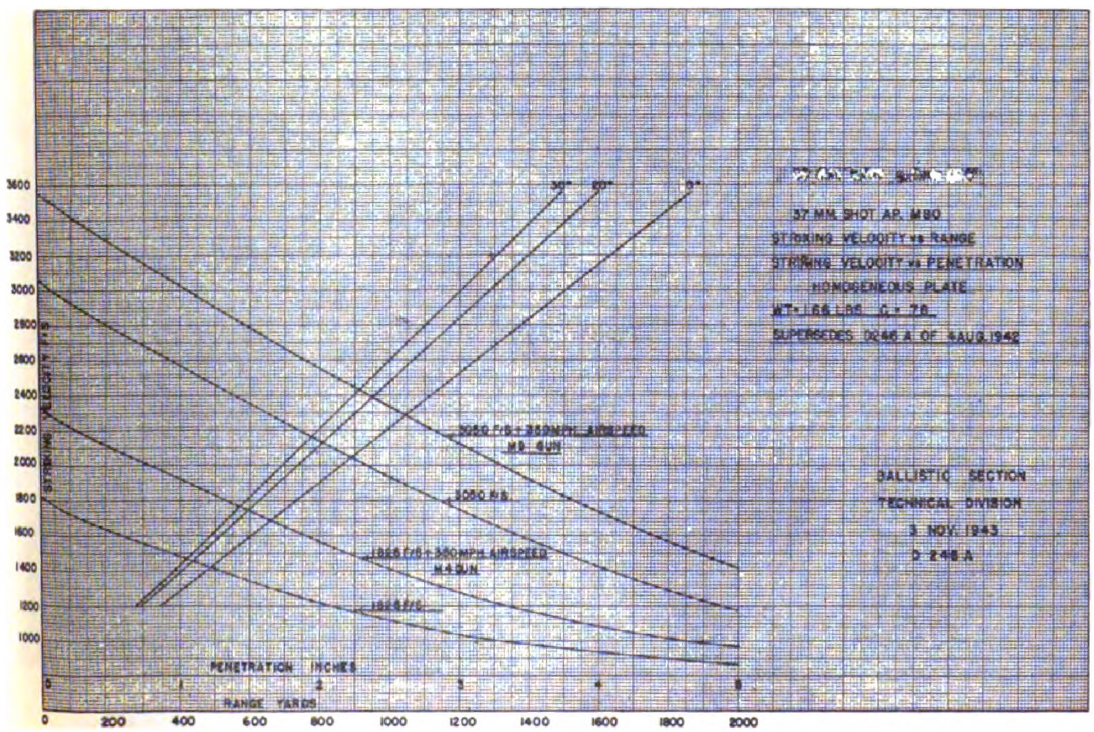


Figure 112. Armor Penetration of 37mm Shot, A.P. M80—Homogeneous Plate.

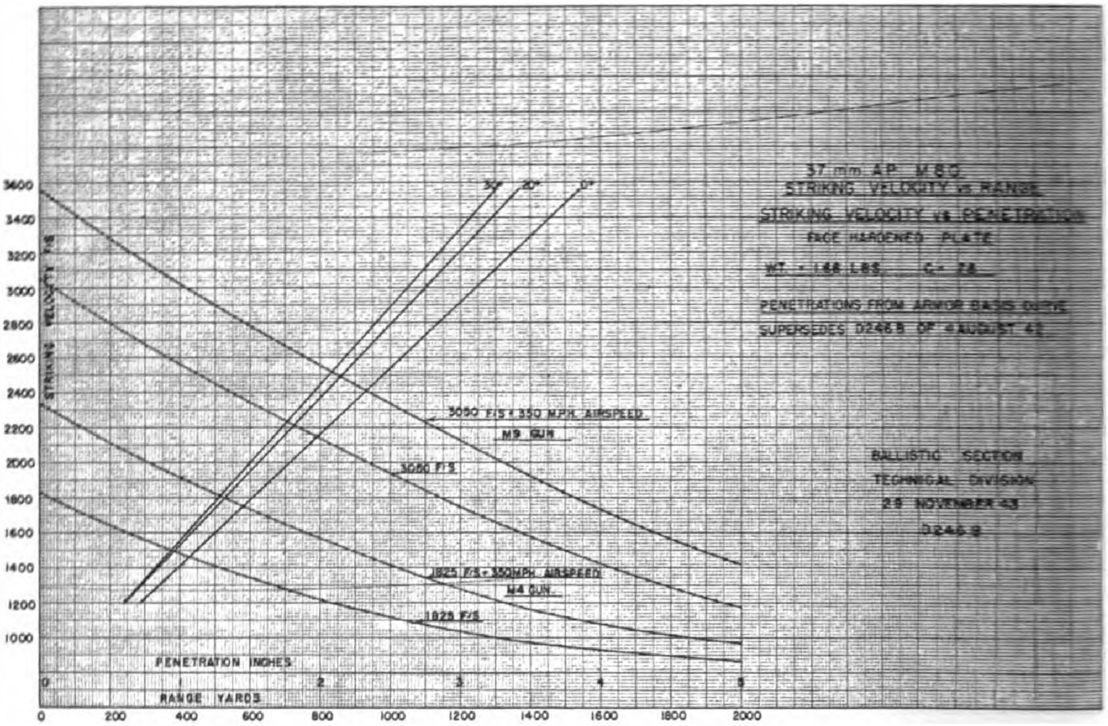


Figure 113. Armor Penetration of 37mm A.P. M80—Face Hardened Plate.

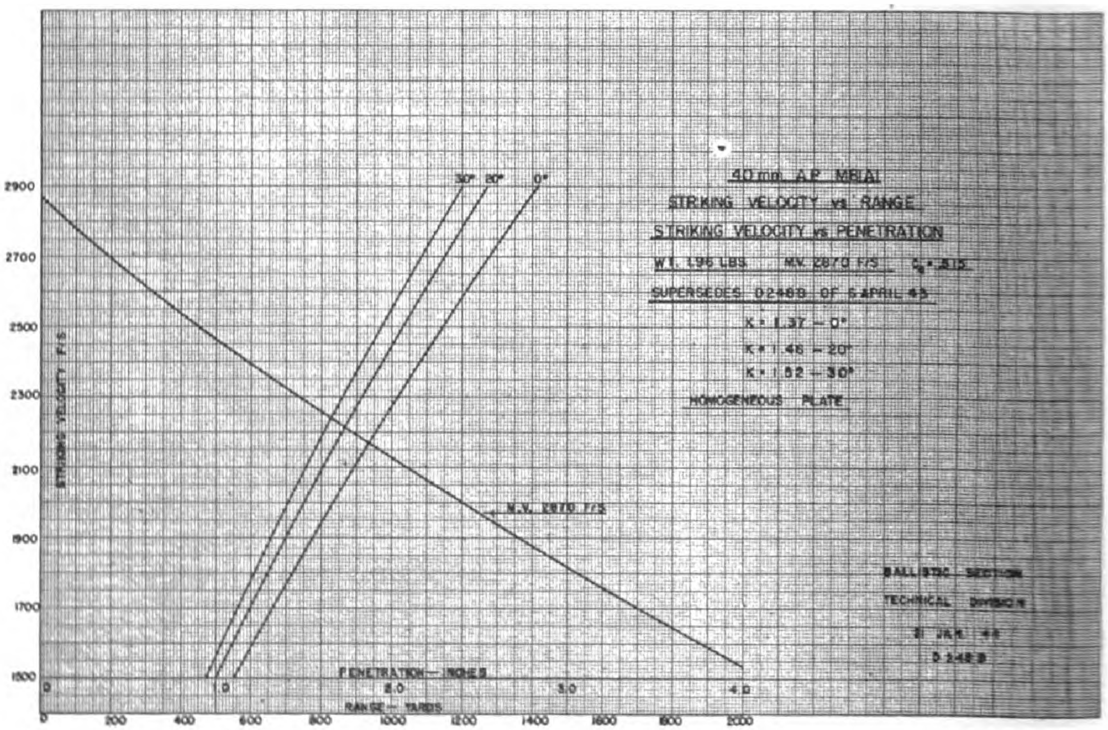


Figure 114. Armor Penetration of 40mm A.P. M81A1—Homogeneous Plate.

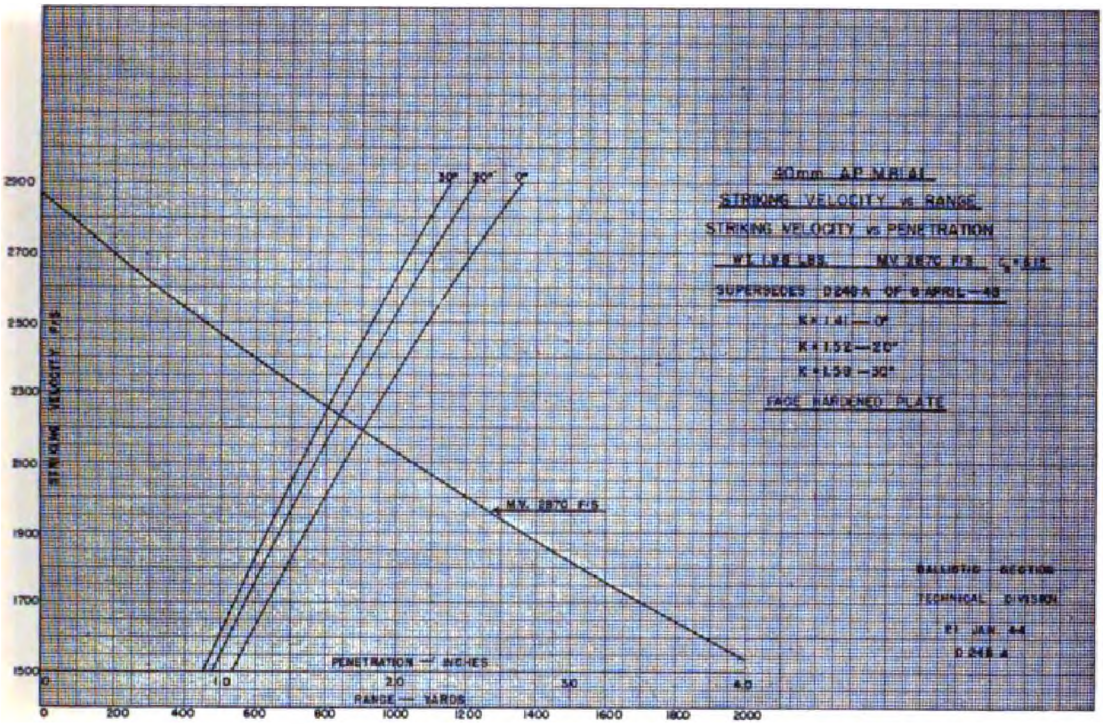


Figure 115. Armor Penetration of 40mm A.P. M81A1—Face Hardened Plate.

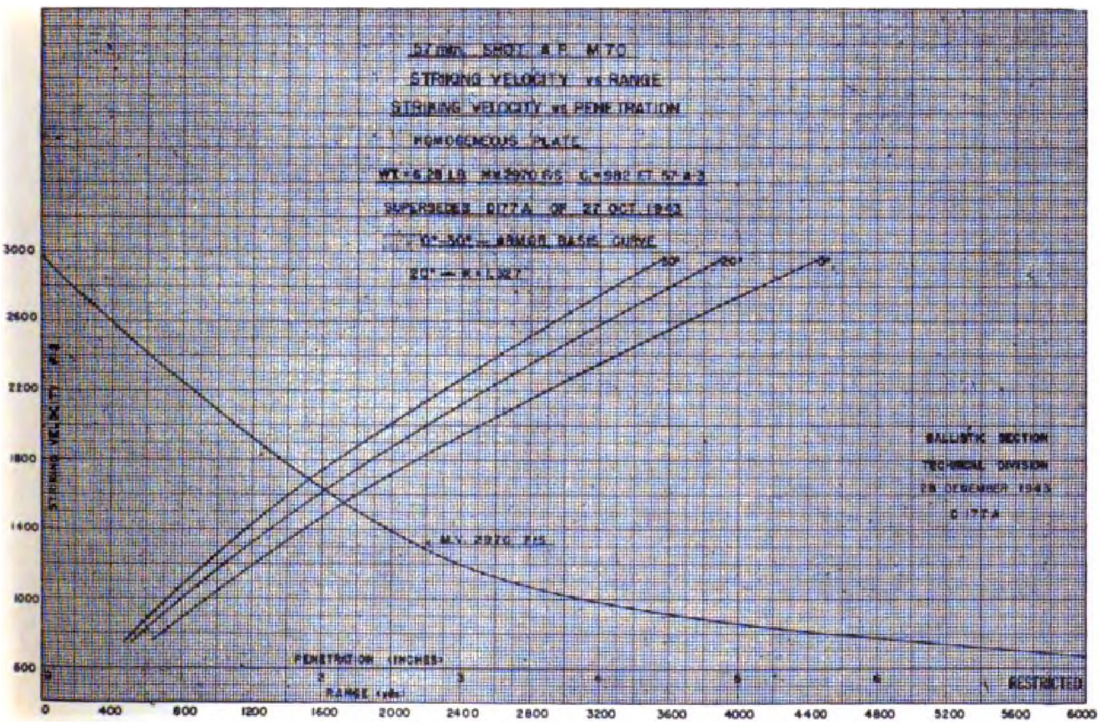


Figure 116. Armor Penetration of 57mm Shot A.P. M70—Homogeneous Plate.

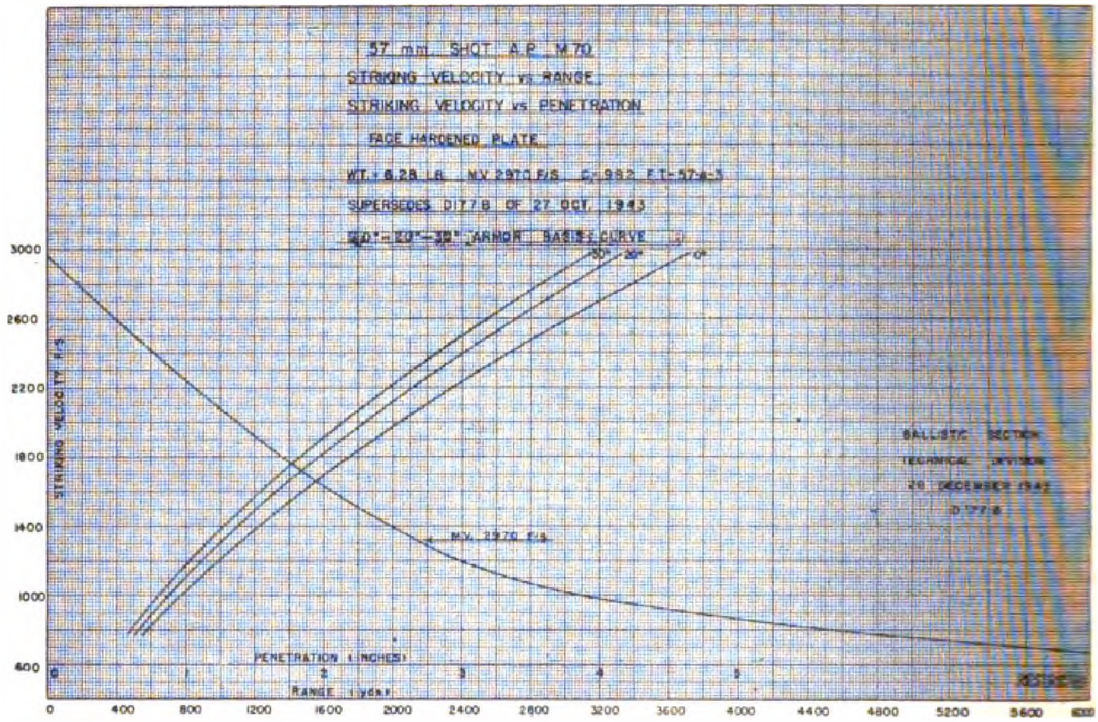


Figure 117. Armor Penetration of 57mm Shot A.P. M70—Face Hardened Plate.

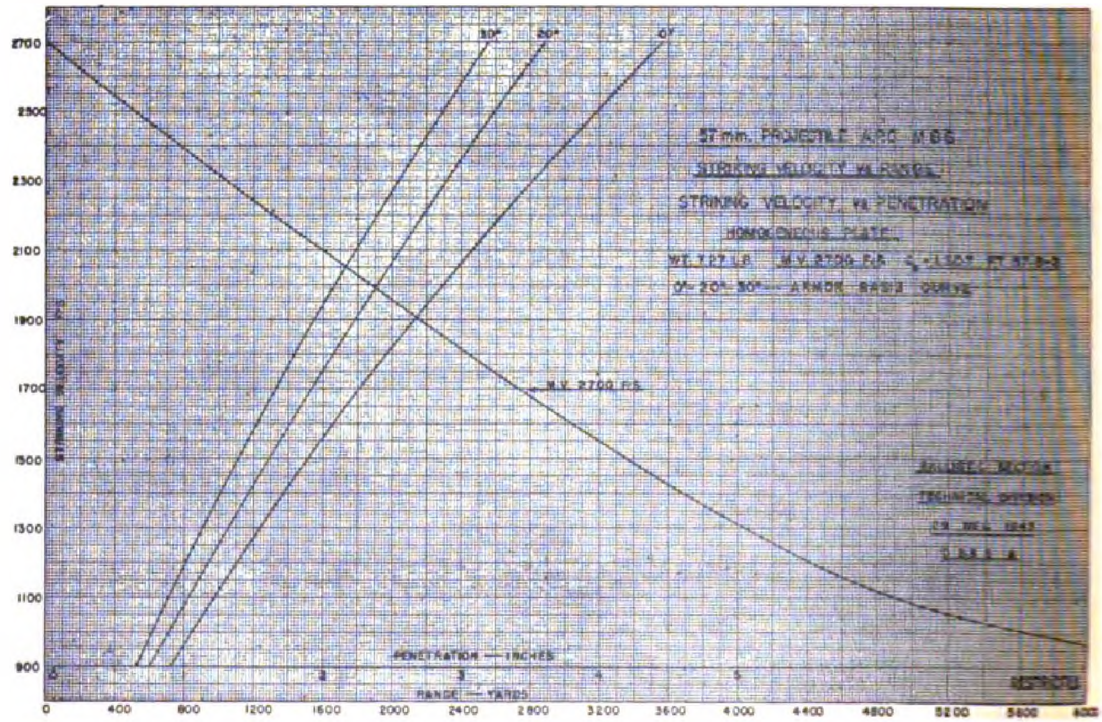


Figure 118. Armor Penetration of 57mm Projectile A.P.C. M86—Homogeneous Plate.

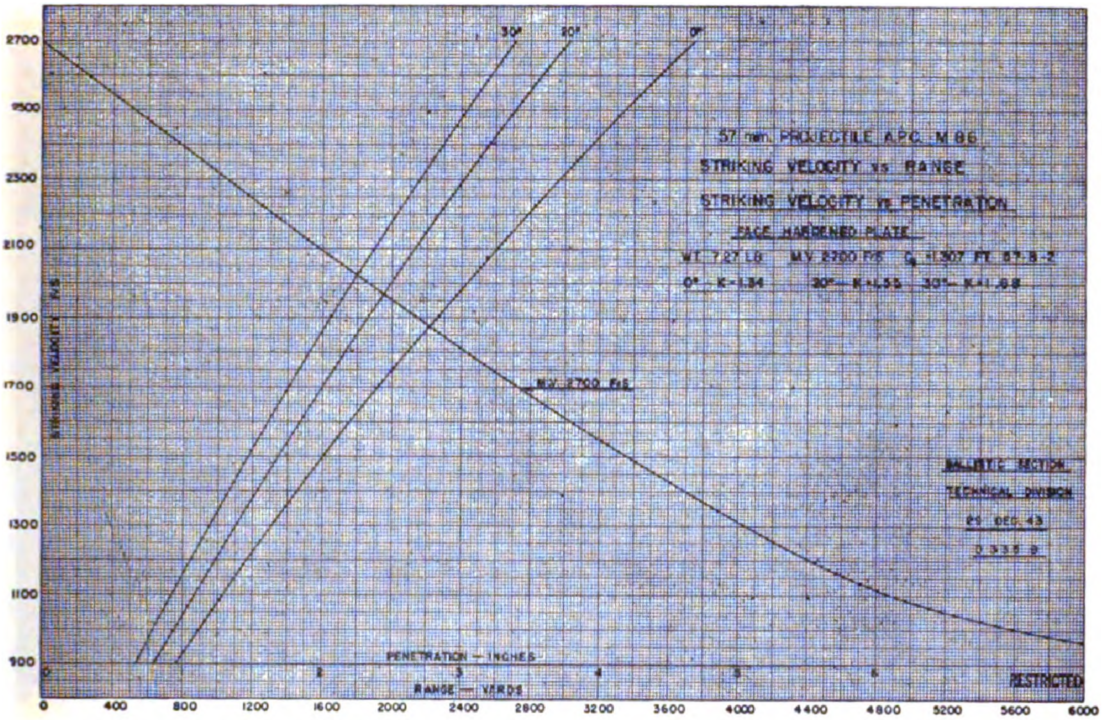


Figure 119. Armor Penetration of 57mm Projectile A.P.C. M86—Face Hardened Plate.

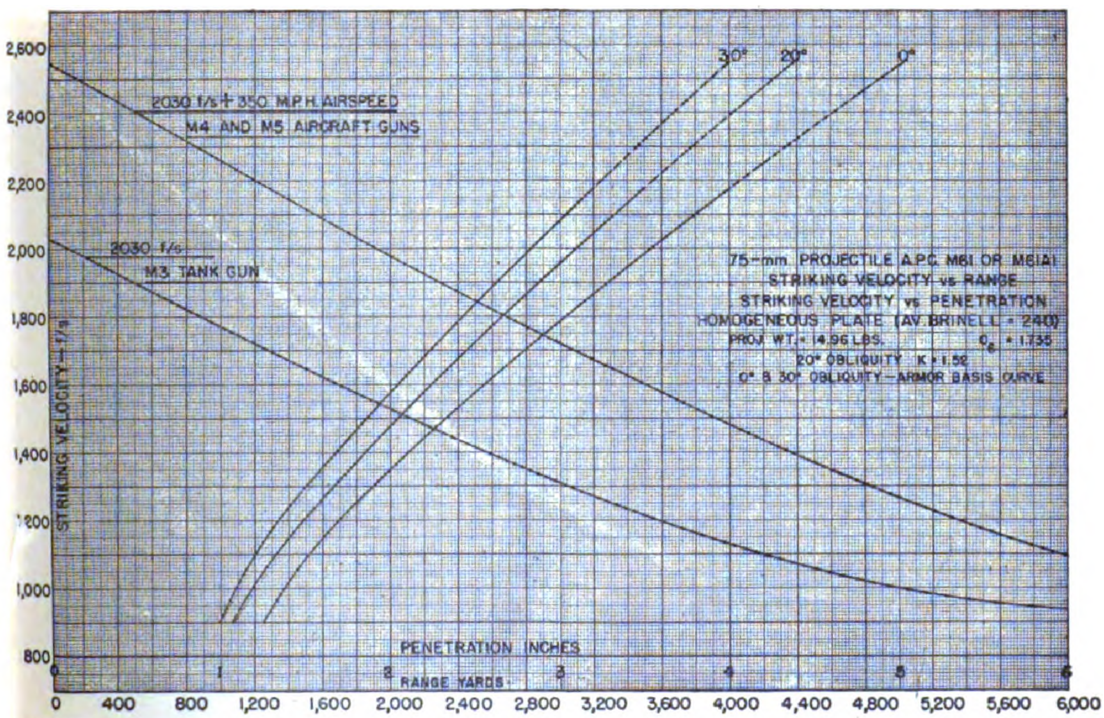


Figure 120. Armor Penetration of 75mm Projectile A.P.C. M81—Homogeneous Plate.

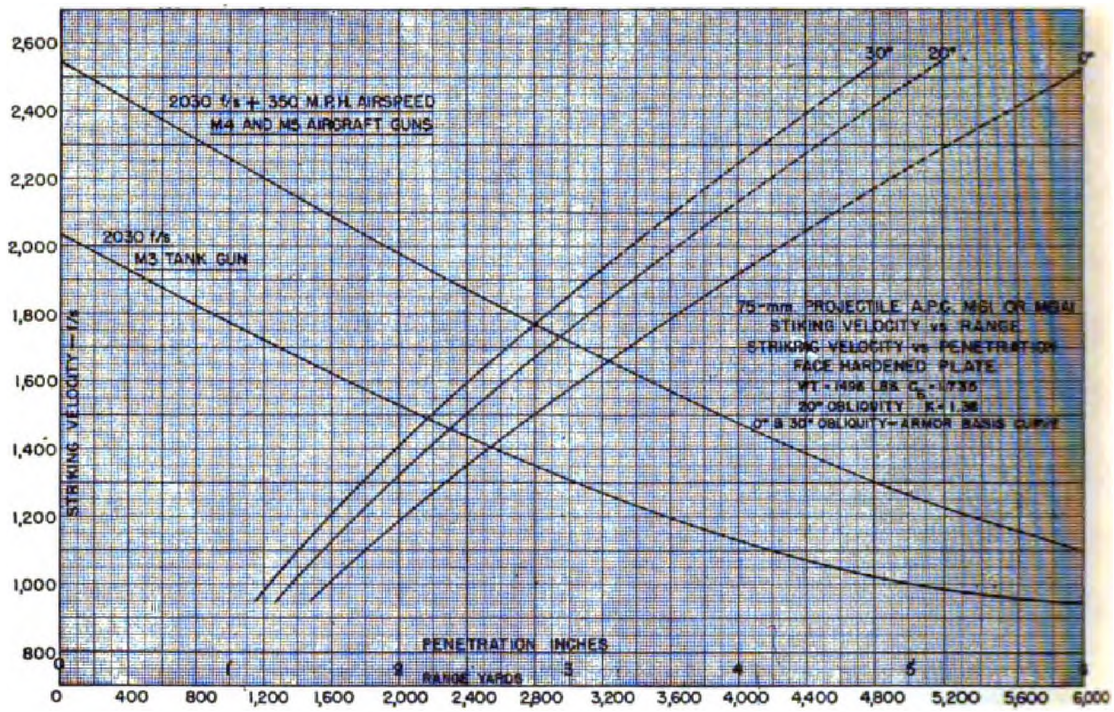


Figure 121. Armor Penetration of 75mm Projectile A.P.C. M61 or M61A1—Face Hardened Plate.

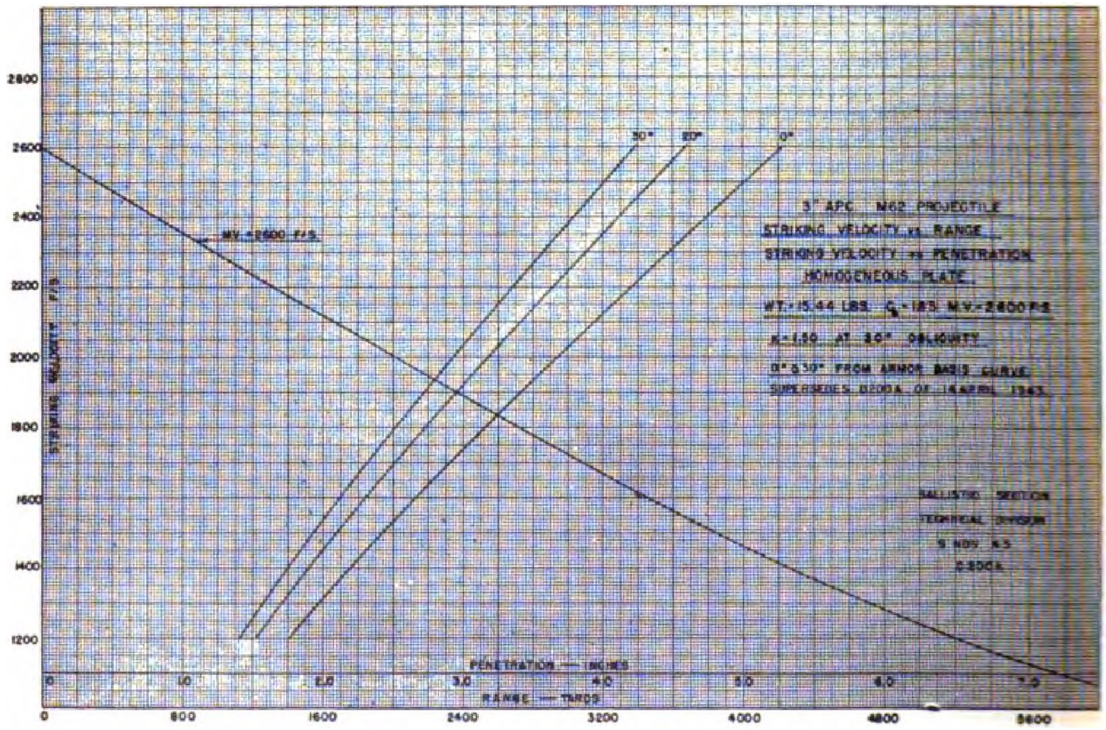


Figure 122. Armor Penetration of 3" A.P.C. Projectile M62—Homogeneous Plate.

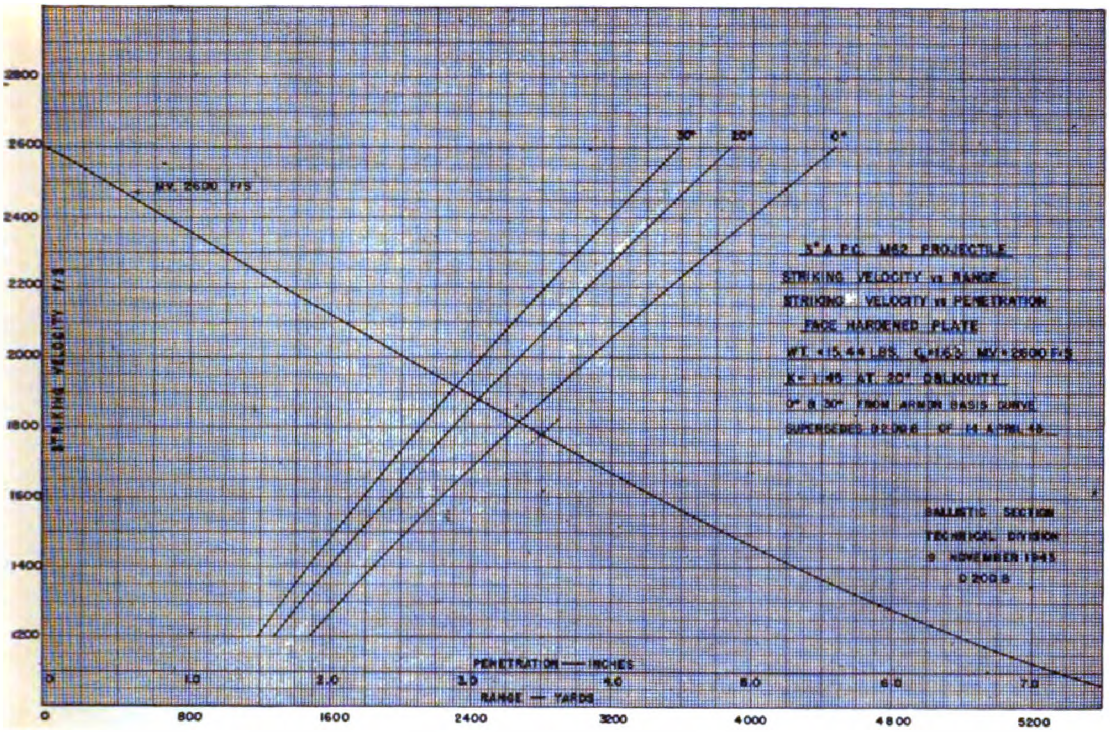


Figure 123. Armor Penetration of 3" A.P.C. Projectile M62—Face Hardened Plate.

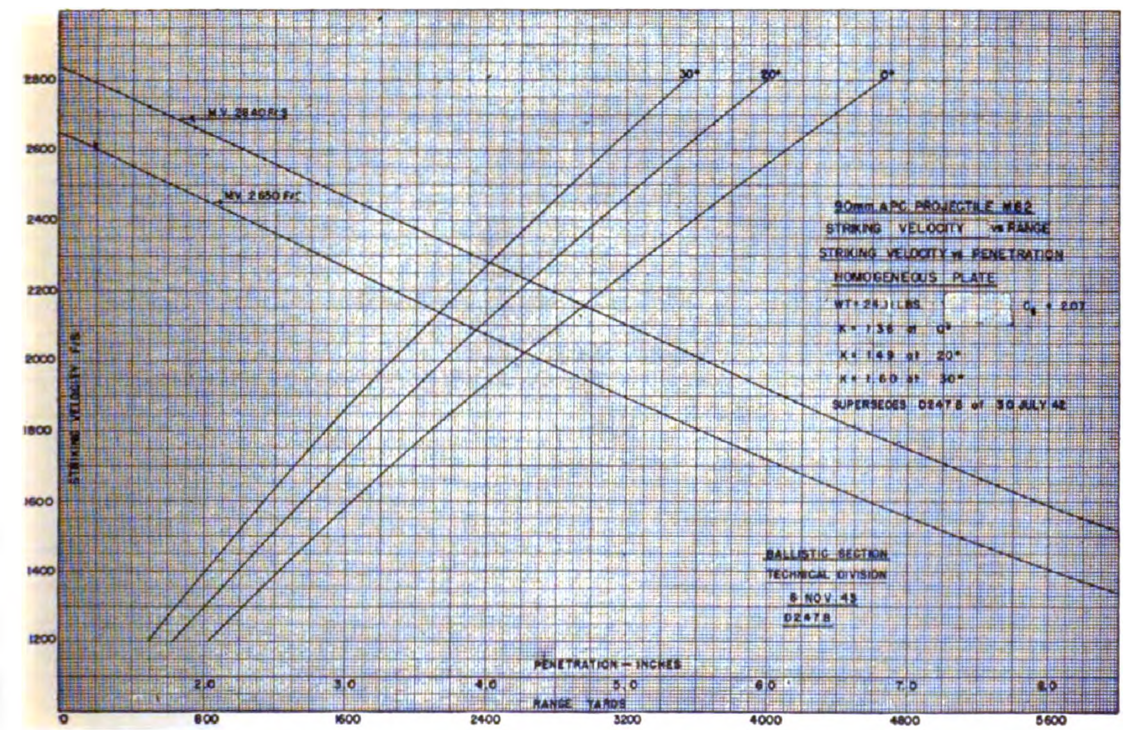


Figure 124. Armor Penetration of 90mm A.P.C. Projectile M82—Homogeneous Plate.

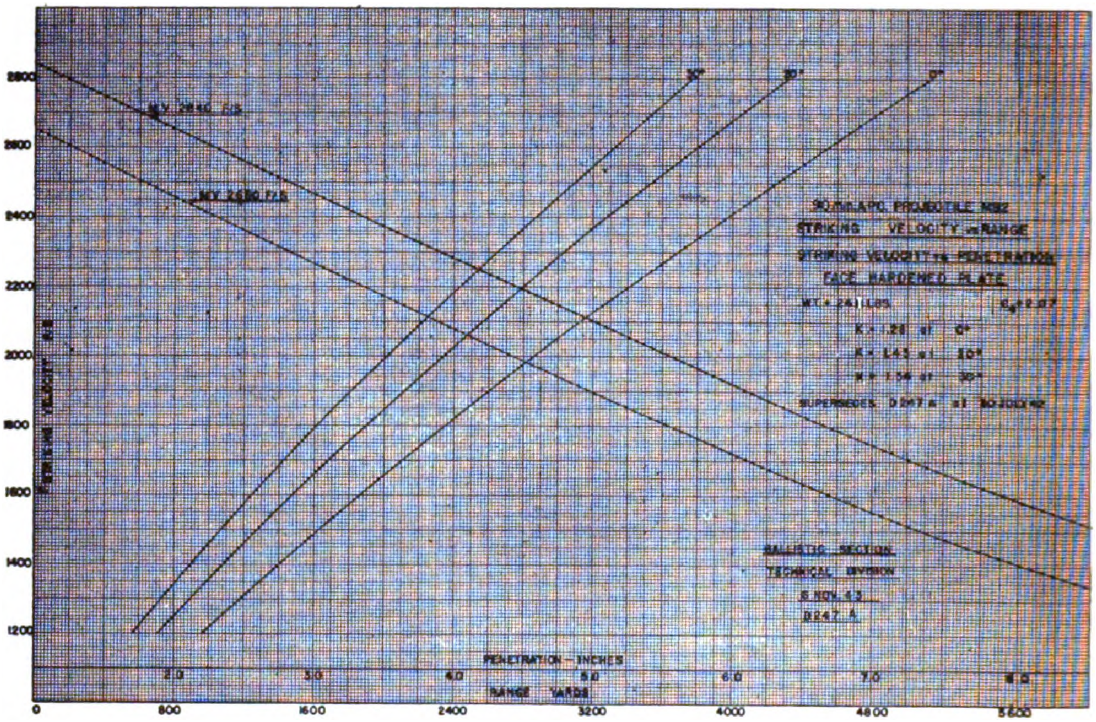


Figure 125. Armor Penetration of 90mm A.P.C. Projectile M82—Face Hardened Plate.

CONCRETE PENETRATION

57-MM GUN, M1, FIRING PROJECTILE, A.P.C., M86

PROJECTILE WEIGHT: 7.27 lb. **COMPLETE ROUND WEIGHT: 13.73 LB.** **MUZZLE VELOCITY: 2,700 F/S**

			0	500	1,000	2,000	3,000
Range (yd.)			0	500	1,000	2,000	3,000
Terminal velocity (f/s)			2,700	2,510	2,390	1,950	1,620
Probability of hitting target 1 yd. square in any one round				.08			
5,000 p.s.i.	Penetration depth of one round into thick concrete	Face normal to angle of fall (ft.)	2.3	2.0	1.8	1.4	1.2
		Face vertical (ft.)	2.3	2.0	1.8	1.4	1.2
	Thickness of concrete perforated	Face normal to angle of fall (ft.)	3.2	2.7	2.6	2.1	1.7
		Face vertical (ft.)	3.2	2.7	2.6	2.1	1.7
	Volume of concrete excavated by first round (cu. ft.)			3			
	Number of rounds falling in circle of —— yd. diameter necessary to perforate concrete	3 ft. thick					
		5 ft. thick					
		7 ft. thick					
Number of hits, number of rounds, and total weight (lb.) of complete rounds necessary to make a breach 4 yd. wide in a reinforced (5,000 p.s.i.) concrete wall	10 ft. high, 6 ft. thick						
	Necessary number of hits			175			
	Total number of rounds			370			
	Total complete round weight (lb.)			5,100			
	No. of rds. fired at each point of aim			370			
	Deflection difference between successive aiming points (ft.)						
	No. of different aiming points			1			
	10 ft. high, 10 ft. thick						
	Necessary number of hits			300			
	Total number of rounds			620			
	Total complete round weight (lb.)			8,500			
	No. of rds. fired at each point of aim			620			
	Deflection difference between successive aiming point (ft.)						
	No. of different aiming points			1			

Table 1.

75-MM GUN, M3, FIRING SHELL, H.E., M48, WITH C.P., T105 FUZE

SHELL WEIGHT: 15.04 LB.   COMPLETE ROUND WEIGHT: 19.93 LB.   MUZZLE VELOCITY: 1,980 F/S

Range (yd.)	0	500	1,000	2,000	3,000	4,000	5,000
Terminal velocity (f/s)	1,980	1,850	1,720	1,490	1,290	1,130	1,020
Probability of hitting target 1 yd. square in any one round			0.85	0.19	0.057	0.022	0.010
5,000 p.s.i. — Penetration depth of one round into thick concrete — Face normal to angle of fall (ft.)	1.7	1.6	1.6	1.3	0.9	0.8	0.7
Face vertical (ft.)	1.7	1.7	1.6	1.3	0.9	0.8	0.6
Thickness of concrete perforated — Face normal to angle of fall (ft.)	2.4	2.1	1.9	1.7	1.5	1.3	1.2
Face vertical (ft.)	2.4	2.1	1.9	1.7	1.5	1.3	1.2
Volume of concrete excavated by first round (cu. ft.)			3	3			
Number of rounds falling in circle of 0.83 yd. diameter necessary to perforate concrete — 3 ft. thick			5	8	13	17	20
5 ft. thick			14	21	36	48	63
7 ft. thick			27	41	72		
Number of hits, number of rounds, and total weight (lb.) of complete rounds necessary to make a breach 4 yd. wide in a reinforced (5,000 p.s.i.) concrete wall — 10 ft. high, 6 ft. thick							
Necessary number of hits			200	240			
Total number of rounds			210	260			
Total complete round weight (lb.)			4,200	5,200			
No. of rds. fired at each point of aim			35	65			
Deflection difference between successive aiming points (ft.)			2	3			
No. of different aiming points			6	4			
10 ft. high, 10 ft. thick							
Necessary number of hits			320	400			
Total number of rounds			360	420			
Total complete round weight (lb.)			7,200	8,400			
No. of rds. fired at each point of aim			60	105			
Deflection difference between successive aiming points (ft.)			2	3			
No. of different aiming points			6	4			

Table 2.

75-MM GUN, M3, FIRING PROJECTILE, A.P.C., M61 OR M61A1

PROJECTILE WEIGHT: 14.90 LB.   COMPLETE ROUND WEIGHT: 20.08 LB.   MUZZLE VELOCITY: 2,030 F/S

Range (yd.)	0	500	1,000	2,000	3,000	4,000	5,000
Terminal velocity (f/s)	2,030	1,900	1,770	1,520	1,300	1,120	1,020
Probability of hitting target 1 yd. square in any one round			0.85	0.19	0.057	0.022	0.0096
9,000 p.s.i. — Penetration depth of one round into thick concrete — Face normal to angle of fall (ft.)	1.9	1.7	1.6	1.3	1.0	0.8	0.7
Face vertical (ft.)	1.9	1.7	1.6	1.3	1.0	0.8	0.7
Thickness of concrete perforated — Face normal to angle of fall (ft.)	2.5	2.3	2.1	1.8	1.5	1.3	1.2
Face vertical (ft.)	2.5	2.3	2.1	1.8	1.5	1.3	1.2
Volume of concrete excavated by first round (cu. ft.)			3	3			
Number of rounds falling in circle of 0.83 yd. diameter necessary to perforate concrete — 3 ft. thick			5	7	10	17	21
5 ft. thick			13	19	30	47	
7 ft. thick			25	27	60		
Number of hits,[1] number of rounds, and total weight (lb.) of complete rounds necessary to make a breach 4 yd. wide in a reinforced (5,000 p.s.i.) concrete wall — 10 ft. high, 6 ft. thick							
Necessary number of hits			200	240			
Total number of rounds			210	360			
Total complete round weight (lb.)			4,200	7,200			
No. of rds. fired at each point of aim			35	65			
Deflection difference between successive aiming points (ft.)			2	3			
No. of different aiming points			6	4			
10 ft. high, 10 ft. thick							
Necessary number of hits			320	400			
Total number of rounds			360	420			
Total complete round weight (lb.)			7,200	8,400			
No. of rds. fired at each point of aim			60	105			
Deflection difference between successive aiming points (ft.)			2	3			
No. of different aiming points			6	4			

[1]Replace about one-fifth of rounds with H.E. shell, superquick fuzed, against reinforced concrete.

Table 3.

3-INCH GUNS, M5, M6, M7, FIRING SHELL, H.E., M42B1, WITH C.P., T105 FUZE

PROJECTILE WEIGHT: 13.21 LB. COMPLETE ROUND WEIGHT: 24.95 LB. MUZZLE VELOCITY: 2,800 F/S

			0	500	1,000	2,000	3,000	4,000	5,000
Range (yd.)			0	500	1,000	2,000	3,000	4,000	5,000
Terminal velocity (f/s)			2,800	2,620	2,450	2,100	1,780	1,480	1,230
Probability of hitting target 1 yd. square in any one round						0.35	0.11	0.046	0.020
5,000 p.s.i.	Penetration depth of one round into thick concrete	Face normal to angle of fall (ft.) Face vertical (ft.)	2.6 2.6	2.3 2.3	2.0 2.0	1.7 1.7	1.4 1.4	1.0 1.0	0.8 0.8
	Thickness of concrete perforated	Face normal to angle of fall (ft.) Face vertical (ft.)	3.6 3.6	3.2 3.2	3.0 3.0	2.5 2.5	2.1 2.1	1.6 1.6	1.4 1.4
	Volume of concrete excavated by first round (cu. ft.)				6				
	Number of rounds falling in circle of 0.83 yd. diameter necessary to perforate concrete	3 ft. thick 5 ft. thick 7 ft. thick			1-2 5 10	3 8 16	5 14 27	10 30	15 43
Number of hits, number of rounds, and total weight (lb.) of complete rounds necessary to make a breach 4 yd. wide in a reinforced (5,000 p.s.i.) concrete wall	10 ft. high, 6 ft. thick								
	Necessary number of hits				100				
	Total number of rounds				210				
	Total complete round weight (lb.)				5,200				
	No. of rds. fired at each point of aim				35				
	Deflection difference between successive aiming points (ft.)				2				
	No. of different aiming points				6				
	10 ft. high, 10 ft. thick								
	Necessary number of hits				170				
	Total number of rounds				360				
	Total complete round weight (lb.)				9,000				
	No. of rds. fired at each point of aim				60				
	Deflection difference between successive aiming points (ft.)				2				
	No. of different aiming points				6				

Table 4.

76-MM GUNS, M1A1, M1A2, FIRING SHELL, H.E., M42B1, WITH C.P., T105 FUZE

PROJECTILE WEIGHT: 13.21 LB. COMPLETE ROUND WEIGHT: 22.39 LB. MUZZLE VELOCITY: 2,700 F/S

			0	500	1,000	2,000	3,000	4,000	5,000
Range (yd.)			0	500	1,000	2,000	3,000	4,000	5,000
Terminal velocity (f/s)			2,700	2,520	2,345	2,007	1,695	1,411	1,169
Probability of hitting target 1 yd. square in any one round					0.85	0.19	0.056	0.023	0.010
5,000 p.s.i.	Penetration depth of one round into thick concrete	Face normal to angle of fall (ft.) Face vertical (ft.)	2.6 2.6	2.3 2.3	2.0 2.0	1.7 1.7	1.4 1.4	1.0 1.0	0.8 0.8
	Thickness of concrete perforated	Face normal to angle of fall (ft.) Face vertical (ft.)	3.6 3.6	3.2 3.2	3.0 3.0	2.5 2.5	2.1 2.1	1.6 1.6	1.4 1.4
	Volume of concrete excavated by first round (cu. ft.)				6				
	Number of rounds falling in circle of 0.83 yd. diameter necessary to perforate concrete	3 ft. thick 5 ft. thick 7 ft. thick			1 5 10	3 8 16	5 14 27	10 30	15 43
Number of hits, number of rounds, and total weight (lb.) of complete rounds necessary to make a breach 4 yd. wide in a reinforced (5,000 p.s.i.) concrete wall	10 ft. high, 6 ft. thick								
	Necessary number of hits				100				
	Total number of rounds				210				
	Total complete round weight (lb.)				4,700				
	No. of rds. fired at each point of aim				35				
	Deflection difference between successive aiming points (ft.)				2				
	No. of different aiming points				6				
	10 ft. high, 10 ft. thick								
	Necessary number of hits				170				
	Total number of rounds				360				
	Total complete round weight (lb.)				8,100				
	No. of rds. fired at each point of aim				60				
	Deflection difference between successive aiming points (ft.)				2				
	No. of different aiming points				6				

Table 5.

76-MM GUNS, M1A1, M1A2, OR 3-INCH GUNS, M5, M6, M7, FIRING PROJECTILE, A.P.C., M62 OR M62A1

PROJECTILE WEIGHT: 15.40 LB. **COMPLETE ROUND WEIGHT IN 76-MM: 24.67 LB.; IN 3-IN. GUN: 27.23 LB.**
MUZZLE VELOCITY: 2,600 F/S

Range (yd.)	0	500	1,000	2,000	3,000	4,000	5,000
Terminal velocity (f/s)	2,600	2,450	2,290	2,000	1,720	1,466	1,240
Probability of hitting target 1 yd. square in any one round			0.49	0.10	0.034	0.015	0.0063
5,000 p.s.i. — Penetration depth of one round into thick concrete — Face normal to angle of fall (ft.)	2.6	2.5	2.3	1.9	1.5	1.2	1.0
5,000 p.s.i. — Penetration depth of one round into thick concrete — Face vertical (ft.)	2.6	2.5	2.3	1.9	1.5	1.2	0.9
5,000 p.s.i. — Thickness of concrete perforated — Face normal to angle of fall (ft.)	3.6	3.3	3.1	2.6	2.2	1.8	1.5
5,000 p.s.i. — Thickness of concrete perforated — Face vertical (ft.)	3.6	3.3	3.1	2.6	2.2	1.8	1.5
5,000 p.s.i. — Volume of concrete excavated by first round (cu. ft.)			6				
5,000 p.s.i. — Number of rounds falling in circle of 0.83 yd. diameter necessary to perforate concrete — 3 ft. thick			1	3	5	8	12
5 ft. thick			6	9	14	21	35
7 ft. thick			12	18	26	40	
Number of hits,[1] number of rounds, and total weight (lb.) of complete rounds necessary to make a breach 4 yd. wide in a reinforced (5,000 p.s.i.) concrete wall — 10 ft. high, 6 ft. thick							
Necessary number of hits			110				
Total number of rounds			210				
Total complete round weight (lb.)			5,700[2]				
No. of rds. fired at each point of aim			35				
Deflection difference between successive aiming points (ft.)			2				
No. of different aiming points			6				
10 ft. high, 10 ft. thick							
Necessary number of hits			180				
Total number of rounds			360				
Total complete round weight (lb.)			9,800[3]				
No. of rds. fired at each point of aim			60				
Deflection difference between successive aiming points (ft.)			2				
No. of different aiming points			6				

[1]Replace about one-fifth of rounds with H.E. shell, superquick fuzed, against reinforced concrete.
[2]Weight given is for 3-in. gun. Weight for 76-mm gun is 5,200 lb.
[3]Weight given is for 3-in. gun. Weight for 76-mm gun is 8,900 lb.

Table 6.

90-MM GUNS, M1A1, M2, M3, FIRING SHELL, H.E., M71, WITH C.P., T105 FUZE

PROJECTILE WEIGHT: 23.74 LB. **COMPLETE ROUND WEIGHT: 42.38 LB.** **MUZZLE VELOCITY: 2,700 F/S**

Range (yd.)	0	1,000	2,000	3,000	4,000	6,000	8,000
Terminal velocity (f/s)	2,700	2,460	2,230	2,010	1,800	1,400	1,100
Probability of hitting target 1 yd. square in any one round					0.047		
5,000 p.s.i. — Penetration depth of one round into thick concrete — Face normal to angle of fall (ft.)	3.0	2.7	2.4	2.0	1.7	1.1	0.8
5,000 p.s.i. — Penetration depth of one round into thick concrete — Face vertical (ft.)	3.0	2.7	2.4	2.0	1.7	1.1	0.7
5,000 p.s.i. — Thickness of concrete perforated — Face normal to angle of fall (ft.)	4.2	3.8	3.4	3.0	2.6	1.9	1.6
5,000 p.s.i. — Thickness of concrete perforated — Face vertical (ft.)	4.2	3.8	3.4	3.0	2.6	1.9	1.6
5,000 p.s.i. — Volume of concrete excavated by first round (cu. ft.)		11	9	8	7	6	
5,000 p.s.i. — Number of rounds falling in circle of 1 yd. diameter necessary to perforate concrete — 3 ft. thick		1	1	3	3		
5 ft. thick		3	5	8	10		
7 ft. thick		7	10	14	20		
Number of hits, number of rounds, and total weight (lb.) of complete rounds necessary to make a breach 4 yd. wide in a reinforced (5,000 p.s.i.) concrete wall — 10 ft. high, 6 ft. thick							
Necessary number of hits		60	75	90	115		
Total number of rounds		72	130	240	520		
Total complete round weight (lb.)		3,100	5,500	10,200	22,000		
No. of rds. fired at each point of aim		12	65	120	260		
Deflection difference between successive aiming points (ft.)		2	6	6	6		
No. of different aiming points		6	2	2	2		
10 ft. high, 10 ft. thick							
Necessary number of hits		100	125	150	190		
Total number of rounds		132	180	380	840		
Total complete round weight (lb.)		5,600	7,600	16,100	35,600		
No. of rds. fired at each point of aim		22	90	190	420		
Deflection difference between successive aiming points (ft.)		2	6	6	6		
No. of different aiming points		6	2	2	2		

Table 7.

90-MM GUNS M1A1, M2, M3, FIRING PROJECTILE, A.P.C., M82

PROJECTILE WEIGHT: 24.10 LB. COMPLETE ROUND WEIGHT: 42.75 LB. MUZZLE VELOCITY: 2,670 F/S

			0	1,000	2,000	3,000	4,000	6,000	8,000
Range (yd.)			0	1,000	2,000	3,000	4,000	6,000	8,000
Terminal velocity (f/s)			2,670	2,440	2,200	2,015	1,770	1,380	1,100
Probability of hitting target 1 yd. square in any one round					0.36		0.052	0.013	
5,000 p.s.i.	Penetration depth of one round into thick concrete	Face normal to angle of fall (ft.)	3.0	2.7	2.2	1.8	1.6	1.2	0.8
		Face vertical (ft.)	3.0	2.7	2.2	1.8	1.6	1.1	0.7
	Thickness of concrete perforated	Face normal to angle of fall (ft.)	4.2	3.7	3.2	2.7	2.4	1.9	1.4
		Face vertical (ft.)	4.2	3.7	3.2	2.7	2.4	1.9	1.4
	Volume of concrete excavated by first round (cu. ft.)			11	9	8	7	6	
	Number of rounds falling in circle of 1 yd. diameter necessary to perforate concrete	3 ft. thick		1	1	3	4	6	
		5 ft. thick		3	5	7	9		
		7 ft. thick		7	10	14	18		
Number of hits,[1] number of rounds, and total weight (lb.) of complete rounds necessary to make a breach 4 yd. wide in a reinforced (5,000 p.s.i.) concrete wall	10 ft. high, 6 ft. thick								
	Necessary number of hits			60	75	90	115		
	Total number of rounds			72	130	240	520		
	Total complete round weight (lb.)			3,100	5,600	10,300	22,200		
	No. of rds. fired at each point of aim			12	65	120	260		
	Deflection difference between successive aiming points (ft.)			2	6	6	6		
	No. of different aiming points			6	2	2	2		
	10 ft. high, 10 ft. thick								
	Necessary number of hits			100	120	150	185		
	Total number of rounds			132	180	380	840		
	Total complete round weight (lb.)			5,600	7,700	16,200	35,900		
	No. of rds. fired at each point of aim			22	90	190	420		
	Deflection difference between successive aiming points (ft.)			2	6	6	6		
	No. of different aiming points			6	2	2	2		

[1]Replace about one-fifth of rounds with H.E. shell, superquick fuzed, against reinforced concrete.

Table 8.

105-MM HOWITZER, M2A1, FIRING SHELL, H.E., M1, WITH C.P., T105 FUZE

PROJECTILE WEIGHT: 33.82 LB. COMPLETE ROUND WEIGHT: 42.89 LB. MUZZLE VELOCITY: 1,550 F/S

			0	500	1,000	2,000	3,000	4,000	5,000	8,000
Range (yd.)			0	500	1,000	2,000	3,000	4,000	5,000	8,000
Terminal velocity (f/s)			1,550	1,460	1,370	1,210	1,080	1,020	980	900
Probability of hitting target 1 yd. square in any one round							0.065		0.012	
5,000 p.s.i.	Penetration depth of one round into thick concrete	Face normal to angle of fall (ft.)	1.5	1.4	1.3	1.1	0.9	0.8	0.9	
		Face vertical (ft.)	1.5	1.3	1.2	1.0	0.9	0.8	0.7	
		Face horizontal[1] (ft.)							0.5	0.6
	Thickness of concrete perforated	Face normal to angle of fall (ft.)	2.4	2.3	2.1	1.8	1.6	1.5	1.5	
		Face vertical (ft.)	2.4	2.3	2.1	1.8	1.6	1.5	1.4	
		Face horizontal[1] (ft.)							1.1	1.1
	Volume of concrete excavated by first round (cu. ft.)				7	6	5			
	Number of rounds falling in circle of 1 yd. diameter necessary to perforate concrete	3 ft. thick			5		10		12	
		5 ft. thick			14		27		33	
		7 ft. thick			27		53		64	
Number of hits, number of rounds, and total weight (lb.) of complete rounds necessary to make a breach 4 yd. wide in a reinforced (5,000 p.s.i.) concrete wall	10 ft. high, 6 ft. thick									
	Necessary number of hits				90	110	120			
	Total number of rounds				120	220	540			
	Total complete round weight (lb.)				5,100	9,400	23,200			
	No. of rds. fired at each point of aim				20	110	270			
	Deflection difference between successive aiming points (ft.)				2	6	6			
	No. of different aiming points				6	2	2			
	10 ft. high, 10 ft. thick									
	Necessary number of hits				150	175	200			
	Total number of rounds				180	360	880			
	Total complete round weight (lb.)				7,700	15,400	37,700			
	No. of rds. fired at each point of aim				30	180	440			
	Deflection difference between successive aiming points (ft.)				2	6	6			
	No. of different aiming points				6	2	2			

[1]High-angle fire to be used against horizontal targets. Zone 6 charge for 8,000-yd. range; Zone 4, for 5,000-yd. range.

Table 9.

105-MM HOWITZER, M3, FIRING SHELL, H.E., M1, WITH C.P., T105 FUZE

PROJECTILE WEIGHT: 33.82 LB. COMPLETE ROUND WEIGHT: 41.18 LB. MUZZLE VELOCITY: 1,020 F/S

			0	500	1,000	2,000	3,000	4,000	5,000
Range (yd.)			0	500	1,000	2,000	3,000	4,000	5,000
Terminal velocity (f/s)			1,020	990	970	930	890	860	830
Probability of hitting target 1 yd. square in any one round					0.11				
	Penetration depth of one round into thick concrete	Face normal to angle of fall (ft.)	1.0	0.9	0.8	0.7	0.7	0.7	0.7
		Face vertical (ft.)	1.0	0.9	0.8	0.7	0.6	0.5	0.5
	Thickness of concrete perforated	Face normal to angle of fall (ft.)	1.6	1.5	1.4	1.4	1.4	1.3	1.3
		Face vertical (ft.)	1.6	1.5	1.4	1.3	1.3	1.2	1.2
	Volume of concrete excavated by first round (cu. ft.)				3	3			
	Number of rounds falling in circle of 1 yd. diameter necessary to perforate concrete	3 ft. thick			12				
		5 ft. thick			33				
		7 ft. thick			65				
weight (lb.) of complete rounds necessary to make a breach 4 yd. wide in a reinforced (5,000 p.s.i.) concrete wall	10 ft. high, 6 ft. thick								
	Necessary number of hits				240				
	Total number of rounds				510				
	Total complete round weight (lb.)				21,000				
	No. of rds. fired at each point of aim				170				
	Deflection difference between successive aiming points (ft.)				4				
	No. of different aiming points				3				
	10 ft. high, 10 ft. thick								
	Necessary number of hits				400				
	Total number of rounds				720				
	Total complete round weight (lb.)				29,600				
	No. of rds. fired at each point of aim				240				
	Deflection difference between successive aiming points (ft.)				4				
	No. of different aiming points				3				

Table 10.

4.5-INCH GUN, M1, FIRING SHELL, H.E., M65, WITH C.P., T105 FUZE

PROJECTILE WEIGHT: 55.65 LB. COMPLETE ROUND WEIGHT: 66.71 LB. MUZZLE VELOCITY: 2,275 F/S

			0	1,000	3,000	5,000	7,500	10,000	12,500	13,000
Range (yd.)			0	1,000	3,000	5,000	7,500	10,000	12,500	13,000
Terminal velocity (f/s)			2,275	2,130	1,870	1,610	1,320	1,110	1,040	1,100
Probability of hitting target 1 yd. square in any one round					0.38	0.055	0.010	0.0029		
5,000 p.s.i.	Penetration depth of one round into thick concrete	Face normal to angle of fall (ft.)	3.8	3.5	2.7	2.1	1.6	1.2	1.2	
		Face vertical (ft.)	3.8	3.5	2.6	2.0	1.5	1.0	0.9	
		Face horizontal[1]								1.0
	Thickness of concrete perforated	Face normal to angle of fall (ft.)	4.8	4.6	3.8	3.2	2.5	2.1	2.0	
		Face vertical (ft.)	4.8	4.6	3.8	3.2	2.4	1.9	1.7	
		Face horizontal[1]								1.9
	Volume of concrete excavated by first round (cu. ft.)			19	15	11				
	Number of rounds falling in circle of 1 yd. diameter necessary to perforate concrete	3 ft. thick		1	1	1	4	6		
		5 ft. thick		1-2	4	8	16	22		
		7 ft. thick		5	10	15	32	44		
Number of hits, number of rounds, and total weight (lb.) of complete rounds necessary to make a breach 4 yd. wide in a reinforced (5,000 p.s.i.) concrete wall	10 ft. high, 6 ft. thick									
	Necessary number of hits			35	45	60				
	Total number of rounds			42	140	520				
	Total complete round weight (lb.)			2,800	9,300	34,700				
	No. of rds. fired at each point of aim			7	70	260				
	Deflection difference between successive aiming points (ft.)			2	6	6				
	No. of different aiming points			6	2	2				
	10 ft. high, 10 ft. thick									
	Necessary number of hits			55	75	100				
	Total number of rounds			60	230	800				
	Total complete round weight (lb.)			4,400	15,300	53,400				
	No. of rds. fired at each point of aim			11	115	400				
	Deflection difference between successive aiming points (ft.)			2	6	6				
	No. of different aiming points			6	2	2				

[1] High-angle fire to be used against horizontal targets at normal charge.

Table 11.

155-MM HOWITZER, M1918, FIRING SHELL, H.E., M102, WITH C.P., T105 FUZE

PROJECTILE WEIGHT: 95.64 LB. COMPLETE ROUND WEIGHT: 103.92 LB. MUZZLE VELOCITY: 1,476 F/S

				0	1,000	2,000	4,000	6,000	8,000	10,000
Range (yd.)				0	1,000	2,000	4,000	6,000	8,000	10,000
Terminal velocity (f/s)				1,476	1,340	1,210	1,040	980	940	[illegible]
Probability of hitting target 1 yd. square in any one round					0.89	0.13	0.016	0.0040		
5,000 p.s.i.	Penetration depth of one round into thick concrete	Face normal to angle of fall (ft.)		2.1	1.8	1.6	1.4	1.3	1.2	1.2
		Face vertical (ft.)		2.1	1.8	1.6	1.2	1.0	0.9	0.6
	Thickness of concrete perforated	Face normal to angle of fall (ft.)		3.2	3.0	2.8	2.4	2.3	2.2	2.1
		Face vertical (ft.)		3.2	3.0	2.7	2.3	2.1	1.8	
	Volume of concrete excavated by first round (cu. ft.)				14	11				
	Number of rounds falling in circle of 1.33 yd. diameter necessary to perforate concrete	3 ft. thick			1-2	2	4	5		
		5 ft. thick			6	9	13	15		
		7 ft. thick			12	17	25	29		
Number of hits, number of rounds, and total weight (lb.) of complete rounds necessary to make a breach 4 yd. wide in a reinforced (5,000 p.s.i.) concrete wall	10 ft. high, 6 ft. thick									
	Necessary number of hits				50	60				
	Total number of rounds				84	220				
	Total complete round weight (lb.)				8,700	22,900				
	No. of rds. fired at each point of aim				14	110				
	Deflection difference between successive aiming points (ft.)				2	6				
	No. of different aiming points				6	2				
	10 ft. high, 10 ft. thick									
	Necessary number of hits				80	95				
	Total number of rounds				162	340				
	Total complete round weight (lb.)				16,800	35,300				
	No. of rds. fired at each point of aim				27	170				
	Deflection difference between successive aiming points (ft.)				2	6				
	No. of different aiming points				6	2				

Table 12.

155-MM HOWITZER, M1, FIRING SHELL, H.E., M107, WITH C.P., T105 FUZE

PROJECTILE WEIGHT: 95.35 LB. COMPLETE ROUND WEIGHT: 108.48 LB. MUZZLE VELOCITY: 1,850 F/S

			0	1,000	3,000	5,000	7,500	10,000	12,500	15,000
Range (yd.)			0	1,000	3,000	5,000	7,500	10,000	12,500	15,000
Terminal velocity (f/s)			1,850	1,710	1,570	1,210	1,030	990	980	1,010
Probability of hitting target 1 yd. square in any one round					0.19	0.044	0.014	0.0035	0.0015	[illegible]
5,000 p.s.i.	Penetration depth of one round into thick concrete	Face normal to angle of fall (ft.)	2.9	2.6	2.0	1.6	1.3	1.2	1.2	1.3
		Face vertical (ft.)	2.9	2.6	2.0	1.5	1.1	0.9	0.7	
		Face horizontal[1] (ft.)						0.9	1.1	
	Thickness of concrete perforated	Face normal to angle of fall (ft.)	4.2	3.9	3.2	2.7	2.4	2.2	2.2	2.3
		Face vertical (ft.)	4.2	3.9	3.2	2.6	2.2	1.8		
		Face horizontal[1] (ft.)						1.9	2.2	
	Volume of concrete excavated by first round (cu. ft.)			22	16	11				
	Number of rounds falling in circle of 1.33 yd. diameter necessary to perforate concrete	3 ft. thick		1	1	2	5	5	5	5
		5 ft. thick		3	5	9	13	14	14	[illegible]
		7 ft. thick		7	11	18	25	28	28	25
Number of hits, number of rounds, and total weight (lb.) of complete rounds necessary to make a breach 4 yd. wide in a reinforced (5,000 p.s.i.) concrete wall	10 ft. high, 6 ft. thick									
	Necessary number of hits			30	40	60				
	Total number of rounds			36	100	420				
	Total complete round weight (lb.)			3,900	10,800	45,600				
	No. of rds. fired at each point of aim			6	50	210				
	Deflection difference between successive aiming points (ft.)			2	6	6				
	No. of different aiming points			6	2	2				
	10 ft. high, 10 ft. thick									
	Necessary number of hits			50	70	95				
	Total number of rounds			60	160	620				
	Total complete round weight (lb.)			6,500	17,400	67,300				
	No. of rds. fired at each point of aim			10	80	310				
	Deflection difference between successive aiming points (ft.)			2	6	6				
	No. of different aiming points			6	2	2				

[1]High-angle fire to be used against horizontal targets. Zone 6 charge for 12,500-yd. range; Zone 5, for 10,000-yd range.

Table 13.

155-MM GUN, M1917 (G.P.F.), FIRING SHELL, H.E., M101, WITH C.P., T105 FUZE

PROJECTILE WEIGHT: 95.14 LB. **COMPLETE ROUND WEIGHT: 119.82 LB.** **MUZZLE VELOCITY: 2,410 F/S**

			0	1,000	3,000	5,000	7,500	10,000	12,500	15,000
Range (yd.)			0	1,000	3,000	5,000	7,500	10,000	12,500	15,000
Terminal velocity (f/s)			2,410	2,260	1,970	1,690	1,380	1,140	1,030	990
Probability of hitting target 1 yd. square in any one round					0.18	0.042	0.010	0.0032	0.0015	
5,000 p.s.i.	Penetration depth of one round into thick concrete	Face normal to angle of fall (ft.)	4.3	3.8	3.0	2.5	1.9	1.5	1.5	1.2
5,000 p.s.i.	Penetration depth of one round into thick concrete	Face vertical (ft.)	4.3	3.8	3.0	2.4	1.8	1.3	0.9	0.7
5,000 p.s.i.	Thickness of concrete perforated	Face normal to angle of fall (ft.)	5.7	5.2	4.5	3.8	3.1	2.5	2.4	2.3
5,000 p.s.i.	Thickness of concrete perforated	Face vertical (ft.)	5.7	5.2	4.5	3.6	2.9	2.4	1.9	
5,000 p.s.i.	Volume of concrete excavated by first round (cu. ft.)			37	30	21				
5,000 p.s.i.	Number of rounds falling in circle of 1.33 yd. diameter necessary to perforate concrete	3 ft. thick		1	1	1	1-2	4		
5,000 p.s.i.	Number of rounds falling in circle of 1.33 yd. diameter necessary to perforate concrete	5 ft. thick		1-2	2	4	6	9		
5,000 p.s.i.	Number of rounds falling in circle of 1.33 yd. diameter necessary to perforate concrete	7 ft. thick		3	5	7	11	19		
Number of hits, number of rounds, and total weight (lb.) of complete rounds necessary to make a breach 4 yd. wide in a reinforced (5,000 p.s.i.) concrete wall	10 ft. high, 6 ft. thick									
	Necessary number of hits			18	24	30				
	Total number of rounds			21	56	170				
	Total complete round weight (lb.)			2,500	6,700	20,400				
	No. of rds. fired at each point of aim			7	28					
	Deflection difference between successive aiming points (ft.)			4	6					
	No. of different aiming points			3	2	1				
	10 ft. high, 10 ft. thick									
	Necessary number of hits			30	40	50				
	Total number of rounds			33	80	260				
	Total complete round weight (lb.)			4,000	9,600	31,200				
	No. of rds. fired at each point of aim			11	40					
	Deflection difference between successive aiming points (ft.)			4	6					
	No. of different aiming points			3	2	1				

Table 14.

155-MM GUN, M1917 (G.P.F.), FIRING PROJECTILE, A.P., M112 OR M112B1

PROJECTILE WEIGHT: 100.00 LB. **COMPLETE ROUND WEIGHT: 124.75 LB.** **MUZZLE VELOCITY: 2,360 F/S**

			0	1,000	3,000	5,000	7,500	10,000	12,500	15,000
Range (yd.)			0	1,000	3,000	5,000	7,500	10,000	12,500	15,000
Terminal velocity (f/s)			2,360	2,210	1,900	1,600	1,280	1,070	1,010	1,000
Probability of hitting target 1 yd. square in any one round					0.18	0.042	0.010	0.0032	0.0015	
5,000 p.s.i.	Penetration depth of one round into thick concrete	Face normal to angle of fall (ft.)	4.3	3.8	3.0	2.3	1.8	1.4	1.3	1.3
5,000 p.s.i.	Penetration depth of one round into thick concrete	Face vertical (ft.)	4.3	3.8	2.9	2.3	1.6	1.2	0.8	0.6
5,000 p.s.i.	Thickness of concrete perforated	Face normal to angle of fall (ft.)	5.7	5.2	4.3	3.6	2.9	2.5	2.3	2.2
5,000 p.s.i.	Thickness of concrete perforated	Face vertical (ft.)	5.7	5.2	4.3	3.4	2.7	2.2	1.8	
5,000 p.s.i.	Volume of concrete excavated by first round (cu. ft.)			37	27	19				
5,000 p.s.i.	Number of rounds falling in circle of 1.33 yd. diameter necessary to perforate concrete	3 ft. thick		1	1	1	2	3		
5,000 p.s.i.	Number of rounds falling in circle of 1.33 yd. diameter necessary to perforate concrete	5 ft. thick		1-2	3	4	7	12		
5,000 p.s.i.	Number of rounds falling in circle of 1.33 yd. diameter necessary to perforate concrete	7 ft. thick		3	5	8	13	23		
Number of hits,[1] number of rounds, and total weight (lb.) of complete rounds necessary to make a breach 4 yds. wide in a reinforced (5,000 p.s.i.) concrete wall	10 ft. high, 6 ft. thick									
	Necessary number of hits			18	24	33				
	Total number of rounds			24	60	210				
	Total complete round weight (lb.)			3,000	7,500	26,200				
	No. of rds. fired at each point of aim			4	30	105				
	Deflection difference between successive aiming points (ft.)			2	6	6				
	No. of different aiming points			6	2	2				
	10 ft. high, 10 ft. thick									
	Necessary number of hits			30	40	55				
	Total number of rounds			36	90	340				
	Total complete round weight (lb.)			4,500	11,200	42,400				
	No. of rds. fired at each point of aim			6	45	170				
	Deflection difference between successive aiming points (ft.)			2	6	6				
	No. of different aiming points			6	2	2				

[1]Replace about one-fifth of rounds with H.E. shell, superquick fused, against reinforced concrete.

Table 15.

155-MM GUNS, M1, M1A1, FIRING SHELL, H.E., M101, WITH C.P., T105 FUZE

PROJECTILE WEIGHT: 95.14 LB. COMPLETE ROUND WEIGHT: 125.82 LB. MUZZLE VELOCITY: 2,800 F/S

			0	1,000	3,000	5,000	7,500	10,000	12,500	15,000
Range (yd.)			0	1,000	3,000	5,000	7,500	10,000	12,500	15,000
Terminal velocity (f/s)			2,800	2,640	2,330	2,030	1,680	1,370	1,130	1,050
Probability of hitting target 1 yd. square in any one round					0.075	0.021	0.0065	0.0026	0.0012	
5,000 p.s.i.	Penetration depth of one round into thick concrete	Face normal to angle of fall (ft.)	5.0	4.6	4.0	3.2	2.4	1.9	1.4	1.2
		Face vertical (ft.)	5.0	4.6	4.0	3.2	2.3	1.7	1.2	0.9
		Face horizontal[1] (ft.)								1.1
	Thickness of concrete perforated	Face normal to angle of fall (ft.)	7.0	6.6	5.6	4.6	3.6	3.0	2.6	2.3
		Face vertical (ft.)	7.0	6.6	5.6	4.6	3.5	2.9	2.3	1.9
		Face horizontal[1] (ft.)								2.2
	Volume of concrete excavated by first round (cu. ft.)			51	40	30				
	Number of rounds falling in circle of 1.33 yd. diameter necessary to perforate concrete	3 ft. thick		1	1	1	1	1-2	3	
		5 ft. thick		1	1	2	3	5	9	
		7 ft. thick		2	3	4	6	10	17	
Number of hits, number of rounds, and total weight (lb.) of complete rounds necessary to make a breach 4 yd. wide in a reinforced (5,000 p.s.i.) concrete wall	10 ft. high, 6 ft. thick									
	Necessary number of hits			12	16	21				
	Total number of rounds			16	70	240				
	Total complete round weight (lb.)			2,000	8,900	30,200				
	No. of rds. fired at each point of aim			8						
	Deflection difference between successive aiming points (ft.)			6						
	No. of different aiming points			2	1	1				
	10 ft. high, 10 ft. thick									
	Necessary number of hits			21	27	35				
	Total number of rounds			28	110	380				
	Total complete round weight (lb.)			3,500	13,800	47,800				
	No. of rds. fired at each point of aim			14						
	Deflection difference between successive aiming points (ft.)			6						
	No. of different aiming points			2	1	1				

[1]High-angle fire to be used against horizontal targets at normal charge.

Table 16.

155-MM GUNS, M1, M1A1, FIRING PROJECTILE, A.P., M112 OR M112B1

PROJECTILE WEIGHT: 100.00 LB. COMPLETE ROUND WEIGHT: 131.28 LB. MUZZLE VELOCITY: 2,743 F/S

			0	1,000	3,000	5,000	7,500	10,000	12,500	15,000
Range (yd.)			0	1,000	3,000	5,000	7,500	10,000	12,500	15,000
Terminal velocity (f/s)			2,745	2,580	2,260	1,940	1,570	1,270	1,080	1,010
Probability of hitting target 1 yd. square in any one round					0.5	0.10	0.028	0.0095	0.0045	
5,000 p.s.i.	Penetration depth of one round into thick concrete	Face normal to angle of fall (ft.)	5.2	4.8	4.0	3.2	2.4	1.8	1.4	1.3
		Face vertical (ft.)	5.2	4.8	4.0	3.1	2.2	1.6	1.1	0.8
	Thickness of concrete perforated	Face normal to angle of fall (ft.)	7.1	6.5	5.4	4.5	3.6	2.9	2.4	2.3
		Face vertical (ft.)	7.1	6.5	5.4	4.5	3.5	2.7	2.2	1.8
	Volume of concrete excavated by first round (cu. ft.)			51	45	29	20			
	Number of rounds falling in circle of 1.33 yd. diameter necessary to perforate concrete	3 ft. thick		1	1	1	1	1-2	4	
		5 ft. thick		1	1	3	4	7	11	
		7 ft. thick		2	3	5	8	13		
Number of hits,[1] number of rounds, and total weight (lb.) of complete rounds necessary to make a breach 4 yd. wide in a reinforced (5,000 p.s.i.) concrete wall	10 ft. high, 6 ft. thick									
	Necessary number of hits			12	17	22	33			
	Total number of rounds			18	26	65	300			
	Total complete round weight (lb.)			2,400	3,400	8,500	39,400			
	No. of rds. fired at each point of aim			3	13	33				
	Deflection difference between successive aiming points (ft.)			2	6	6				
	No. of different aiming points			6	2	2	1			
	10 ft. high, 10 ft. thick									
	Necessary number of hits			21	28	37	55			
	Total number of rounds			24	42	100	550			
	Total complete round weight (lb.)			3,200	5,500	13,100	72,200			
	No. of rds. fired at each point of aim			4	21	50				
	Deflection difference between successive aiming points (ft.)			2	6	6				
	No. of different aiming points			6	2	2	1			

[1]Replace about one-fifth of rounds with H.E. shell, superquick fuzed, against reinforced concrete.

Table 17.

8-INCH HOWITZER, M1, FIRING SHELL, H.E., M106, WITH C.P., T105 FUZE

PROJECTILE WEIGHT: 200.34 LB. COMPLETE ROUND WEIGHT: 228.52 LB. MUZZLE VELOCITY: 1,950 F/S

			0	1,000	3,000	5,000	7,500	10,000	12,500	15,000
Range (yd.)			0	1,000	3,000	5,000	7,500	10,000	12,500	15,000
Terminal velocity (f/s)			1,950	1,820	1,580	1,370	1,160	1,060	1,030	1,030
Probability of hitting target 1 yd. square in any one round							0.060	0.018	0.0056	0.0021
5,000 p.s.i.	Penetration depth of one round into thick concrete	Face normal to angle of fall (ft.) Face vertical (ft.) Face horizontal[1] (ft.)	4.0 40	3.7 3.7	3.1 3.1	2.6 2.4	2.1 1.9	1.8 1.4 1.3	1.8 1.1 1.4	1.8 1.5
5,000 p.s.i.	Thickness of concrete perforated	Face normal to angle of fall (ft.) Face vertical (ft.) Face horizontal[1] (ft.)	6.0 6.0	5.5 5.5	4.7 4.7	4.0 4.0	3.5 3.3	3.2 2.8 2.7	3.1 2.4 2.7	3.1 2.9
5,000 p.s.i.	Volume of concrete excavated by first round (cu. ft.)			50	40	30	22			
5,000 p.s.i.	Number of rounds falling in circle of 1.67 yd. diameter necessary to perforate concrete	3 ft. thick 5 ft. thick 7 ft. thick		1 1 3	1 2 5	1 4 8	1 6 11	1 7 14	1 8 15	1 8 15
Number of hits, number of rounds, and total weight (lb.) of complete rounds necessary to make a breach 4 yd. wide in a reinforced (5,000 p.s.i.) concrete wall	10 ft. high, 6 ft. thick									
	Necessary number of hits			12	16	21	30	35		
	Total number of rounds			15	24	50	250	440		
	Total complete round weight (lb.)			3,400	5,500	11,400	57,100	100,500		
	No. of rds. fired at each point of aim			5	8	25	125			
	Deflection difference between successive aiming points (ft.)			4	4	6	6			
	No. of different aiming points			3	3	2	2	1		
	10 ft. high, 10 ft. thick									
	Necessary number of hits			21	27	35	50	55		
	Total number of rounds			24	39	80	390	650		
	Total complete round weight (lb.)			5,500	8,900	18,300	89,100	148,500		
	No. of rds. fired at each point of aim			8	13	40	145			
	Deflection difference between successive aiming points (ft.)			4	4	6	6			
	No. of different aiming points			3	3	2	2	1		

High-angle fire to be used against horizontal targets. Zone 7 charge at 15,000-yd. range; Zone 6 at 12,500-yd. range; Zone 5 at 10,000-yd. range.

Table 18.

8-INCH GUN, M1, FIRING SHELL, H.E., M103, WITH C.P., T105 FUZE

PROJECTILE WEIGHT: 240.34 LB. COMPLETE ROUND WEIGHT: 338.34 LB. MUZZLE VELOCITY: 2,850 F/S

			0	10,000	12,000	15,000	19,000	23,000	27,000	31,000
Range (yd.)			0	10,000	12,000	15,000	19,000	23,000	27,000	31,000
Terminal velocity (f/s)			2,850	1,920	1,750	1,520	1,290	1,160	1,120	1,150
Probability of hitting target 1 yd. square in any one round					0.0088	0.0035	0.0010	0.00024		
5,000 p.s.i.	Penetration depth of one round into thick concrete	Face normal to angle of fall (ft.) Face vertical (ft.)	8.0 8.0			3.5 3.0	2.7 2.0	2.5 1.4	2.3	2.4
5,000 p.s.i.	Thickness of concrete perforated	Face normal to angle of fall (ft.) Face vertical (ft.)	11.6 11.6			5.2 4.9	4.5 3.7	3.8 2.9	3.7	3.8
5,000 p.s.i.	Volume of concrete excavated by first round (cu. ft.)			75	65	55				
5,000 p.s.i.	Number of rounds falling in circle of 1.67 yd. diameter necessary to perforate concrete	3 ft. thick 5 ft. thick 7 ft. thick		1 1 2	1 2 3	1 3 5	1 4 8	1 6 11	1 7 12	1
Number of hits, number of rounds, and total weight (lb.) of complete rounds necessary to make a breach 4 yd. wide in a reinforced (5,000 p.s.i.) concrete wall	10 ft. high, 6 ft. thick									
	Necessary number of hits			8	10					
	Total number of rounds			290	625					
	Total complete round weight (lb.)			98,000	211,000					
	No. of rds. fired at each point of aim									
	Deflection difference between successive aiming points (ft.)									
	No. of different aiming points			1	1					
	10 ft. high, 10 ft. thick									
	Necessary number of hits			14	16					
	Total number of rounds			475	1,000					
	Total complete round weight (lb.)			161,000	338,000					
	No. of rds. fired at each point of aim									
	Deflection difference between successive aiming points (ft.)									
	No. of different aiming points			1	1					

Table 19.

240-MM HOWITZER, M1, FIRING SHELL, H.E., M114, WITH C.P., T105 FUZE

PROJECTILE WEIGHT: 360.34 LB. COMPLETE ROUND WEIGHT: 438.59 LB. MUZZLE VELOCITY: 2,300 F/S

			0	8,000	10,000	12,500	15,000	19,000	23,000
Range (yd.)			0	8,000	10,000	12,500	15,000	19,000	23,000
Terminal velocity (f/s)			2,300			1,240	1,120	1,080	1,110
Probability of hitting target 1 yd. square in any one round					0.0068	0.0034	0.0019	0.0009	
5,000 p.s.i.	Penetration depth of one round into thick concrete	Face normal to angle of fall (ft.)	7.0			3.1	2.7	2.6	2.7
		Face vertical (ft.)	7.0			2.5	1.9	1.2	
		Face horizontal[1] (ft.)					2.3	2.7	
	Thickness of concrete perforated	Face normal to angle of fall (ft.)	9.7			4.9	4.4	4.1	4.4
		Face vertical (ft.)	9.7			4.2	1.7		
		Face horizontal[1] (ft.)					3.6	4.1	
	Volume of concrete excavated by first round (cu. ft.)					45			
	Number of rounds falling in circle of 2 yd. diameter necessary to perforate concrete	3 ft. thick		1	1	1	1	1	1
		5 ft. thick		1	2	3	5	5	5
		7 ft. thick		2	3	5	9	10	10
Number of hits, number of rounds, and total weight (lb.) of complete rounds necessary to make a breach 4 yd. wide in a reinforced (5,000 p.s.i.) concrete wall	10 ft. high, 6 ft. thick								
	Necessary number of hits			10	12				
	Total number of rounds			255	530				
	Total complete round weight (lb.)			112,000	232,000				
	No. of rds. fired at each point of aim								
	Deflection difference between successive aiming points (ft.)								
	No. of different aiming points			1	1	1			
	10 ft. high, 10 ft. thick								
	Necessary number of hits			16	20				
	Total number of rounds			385	880				
	Total complete round weight (lb.)			169,000	386,000				
	No. of rds. fired at each point of aim								
	Deflection difference between successive aiming points (ft.)								
	No. of different aiming points					1			

[1]High angle fire to be used against horizontal targets. Zone 3 charge for 19,000-yd. range; Zone 2, for 15,000-yd range

Table 20.

SHELL FRAGMENT DAMAGE

Tables of Fragment Damage. These tables give the number B of effective hits per sq. ft. of target area at a given distance r from the burst. The numbers B are averages for different directions from the burst. They are properly applied only to a considerable number of bursts with random orientation of the projectile axis relative to the target.

Damage Patterns. As distinguished from damage tables, the damage patterns represent typical individual cases and vary with the remaining velocity of the projectile, the angle of fall, and the height of burst. Both damage tables and damage patterns presuppose a graze or air burst with *no shielding* of target. The user of the data given here must make due allowance for target shielding and the penetration of the projectile into the ground before burst. The amount of this penetration will depend upon the remaining velocity, angle of fall of the projectile, the nature of the soil, and the projectile and fuze. In the fragment damage patterns, shadings of different types indicate regions of decreasing density of hits. The regions distinguished are those where there is at least one hit per 1, 4, 10, or 25 sq. ft. of area. These units of area are understood as *normal* to the fragment trajectories. *Unshaded regions entering near the burst do not indicate that there are no effective hits in these regions, but merely that the density of effective hits is less than that belonging to the nearest shaded area.*

The white centers of the fragment patterns are used to indicate the origin of the polar system above which the missile bursts. In general, these areas suffer the highest type of fragment damage as well as blast damage.

Types of Damage. The types of damage considered are casualties, and normal perforations of mild steel of ⅛-in., ¼-in., and ½-in. thickness. A casualty is supposed caused by a hit with at least 58 ft.-lb. of energy. It is incapacitation and not necessarily death. Damage occasioned by perforation of ⅛-in. mild steel is considered effective against airplanes on the ground. In antiaircraft fire against modern bombers, the most effective damage varies from that with ⅛-in. perfor-

:ion to ⅜-in. perforation of mild steel. Damage in which there are perforations ' ¼-in. or ½-in. mild steel is effective against trucks, light armored vehicles, ilway rolling stock, and targets of similar resistant nature.

The Choice of Shells. The artilleryman should first decide upon the type of erforation which his target requires for effective damage. The tables will then iow him the average number of effective hits to be expected for ground bursts : a given distance from the target provided the target is unshielded and a suf- cient number of shots are used.

If the target is shielded, as when men are in medium foxholes, air bursts will icrease the chance of effective damage, particularly if the target area is extended. he fragment patterns will indicate how the damage done by an individual shell aries with the height of burst and angle of fall.

For the shells considered, the optimum height of burst against shielded per- onnel is approximately 30 ft. This optimum is for a *controlled* height of burst 'ithout dispersion in height. In actual practice, the height of burst of a shell ı time fire suffers considerable dispersion and when the mechanical time fuze, [67 or M43, is used, the projectile fails in general on ground impact. In such ises, the optimum *mean* height of burst is generally higher than 30 ft. For the ıze, M67 or M43, there may be used the following practical rule which assures agment damage near the optimum against enemy personnel in medium foxholes.

Adjust the mean height of burst to a value which is twice the probable error in ie height of burst as listed in the firing tables, restricting H, however, to values etween 30 ft. and 120 ft.

The patterns indicate how the fragment damage falls off with height of burst bove 30 ft. This accounts for the upper limit of 120 ft. On the other hand, ie failure of shells with the fuzes, M67 and M43, to detonate on ground impact, iakes it necessary to raise the height of burst as far as is consistent with the iaximum damage effect. The above rule is designed for this end.

The Sources of Data. The data from which the damage tables and patterns ave been derived is taken from measurements of fragment velocity, retardation, iape, and penetration, and the mass and angular distribution of fragments as iade at the various Army and Navy proving grounds and laboratories.

Hand Grenade, Mk. II, TNT Loading. Initial Fragment Velocity, 2,900 F/S.

CASUALTIES

Distance from burst (ft.)	Total number of effective fragments	Average number of effective frag-ments per sq. ft.	For the lightest effective fragment	
			Weight (oz.)	Velocity (f/s)
r	N	B	m	v
10	295	.234	.012	2,230
20	233	.0463	.017	1,870
30	188	.0166	.022	1,640
40	147	.0073	.028	1,460
50	111	.0035	.035	1,310
60	86	.0019	.041	1,210
70	64	.0010	.048	1,120
80	47	.0006	.055	1,040
100	30	.0002	.067	943
120	19	.0001	.079	870
140	13	.0001	.089	817

Table 21.

PERFORATION OF ⅛-IN. MILD STEEL

Distance from burst (ft.)	Total number of effective fragments	Average number of effective frag-ments per sq. ft.	For the lightest effective fragment	
			Weight (oz.)	Velocity (f/s)
r	N	B	m	v
10	86	.0686	.041	2,550
20	43	.0086	.057	2,270
30	22	.0020	.075	2,080
40	11	.0005	.095	1,920
50	7	.0002	.120	1,810
60	4	.0001	.147	1,710
70	3	.0001	.176	1,610

Table 22.

20-mm H.E. Shell, T16.
Initial Fragment Velocity 2,160 F/S.

CASUALTIES

Distance from burst (ft.)	Total number of effective fragments	Average number of effective fragments per sq. ft.	For the lightest effective fragment: Weight (oz.)	For the lightest effective fragment: Velocity (f/s)
r	N	B	m	v
10	38	.0304	.018	1,820
20	27	.0054	.025	1,540
30	18	.0016	.033	1,340
40	12	.0006	.040	1,220
50	7	.0002	.050	1,090
60	6	.0001	.056	1,030
70	5	.0001	.062	980
80	5	.0001	.068	935

Table 23.

20-mm H.E.I. Shell, M97 (T23).
Initial Fragment Velocity 1,960 F/S.

CASUALTIES

Distance from burst (ft.)	Total number of effective fragments	Average number of effective fragments per sq. ft.	For the lightest effective fragment: Weight (oz.)	For the lightest effective fragment: Velocity (f/s)
r	N	B	m	v
10	30	.0239	.024	1,570
20	21	.0042	.033	1,340
30	15	.0013	.042	1,190
40	11	.0005	.050	1,090
50	10	.0003	.057	1,020
60	9	.0002	.063	972
70	8	.0001	.069	929
80	7	.0001	.075	891

Table 24.

8-in. H.E. Shell, M103. Initial Fragment Velocity 2,500 F/S.

CASUALTIES

Distance from burst (ft.)	Total number of effective fragments	Average number of effective fragments per sq. ft.	For the lightest effective fragment: Weight (oz.)	For the lightest effective fragment: Velocity (f/s)
r	N	B	m	v
20	1,860	.370	.020	1,730
30	1,770	.156	.027	1,480
50	1,680	.0533	.040	1,220
70	1,560	.0253	.055	1,040
100	1,470	.0117	.074	897
150	1,360	.0048	.101	768
200	1,260	.0025	.130	676
300	1,080	.0010	.195	553
500	865	.0003	.359	407
800	647	.0001	.715	289

Table 25.

PERFORATION OF 1/8-IN. MILD STEEL

Distance from burst (ft.)	Total number of effective fragments	Average number of effective fragments per sq. ft.	For the lightest effective fragment: Weight (oz.)	For the lightest effective fragment: Velocity (f/s)
r	N	B	m	v
20	1,440	.286	.082	2,010
30	1,330	.118	.107	1,860
40	1,250	.0622	.136	1,750
60	1,060	.0233	.207	1,510
80	922	.0115	.293	1,360
100	835	.0066	.390	1,250
150	670	.0024	.655	1,080
200	567	.0011	.934	983
300	418	.0004	1.52	867
500	257	.0001	2.98	733

Table 26.

PERFORATION OF 1/4-IN. MILD STEEL

r	N	B	m	v
20	762	.152	.485	2,230
30	711	.0629	.566	2,110
40	670	.0333	.655	2,020
60	590	.0130	.855	1,850
80	514	.0064	1.10	1,710
100	447	.0036	1.37	1,600
150	323	.0011	2.16	1,390
200	252	.0005	3.15	1,240
275	179	.0002	4.70	1,110
400	106	.0001	7.45	983

Table 27.

PERFORATION OF 1/2-IN. MILD STEEL

r	N	B	m	v
20	245	.0487	3.27	2,360
30	232	.0205	3.55	2,290
40	225	.0112	3.86	2,230
60	188	.0042	4.53	2,110
80	156	.0019	5.23	2,010
100	133	.0011	5.97	1,930
120	119	.0007	6.81	1,850
140	100	.0004	7.72	1,780
170	80	.0002	9.20	1,680
225	40	.0001	13.3	1,470

Table 28.

240-mm H.E. Shell, M114. Initial Fragment Velocity 3,300 F/S.

CASUALTIES

Distance from burst (ft.)	Total number of effective fragments	Average number of effective fragments per sq. ft.	For the lightest effective fragment: Weight (oz.)	For the lightest effective fragment: Velocity (f/s)
r	N	B	m	v
20	4,160	.825	.013	2,140
30	4,080	.360	.017	1,870
50	3,660	.117	.028	1,460
70	3,310	.0538	.040	1,220
100	3,000	.0239	.060	1,000
150	2,720	.0096	.087	827
250	2,360	.0030	.140	652
400	1,990	.0010	.240	498
700	1,520	.0002	.521	338
1,000	1,050	.0001	.928	253

Table 29.

PERFORATION OF 1/8-IN. MILD STEEL

Distance from burst (ft.)	Total number of effective fragments	Average number of effective fragments per sq. ft.	For the lightest effective fragment: Weight (oz.)	For the lightest effective fragment: Velocity (f/s)
r	N	B	m	v
20	3,250	.647	.042	2,530
30	3,070	.271	.055	2,300
50	2,720	0865	.087	1,970
70	2,420	0393	.132	1,770
100	2,040	.0162	.220	1,480
150	1,670	.0059	.412	1,230
200	1,360	0027	.639	1,090
275	1,010	.0011	.980	970
400	638	.0003	1.70	841
600	379	.0001	3.05	735

Table 30.

r	N	B	m	v
20	2,000	.399	.235	2,880
30	1,910	.169	.276	2,720
40	1,820	.0903	.325	2,560
60	1,640	.0362	.436	2,310
80	1,460	.0182	.560	2,120
100	1,280	.0102	.700	1,970
150	885	.0031	1.17	1,680
200	622	.0012	1.75	1,480
300	362	.0003	3.28	1,230
500	177	.0001	7.05	997

PERFORATION OF 1/4-IN. MILD STEEL

Table 31.

r	N	B	m	v
20	700	.139	1.54	3,070
30	638	.0564	1.70	2,980
40	597	.0297	1.85	2,880
60	498	.0110	2.23	2,700
80	432	.0054	2.60	2,550
100	383	.0030	3.01	2,420
150	333	.0012	4.22	2,160
200	251	.0005	5.60	1,970
250	165	.0002	7.27	1,810
300	82	.0001	9.15	1,680

PERFORATION OF 1/2-IN. MILD STEEL

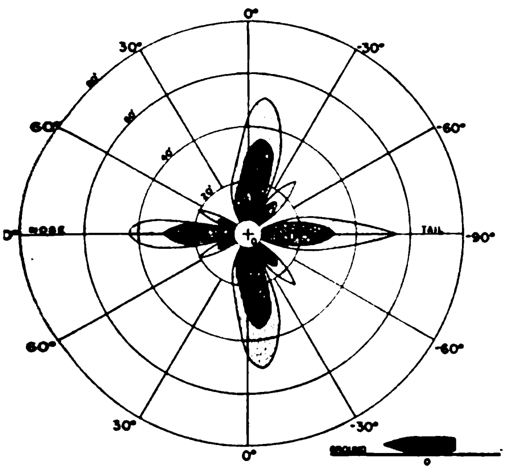
Table 32.

At least 1 hit per 4 sq. ft.

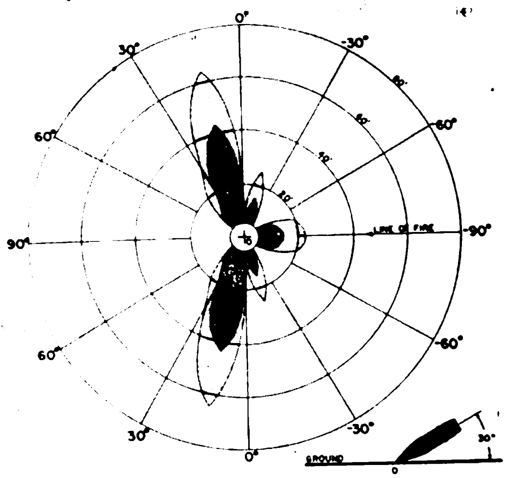
At least 1 hit per 10 sq. ft.

At least 1 hit per 25 sq. ft.

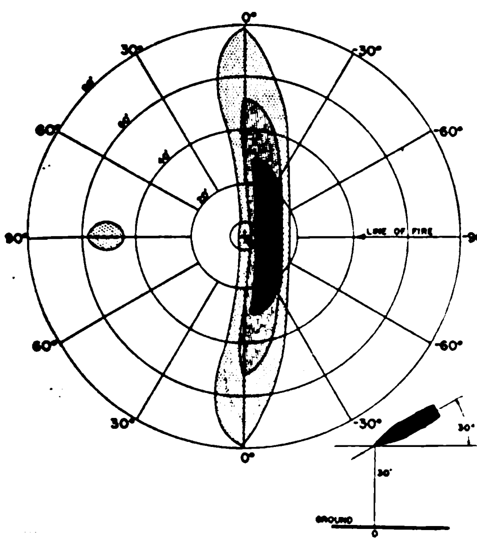
75-mm Shell, H.E., M48. Casualties.



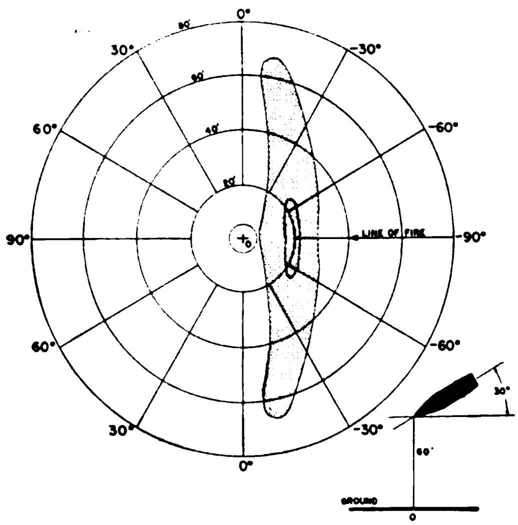
Ground Burst
Shell Horizontal at rest



Ground Burst
Remaining Velocity 800 f/s
Range 8,500 yd. (normal charge)—75-mm Gun, M3



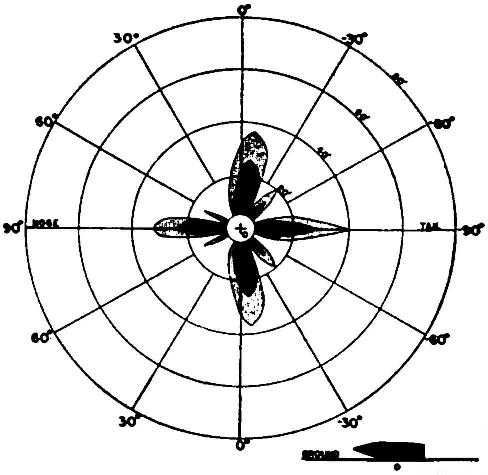
Height of Burst 30 ft.
Remaining Velocity 800 f/s
Range 8,500 yd. (normal charge)—75-mm Gun, M3



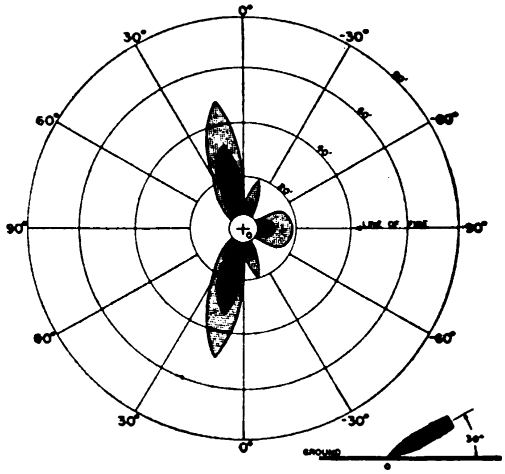
Height of Burst 60 ft.
Remaining Velocity 800 f/s
Range 8,500 yd. (normal charge)—75-mm Gun, M3

Figure 126.

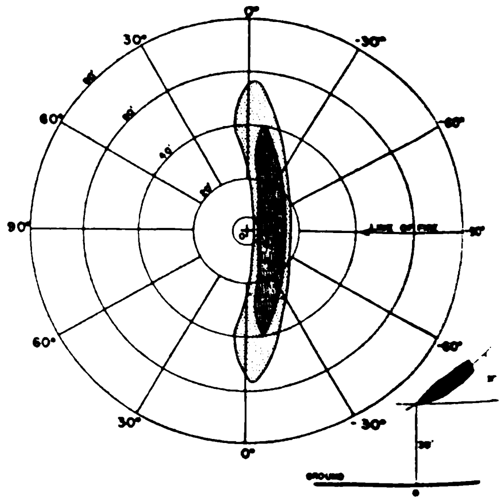
75-mm Shell, H.E., M48. Perforation of ⅛-in. Mild Steel.



Ground Burst
Shell Horizontal at rest

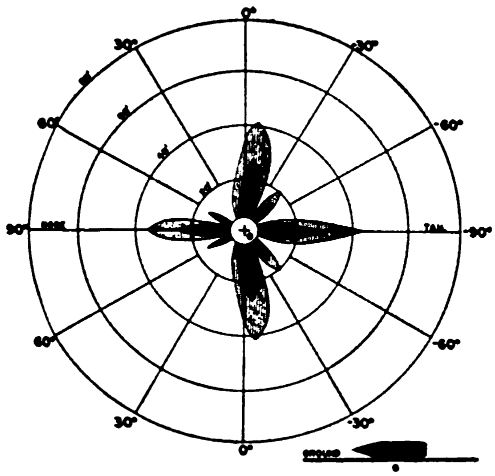


Ground Burst
Remaining Velocity 800 f/s
Range 8,500 yd. (normal charge)—75-mm
Gun, M3

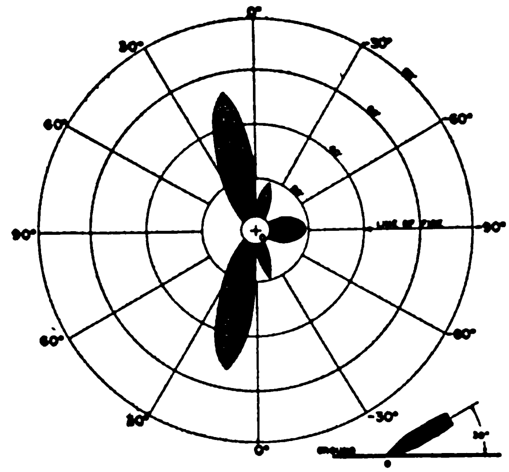


Height of Burst 30 ft.
Remaining Velocity 800 f/s
Range 8,500 yd. (normal charge)—75-mm
Gun M3

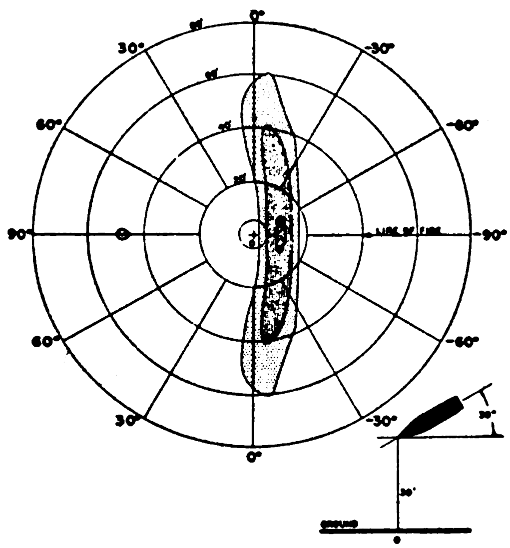
Figure 127.



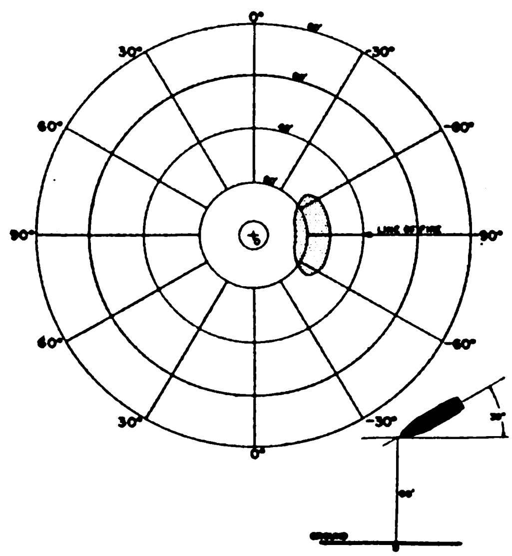
Ground Burst
Shell Horizontal at rest



Ground Burst
Remaining Velocity 815 f/s
Range 10,500 yd.—3-in. Gun, M5

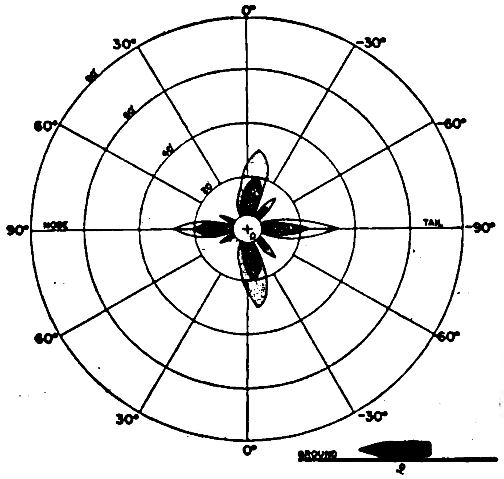


Height of Burst 30 ft.
Remaining Velocity 815 f/s
Range 10,500 yd.—3-in. Gun, M5

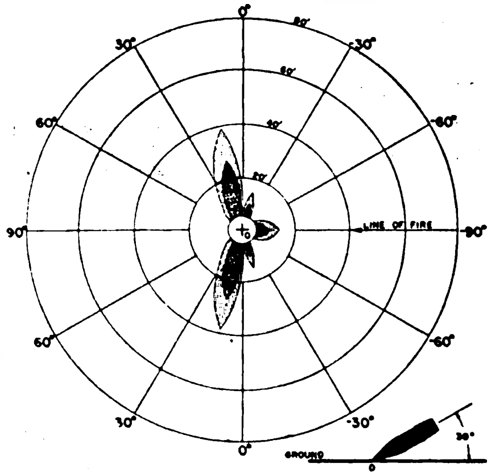


Height of Burst 60 ft.
Remaining Velocity 815 f/s
Range 10,500 yd.—3-in. Gun, M5

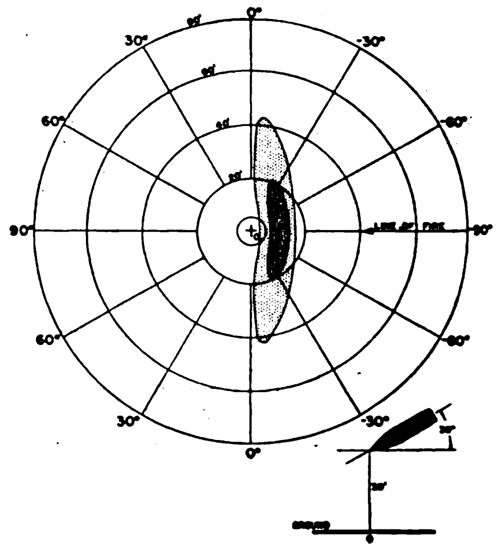
Figure 128. Fragment Damage Pattern—Casualties. 3-in. Shell H.E., M42A1.



Ground Burst
Shell Horizontal at rest

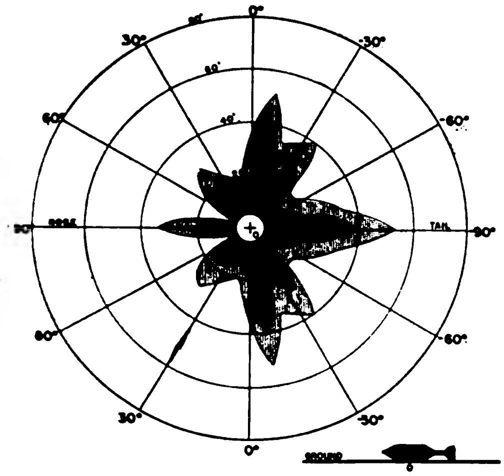


Ground Burst
Remaining Velocity 815 f/s
Range 10,500 yd.—3-in. Gun, M5

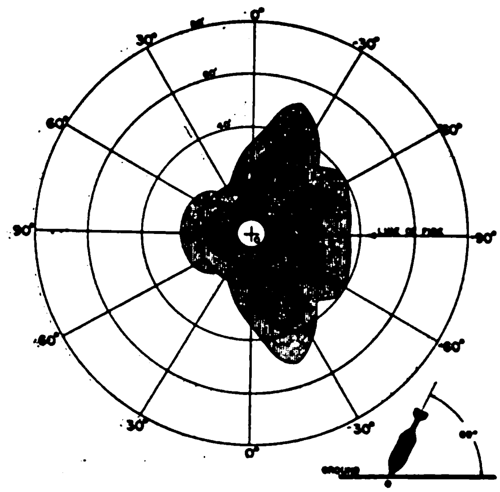


Height of Burst 30 ft.
Remaining Velocity 815 f/s
Range 10,500 yd.—3-in. Gun, M5

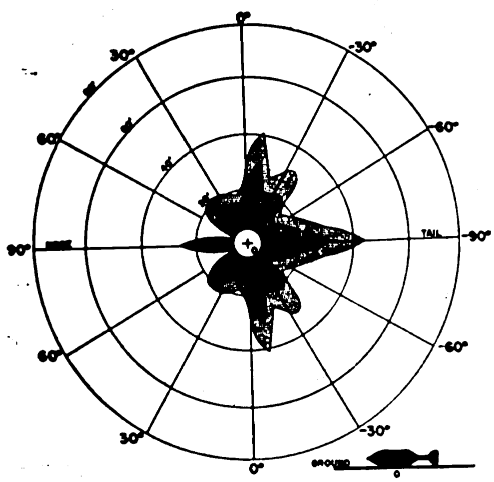
Figure 129. Fragment Damage Pattern—Perforation of ⅛-in. Mild Steel. 3-in. Shell, H.E., M42A1



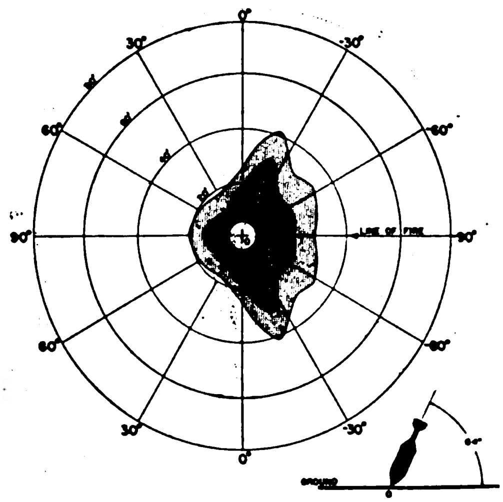
Ground Burst
Shell Horizontal at rest



Ground Burst
Remaining Velocity 459 f/s
Range 1,000 yd.—(charge 4)

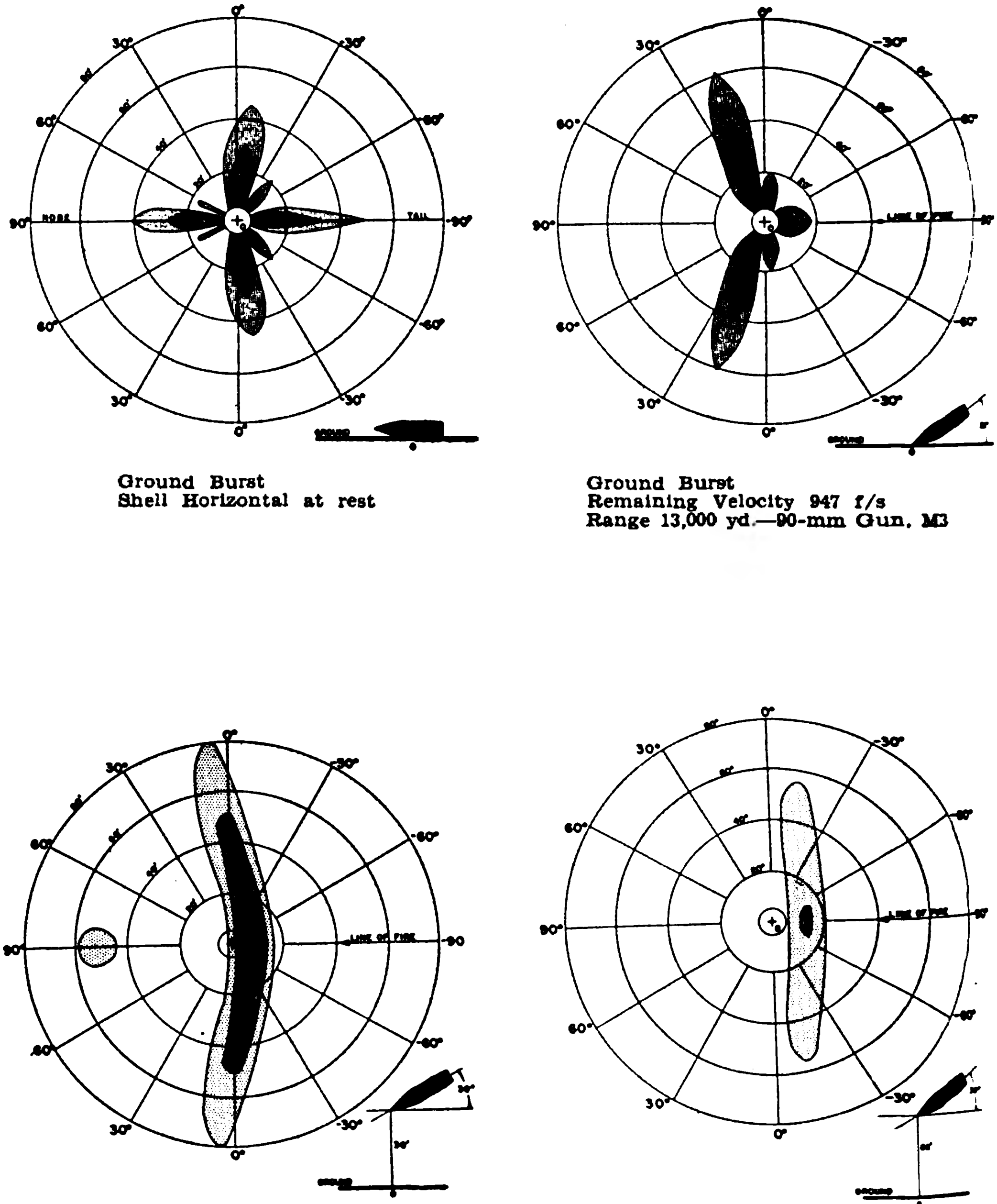


Ground Burst
Shell Horizontal at rest



Ground Burst
Remaining Velocity 459 f/s
Range 1,000 yd.—(charge 4)

Figure 130. Fragment Damage Pattern—Casualties. 81-mm Shell, H.E., M56.



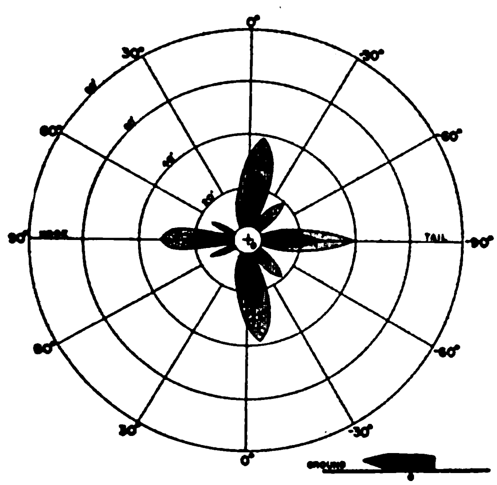
Ground Burst
Shell Horizontal at rest

Ground Burst
Remaining Velocity 947 f/s
Range 13,000 yd.—90-mm Gun, M3

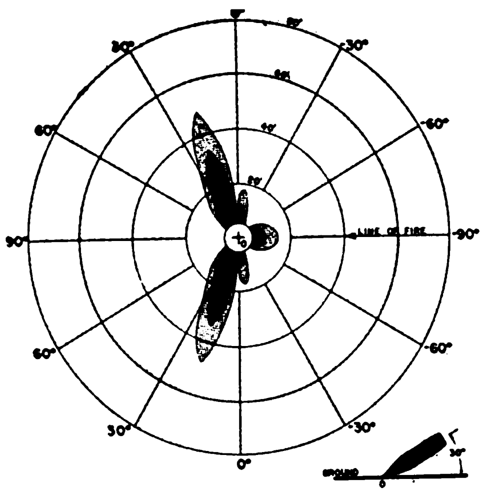
Height of Burst 30 ft.
Remaining Velocity 947 f/s
Range 13,000 yd.—90-mm Gun, M3

Height of Burst 60 ft.
Remaining Velocity 947 f/s
Range 13,000 yd.—90-mm Gun, M3

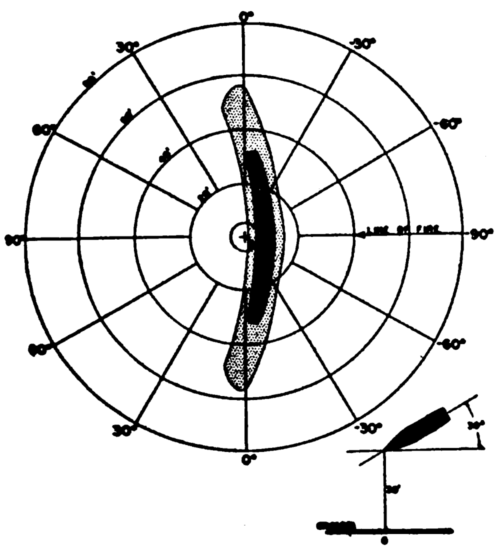
Figure 131. Fragment Damage Pattern—Casualties. 90-mm Shell, H.E., M71.



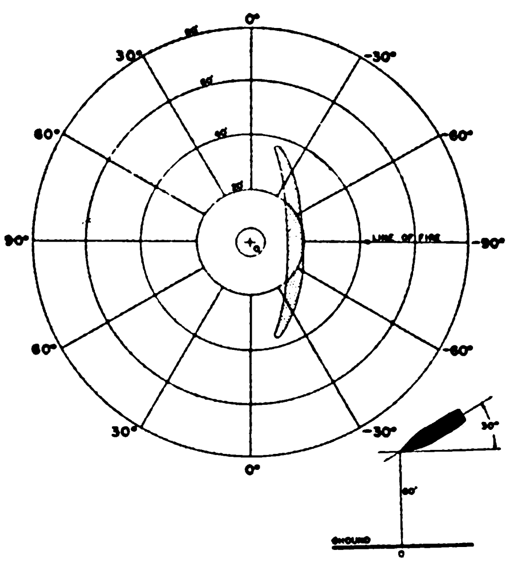
Ground Burst
Shell Horizontal at rest



Ground Burst
Remaining Velocity 947 f/s
Range 13,000 yd.—90-mm Gun, M3

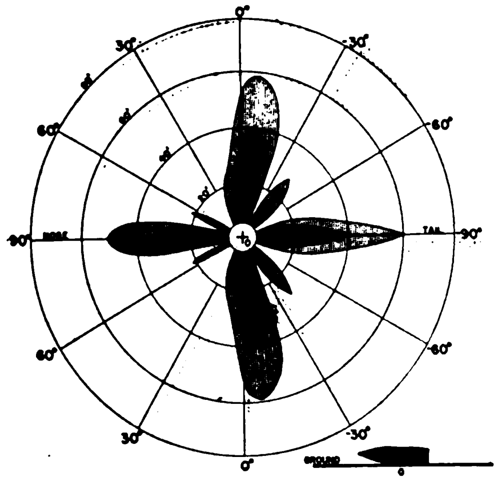


Height of Burst 30 ft.
Remaining Velocity 947 f/s
Range 13,000 yd.—90-mm Gun, M3

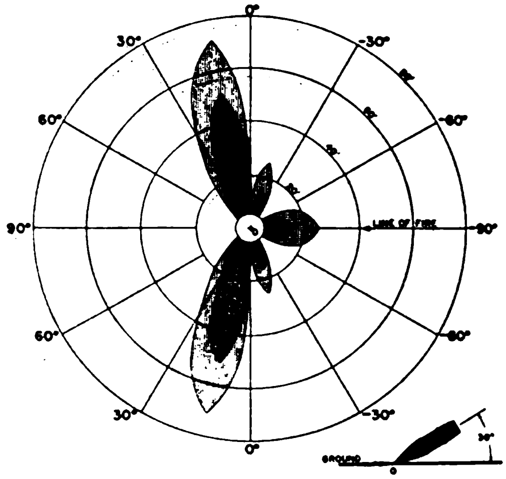


Height of Burst 60 ft.
Remaining Velocity 947 f/s
Range 13,000 yd.—90-mm Gun, M3

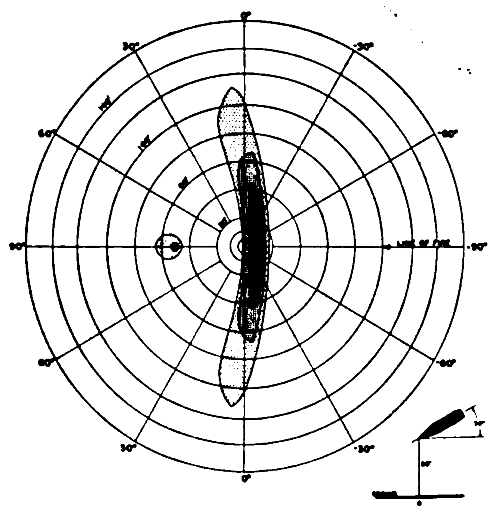
Figure 132. Fragment Damage Pattern—Perforation of ⅛-in. Mild Steel. 90-mm Shell, H.E., M71.



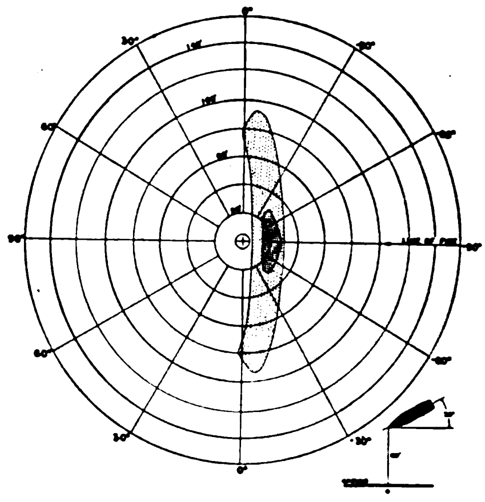
Ground Burst
Shell Horizontal at rest



Ground Burst
Remaining Velocity 800 f/s
Range 7,000 yd. (charge 5)—105-mm How., M2A1

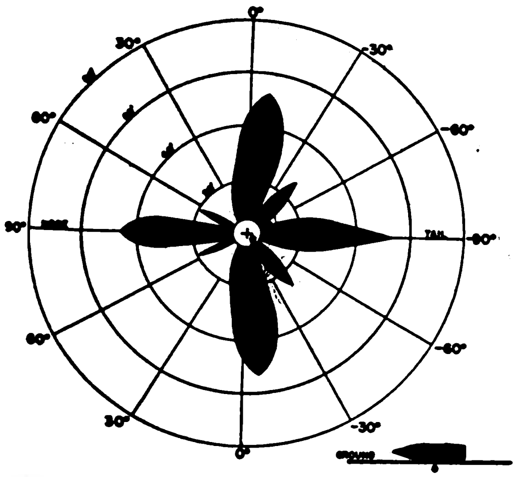


Height of Burst 30 ft.
Remaining Velocity 800 f/s
Range 7,000 yd. (charge 5)—105-mm How., M2A1

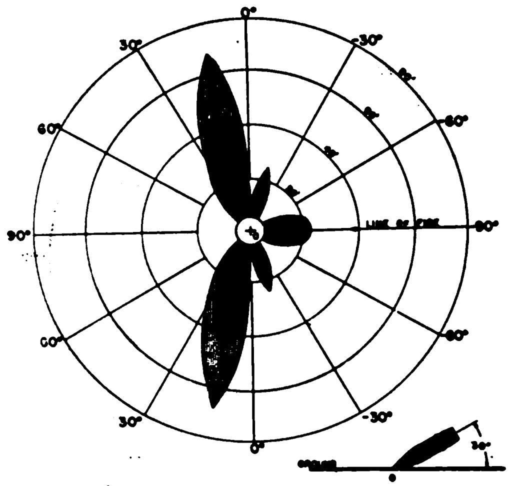


Height of Burst 60 ft.
Remaining Velocity 800 f/s
Range 7,000 yd. (charge 5)—105-mm How., M2A1

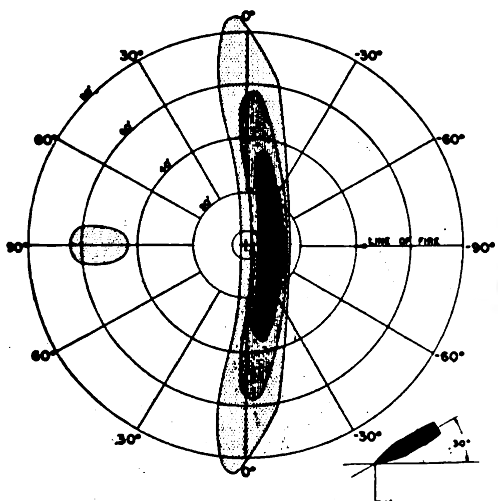
Figure 133. Fragment Damage Patterns—Casualties. 105-mm Shell, H.E., M1.



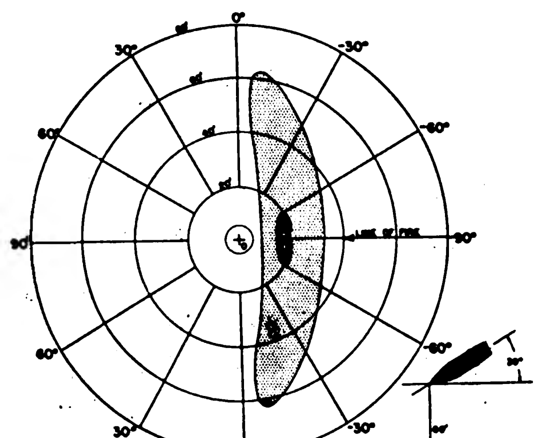
Ground Burst
Shell Horizontal at rest



Ground Burst
Remaining Velocity 800 f/s
Range 7,000 yd. (charge 5)—105-mm How., M2A1

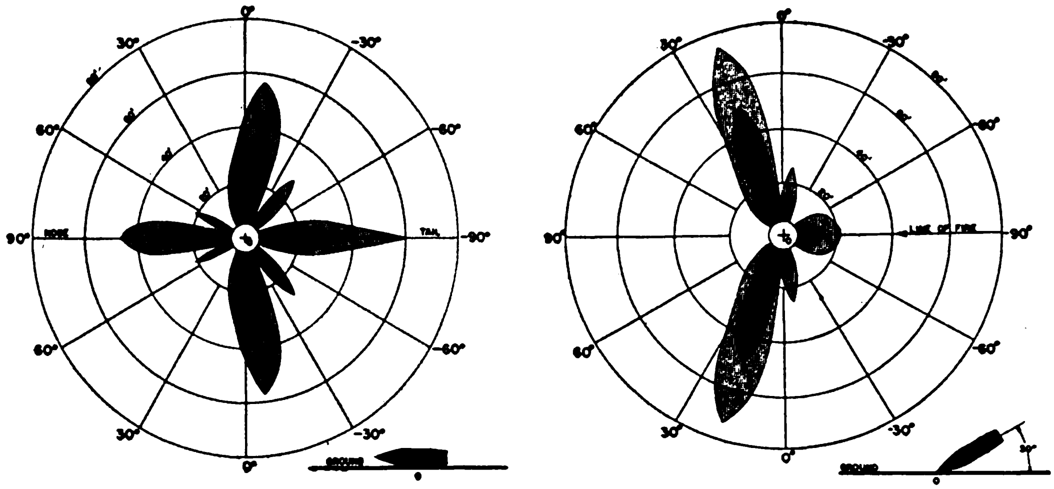


Height of Burst 30 ft.
Remaining Velocity 800 f/s
Range 7,000 yd. (charge 5)—105-mm How., M2A1



Height of Burst 60 ft.
Remaining Velocity 800 f/s
Range 7,000 yd. (charge 5)—105-mm How., M2A1

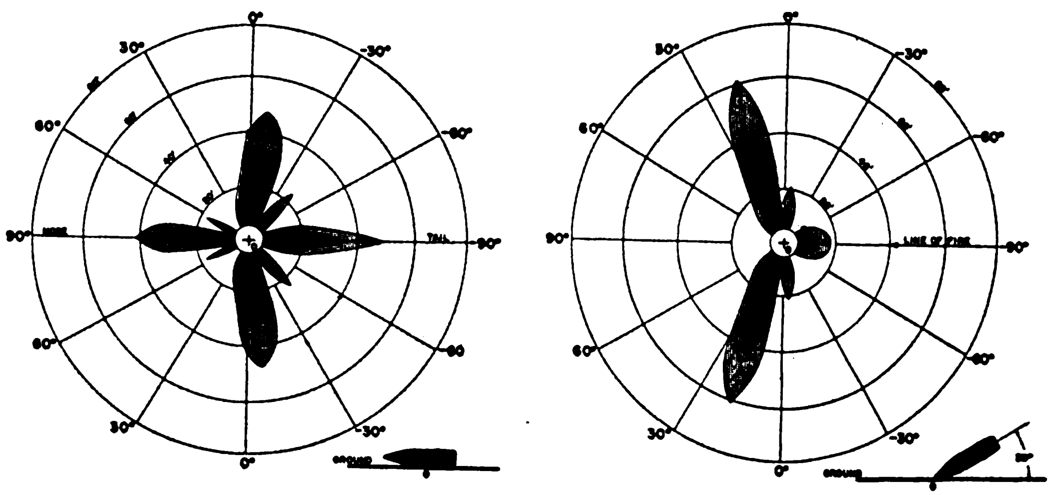
Figure 134. Fragment Damage Pattern—Perforation of ⅛-in. Mild Steel. 105-mm Shell, H.E., M1.



Ground Burst
Shell Horizontal at rest

Ground Burst
Remaining Velocity 960 f/s

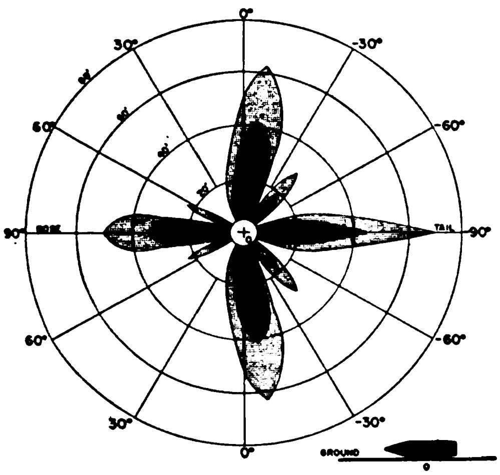
Figure 134A. 105-mm Shell, H.E., M38A1. Perforation of ⅛-in. Mild Steel.



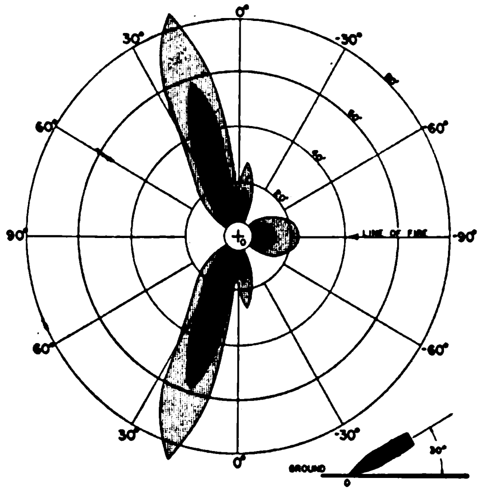
Ground Burst
Shell Horizontal at rest

Ground Burst
Remaining Velocity 960 f/s

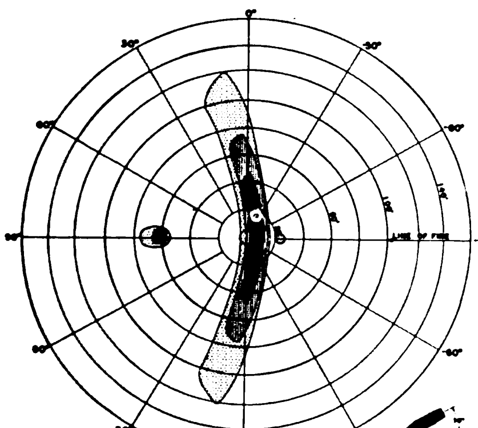
Figure 135. Fragment Damage Patterns. 105-mm Shell, H.E., M38A1.



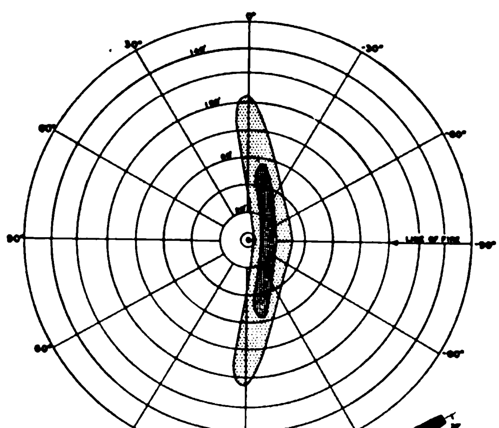
Ground Burst
Shell Horizontal at rest



Ground Burst
Remaining Velocity 1,000 f/s
Range 12,000 yd. (normal charge)—4.5-in. Gun, M1

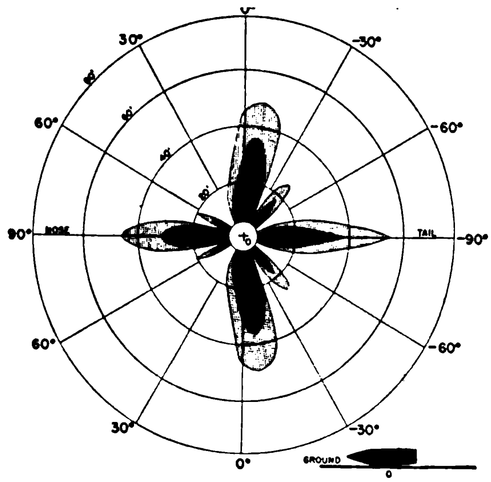


Height of Burst 30 ft.
Remaining Velocity 1,000 f/s
Range 12,000 yd. (normal charge)—4.5-in. Gun, M1

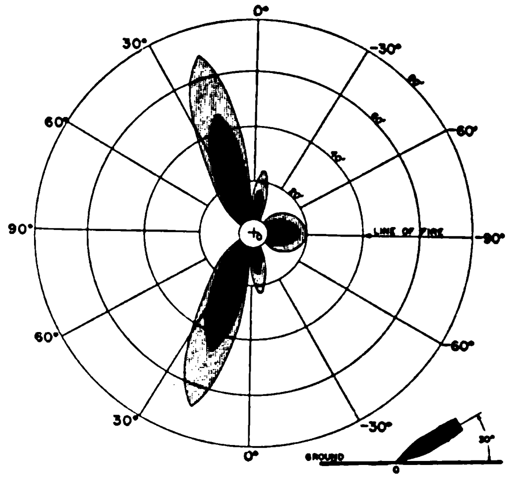


Height of Burst 60 ft.
Remaining Velocity 1,000 f/s
Range 12,000 yd. (normal charge)—4.5-in. Gun, M1

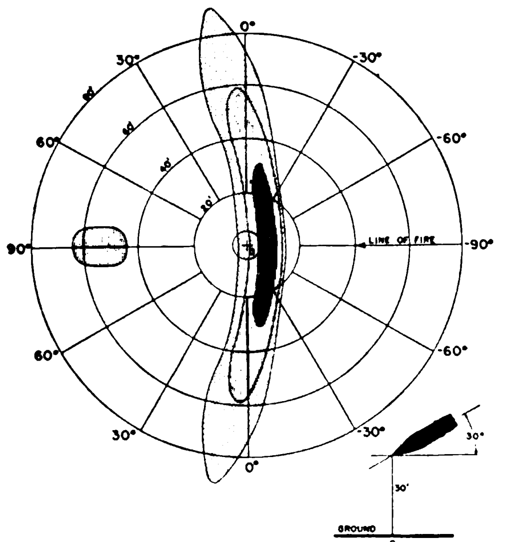
Figure 136. Fragment Damage Patterns—Casualties. 4.5-in. Shell, H.E., M65.



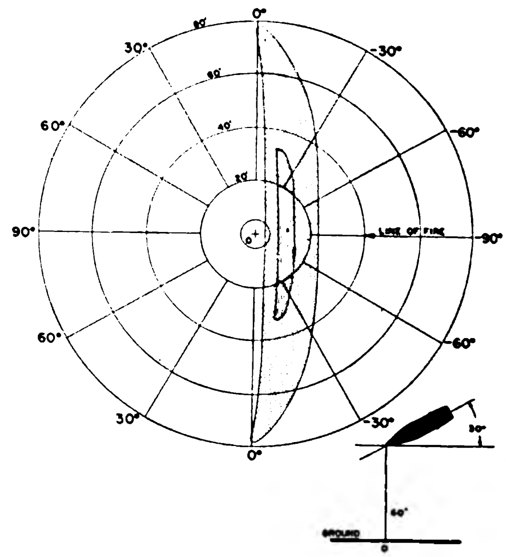
Ground Burst
Shell Horizontal at rest



Ground Burst
Remaining Velocity 1,000 f/s
Range 12,000 yd. (normal charge)—4.5-in. Gun, M1

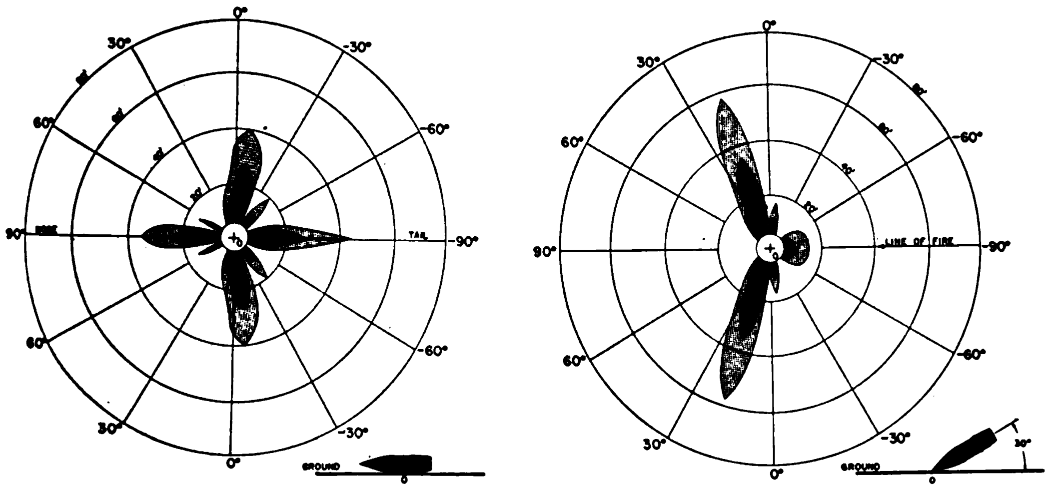


Height of Burst 30 ft.
Remaining Velocity 1,000 f/s
Range 12,000 yd. (normal charge)—4.5-in. Gun, M1



Height of Burst 60 ft.
Remaining Velocity 1,000 f/s
Range 12,000 yd. (normal charge)—4.5-in. Gun, M1

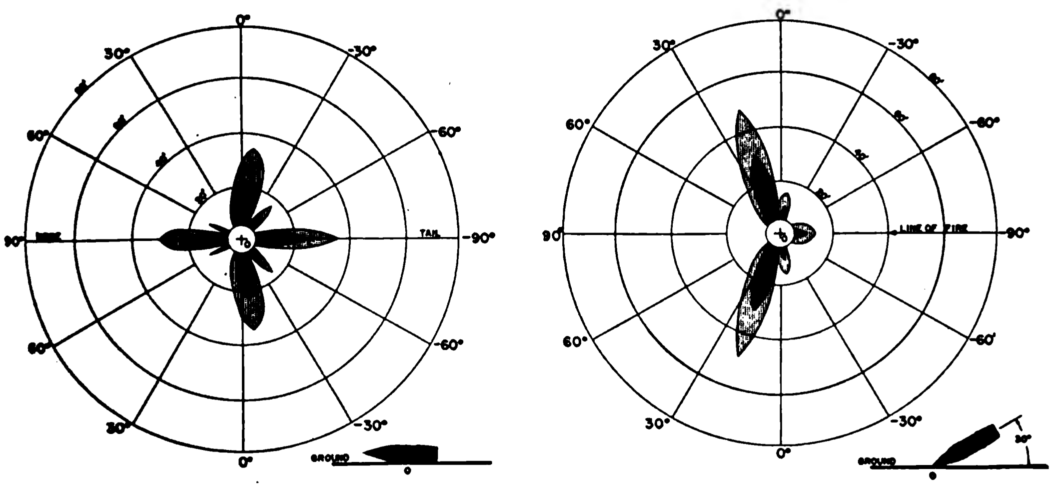
Figure 137. Fragment Damage Pattern—Perforation of 1/8-in. Mild Steel. 4.5-in. Shell, H.E., M65.



Ground Burst
Shell Horizontal at rest

Ground Burst
Remaining Velocity 960 f/s

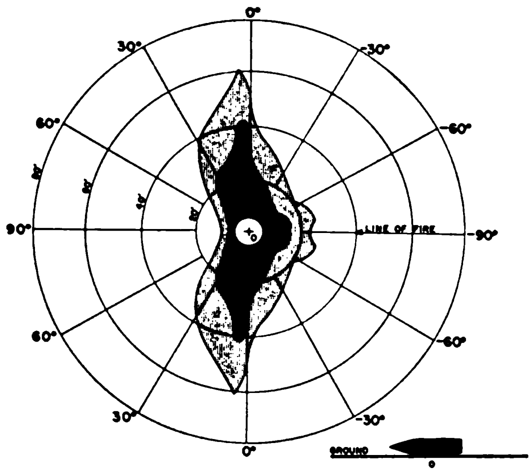
Figure 138A. 120-mm Shell, H.E., M73. Casualties.



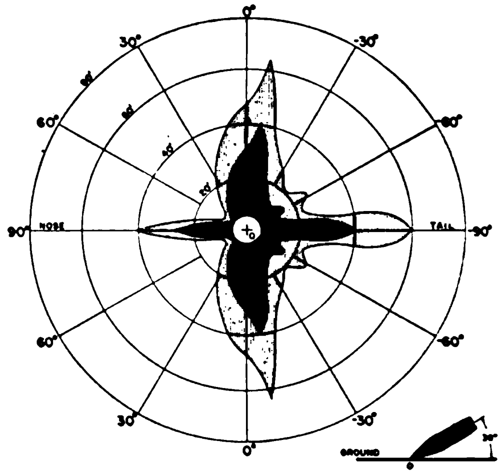
Ground Burst
Shell Horizontal at rest

Ground Burst
Remaining Velocity 960 f/s

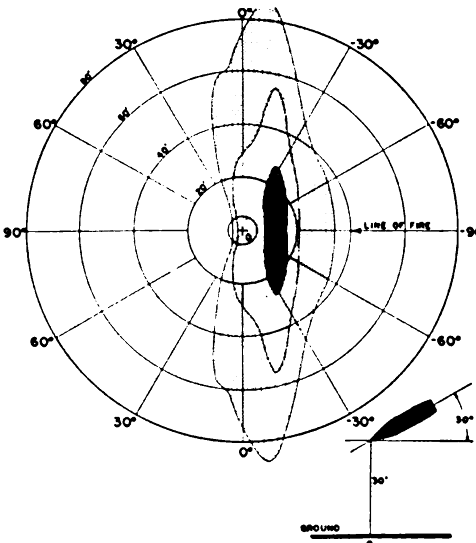
Figure 138B. 120-mm Shell, H.E., M73. Perforation of ⅛-in. Mild Steel.



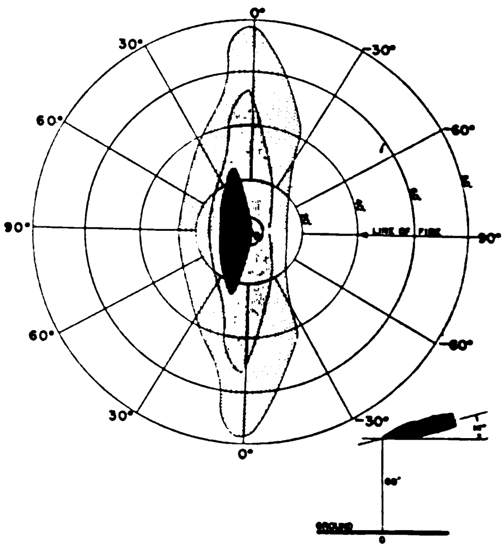
Ground Burst
Shell Horizontal at rest



Ground Burst
Remaining Velocity 900 f/s
Range 9,000 yd. (charge 5)—155-mm How., M1

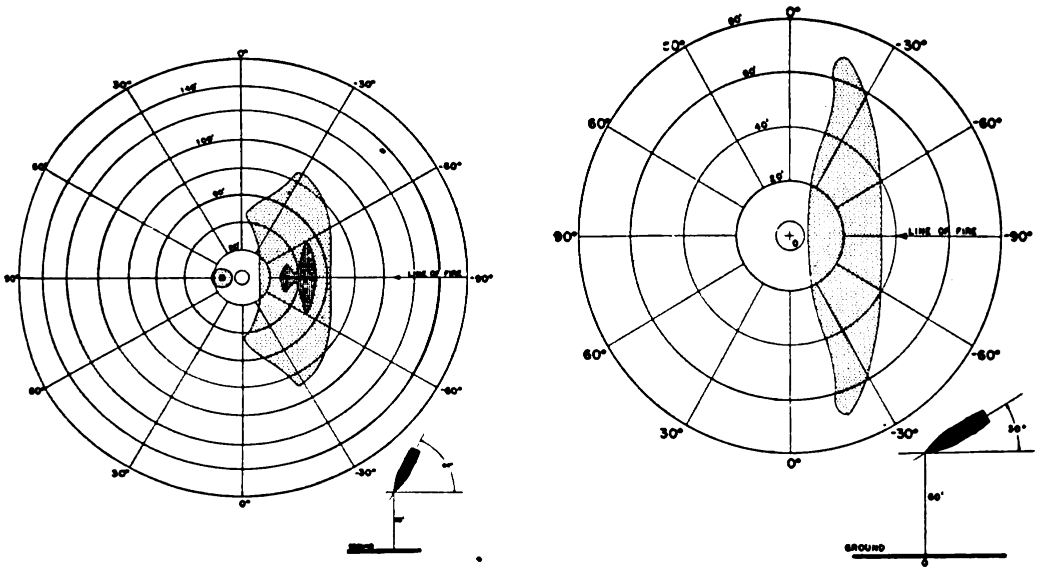


Height of Burst 30 ft.
Remaining Velocity 900 f/s
Range 9,000 yd. (charge 5)—155-mm How., M1



Height of Burst 60 ft.
Remaining Velocity 900 f/s
Range 9,000 yd. (charge 5)—155-mm How., M1

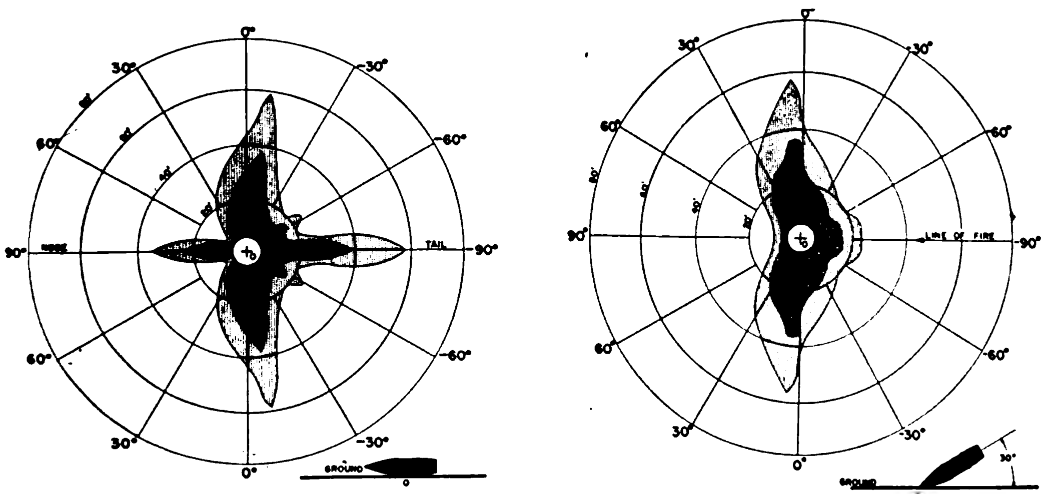
Figure 139. Fragment Damage Patterns—Casualties. 155-mm Shell, H.E., M107.



Height of Burst 30 ft.
Remaining Velocity 950 f/s
Range 9,000 yd. (charge 5)—155-mm How., M1

Height of Burst 60 ft.
Remaining Velocity 950 f/s
Range 9,000 yd. (charge 5)—155-mm How., M1

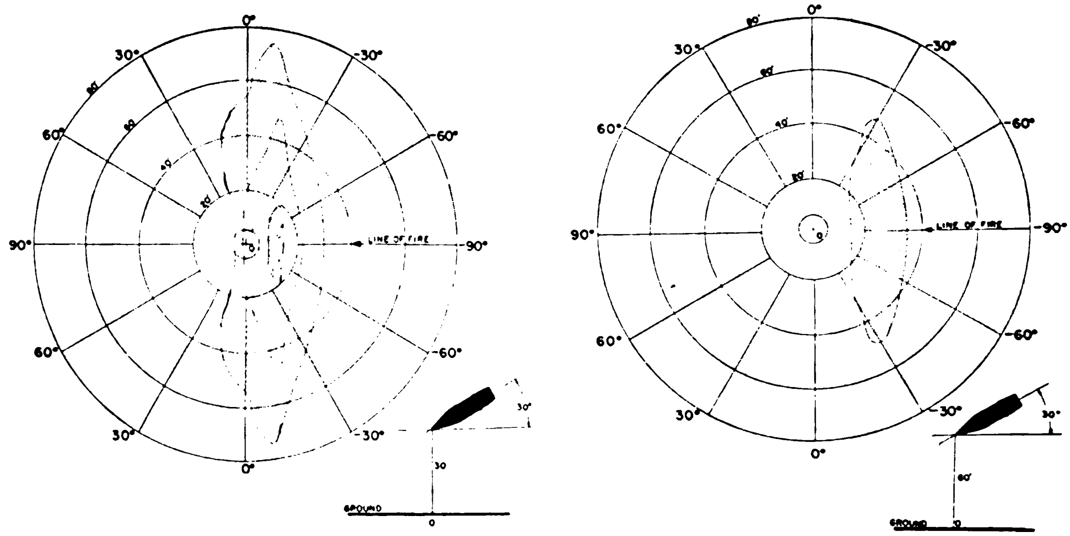
Figure 140. Fragment Damage Patterns—Casualties. 155-mm Shell, H.E., M107.



Ground Burst
Shell Horizontal at rest

Ground Burst
Remaining Velocity 900 f/s
Range 9,000 yd. (charge 5)—155-mm How., M1

Figure 141. Fragment Damage Patterns—Perforation of ⅛-in. Mild Steel. 155-mm Shell, H.E., M107.



Height of Burst 90 ft.
Remaining Velocity 900 f/s
Range 9,000 yd. (charge 5)—155-mm How., M1

Height of Burst 60 ft.
Remaining Velocity 900 f/s
Range 9,000 yd. (charge 5)—155-mm How., M1

Figure 141. Fragment Damage Patterns—Perforation of ⅛-in. Mild Steel. 155-mm Shell, H.E., M107.

CHAPTER 4

AMMUNITION SUPPLY

Logistics has been defined as the art, science, or ability of getting the proper troops with the proper equipment to the proper place at the proper time. With no other item of supply does the science become more complex than with the supply of ammunition.

The mass, the many sizes and types, and the explosive nature of ammunition all combine to present problems which call for flexible and continuous solutions. These problems assume great proportions when we consider that an adequate and timely supply of ammunition to combat troops is indispensable to successful prosecution of any military operation. No other single item of supply is so vital to combat.

Figure 1. Empty Shell Cases From Anzio.

Cardinal principles of any supply system include simplicity, mobility, flexibility, continuity, security, and forward movement. The goal of each man in the chain of ammunition supply should be the achievement of these principles.

Each commanding officer is responsible for the supply of ammunition to all units within his command, and although he may delegate duties attendant upon such responsibility, the responsibility itself is his.

Terms commonly used in supply of ammunition with which we should be familiar include:

Allocation. The *act* of obligating or reserving a definite quantity of ammunition at a specified installation for a specific organization. It is often applied in the field to the ammunition itself, when it becomes synonymous with 'ammunition credit.'

Ammunition Credit. A specific amount of ammunition reserved for and placed at the disposal of the commander of a designated organization at a specified ammunition supply installation. It is a tangible quantity of ammunition.

Ammunition in Hands of Troops. Ammunition in physical control of a reporting unit. It includes prescribed load, ammunition in unit rolling reserves, and ammunition at gun positions.

Ammunition Officer. Ordnance staff officer in a division or larger unit designated to supervise matters pertaining to ammunition supply of that unit. He may be the Ordnance officer on the special staff or another officer in the Ordnance Department.

Ammunition Supply Installation. General term used to designate any organized locality for reception, classification, storage or issue of ammunition. Ground Forces installations are classified as follows:

1. *Ammunition Depot:* Installation from which most issues are made to other ammunition supply installations.

2. *Ammunition Supply Point (ASP):* an ammunition supply installation in the combat zone. Most issues are direct to using units.

3. *Railhead (truck head):* point to which supplies are transported by rail (truck) and are unloaded and reloaded for transportation by other means to designated points.

Figure 2. Ammunition Depot Communications Zone.

Complete Round. All components necessary to fire a weapon once and function the projectile at the target. For purposes of supply in the field, it includes additional fuzes and primers, if specifically prescribed.

Day of Supply. Estimated average expenditure of various items of supply per day in campaign, expressed in quantities of specific items or in pounds per man per day. A day of supply for ammunition is expressed in rounds per weapon per day.

Expenditure. **The quantity of ammunition used by an organization.** (Small arms ammunition considered expended at time of issue to troops; artillery ammunition expended when fired).

Lot Number. Assigned to ammunition at time of manufacture. Ammunition of same lot number is manufactured under as nearly identical conditions as possible, and the ammunition is kept together as far as possible. (This is particularly important in the combat zone where ballistic performance is a prime factor).

Munitions Officer. An officer in a unit smaller than a division, designated to supervise ammunition supply. This may be a unit S4 or someone designated as his agent. Ordinarily he is an officer of the using arm.

Prescribed Load. Specified quantity of each type of ammunition to be carried on unit vehicles and by personnel.

Transportation Order. Authority for a specified ammunition supply installation to issue a definite quantity of ammunition to a designated organization.

Unit of Fire. Unit of measure within the theater, determined from tactical view, and based upon experience there. It represents a specified number of rounds per weapon, varying with types and calibers of the weapons. The unit of fire is not synonymous with 'day of supply'. It represents a balanced expenditure by various weapons under condition of normal action. The unit of fire as prescribed by the War Department may be modified by theater commanders as necessary.

Special terms which pertain to Army Air Forces include:

Airdrome. Landing field with necessary installations for serving, arming, operating and maintaining tactical air units.

Air Force Service Command. Organization sustaining tactical air units within a numbered air force and directly responsible to the air force commander for all supply and maintenance of the entire numbered air force.

Ammunition Supply Installations (See above) specifically designated for Army Air Forces are:

1. *Airdrome Distributing Point (DP).* Supply installation at dispersed airdrome. Normally one DP for each airdrome. The ammunition section of each DP is operated by the ordnance section of the combat squadron.

2. *Refilling Point (RP).* Supply installation at a service center. Ammunition at this point constitutes reserve for airdrome DPs and supplies transient tactical units at the service center.

Mission of Fire. Total amount of ammunition of all types required to load a squadron of planes once under any circumstances. For squadrons carrying bombs, the mission of fire contains, for every type of bomb, the full load which the entire squadron is capable of carrying in preparation for any tactical mission.

Service Center. Command organized and equipped for sustaining operations of one or more tactical air units. It comprises personnel, supplies, equipment, airdromes and everything necessary to support the units currently assigned.

FLOW OF AMMUNITION AND TYPES OF INSTALLATIONS

The Communications Zone. The Communications Zone plays a key role in the flow of ammunition supplies. Since it is impossible to coordinate Zone of Interior shipments with Combat Zone needs, the Communications Zone must receive shipments from the interior, absorb sporadic flow, and, while governing distribution among supply installations, constantly push ammunition forward to combat troops as it is needed.

In well established theaters, the Communications Zone is normally divided into an advance section, an intermediate section, and a base section. Depots in the advance section are stocked with quantities and kinds of ammunition required by the tactical situation while those in the base section are primarily receiving and storage stations. The intermediate section serves as reserve stores. Shipments from advance depots to the Combat Zone must be replaced immediately by ammunition brought up from intermediate or base sections.

As a general rule, ammunition shipped from a Communications Zone depot to Combat Zone installations is delivered by Communications Zone agencies and personnel. (See Fig. 2.)

The Combat Zone. There are two main types of army ammunition supply installations: Ammunition Supply Points (ASP's) and Army Ammunition Depots.

ASP's issue ammunition directly to combat troops. There are usually two per division. They are generally smaller, of a more temporary nature, and located nearer the front lines than depots.

Army ammunition depots, larger and more or less permanent installations, are located to the rear of the combat zone. Although they issue ammunition to troops, their primary mission is to function as reserve for ASP's.

The army ordnance officer is vested with the responsibility of submitting recommendations to the Army Commander concerning sites for combat zone ammunition supply installations. Varying conditions will prevail, but always the aim will be to locate these installations in such a position as to insure continuous, prompt flow of ammunition to points accessible to combat troops.

Knitting army installations to the supply points of the communications zone will be a number of transfer points, depending upon the amount of ammunition, the number of supply points, and other varying factors. These transfer points consist of railheads, truck heads, or navigation heads where ammunition is unloaded and loaded. They may sometimes have limited storage facilities which may be employed for brief periods of time.

In some cases transfer points may be established at advanced points where trucks of using units may meet conveyances of the Communications Zone or army ASP's or depots. In addition, trucks from army depots or ASP's may unload ammunition at predetermined points where using unit trucks will pick it up at a later time. The latter are referred to as 'roadside ASP's.'

Units. When it is deemed necessary or desirable and providing it does not conflict with policies of higher authority, division commanders may direct establishment of division supply points which are operated along the lines of ASP's. In addition, a division may maintain a 'rolling reserve' or stocks of ammunition on motor or rail transportation at all times ready for delivery on call. It is replenished by an 'endless chain' system which provides that the advance base notify the reserve base immediately upon issue of ammunition. As the supply leaves the advance base, like quantities are dispatched from the rear.

RESPONSIBILITIES FOR PLANNING AND SUPPLY

General. Ammunition constitutes one of the most essential items of supply to combat troops. Its uninterrupted flow is an indispensable factor in the successful accomplishment of any tactical mission. The very great requirements, aggravated by the complexities caused by the numerous kinds and types of ammunition, create a difficult supply problem. Only by careful planning in each echelon of command and by prompt notification of requirements can this supply problem be handled to meet the needs of the combat troops.

Planning of the ammunition supply rests with the Ordnance officer of divisions and higher echelons. An ammunition plan is formulated, after instructions have been issued by G-4, in accordance with the tactical plan of the echelon commander. This plan is submitted to the echelon commander for approval. The plan must be based on tactical considerations, sudden and urgent demands, and availability of both transportation facilities and locations for supply points. Furthermore, the plan must be flexible, have simplicity, and provide security for its continuous operation. It should also be capable of further expansion and development so as to include future operations and conditions.

Responsibility for the supply of ammunition is a command function of the commander. The echelon commander charges the ordnance officer, who is a Special Staff Officer in Divisions and higher echelons, with the administrative work of ammunition supply. In units smaller than a Division the unit commander normally appoints a Unit Munitions Officer who operates the administrative tasks of Ammunition Supply.

Organization and Operations of Army Ammunition Installation. The provisions for procurement of ammunition, the distribution of ammunition to the combat zone, the establishment and operation of army ammunition supply points, the maintenance of ammunition reserves, the delivery of ammunition to the army ammunition supply points, and the maintenance of ammunition are the responsibilities of Ordnance service.

The obtaining of ammunition from the Army supply points and its transportation and distribution to the using troops are the responsibilities of the commanders of the combat troops concerned.

The impetus of supply is from rear to front; and so it becomes the primary function of each echelon in the supply chain to push the ammunition as far forward as possible. The organization and administration of the supply system begins with procurement in the Zone of Interior and storage until requested. However, it is desirable to ship ammunition direct to the communications zone without handling or storing if possible. This can be accomplished satisfactorily providing the request from a theater of operations are interlocked with previously planned requests.

The communications zone will not be organized the same in every theater of operations. Basically each communication zone comes into being as the combat zone advances after the initial phases in the theater. As the advance continues the communication zone may be divided into a base section to secure centralized control and decentralized operation. Within the zone the advanced depots will have balanced stocks of ammunition established at a level to meet the combat requirements of the troops in the combat zone. In the base, or rear sections, ammunition arriving from the Zone of Interior will be received, classified, and stored in depots.

All ammunition going forward into the combat zone has its movement controlled by the regulating station. The purpose of this office is to maintain a smooth flow of supply and to assure flexibility by placing requirements in the proper depots, in balanced quantities, for the combat troops. The ammunition shipments are moved into the combat zone in the order of their relative importance as compared to other supplies needed by the combat troops.

The Army is the largest administrative echelon in the combat zone. The supply of ammunition is organized, supervised, and controlled by the army commander to best serve the requirements of his troops. The administration of ammunition supply is handled through command channels while the physical ammunition is pushed forward under direct army control. Army ammunition supply installations are established throughout the combat zone and are located to facilitate a continuous, prompt flow of ammunition to points easily reached by combat troops. The locations of the supply points are selected after consideration has been given to recommendations from corps ordnance officers, who, in turn, have considered recommendations from division ordnance officers.

Ammunition Planning. It is the responsibility of command and the duty of the staff to coordinate the ammunition supply requirements and the tactical situation. The ammunition plan must be continuous and should be flexible enough to provide for future developments of the tactical situation. Initially the theater commander will receive balanced stocks of ammunition on an automatic basis by a prearranged schedule from the Zone of Interior. However, plans for ammunition supply will be adjusted so as to meet current requirements or expenditures, as soon as possible. Thereafter, ammunition will be shipped to the theater of operations in the quantities necessary to maintain stocks at the prescribed levels. Scheduled shipments are continually checked against expenditures, estimates of further requirements, and present stocks on hand. Any unusual demands on scheduled shipments may necessitate submission of ammunition requests to supplement stocks on hand.

An ammunition plan to fulfill all the requirements must be based on the following factors. It must:

1. Keep tactical commanders informed of the correct status of, and of all changes in, the ammunition situation.
2. Maintain stocks in the hands of troops at the levels prescribed by units of fire or prescribed ammunition levels.
3. Be capable of meeting sudden, unexpected, and urgent demands.
4. Maintain adequate stocks in the next higher echelon of supply to meet anticipated requirements.
5. Provide proper checks on status of ammunition in the hands of troops and on the status of ammunition held in supply points.
6. Satisfy the requirements of accountability of ammunition, whenever and to the extent required.

Control Systems. *General.* The administrative details governing the supply of ammunition in the field are especially designed to provide any degree of control that may be required by the commander over existing supplies of ammunition. The system of credits and reports provides the control, and the length of the reporting period provides the flexibility. Thus under circumstances where the existing ammunition stocks are limited, control may be tightened by shortening the length of the reporting period and decreasing the length of time for which credits are allotted. On the other hand, control may be relaxed by lengthening the reporting and credit period.

Allocation of Credits. When an army enters a combat zone, the theater commander issues to the army allocations of ammunition credit upon depots in the communication zone. The ammunition credits allocated to the army are received by the army ordnance officer and entered into the records. Thereafter, in accordance with the tactical plan, the required ammunition covered by such credits is ordered forward to the army ammunition depots and ASP's as stock levels are maintained. Control is enforced by making allocations of ammunition to lower echelons in accordance with the approved tactical plan, special instructions from the unit commander or his staff, and with view to the available ammunition. Normally a division commander does not sub-allocate ammunition credits but establishes a basic load to be maintained by subordinate units.

Ammunition Reports. The purposes served by ammunition reports are these:

They inform the commander of the status of ammunition on hand in the organizations of his command.

They provide a basis for the allocation of the ammunition held in stock on credits.

They provide higher echelons with a basis for requesting additional credits, and in turn for resupplying ASP's and Depots.

They show the total amounts, by type and kind available to the echelon from all prior allocations.

They show the available balance at each supply installation.

They indicate the amount expended during the period covered.

Requests. A request for additional ammunition may be made orally or in writing by any echelon unit or commander if for any reason the credits established for his echelon or unit are found to be inadequate. This request will be the basis for an additional allocation of ammunition to the requesting echelons or units by higher echelons. This request may be submitted by any means of communication which will fulfill the requirements within the obligatory time limit.

Target System of Ammunition Supply. This modified control procedure may be authorized for use by the theater commander when there is available unlimited quantities of ammunition, resupply is reasonably certain, and only slight control is necessary. The establishment of prescribed unit ammunition loads is a command function and a continuous process. The prescribed ammunition load will specify the quantity of each type of ammunition to be carried by the unit. These quantities may be expressed in rounds and/or in units of fire. Ordinarily the prescribed unit ammunition level will be established by Division and/or Corps, and will govern the total quantities in the hands of the combat units.

An ammunition level for a unit will include a prescribed load carried on combat elements, a unit resupply in a rolling reserve, and unit dumps, if authorized by higher echelon. These levels will vary from time to time in view of the following factors:

The combat mission of the particular unit and the type of action expected.

The organic transportation of the unit and the transportation it can secure from higher echelons.

The capabilities of the enemy forces that the unit will oppose.

The time and distance involved in resupply to the unit.

The certainty of resupply.

The maintaining of these prescribed ammunition levels consists of the replacing of expended ammunition, round for round, by withdrawals at Army depots or

ASP's, without the establishment of allocations or credits. The army commander, through the Ordnance officer, establishes and maintains stock levels at each depot and ASP sufficient to insure using units of an adequate resupply no matter what their requirements. (See also page 327.)

Computation of a Unit of Fire. The term Unit of Fire is not synonymous with the terms 'Day of Supply' or Basic Load. The determination of a unit of fire is based upon experience of an echelon in a theater and is a unit of measure for ammunition supply. It represents a specified number of rounds per weapon, or organization which varies with the types and calibers of the weapons, and the organizations of that unit. A unit of fire, prescribed by the War Department, may be modified by theater commanders, as necessary, in view of the diverse tactical employment of echelons under their command.

The unit of fire of an organization is normally of a value less than the basic load of that organization. It is not to be expected that an organization will expend a unit of fire in one day of action; nor will the same percentages of all types of ammunition in the unit of fire be expended by any organization in any given period of time.

A basic load, in comparison, will normally be up to one and a half times the value of a unit of fire for that organization. This basic load is a prescribed load composed of that ammunition carried on unit combat vehicles, by unit personnel, and in cargo vehicle transported reserves of the unit. The basis for determining the amount of this basic load is found by adding units of fire per weapon and load listings for each vehicle. (See Fig. 3B and page 335.)

Ammunition Supply Operations of a Division Ordnance Officer. A Division Ordnance Officer is responsible for the general supervision and coordination of the ammunition supply system within a division. Normally the duties of ammunition supply are delegated to a Division Ammunition Officer, who is an assistant to the Ordnance officer. The duties of the division ammunition officer include the following:

1. Recommendations concerning advanced planning to insure adequate ammunition supply to the division and its attached units.
2. Maintenance of division ammunition records, receiving of reports from subordinate units, and preparation of ammunition reports to higher echelons.
3. Recommendations concerning the number and locations of ASP's to support the division and its attached units.
4. Furnishing of technical information on ammunition and also on foreign ammunition which may fall into the hands of the combat troops.
5. Supervision of ammunition supply to and within the units of the Division with respect to the following: To advise units of the location and routes to the ASP's. To prepare a schedule for unit trains at ASP's after consulting the ASP commander. To check and authenticate transportation orders; and to establish and maintain in operation a division ammunition office for executing all duties delegated by the Division Ordnance Officer.

Planning the Ammunition Supply. The division Ordnance officer recommends to higher echelons the number and location of ASP's for supplying the Division. After consultation with the echelon commander and/or G-3 and G-4, he estimates the quantities and kinds of ammunition which combat troops will require to complete the tactical mission. He submits requests to higher echelons.

Control of the Ammunition Supply. Control of the ammunition is direct, by approval or disapproval of transportation orders submitted by the using units. This control is based on the availability of ammunition credits, the tactical situation, and the policies of the Division commander.

Procedures for Issue. Allocations are normally not established for units of a Division, but may be made to units attached to the Division for specific tactical missions. The units of the Division and attached units prepare transportation orders for their requirements, and present them for authentication to the Division ammunition officer. The Division ammunition officer checks the transportation order for correctness of amounts, code numbers and/or nomenclature, and that sufficient trucks are being dispatched to carry the requested ammunition. In addition, he must be certain the ammunition is available at the ASP and that the requirements of other division units can be fulfilled from existing credits.

Existing credits may not fulfill the immediate requirements of divisional units, so, for purposes of control, it may become necessary to allocate specific amounts to a particular unit.

Any using unit may procure ammunition by going directly to a depot or ASP without securing an authenticated transportation order from the Division Ammunition Officer. This situation may prevail when the Division ammunition officer cannot be contacted because of the location of a using unit. The ASP will, under these circumstances, retain a copy of the transportation order to be delivered to the Division ammunition officer upon his next liaison contact. This transportation order will then be posted as though it were a normal transaction to the records of the Division Ammunition office.

Division Reserves: Division Supply Points may be established by the Division Ordnance officer upon direction by the Division commander. These Division dumps are normally established only on authorization from higher echelon headquarters and are temporary in nature. However, the operation is similar to an ASP and its stock of ammunition usually is exhausted as units are directed to draw from the stock, since it is not replenished. The personnel for this work may be furnished by the divisional units, but more likely by divisional Ordnance personnel under the direct supervision of the Division ammunition officer. These temporary dumps are only necessary when an excess stock or level of ammunition is required for a tactical mission of limited reach and duration.

A rolling reserve for a Division is a balanced load of ammunition, in excess of basic load of the combat elements, which is kept on motor vehicles at all times for immediate movement. The loading types and quantities are prescribed by the Division commander or the Division G-4. The rolling reserve is directly under a train commander, who may well be the Division ammunition officer. Vehicles of the rolling reserve should be unit loaded so as to facilitate either direct delivery or exchange of loaded vehicles for empty vehicles with a tactical unit. These exchanges or transfers may be at a predetermined half-way point, or may be dispatched from the bivouac of the ammunition train direct to the tactical unit upon request by the tactical commanders. The train is located, normally in an assembly area, as far forward as reasonable security permits, and may even be divided so as to offer a smaller target to the enemy as sections are pushed into closer proximity with the combat units of the Division. During combat, the assembly area of this reserve is published in the administrative annex to the combat orders, so that unit commanders may dispatch messengers for their requirements of ammunition. Any vehicles which go forward to deliver their loads of ammunition carry transportation orders for refill at an ASP prior to their return to the ammunition train assembly area, they will draw this refill ammunition at the ASP.

In actions where the tactical movements are comparatively rapid a modified rolling reserve method may be employed to advantage. Guides from using unit are dispatched to an advance station, where the remainder of the Division reserve train is assembled. Upon notification, the rear station advances vehicles with the same vehicular loads to the advance station. After delivering the requested ammunition to the combat units, the trucks from the advance station go to an ASP, reload, and return to the rear station. If the turn-around is of great distance, and there is sufficient transportation available, there may be three stations—advance, intermediate, and rear—established.

Records. The division ammunition officer maintains a division credit record which shows a running balance of the total quantities of ammunition available in the combat units and the amounts available on call at each ASP. Separate cards are maintained for each type of ammunition. Higher echelon allocations to the division and transportation orders issued to units of the division are posted to this division credit record. When division reserves are established the division ammunition officer will maintain a status of stock records similar to that maintained by ASP's.

Reports. The division ammunition officer receives reports of the quantities expended. These reports from subordinate unit munitions officers, the munitions officer of the Division artillery, and the munition officers of attached units, are consolidated for reports to higher echelons. The reports to higher echelons may show total types and quantities of ammunition on hand and/or totals remaining in ASP's as higher headquarters direct.

Ammunition Supply Operation of a Type Corps.

Duties. The primary functions of the corps ammunition officer in a Type Corps are five:

To prepare targets for ASP's and present same to Army ordnance officer (See below: Target).

To bring to the attention of the Army ordnance officer deficiencies in stocks at ASP's as determined from ASP status reports.

To prepare transportation orders by corps troops.

To receive and consolidate daily the reports of expenditures of all divisions and corps troops.

To accumulate and assemble experience tables on the operation for future planning.

Personnel. The corps ammunition officer requires the following assistants: assistant ammunition officer, chief clerk, ammunition sergeant, file clerk, typist. The duties of these men are obvious and include maintenance of up to date weapons lists, expenditure and experience tables, liaison with units and bases, etc.

Operations. Targets. To replace the outmoded credit system of depot stockage, a 'target' is prescribed as the level to be maintained in a depot. An ammunition target is a list of ammunition items prescribed as the normal level for a depot, ASP, or DP. It is based upon the following factors:

Tactical estimate of the situation in conjunction with G-2, G-3, and G-4, and artillery officer's estimate, strength of friendly forces, availability of transportation, capability for resupply, *i.e.,* reaction time on replacement of issues, and previous experience in battle.

A target is prepared by the ammunition officer as long as practicable prior to the necessary opening time for the installation concerned. The target should prescribe units to be served, time of opening, and recommended general location. This target, after approval by G-4, is sent to the army ordnance officer as a request for stockage. In general the target should be the minimum safe stockage.

Liaison between combat troops and army. In order to obviate the necessity on the part of divisional personnel for communication and transaction of administrative business with army, the corps ammunition officer represents his troops in necessary dealing with army. He reports by the most expeditious means—telephone, radio, air courier, pigeon, motorcycle messenger, etc.—his observations of deficiencies or excesses in ASP or depot stocks, and any unforeseen changes in the situation which require alteration on targets to include other types, quantities, or locations of ASP's. At such times as he deems it advisable he inquires into availability of certain critical items in the theater; he supplied this information to his corps and division commanders as required for the plan of fires. The corps ammunition officer acquaints the army ordnance officer with information of the new enemy ammunition and of faulty ammunition received in the combat zone.

Expenditure reports. Expenditure reports are received from division ammunition officers daily to include expenditures of all ammunition items by units of the division and attached troops. The information for the division ammunition officer's report is received by him from reports of actual expenditures by the S-4, divisional artillery, and from reports of issues by infantry regimental S-4's to subunits. Expenditure reports from corps artillery and tank destroyer units are received by the corps ammunition officer from the S-4 of the corps artillery section who receives his reports from brigade or regimental S-4's. The corp ammunition officer receives expenditure reports from all other corps troops direct. These reports are consolidated in the corps ammunition office and submitted to the army ordnance officer, corps G-4, and to the ordnance officer. A copy is filed in the ammunition office as an historical record.

Experience tables. Experience tables on ammunition are invaluable in the planning of subsequent operations. They should be carefully prepared from all available data on past operations of our own troops, our allies, and our enemy. Accom-

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*The information on Type Corps was furnished by Lt. Col. John Ray, Ammunition Officer of First Army.

panying any statistical tables should be a brief description of the campaign covered by the tables, what was the enemy strength, our strength, duration of campaign, type of operation, report of sizeable losses of stocks caused by enemy action or by accidental or intentional destruction, and a detailed tabulation of units and weapons engaged. From these data, as modified by the contemplated plan, an intelligent target or loading list can be prepared for future operations.

Failure to make use of recent previous experience data has already caused terrific waste of ship tonnage, and shortage of certain ammunition items and other classes of supplies in allied operations in the current war. For example in a large-scale landing operation on enemy soil, it is estimated that at least 10,000 tons of unnecessary ammunition was landed during the first 14 days, and at the same time there was a shortage of vehicles, rations, and a few items of ammunition, all of which could have replaced the unnecessary supplies if previous experience in the same theater had been followed.

Communications. The most important fighting weapons of any ammunition officer are communications. Every possible means must be used to obtain and disseminate information. It is often necessary during the course of a day to employ every means of communication which has ever been devised. Without communications the ammunition officer must try to cover many miles of road and cannot possibly complete his day's work.

Conclusions. It is not possible to enumerate all the difficulties and pitfalls which may befall the corps or division ammunition officer. Stated briefly, he may conduct his part of any campaign efficiently if he:

Resorts to common sense.

Acts boldly and energetically.

Keeps a constant personal check on the operations of all units of the corps and on ammunition officers above and below him.

Continually reduces the amount of paper work required of his troops and establishes a uniform system for all reports.

Allows himself to benefit from experience of himself and others.

Blames himself if any unit or organization in his corps must hold its fire, or on the other hand accumulates an oversupply, regardless of the reason.

Independent Corps (Reinforced). *Duties.* All of the duties prescribed for the corps ammunition officer in the type corps (see above) are included in the duties of the ammunition officer of the independent corps.

Personnel. In addition to the personnel listed in Section I for the staff of the type corps ammunition officer, two experienced enlisted men are required, in order that the office can be split if necessary. Three jeeps and drivers are also necessary.

Operations. Operation of the independent corps (reinforced) ammunition section include the operations prescribed above, obviously modified as pertain to dealings with army. In short, the functions of the army ammunition officer are added to those of the corps ammunition officer in the independent corps. The additional operations are discussed below.

Targets are prepared exactly as above, but are presented for action to the base section or theater ordnance officer.

Liaison is conducted with base section or theater in a manner exactly similar to liaison with army as prescribed above.

Expenditure reports are consolidated and transmitted by teletype (if possible) or other available means to the base section ordnance officer, to G-4 for transmittal to theater or army group G-4 and G-4 of base section. The expenditure report is used as a basis for the restockage of corps depots and/or ASP's by base section in the absence of a specific request for controlled shipment.

Experience tables are kept as outlined above.

Communication both forward and rear is a fundamental requisite for successful operation.

Operation of depots and ASP's becomes a fundamental duty of the ammunition officer. For a reinforced corps of three infantry divisions, one armored division corps troops including four regiments of artillery, and ten battalions of tank destroyer with normal antiaircraft, etc., the necessary depots and ASP's for a

1	1	2	3	4	5	6	7	8	9	10
		Artillery				*AAA* ②			*AT*	
1	*Type of Combat*	*75-mm Gun and 105-mm How*	*155-mm How*	*155-mm Gun and larger*	*Inf Am*	*37-mm 40-mm cal .50 & SA*	*3" & 90-mm Gun*	*4.2" Chem Mort*	*37-mm 57-mm and 75-mm Gun*	*3" Gun*
2	Attack of position									
3	Permanent fortifications									
4	First day	2.0	2.0	2.0	1.0	0.5	0.5	2.0	1.0	3.0
5	Succeeding days	1.0	1.0	1.0	0.5	0.3	0.3	1.0	0.5	1.0
6	Deliberately organized									
7	First day	1.5	1.5	1.5	1.0	0.5	0.5	2.0	1.0	1.0
8	Succeeding days	0.8	0.8	0.8	0.5	0.3	0.3	1.0	0.5	0.5
9	Hastily organized	0.8	0.5	0.5	0.5	0.5	0.5	1.5	0.8	0.5
10	Covering and security force action	0.3	0.2		0.3	0.1	0.1	3.0	0.5	0.5
11	Defense of position									
12	First day	2.0	2.0	2.0	1.5	0.5	0.5	3.0	2.0	2.0
13	Suceeding days	1.0	1.0	1.0	1.0	0.5	0.5	1.5	1.0	1.0
14	Inactive situation ①	0.1	0.1	0.1	0.2	0.1	0.1	0.25	0.5	0.5
15	Meeting engagement	0.5	0.5	0.3	0.5	0.2	0.1	2.0	1.0	1.0
16	Pursuit	0.5	0.5		0.3	0.1	0.1	1.0	0.5	0.5
17	Retirement or delaying action	1.0	0.5		0.2	0.3	0.2	3.0	0.5	0.5

① Force in contact but neither side attacking.
② When used only on AA missions.

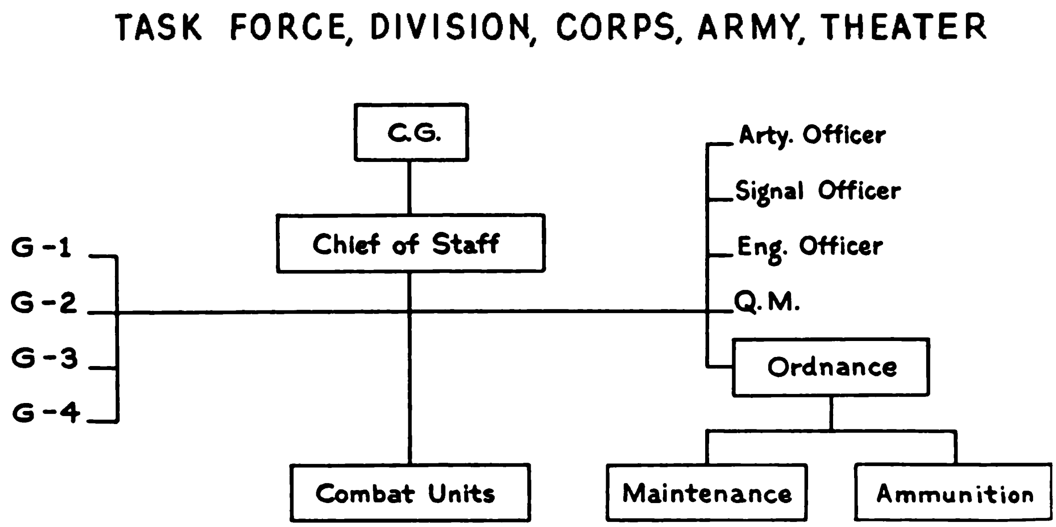
1	1	2	3	4	5	6
		Average rate per gun per hour				
1	*Kind of fire or phase of action*	*75-mm gun or howitzer*	*105-mm howitzer*	*155-mm howitzer*	*155-mm gun*	*240-mm howitzer*
2	Advance guard action, development, and deployment	25	25	12		
3	Preparation	85	80	25	25	5
4	Supporting fires during the attack (including counterbattery):					
5	First 2 hours	70	50	25	25	5
6	After 2 hours	40	30	15	15	5
7	Exploitation, pursuit, delaying action, or delaying enemy development	25	25	12	12	5
8	Counterpreparation	85	60	25	25	5
9	Defensive fires against infantry attack (including counterbattery)	70	50	25	25	5

① These figures are suitable for computing expenditures for periods of time less than 6 hours.

Figure 3. Supply

fast-moving campaign have been operated with two experienced ammunition companies.

The ammunition officer maintains rigid control of operations of his companies He must train them to become highly flexible in manner of operation and to the end that one company can operate four or five ASP's simultaneously, and completely separated geographically. The company personnel must expect to be overworked and to meet unusual and harrying conditions. Morale must be strengthened by causing the individual soldier to realize his importance to the success



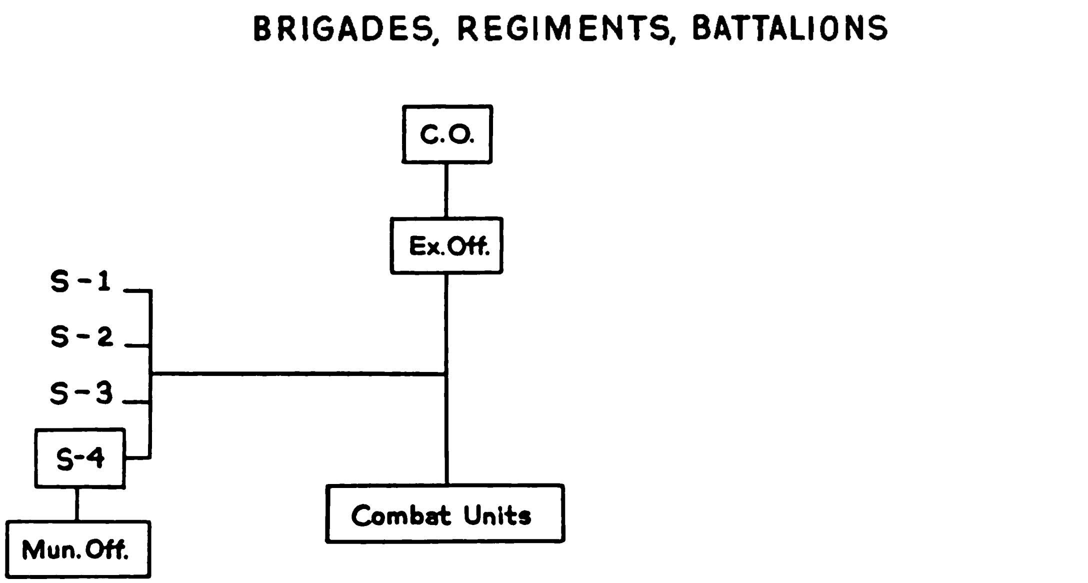


Figure 3A. Location of Ammunition Officer in a Theater Army, Task Force, Corps or Division and Brigade, Regiment or Battalion.

of the operation as a whole. He soon becomes proud of being close to the front on his daily dealing with men of the fighting arms.

The ammunition officer and his representatives make daily contact with all troop units and with all depots and ASP's both by receiving their reports and by being at the depot during active operation. Personal contact by the corps ammunition officer with division and regimental ammunition officers at the ASP

FIGURE 3B. WEIGHTS AND DATA
Ammunition—(Except Aircraft and Chemical Ammunition)—For Theater of Operations
Representative Packings

	1	2	3	4	5	6	7	8
				Container (1)				
	Weapon	Proportion of Types	Unit of Fire Rounds (per weapon)	Rounds (1)	Gross Weight (pounds) (1)	Average Weight per round incl. packing (pounds) (1)	Rounds per ton	Boxes per ton
1	Carbine, caliber .30, M-1	100% Ball	60	3,000	100	0.033	60,000	20
2	Gun, machine, caliber .30	80% AP 20% Tracer	2,000	1,000 1,250	77 96	0.077 0.077	26,000 26,200	26 21
3	Rifle, automatic, cal. .30 M1918A2	80% AP 20% Tracer	750	1,500	116	0.077	25,500	17
4	Rifle, cal. .30, M-1, M-03	80% AP 20% Tracer	150	1,344	103	.077	2,688	20
5	Pistol, automatic, cal. .45	100% Ball	10	1,800	98	0.054	36,000	20
6	Gun, submachine, cal. .45	100%	200	2,000	110	.054	36,000	18
7	Gun, machine, cal. .50 (HB), flexible and fixed	40% AP 20% Tracer 40% Incend	500	265	86	0.32	6,100	23
8	Gun, machine, cal. .50, antiwater cooled	40% AP 20% Tracer 40% Incend	1,200	220	71	0.32	6,150	28
9	Gun, machine, 20-mm, antiaircraft	80% HE 20% AP	540	120	94.8	.79	2,520	21
10	Gun, 37-mm, antitank, wheeled	90% HE 10% AP	300	24	102	4.25	552	23
11	Gun, 37-mm, tank, M-6 (combat) vehicles)	30% HE 60% AP 10% Cannister	100	20	100	5	400	20
12	Gun, 37-mm, antitank, wheeled	85% AP 10% HE 5% Cannister						
13	Gun, 40-mm, antiaircraft	90% HE 10% AP	300	24	158	6.7	312	13
14	Gun, 57-mm, antitank	100% AP	100	3 4	48.5 64.5	16.16	123 124	41 31

FIGURE 3B. WEIGHTS AND DATA—Continued.

	1	2	3	4	5	6	7	8
				Container (1)				
	Weapon	Proportion of Types	Unit of Fire Rounds (per weapon)	Rounds (1)	Gross Weight (pounds) (1)	Average Weight per round incl. packing (pounds) (1)	Rounds per ton	Boxes per ton
15	Mortar, 60-mm	97% HE 3% Illum.	100	18	81	4.5	450	25
16	Mortar, 81-mm including combat vehicles	60% HE L 25% HE Hv 15% WP	L 70 Hv 30	L6 HV3 WP3	58 42 45	9.7 14 15	204 144 135	34 48 45
17	Gun, 75-mm, tank	50% HE Super 40% AP 10% Smoke	100	3	69	23	87	29
18	Gun, 75-mm, field	10% HE Super 40% HE Normal 30% HE Reduced 10% WP 10% HS	300	3	69	23	87	29
19	Gun, 75-mm antitank	25% HE Super 75% AP	50					
20	Howitzer, 75-mm, field pack	77.5% HE 2.5% HE, AT 10% WP 10% HS	300 300	3	69	23	87	29
21	Howitzer, 75-mm, self-propelled	85% HE 10% WP 5% HE, AT	300	3	69	23	87	29
22	Gun, 76-mm, S.P.	50% HE Super 40% AP 10% Smoke	(3)	3	87	29	69	23
23	Gun, 3", antiaircraft, mobile	95% HE 5% AP	150	4	151	38	52	13
24	Gun, 3", antitank, wheeled and self-propelled mount	25% HE 75% AP	75					
25	Gun, 90-mm, antiaircraft, mobile fixed & AMTB	95% HE 5% APC	125	2	112	56	36	18
26	Gun, 90 mm SP	60% HE 30% APC [illegible] Smk HC [illegible] Smk WP	125	4	234	58	36	9

27	Howitzer, 105-mm, field and self-propelled mount	77.5% HE 2.5% HE, AT 10% WP 10% HS	200
28	Howitzer, 105-mm M3	80% HE 20% HE, AT	200
29	Howitzer, 155-mm, field, 81917-18	80% HE 10% WP 10% HS	150
30	Charge, prop., 155-mm, howitzer, M-1917-18	50% Normal 50% Reduced	
31	Howitzer, 155-mm, field, M1	80% HE 10% WP 10% HS	150
32	Charge, prop., 155-mm, howitzer, M-1	70% Normal 30% Reduced	
33	Gun, 45", medium, field	100% HE	150
34	Charge, prop., 4.5" gun	60% HE 40% Normal	
35	Gun, 155-mm, M1917-18, SP	90% HE 5% HS 5% WP 100% Normal	(3)
36	Charge, prop., 155-mm M1917-18	90% HE 5% HS 5% WP 100% Normal	(3)
37	Gun, 155-mm, field, M-1	90% HE 5% HS 5% WP	100
38	Charge, prop., 155-mm gun, M-1	100% Normal	
39	a. Shell, HE, Mk IIIA1		
40	b. Shell, AP, M-112	100% HE	(3)
42	Charge, prop., 8" howitzer field	70% Normal 30% Reduced	(3)
43	Gun, 8", field	100% HE	
41	Howitzer, 8", field		(3)
44	Charge, prop., 8" gun, field	100% Normal	

3	154	51	39	13
3	149	50 51	39	13
1	96	96	21	21
6	53	9	228	38
1	96	96	21	21
6	53	9	228	38
1	53	53	38	38
3	39	13	153	51
1	96	96	21	21
3	109	36	54	18
1	95	95	21	21
3	127	42	48	16
1	96	96	21	21
1	118	118	17	17
1	201	201	10	10
3	105	35	57	19
1	286	286	7	7
3	117	39	51	17

	1	2	3
	Weapon	Proportion of Types	Unit of Fire Rounds (per weapon)
45	Howitzer, 240-mm, field (New)	100% HE (360-lb.)	60
46	Charge, prop., 240-mm (New)	100% Normal (for 360-lb. shell)	
47	Howitzer, 240-mm, field M1918	100% HE	60
48	Charge, prop., 240-mm howitzer, M1918	100% Normal	
49	120-mm gun, A.A.	100% HE	90
50	Charge, prop. (incase cartridge, M24)	100% Normal	
51	Projector, signal, ground M-4: a. All arms and services	Equal proportion of types available	10
52	Projector, pyrotechnic, hand, M-9 (Gd)	Equal proportions AN M37 to M45, inclusive	10
53	Pistol, Very M-5	Equal proportion of types available	10
54	Grenade, hand, fragmentation, Mk II	100% HE	50 (2)
55	Grenade, At, M-9A1 per cal. .30 rifle M-1903 for launching M-9 grenade	100% HE	(3)
56	Torpedo, bangalore	----------	(3)
57	Mine, antitank, M-1	100% HE	(3)
58	Mine, anti-personnel M-2	100% HE	(3)
59	Mine, anti-personnel M-3	100% HE	(3)
60	4.2" Chemical Mortar	60% HE 40% WP	60

-Continued.

4	5	6	7	8
Container (1)				
Rounds (1)	Gross Weight (pounds) (1)	Average Weight per round incl. packing (pounds) (1)	Rounds per ton	Boxes per ton
1	360	360	6	6
1	105	35	19	19
1	345	345	6	6
3	139	46.3	42	14
2	130	65	30	15
2	156	78	26	13
50	65	1.3	1,550	31
60	61	1.01	1,960	33
1,000	103	0.103	19,000	19
25	53	2.12	950	38
10	31	3.10	640	64
10	168	16.8	120	12
5	64	12.8	155	31
10	93.4	9.34	210	21
6	72	12	168	28
2	65	32.5	62	31

is the basis for mutual confidence, provides a ready means for intelligent rationing if necessary, and for checking on compliance by the troops with corps orders relative to unit stock levels.

The ammunition officer must maintain hourly contact by electrical means with all of his depots and ASP's in order to plan interdepot shipments. He must situate his office in such a place as to best maintain contact with the corps transportation officer in order that they may together work plans for shipment. He must contact the base section or theater ordnance officer at least daily to achieve economical and sufficient stockages at all points. In order to work harmoniously with the above named agencies and with his own corps C/S, G-2, G-3, G-4, quartermaster and artillery officer, it is important that he becomes well acquainted personally with officer and enlisted personnel in all offices concerned from base section to infantry and artillery battalion.

Conclusions. The same conclusions as reached above apply with added vigor in the independent corps.

MOVEMENT AND HANDLING PROBLEMS

Figure 3 will illustrate the method whereby ammunition officers may calculate reserves of ammunition needed for a particular operation. First the ammunition officer must know the weapon strength of his unit. Next he will determine the value of the unit of fire for each weapon and by multiplying this value by the number of weapons he will be able to determine the number of rounds in the unit of fire for his organization. If his unit is to fight a certain type of operation, he will determine the number of units of fire needed from a chart, such as this, or from such tables as he may have tabulated as a result of his own and his unit's experiences. Multiplying the value of the unit of fire for his organization by the number of units of fire needed according to the chart, he will obtain the expected expenditures and will be able to stock his reserves accordingly. (See Figure 3B for value of unit of fire.)

In any problem involving ammunition planning there are three factors which must always be considered:

Tonnage—any combat operations involve the expenditure and movement of great quantities of ammunition.

Types and segregation—movement of tonnage alone will not suffice. Certain types can be used in certain weapons only and this variety of types must be always available and kept separated during all phases of handling.

Safety—due to the explosive nature of ammunition suitable precautions must be taken at all points where ammunition is stored or handled.

If any one of these factors is overlooked or neglected at any point in the planning or handling, the operation will be doomed to failure. All ammunition officers must have an accurate conception of these factors and how they may affect ammunition planning and movement.

The following problem will illustrate the factors involved in the movement of ammunition from the standpoint of tonnage and handling alone. For specific information concerning the weights of various items, unit of fire, and other data by type see Figure 3B weights and data. Safety will be discussed in later portions of this chapter.

COMPUTATION OF TRANSPORTATION REQUIRED

Purpose. This example is given to illustrate the relationship of the factors considered in solution of time, labor, and transportation problems.

Problem. The problem is to determine the time required for the operation and the most economical number of trucks. The following facts are assumed:

150 tons of ammunition are to be moved from point A to point B, which is a distance of 5 miles.

The average speed for vehicles during this trip is 15 miles per hour.

2½-ton trucks are to be used; the number of trucks is to be determined.

There are three loading points at A, and therefore provision is made for three unloading points at B.

The optimum number of men per loading and unloading point is estimated to be 8.

The rate of handling per man is estimated to be 5/6 tons per hour.

Solution. Traveling time for each *round* trip is 10 miles (5 plus 5) divided by 15 miles per hour, or 2/3 hour.

8 (number of men per loading point) multiplied by 5/6 (handling rate per man per hour) equals 6 2/3 tons per hour per loading or unloading point.

2½ (capacity of trucks) divided by 6 2/3 (tons per hour) equals ⅜ hour time required to load or unload each truck.

The time required for each truck to load, make the trip, unload, and return to loading point is therefore 2/3 hour (total traveling time) plus ⅜ hour loading time, plus ⅜ hour unloading time, or a total of 1 5/12 hours per loading point.

1 5/12 divided by ⅜ (time required to load each truck) equals 3 7/9 trucks and is the number of trucks which can be loaded in the time required for one round trip. Therefore, 4 trucks can be most advantageously used per loading point, or a total of 12 trucks (4 x 3 loading points). Although each truck will have to wait 1/12 hour, or 5 minutes before it can be reloaded after its initial load, this is more advantageous than to use 3 trucks and allow a 17½ minute wait after each third truck. The actual total round trip will therefore require 1 5/12 hour (minimum time) plus 1/12 hour (waiting time) or 1½ hours.

150 (total tonnage) divided by 3 (loading points) equals 50 tons per loading point.

50 tons divided by 2½ (capacity of trucks) equals 20 truck loads per loading point.

20 truck loads divided by 4 (trucks per loading point as determined above) equals 5 loads per truck.

4 (number of trucks per loading point) multiplied by ⅜ (time required to load each truck) equals 1½ hours to load each truck one time. 5 (loads per truck) times 1½ equals 7½ hours to load entire shipment.

7½ hours plus 1/3 hour (time for last truck to travel to point B) plus ⅜ hour (time to unload last truck) equals 8 5/24 hours to complete the operation.

8 (number of men per loading and unloading point) multiplied by 6 (number of loading plus unloading points) equals 48. This is the number of men required for loading and unloading exclusive of checkers, supervisors, guides, and drivers.

Conclusion. Twelve 2½-ton trucks (4 trucks per loading point × 3 loading points) will be needed for 8 5/24 hours, and should be requested for 8½ hours to allow for slight delays.

48 ammunition handlers will be required for 7½ hours. This is normally too long for such labor without rest. Therefore, if available, 96 men should be used for handling, and will be required to work two shifts of 48 men each for approximately 3¾ hours.

FORMS USED IN AMMUNITION SUPPLY

There are three standard W.D., A.G.O. forms used in recording and rendering reports required for ammunition supply system. They bear the numbers 580 through 582 inclusive.

W.D., A.G.O. Form No. 580. The ammunition situation report is normally used by ground units for reporting ammunition in hands of troops. (Form No. 581 may be used at discretion of appropriate commanders. Essential difference between the two forms is that No. 580 requires a report of expeditures (col. 4 and 9) as well as balance on hand. Form No. 581 requires no reports of expenditures.)

Normal entries for WD, AGO No. 580 are as follows: (See Fig. 3C.)

'Unit'; designation of reporting unit.
'Location'; location of reporting unit.
'From' and 'To'; limits of reporting period.
'Comp. Rds. Code'; code symbols of all items on hand listed alphabetically.
'Bal. Last Report'; quantity on hand at beginning of reporting period.
'Received'; quantity received during reporting period.
'Expended'; quantity expended during reporting period.
'Bal. on Hand'; balance on hand at close of reporting period.
'Signature'; munitions officer of reporting unit signs here.

The alternate form (WD, AGO No. 581) may be used by inserting an 'X' or check in box marked 'Report ....' and the words 'In Hands of Troops' are entered in the blank space.

The office to which report is submitted is entered on line 'To.' Reporting unit is indicated on line 'From,' but the line 'Location of ammunition' may be left blank.

Any explanation deemed necessary goes into 'Instruction' line. Appropriate quantities are entered opposite codes. If additional codes must be indicated, they are entered in column 'A.'

The unit munitions officer signs as initiating officer, and S-4 of the reporting unit signs on the line 'Approved by.'

Normally a report of ammunition in hands of troops is made in two copies. The original is sent to the officer to whom the report is made, and the copy is filed by the reporting unit. Additional copies may be prepared and distributed if desired.

W.D., A.G.O. Form No. 581 is a multi-purpose form. In addition to its use already outlined for reporting ammunition in hands of troops, it is used for:

1. *Allocations:* in which case the box 'allocations' is checked, and the report is filled out accordingly. The serial number assigned by the allocating organization is entered in the box 'Approving Office No.', while the voucher number assigned by the receiving unit is entered in box marked 'Receiving Office No.' Allocations are normally prepared in three copies. The original goes to the organization receiving the ammunition. One copy is filed by the allocating officer.

2. *Allocation Cancellation:* In order to cancel allocations for specific quantities of ammunition, WD, AGO No. 581 is prepared as for an allocation, with the word 'cancellation' entered after 'Allocation' in upper left corner. Distribution is same as for allocation.'

3. *Allocation Request:* The word 'Request' is entered after 'allocation' in upper left, and quantities desired are entered opposite appropriate codes. Two copies of this request will usually suffice. The original goes to the allocating officer, and a copy is retained by the requesting unit.

4. *Transportation Orders:* The box designated 'Transportation Order' is checked, and the headquarters approving the order is entered on the line 'To.' Unit requesting ammunition is entered on the 'From' line. The ASP or depot issuing the ammunition will be entered on 'Location' line. The remainder of the form will be filled out according to needs, and the munitions officer of the using unit, or his representative, signs on the 'Initiated by' line. The authenticating officer (division ammunition officer for divisional or attached units) signs on the line 'Approved by,' and the voucher number assigned by the authenticating officer is entered in 'Approving Office No.' box.

When the ammunition has been issued by the ASP or depot, the commander of the ammunition train signs on the line 'Received by.' Voucher number assigned by the issuing ASP or depot is entered in 'Receiving Office No.' box. Transportation orders are prepared in triplicate, and the original is retained by the ASP or depot. The authenticating officer files a copy, and the third copy is retained by the unit receiving the ammunition.

5. *Shipping Request:* A copy of WD AGO Form No. 581 becomes a Shipping Request when the box marked "Shipping ...." is checked, and the blank space is filled in "Request." The office upon which request is made, the requesting organization, and location of ammunition are entered. Designation of the army ASP or depot to which requested Shipment is to be made, with any other instructions, will be entered on the line labeled "Instructions." Quantities are filled in and the army ammunition officer signs on the line "Initiated by." The army ordnance officer signs on "Approved by" line, and the receiving officer or his representative signs on "Received by" line.

Normally four copies of the Shipping Request are made up: original and one copy go to office to which request is submitted and one copy is sent to the army ammunition supply installation who receive the shipment. The final copy is filed in the army ammunition office.

6. *Shipping Order:* This may also be made on WD AGO No. 581 by checking the box "Shipping ...." and writing in "Order." Destination of the ship-

ment is entered opposite "To" and the ASP or depot from which the shipment is to be made is entered on line "From ...."

Normally the line marked "Location of Ammunition" is left blank when the order is sent directly to an ammunition supply installation. The remainder of the form is filled with appropriate information, and ordinarily three copies are prepared: the original for the ASP or depot making the shipment; one copy for ASP or depot which is to receive the shipment; and the final copy for file by the officer issuing the order.

7. *Shipping Ticket:* By using the flexible "Shipping ...." box and adding "Ticket," form 581 may be used for still another purpose. When using the form for a shipping ticket, we normally leave the "Location of ammunition" blank. Other blanks are filled out appropriately and normally four copies of the shipping ticket are prepared. The original goes, under separate cover, to the depot or ASP receiving the shipment. One copy is sent to the officer ordering the receiving of the shipment, one copy is sent to the officer ordering the shipment, one copy is filed by the shipping depot or ASP, and the last copy accompanies the shipment as an invoice or packing list.

W.D., A.G.O. Form No. 582. This is a multi-purpose form used for posting ammunition records of stock and locations. Division Credit Record, Division Credit Report, Corps Credit Record, Corps Summary of Ammunition Status, Corps Credit Report, Status of Stocks Record, Status of Stocks Report, Locator Record, Army Status of Stocks Record, Army Master Status of Stocks Record, Army credit Record, and Army Report are all maintained and submitted on WD AGO Form No. 582.

1. *Division Credit Record:* To show a continuous balance of quantities of each type of ammunition allocated to the division and the amounts available for issue to divisional and attached units, WD AGO Form No. 582 is used, with a separate card maintained for each item of ammunition and filed in alphabetical order by code symbol. The code symbol is indicated at the top of the form. The division is identified as the "Unit Keeping Record." The words "Total Credit" are entered in the heading of the first blank column to the right of the "Unit Voucher" column. Designations of ASP's storing ammunition allocated to the division are entered in the headings of the remaining blank columns.

Corps allocations to divisions are posted as follows: A brief description (number, time received, source, etc.) of the allocation is entered in the "Unit-Voucher" column. Quantity allocated goes into the "Total Credit" column opposite 'Amt.' The latter figure is also entered in the column corresponding to the ASP in which the ammunition is located. The new allocation is added to the last previous balance in each column, and the new balance is entered in the "Bal" line, below the new "Amt" entries.

Cancellations of corps allocation to division are posted in the same manner as allocations, except that the quantity canceled is *subtracted* from the last balance. Transportation orders of divisional or attached units are entered in the same manner.

At the close of each reporting period, the word "Report" and the date and hour of the close of the reporting period are entered in the "Unit-Voucher" column. Last previous balances are brought down to "Bal" line, and a wavy line may be drawn through the "Amt." line above the balance.

2. *Division Credit Report:* This form is submitted to inform corps of the unused balances of the ammunition available to division and the quantity available at each ASP supplying that division. The date and hour of the close of reporting period are entered after the word "Code" in the upper margin. Designation of the division and description of the report are entered after "Unit Keeping Record." The first blank column to the right of "Unit Voucher" column is labeled "Total Credit." Designations of ASP's storing ammunition allocated to this division are entered in headings of remaining blank columns to the right.

Code symbols of all items of ammunition are listed alphabetically in the "Unit-Voucher" column. Each balance listed on the "Report" line of each division credit record card is entered in the corresponding column of the division credit report on the same line as the code symbol for that item of ammunition. Normally only

W.D., A.G.O. Form No. 580

AMMUNITION SITUATION REPORT

(Ammunition in Hands of Troops)

Unit ____________________ Location ____________________

From ____________________ To ____________________

(Date and Hour) (Date and Hour)

Comp. Rds. Code	Bal. Last Report	Received	Expended	Bal. on Hand	Comp. Rds. Code	Bal. Last Report	Received	Expended	Bal. on Hand

See W.D., A.G.O. Form No. 581
for code designation

____
(Signature)

Figure 3c. Ammunition Situation Report (W.D., A.G.O. Form No. 580).

☐ ALLOCATION

AMMUNITION
(Check One)

☐ TRANSPORTATION ORDER
(Requisition)

☐ REPORT ____________ ____________ 194___ ☐ SHIPPING ____________
(On Hand or Expended) (Date and Time) (Request, Order, or Ticket)

To: ____________

From: ____________

Location of ammunition: ____________

Instructions: ____________

Line	Column "A"		Column "B"		Column "C"		Column "D"	
	CODE	QUANTITY	CODE	QUANTITY	CODE	QUANTITY	CODE	QUANTITY
1	P1ZAM		R1MDA		R4CAA			
2	P1ZAN		R1MIA		R4CDA			
3	P1ZAO		R1MJA		R4FCA			
4	P1ZAP		R1MLA		R4FLA			
5	P1ZCM		R1MMA		R4FPA			
6	P1ZBC		R1PAA		R7AEA			
7	P1ZBD		R1PCA		R7AIA			
8	P1ZBE		R1PEA		R7ANA			
9	P1ZBG		R1QBA		R7FAB			
10	P1ZCN		R1QCA		S4GCA			
11	P1ZCD		R1QDA		S4NBA			
12	P1ZCE		R1QEA		S4NIA			
13	P1ZCF		R1QIA		S4NHB			
14	P1ZCG		R1QLA		S4QFB			
15	P5EAB		R1SAA		S4PBA			
16	P5EIA		R1SBA		S5IBA			
17	P5HJA		R1SDA		S5ICA			
18	P5HNA		R1SFA		S5RNA			
19	P5HOA		R2ZCP		S5ROA			
20	P5NIA		R2ZDA		S5RPA			
21	P5NSA		R2ZDB		S5RQA			
22	P6OCA		R2ZDC		S5RRA			
23	P6ODA		R2ZCH		S5RSA			
24	P5HBB		R2ZCI		S5RTA			
25	P5SGB		R2ZDS		S5RUA			
26	P5SHB		R2ZDT		S9AEA			
27	R1GBA		R2ZCL		S9AFA			
28	R1GHB		R2ZDR		T1CAA			
29	R1GIA		R2ZDN		T1EDC			
[illegible]	R1IBB		R2ZDU		T1EDV			
[illegible]	R1LCA		R2ZAQ		T1EOK			
[illegible]	R1LFA		R2ZEF		T1EHA			
33	R1LGA		R2ZAS		T1EPC			
[illegible]	R1LLB		R2ZEG		T1EPM			
[illegible]	R1LNA		R2ZBW		T1EDP			
[illegible]	R1LPA		R2ZEB		T1ICN			
37	R1RAA		R2ZDP		T1ICQ			
38	R1RCA		R2ZEO		T1ICR			
39	R1REA				T1IDF			
40	R3BEA		R4AAA		T2AAD			

Initiated by: ____________ Approving Office no. Receiving Office no. Rec. by: ____________

Approved by: ____________ Date and Time: ____________

GROUND AMMUNITION TRANSACTION
W. D., A.G.O., FORM NO. 891

Figure 3d. Ground Ammunition

DESCRIPTION OF CODE ITEMS OF AMMUNITION

The code symbols printed on the front of this form correspond to the descriptions listed below. They are listed in the same order and according to the same weapon groups. Divisions between weapon groups on the front of the form are shown by heavy black lines in columns "A", "B", and "C". In column "D" every other horizontal line is heavy in order that two lines may normally be used for each item written in by hand. (See appropriate SNL for code designation.)

COLUMN A

155-mm Guns, M1 and M1A1 (Powder Charge P2EAA)

1. P1ZAM HE,M101,w/PDF,M51A1
2. P1ZAN Gas,H,M104,w/PDF,M51A1
3. P1ZAO Smoke,WP,M104,w/PDF,M51A1
4. P1ZAP AP,M112,w/BDF,M60
5. P1ZCM HE,M101,w/MTF,M67

155-mm Guns, M1917, M1917A1, M1918M1 (Powder Charge P2FCC)

6. P1ZBC HE,M101,w/PDF,M51A1
7. P1ZBD Gas,H,M104,w/PDF,M51A1
8. P1ZBE Smoke,WP,M104,w/PDF,M51A1
9. P1ZBG AP,M112,w/BDF,M60
10. P1ZCN HE,M101,w/MTF,M67

8" Howitzer, M1

11. P1ZCD HE,M106,w/PDF,M51A1,gbc
12. P1ZCE HE,M106,w/PDF,M51A1,wbc
13. P1ZCP HE,M106,w/PDF,M67,gbc
14. P1ZCQ HE,M106,w/PDF,M67,wbc

37-mm Automatic Gun, M1A2 (AA)

15. P5EAB HE,M54,w/TR,SD,w/PDF,M56
16. P5ELA APC,M59,w/TR

40-mm Automatic Gun, M1 (Bofors Gun, British)

17. P5HJA AP-T,M81A1,24rds,w/o CL
18. P5HNA HE-T,(SD,No.12),w/PDF,Mk27, (MV,2700 f/s),24rds,w/o CL
19. P5HOA HE-T,(SD,M3),w/PDF,Mk 27, (MV,2700 f/s),24rds,w/o CL

3" AA Guns (Mobile)

20. P5NIA APC,M62,w/BDF,M66A1,w/TR
21. P5NSA HE,M42A1,w/MTF,M43(all mod)
22. P6OCA HE,M42A1,w/PDF,M48
23. P6ODA HE,M42A1,w/PDF,M48A1

90-mm AA Gun, M1

24. P5RSB HE,M71,w/MTF,M43A3
25. P5SGB HE,M71,w/PDF,M48
26. P5SHB APC,M82,w/BDF,M68,w/TR

37-mm Guns, M3, M3A1 (Antitank), M5, M6 (Tank)

27. R1GBA HE,M63,w/BDF,M58
28. R1GHB Canister, M2
29. R1GIA APC,M51,w/TR

57-mm Guns, M1 and 6 Pr. 7 Cwt. (British)

30. R1LBB APC-T,M86,w/BDF,M72

75-mm Guns (all models)

31. R1LCA HE,M48,w/PDF,M48,sc
32. R1LFA HE,M48,w/T&SQF,M54,sc
33. R1LGA HE,M48,w/T&SQF,M54,nc
34. R1LLB Gas,H,MkII(unfuzed),nc
35. R1LNA APC,HE,M61,w/BDF,M66A1, w/TR,sc
36. R1LPA Smoke,WP,MkII,(unfuzed),nc
37. R1RAA HE,M48,w/PDF,M48A1,nc
38. R1RCA HE,M48,w/PDF,M48A1,sc
39. R1REA Smoke,HC,BI,M89(for M2,M3 Guns)
40. R3BEA Fuse,PD,M46(for Mk II Shell)

COLUMN B

75-mm Howitzers, M1, M1A1, M2, M3

1. R1MDA HE,M48,w/T&SQF,M54
2. R1MIA Smoke,WP,M64,w/PDF,M57
3. R1MJA Gas,H,M64,w/PDF,M57
4. R1MLA HE,M48,w/PDF,M48A1
5. R1MMA HE,AT,M66,w/BDF,M62

76-mm Guns, M1, M1A1 (Tank)

6. R1PAA APC,HE,M62,w/BDF,M66A1, w/TR
7. R1PCA Smoke,HC,BI,M88
8. R1PEA HE,M42A1,w/PDF,M48A1

105-mm Howitzer, M2, M2A1, M4

9. R1QBA HE,M1,w/PDF,M48
10. R1QCA HE,M1,w/T&SQF,M54
11. R1QDA HE,M1,w/PDF,M48A1
12. R1QEA HE,AT,M67,w/BDF,M62
13. R1QIA Gas,H,M60,w/PDF,M57
14. R1QLA Smoke,HC,BE,M84,w/T&SQF, M54

105-mm Howitzer, M3 (Airborne)

15. R1SAA HE,M1,w/PDF,M48A1
16. R1SBA HE,AT,M67,w/BDF,M62
17. R1SDA HE,M1,w/PDF,M48
18. R1QFA Smoke,HC,BE,w/T&SQF,M54

4.5" Gun, M1

19. R2ZCP HE,M65,w/PDF,M51A2,sc,M8
20. R2ZDA HE,M65,w/PDF,M51A2,nc,M7
21. R2ZDB HE,M65,w/MTF,M67A1,nc,M7
22. R2ZDC HE,M65,w/MTF,M67A1,sc,M8

155-mm Howitzer, M1

23. R2ZCH HE,M107,w/PDF,M51A2,gbc
24. R2ZCI HE,M107,w/MTF,M67A1,gbc
25. R2ZDS HE,M107,w/PDF,M51A2,wbc
26. R2ZDT HE,M107,w/MTF,M67A1,wbc
27. R2ZCL Gas,H,M110,w/PDF,M51A2,gbc
28. R2ZDE Gas,H,M110,w/PDF,M51A2,wbc
29. R2ZDN Smoke,HC,BE,M116,w/T&SQF, M54,gbc
30. R2ZDU Smoke,HC,BE,M116,w/T&SQF, M54,wbc

155-mm Howitzers, M1917, M1917A1, M1918

31. R2ZAQ HE,M102,w/PDF,M51A2,gbc
32. R2ZEF HE,M102,w/PDF,M51A2,wbc
33. R2ZAS HE,M102,w/T&SQF,M55A1,gbc
34. R2ZEG HE,M102,w/T&SQF,M55A1,wbc
35. R2ZBW Gas,H,M105,w/PDF,M51A1,gbc
36. R2ZEB Gas,H,M105,w/PDF,M51A1,wbc
37. R2ZDP Smoke,HC,BE,M115,w/T&SQF, M54,gbc
38. R2ZEO Smoke,HC,BE,M115,w/T&SQF, M54,wbc

2" Mortar, M3

40. R4AAA Bomb, smoke,MkI/L

COLUMN C

60-mm Mortars

1. R4CAA HE,M49A2,w/PDF,M52
2. R4CDA Illuminating,M83,w/TF(Sand)M65

81-mm Mortars

3. R4FOA HE,M43A1(light),w/PDF,M52
4. R4FLA HE,M56(heavy),w/PDF,M53
5. R4FPA Smoke,WP,M57,w/PDF,M52

Ground Mines

6. R7AEA Anti-personnel,M2,w/FUZE,M6
7. R7AIA Antitank,HE,M1A1,w/FUZE,M1A2
8. R7AKA Anti-personnel,M2A1,w/FUZE,M6

Torpedo, Bangalore

9. R19AB Box of ten, M1A1, torpedos and accessories

Grenade, Hand

10. S4OCA Mk IIA1 (fragmentation), w/FUZE, M10A3

Grenade, Rifle

11. S4NBA AT,M9A1,1/cntr,10 cntrs/box, packed w/11cartridge,RG,M3
12. S4NIA Smoke,WP,M—
13. S4NMB Fragmentation,M17(formerlyT2),1/cntr, 10 cntrs/box,packed w/10 cartridge,RG, M3, 6 cartridge, carbine, M6 and 5 cartridge, aux., M7
14. S4QFB ADAPTER, grenade projection, M1, (packed 48 w/12 CLIP, launcher, positioning, 48 CARTRIDGE, rifle grenade, cal. .30, M3, 30 CTG carbine M6, 24 CTG aux., M7, per box)
15. S4PBA CARTRIDGE, grenade, carbine, M6

Flares

16. S5IBA Flare, trip, parachute, M48
17. S5ICA Flare, trip, M49

Signal, Ground, for Launcher, Grenade, M1, M2, M7, M8

18. S5RNA Amber Star, cluster, M22A1
19. S5ROA Amber Star, para., M21A1
20. S5RPA Green Star, cluster, M20A1
21. S5RQA Green Star, para., M19A1
22. S5RRA White Star, cluster, M18A1
23. S5RSA White Star, para., M17A1
24. S5RTA Red Star, para., M51A1
25. S5RUA Red Star, cluster, M52A1

Launcher, Rocket, AT, 2.36", M1

26. S9AEA Rocket, Smoke, 2.36", M—
27. S9AFA Rocket, AT, 2.36", M6A3

Caliber .30 Carbine

28. T1CAA Cartridge, M1, 50/ctn, 60/ctns (3000 rds)/box, gr. R

Caliber .30 Rifle

29. T1EDC AP,M2,5/clip,12 clips/band.,25 band. (1500rds)/metal-lined box, gr. R
30. T1EDV AP,M2,8/clip,6 clips/band.,28 band. (1344 rds)/metal-lined box, gr. R
31. T1EOK Ball,M2,5/clip,12 clips/band.,25band. (1500 rds)/metal-lined box, gr. R
32. T1EHA Ball,M2,8/clip,6 clips/band.,28 band. (1344 rds)/metal-lined box, gr. R
33. T1EPC Tracer,M1,5/clip,12 clips/band.,25 band. (1500 rds)/metal-lined box, gr. R
34. T1EPM Tracer,M1,8/clip,6 clips/band.,28 band. (1344 rds)/metal-lined box, gr. R

Caliber .30 Machine Guns (Ground)

35. T1EDP AP,M2,200 w/50 TR,M1,250/mgb, 1 belt/metal box, 4 boxes(1000 rds) /wire-bound crate, gr. MG

Caliber .50 Machine Guns (Ground)

36. T1ICN AP,M2,44 w/44 Incend., M1 and 22 TR, M1,110/mgb,1 belt/metal box, 2 boxes (220 rds)/wire-bound crate, gr. MG
37. T1ICQ AP,M2,42 w/42 Incend.,M1 and 21 TR,M1,105/link belt, 1 belt/metal box, 2 boxes (210 rds)/wire-bound crate, gr. AC
38. T1ICR AP,M2,42 w/42 Incend., M1 and 21 TR, M1,105/link belt, 1 belt/metal box, 2 boxes (210 rds)/wire-bound crate, gr. MG
39. T1IDP AP-I,M8,84 w/21 TR.,M1,105/link belt, 1 belt/metal box, 2 boxes (210 rds) /wire-bound crate, gr. MG

Caliber .45 Weapons

40. T2AAD Ball,M1911,50/ctn,16ctns/wooden cntr., 2 cntrs (1600 rds)/wooden box, gr. I

LEGEND OF ABBREVIATIONS

PDF	- Point detonating fuze	gbc	- Green bag chg.	sc	- Super charge
MTF	- Mechanical time fuze	wbc	- White bag chg.	nc	- Normal charge
BDF	- Base detonating fuze	mgb	- Machine gun belt	rc	- Reduced charge
T & SQ	- Time & Super Quick	CL	- Clips	band.	- Bandoleer

Forms—W.D., A.G.O. Form No. 581

Transaction (W.D., A.G.O. Form No. 581).

one copy of this report is prepared, and it is forwarded to the corps ordnance officer.

3. *Corps Credit Record:* This form gives a continuous running balance of types of ammunition allocated to corps with the amounts available for issue to corps troops and attached units or for re-allocation to divisions. The record is maintained for each item of ammunition and is filed in alphabetical order by code symbol. Code on each card is indicated in specified space at top margin. (Abbreviated nomenclature may be entered following the code.) Corps designation is entered after "Unit Keeping Record" and the first blank column to the right of the "Unit-Voucher" column is labeled "Total Credit." Designations of ASP's storing ammunition allocated to the corps are entered in the remaining columns to the right.

Entries are posted to this record in a manner similar to preceding records. Each reporting period is closed out with the entry of the word "Report" and the date and hour of the close in the column for "Unit-Voucher." Balances are brought down, and a wavy line is entered in the "Amt" line above the final balance.

4. *Corps Summary of Ammunition Status:* As a convenient means for consolidating balances reported to army in the corps credit report, and for the purpose of allocating for subordinate units, a corps summary is kept, with a separate card for each item of ammunition. Cards are filed alphabetically according to code symbol. Identification is maintained as on other records and the first column to the right of the "Unit-Voucher" column is labeled "Total Credit" with other columns labeled appropriately to reflect ASP's holding ammunition allocated to corps.

The words "Corps Unallocated" and the date and hour of close of the reporting period are entered in the first line of the "Unit-Voucher" column. Each balance listed on "Report" line of each corps credit card is entered in corresponding column of the corps summary of ammunition status card on "Corps Unallocated" line.

The running balance of the corps credit record is the "Corps Unallocated". Division reports are entered by date and hour in "Unit-Voucher" column and specification of quantities in appropriate columns. The record is closed out when last reports are received in the same manner as the preceding records.

5. *Corps Credit Report.* This report informs army of unused balances of ammunition allocated to the corps and its divisions. It shows total quantity and location of each type of ammunition available and joins the other reports made on WD AGO Form No. 582.

The form is dated after word "Code" in top margin, and identification is entered here. The first blank column to the right of the "Unit Voucher" column is headed "Total Credit," and designations of storage places are entered in other columns as in corps summary ammunition and corps credit record cards.

Code symbols of all items of ammunition are listed in "Unit-Voucher" column in alphabetical order. The total quantities listed on the "Corps Report" line of the corps summary of ammunition status cards are entered in corps credit report in corresponding columns opposite the code symbol for the ammunition.

If the corps summary of ammunition status record is maintained, only one copy of the corps credit report is normally prepared, and it goes to the army ordnance officer.

6. *Status of Stocks Record.* (ASP or Depot) Each ASP or depot maintains a status of stocks record to show, for each item of ammunition, running balances of total stocks on hand and quantities available to corps and all its subordinate units. A card is prepared for each item of ammunition and filed alphabetically by code.

The column to right of "Unit-Voucher" is designated "Total on Hand." The second column becomes "Army Unallocated." The corps supplied by the ASP or Depot goes in the next column.

Receipts are posted by voucher numbers or by shipping ticket designation and added to balance in "Total on Hand" and "Army Unallocated" columns.

Allocations to corps are posted by entering brief description in "Unit-Voucher" column and subtracting allocation from balances in "Total on Hand" and "Army Unallocated" columns. The quantity is also entered in the "Corps" column and added to the previous balance.

Reporting periods are indicated by entering "Report" with date and hour in "Unit Voucher" column. Last balance in each column is brought down to "Bal." line and a wavy line drawn across the card.

STATUS OF STOCKS RECORD

CODE R1GBA — UNIT KEEPING RECORD ASP #3 opened 5 Aug 0600

UNIT — VOUCHER		Total On Hand	Army Unallocated	V Corps
D.V.#1 Depot A S/T #2	AMT.	15 000	15 000	
4 Aug 0700	BAL.	15 000	15 000	
A.V.#2 A.A.#2	AMT.		10 000	10 000
V Corps	BAL.		5 000	10 000
Report	AMT.			
5 Aug 0600	BAL.	15 000	5 000	10 000
C.V.#3 3d Div.T.O.#1	AMT.	1 000		1 000
7th Inf.	BAL.	14 000		9 000
C.V.#4 Army T.O. #1	AMT.	1 000	1 000	
819th T.D. Bn.	BAL.	13 000	4 000	
C.V.#5 V Corps T.O.#1	AMT.	2 000		2 000
823d T.D. Bn.	BAL.	11 000		7 000
Report	AMT.			
6 Aug 0600	BAL.	11 000	4 000	7 000
C.V.#6 3d Div.T.O.#3	AMT.	2 000		2 000
7th Inf.	BAL.	9 000		5 000
C.V.#7 Army T.O.#2	AMT.	1 000	1 000	
819th T.D. Bn.	BAL.	8 000	3 000	

NOTE: The balances brought down and re-entered on the "Report" line are starting balances for the next reporting period. Subsequent transactions are posted in the usual manner.

NOTE: C.V. indicates Credit Voucher, i.e. outgoing shipment or issue.
D.V. indicates Debit Voucher, i.e. incoming shipment or receipt.
A.V. indicates Allocation, does not affect physical stock (Total on Hand).

NOTE: All vouchers (CV, DV and AV) are numbered consecutively in a single series, beginning with the first transaction of the ASP and continuing as long as the site is occupied or until a new series is designated.

Figure 4. ASP Status of Stocks Record.

STATUS OF STOCKS REPORT

CODE Report 6 August 0600 — UNIT KEEPING RECORD ASP #3

UNIT — VOUCHER		Total on Hand	Army Unallocated	V Corps
	AMT.			
P1ZAM	BAL.	24 000	8 000	16 000
	AMT.			
P5EAB	BAL.	16 000	6 000	10 000
	AMT.			
R1GBA	BAL.	11 000	4 000	7 000
	AMT.			
R2ZCH	BAL.	48 000	30 000	18 000
	AMT.			
T2AAD	BAL.	115 000	35 000	80 000

NOTE: Quantities shown for R1GBA are taken from ASP #3 Status of Stocks Record for R1GBA fig. 20. Quantities for other items are from similar records not illustrated in this manual.

Figure 5. ASP Status of Stocks Report.

7. *The Status of Stocks Report* for ASP or Depot informs army of total quantity of each type of ammunition on hand at the ASP or depot, showing quantity unallocated by army and balance available for issue to corps or divisional troops from existing allocations to corps.

Close of reporting period is shown opposite "Code" at top margin of card. The column to the right of "Unit Voucher" column is labeled "Total on Hand,"

and the next column becomes "Army Unallocated." The designation of the corps supplied by the ASP or depot is placed in the third blank column heading. Code symbols of all items are listed in "Unit-Voucher" column.

Each balance listed on "Report" line of each Status of Stocks record card is entered in the corresponding column of the Status of Stocks report on line with the code symbol for that item of ammunition. One copy is prepared normally for army ordnance officer.

8. *The Locator Record* shows running balances of total stocks on hand and quantities in each section of the ASP or depot. Quantity of each lot number is shown. A separate card is maintained for each item.

The code designation is entered at top margin of the card. Appropriate identification is entered here, and the column to the right of "Unit Voucher" becomes "Total on Hand." "Road" and "Stack" designations and lot numbers go into the blank column headings to the right.

Receipts are handled by posting identification of shipment in the "Unit-Voucher" column. Quantity received goes on "Amt" line into "Total on Hand" column as well as into the appropriate "Road-Stack Lot No." column. This amount is added to previous balance. Issues on transfers are handled similarly with amounts being subtracted.

CODE R1GBA — UNIT KEEPING RECORD ASP #3 opened 5 Aug 0600 — LOCATOR RECORD

UNIT — VOUCHER	Stack Lot No.	Total On Hand	A-5 PA 77-24	A-10 PA 77-24	B-21 PA-75-42	B-33 PA 75-42		
D.V. #1 Depot A S/T #2	AMT.	15 000	4 000	3 000	3 000	5 000		
4 Aug 0700	BAL.	15 000	4 000	3 000	3 000	5 000		
C.V. #3 3d Div. T.O. #1	AMT.	1 000	500	500				
7th Inf. - 3d Div.	BAL.	14 000	3 500	2 500				
C.V. #4 Army T.O. #1	AMT.	1 000	500	500				
819th T.D. Bn.	BAL.	13 000	3 000	2 000				
C.V. #5 V Corps T.O. #1	AMT.	2 000			1 000	1 000		
823d T.D. Bn.	BAL.	11 000			2 000	4 000		
C.V. #6 3d Div. T.O. #3	AMT.	2 000	1 000	1 000				
7th Inf.	BAL.	9 000	2 000	1 000				
C.V. #7 Army T.O. #2	AMT.	1 000		1 000				
819th T.D.Bn.	BAL.	8 000		- 0 -				
--------------	AMT.							
	BAL.							
--------------	AMT.							
	BAL.							
--------------	AMT.							
	BAL.							
--------------	AMT.							
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--------------	AMT.							
	BAL.							
--------------	AMT.							
	BAL.							
--------------	AMT.							
	BAL.							
--------------	AMT.							
	BAL.							

Figure 6. Locator Record.

9. *The Army Status of Stocks Record* is also maintained on WD AGO 582. It consists of a card for each item of ammunition and is maintained by army for each ASP or depot. It shows total stock on hand, amounts of "Army Reserve" or "Army Unallocated", and quantities available for corps and its units.

Identification is established at top of card by code and unit keeping record.

The code symbol for the particular item of ammunition is placed after the word "CODE" in the top margin.

An abbreviated nomenclature of the item may be placed after the code symbol in the top margin.

The designation of the army, the designation of the record, and the ASP or depot for which the record is being kept are entered after the words "UNIT KEEPING RECORD," in the top margin.

The words "Total on Hand" are placed in the first blank column heading.

The words "Army Unallocated" are placed in the second blank column heading.

The designations of the corps supplied by the ASP or depot are placed in the next blank column headings.

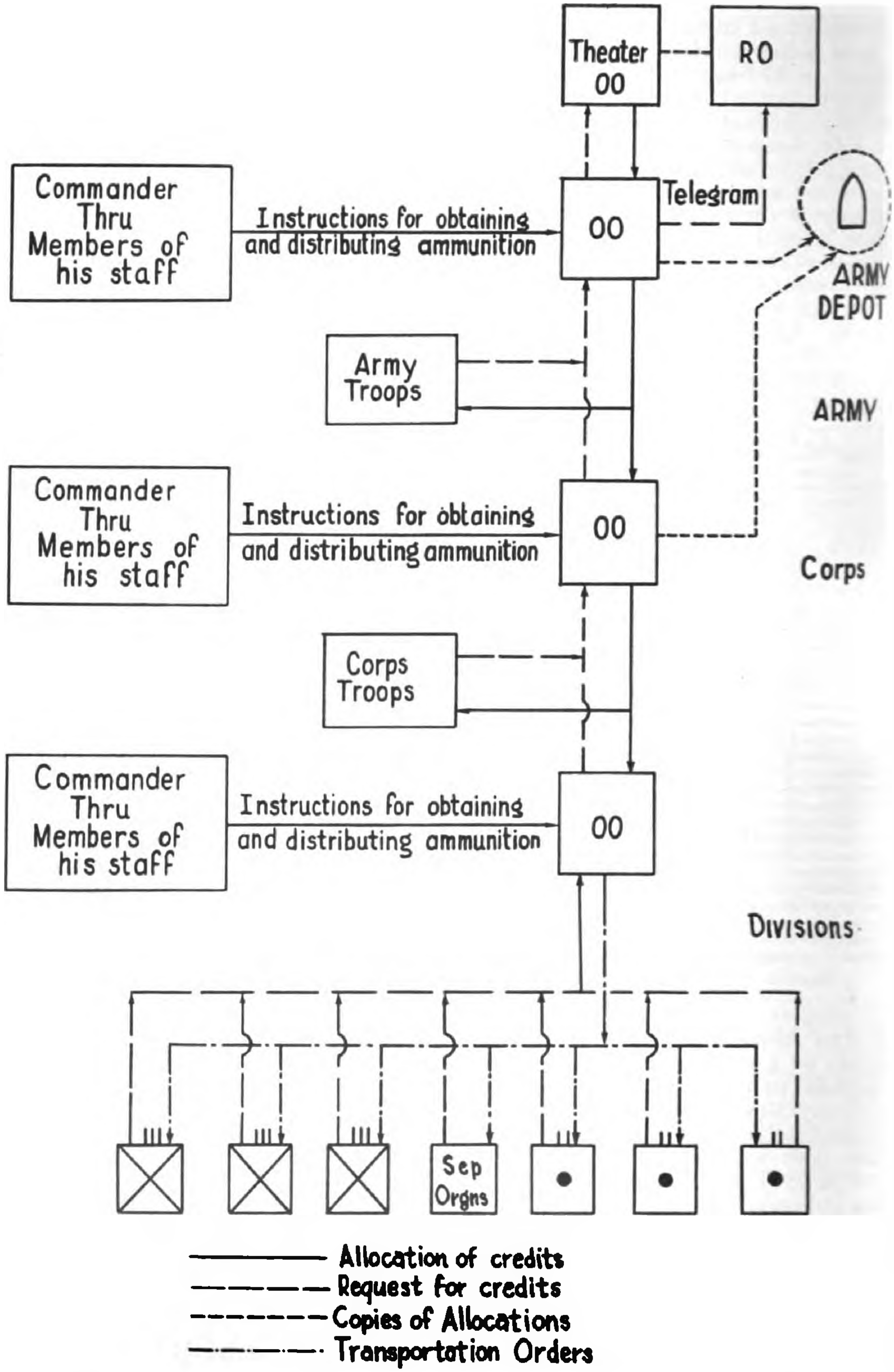

Figure 6A. Schematic Diagram of Flow of Allocations and Requests for Credits.

The receipts of ammunition are posted as follows:

1. The shipping ticket number assigned by the shipper and the designation of the shipper are entered in the "Unit-Voucher" column.

2. The quantity received is entered on the line opposite the word "Amt." in the "Total on Hand" column and also in the "Army Unallocated" column. The amount received is added to the last previous balance on each of those columns and the new balances are entered on the "Bal." line just below the new "Amt." entries.

Army allocations to corps are posted as follows:

1. A brief description of the allocation is written in the "Unit-Voucher" column.

2. The quantity allocated is entered on the line opposite the word "Amt" in the "Army Unallocated" column and subtracted from the previous balance. The new balance is entered in the "Bal." line just below the new "Amt." entry.

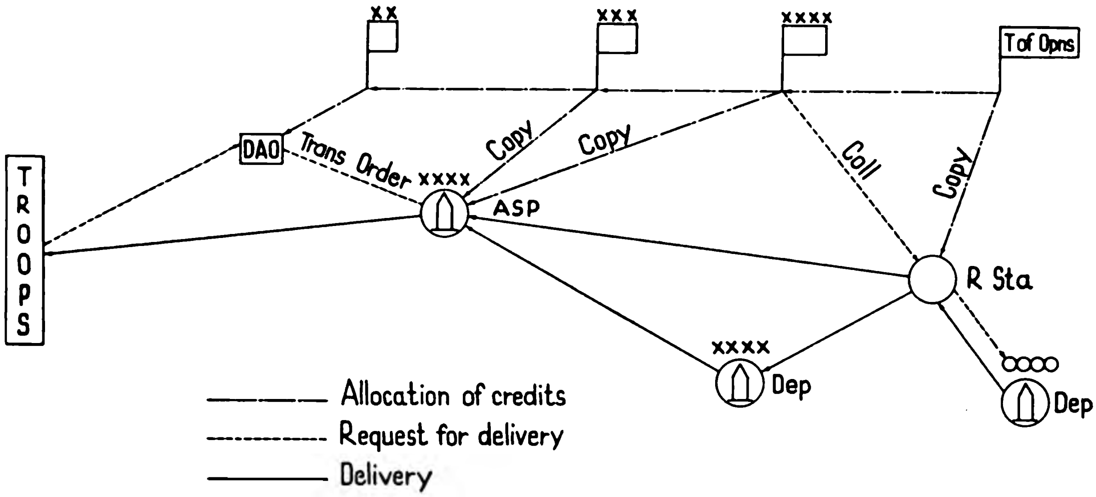

Figure 6B. Diagram of Distribution of Class V Supplies.

3. The quantity allocated is also entered on the same "Amt." line in the "Corps" column and added to the previous balance. The new balance is entered in the "Bal." line just below the new "Amt." entry.

Balances are adjusted as follows:

1. The amounts reported on the status of stock report by the particular ASP or army depot are entered on the "Bal." line in the corresponding columns on the army status of stock record.

2. The balances reported by the ASP or depot replace prior balances and all transactions during the next reporting period are posted, as directed above, from the new balances reported.

Army Master Status of Stocks Record. If there are a number of army ammunition installations, it may be advisable to maintain an army master status of stocks record for each type of ammunition. This record shows the total quantity of ammunition in all army installations and the quantity in each installation. The record is maintained on WD AGO Form No. 582. A separate card is used for each item of ammunition and filed in alphabetical order, by code symbol. Each card is prepared as follows:

The code symbol for the particular item of ammunition is placed after the word "CODE," in the top margin.

An abbreviated nomenclature of the item may be placed after the code symbol, in the top margin.

The designation of the army and the designation of the record are entered after the words "UNIT KEEPING RECORD," in the top margin.

The words "Army Total" are placed in the first blank column heading and the ASP and depot designations are entered in the remaining blank columns to the right.

The date and hour of the close of the reporting period are entered in the "Unit-Voucher" column.

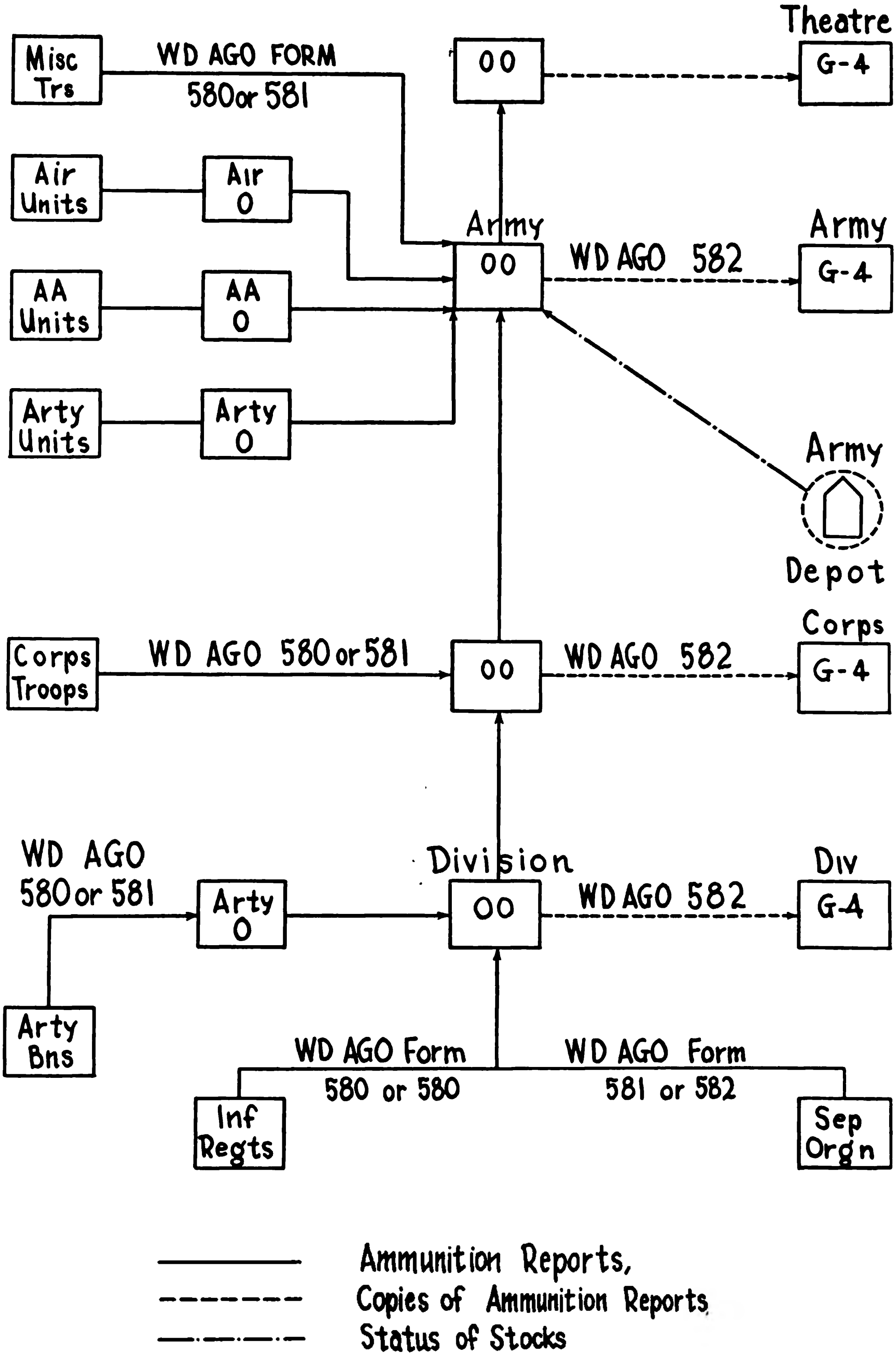

Figure 6C. Schematic Diagram of Flow of Ammunition Reports.

CODE R1CBA

UNIT KEEPING RECORD FIRST ARMY — STATUS OF STOCKS RECORD FOR ASP #3

UNIT — VOUCHER		Total On Hand	Army Unallocated	V Corps
Depot A S/T #2	AMT.	15 000	15 000	
4 Aug 0700	BAL.	15 000	15 000	
A.A.#2 to V Corps	AMT.		10 000	10 000
4 Aug 2300	BAL.		5 000	10 000
--------------	AMT.			
	BAL.			
Report	AMT.			
5 Aug 0600	BAL.	15 000	5 000	10 000
T.O. #1	AMT.	1 000	1 000	
819th T.D. Bn.	BAL.	14 000	4 000	
--------------	AMT.			
	BAL.			
Report	AMT.			
6 Aug 0600	BAL.	11 000	4 000	7 000
T.O. #2	AMT.	1 000	1 000	
819th T.D. Bn.	BAL.	10 000	3 000	
--------------	AMT.			
	BAL.			
--------------	AMT.			
	BAL.			
--------------	AMT.			
	BAL.			
--------------	AMT.			
	BAL.			
--------------	AMT.			
	BAL.			
--------------	AMT.			
	BAL.			

NOTE: The balances entered in the "Report" line are taken from the status of stocks reports of the ASP in order to correct for issues made by the ASP during the reporting period. These balances are the starting balances for the next reporting period and subsequent entries are made in the usual manner.

Figure 7. Army Status of Stocks Record.

CODE R1GBA

UNIT KEEPING RECORD ARMY — MASTER STATUS OF STOCKS RECORD

UNIT — VOUCHER		Army Total	Depot #1	ASP #2	ASP #3	ASP #4
Report	AMT.					
6 Aug 0600	BAL.	42 000	9 000	13 000	11 000	9 000
--------------	AMT.					
	BAL.					
--------------	AMT.					
	BAL.					
--------------	AMT.					
	BAL.					
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--------------	AMT.					
	BAL.					
--------------	AMT.					
	BAL.					
--------------	AMT.					
	BAL.					
--------------	AMT.					
	BAL.					
--------------	AMT.					
	BAL.					

NOTE: Similar entries are made at the close of each reporting period until the card is filled up.

Figure 8. Army Master Status of Stocks Record.

The "Total on Hand" quantity reported by each ASP and depot is entered on the "Bal." line in the column designated for that ASP or depot. The "Total on Hand" quantities reported by all ASP's and depots are added and the grand total is entered on the "Army Total" column.

Army Record of Credits. The army record of credits maintained by army show for each item of ammunition the total quantity allocated to army in the communications zone, the quantities in each communications zone depot, and the quantities in transit to army. The record is maintained on WD AGO Form No. 582. A separate card is maintained for each item of ammunition and filed in alphabetical order, by code symbol. Each card is prepared as follows:

The code symbol for the particular item of ammunition is placed after the word "CODE," in the top margin.

An abbreviated nomenclature may be placed after the code symbol, in the top margin.

The designation of the army and the designation of the record are entered after the words "UNIT KEEPING RECORD," in the top margin.

CODE R1GBA — UNIT KEEPING RECORD FIRST ARMY — RECORD OF CREDITS

UNIT — VOUCHER		Total C.Z. Credit	Depot A	Depot B				In Transit
Theater Allo. #1	AMT.	100 000	100 000					
Rec'd. 3 Aug 0800	BAL.	100 000	100 000					
Theater Allo. #2	AMT.	80 000		80 000				
Rec'd. 3 Aug 0800	BAL.	180 000		80 000				
S.R.#1 3 Aug 1000	AMT.	25 000	25 000					25 000
Depot #1	BAL.	155 000	75 000					25 000
S.R.#2 3 Aug 1000	AMT.	20 000		20 000				20 000
Leesville	BAL.	135 000		60 000				45 000
S.R.#3 3 Aug 1000	AMT.	15 000	15 000					15 000
Boyce	BAL.	120 000	60 000					60 000
S.R.#4 3 Aug 1500	AMT.	20 000		20 000				20 000
Jasper	BAL.	100 000		40 000				80 000
Report	AMT.							
4 Aug 0600	BAL.	100 000	60 000	40 000				80 000
Depot A S/T#1(S.R.#1)	AMT.							25 000
Depot #1 4 Aug 0700	BAL.							55 000
Depot A S/T#2 (S.R.#3	AMT.							15 000
Boyce 4 Aug 0700	BAL.							40 000
Report	AMT.							
5 Aug 0600	BAL.	100 000	60 000	40 000				40 000
Depot B S/T#1(S.R.#2)	AMT.							20 000
Leesville 5 Aug 2100	BAL.							20 000
Report	AMT.							
6 Aug 0600	BAL.	100 000	60 000	40 000				20 000
S.R.#5 6 Aug 1400	AMT.	10 000	10 000					10 000
Boyce	BAL.	90 000	50 000					30 000
	AMT.							
	BAL.							

Figure 9. Army Record of Credits.

The words "Total Communications Zone Credit" are entered in the first blank column heading and the designations of communications zone depots storing the ammunition allocated to army are entered in the remaining blank headings to the right. The words "In Transit" are entered in the last column heading to the right.

Theater of operations allocations to army are posted as follows:

1. A brief description of the allocation is written in the "Unit-Voucher" column.
2. The quantity allocated is entered on the line opposite the word "Amt," in the "Total Communications Zone Credit" column and also in the column corresponding to the depot where the ammunition is stored. The amount of the new allocation is added to the last previous balance in each of those columns and the new balances are entered on the "Bal." line just below the new "Amt." entries.

Shipping requests are posted as follows:

1. A brief description of the request is entered on the "Unit-Voucher" column.
2. The quantity requested is entered on the line opposite the word "Amt." in the "Total Communications Zone Credit" column, in the column designated by the depot where the ammunition is stored, and also in the column headed "In Transit." The amount of the request is subtracted from the previous balances

in the "Total Communications Zone Credit" column and in the column for the depot storing the ammunition. The amount of the request is added to the previous balance in the "In Transit" column. The new balances are entered on the "Bal." line just below the new "Amt." entries.

Each shipment received by an army installation is posted as follows:

1. A brief description of the shipment, including the shipper, the shipping ticket number, the ASP or depot receiving the shipment, and the number of the shipping request initiating the shipment, is entered in the "Unit-Voucher" column.

2. The quantity of the shipment is entered on the line opposite the word "Amt" in the "In Transit" column. The amount of the shipment is subtracted from the last previous balance in that column and the new balance is entered on the "Bal." line just below the new "Amt." entry.

CODE REPORT 6 AUG 0600 — UNIT KEEPING RECORD FIRST ARMY REPORT

UNIT — VOUCHER		Grand Total	Total in Army Installation	In Transit	Total in C.Z. Depots	Depot A	Depot B
	AMT.						
P1ZAM	BAL.	160 000	40 000	10 000	110 000	50 000	60 000
	AMT.						
P5EAB	BAL.	105 000	30 000	5 000	70 000	40 000	30 000
	AMT.						
R1GBA	BAL.	162 000	42 000	20 000	100 000	60 000	40 000
	AMT.						
R2ZCB	BAL.	270 000	80 000	20 000	170 000	100 000	70 000
	AMT.						
T2AAD	BAL.	800 000	300 000	50 000	450 000	250 000	200 000

NOTE: Quantities shown for R1GBA are taken from Army Credit Record for R1GBA, fig. 25, and Army Master Status of Stocks Record for R1GBA, fig. 24. Quantities for other items are from similar records not illustrated in this manual.

Figure 10. Army Report.

Army Report. The army report informs the theater of operations of the army ammunition status. It shows the total quantity of each type of ammunition available to army, the total amount in army ammunition supply installations, the amount in transit to army, and the amount in the communications zone depots allocated to army.

The report is made on WD AGO Form No. 582, prepared as follows:

1. The date and hour of the close of the reporting period for which the report is made are entered after the word "CODE" in the top margin.

2. The designation of the army and the name of the report are entered after the words "UNIT KEEPING RECORD," in the top margin.

3. The words "Grand Total" are entered in the heading of the first blank column to the right of the column headed "UNIT-VOUCHER"; the words "Total in Army Installations" are entered in the third blank column heading; the words "In Transit" are entered in the third blank column heading; the words "Total in Communications Zone Depots" are entered in the fourth blank column heading; and the blank column headings to the right may be used for the designations of communications zone depots storing the ammunition allocated to army.

The code symbols of all items of ammunition are listed in the "UNIT-VOUCHER" column, in alphabetical order.

The total quantities, as consolidated from all reports and records, by army, are entered in the appropriate columns on the same line with the code symbol for each item of ammunition.

Only one copy of the army report is normally prepared. It is sent to the theater ordnance officer.

LAYOUT OF DEPOTS AND ASP's

Selection of Site. Wherever it is to be located and regardless of the quantity or type of ammunition to be stored, certain factors must be considered in the selection of the depot or ASP area. In most cases, the area chosen will not meet *all* requirements. It should, however, possess the best combination of these features.

Separate Area. It is essential that ammunition be segregated in an area specifically set aside for its exclusive storage. This area should be separated by safe distances from bivouac and general purpose areas, public highways and railroads, and other army installations.

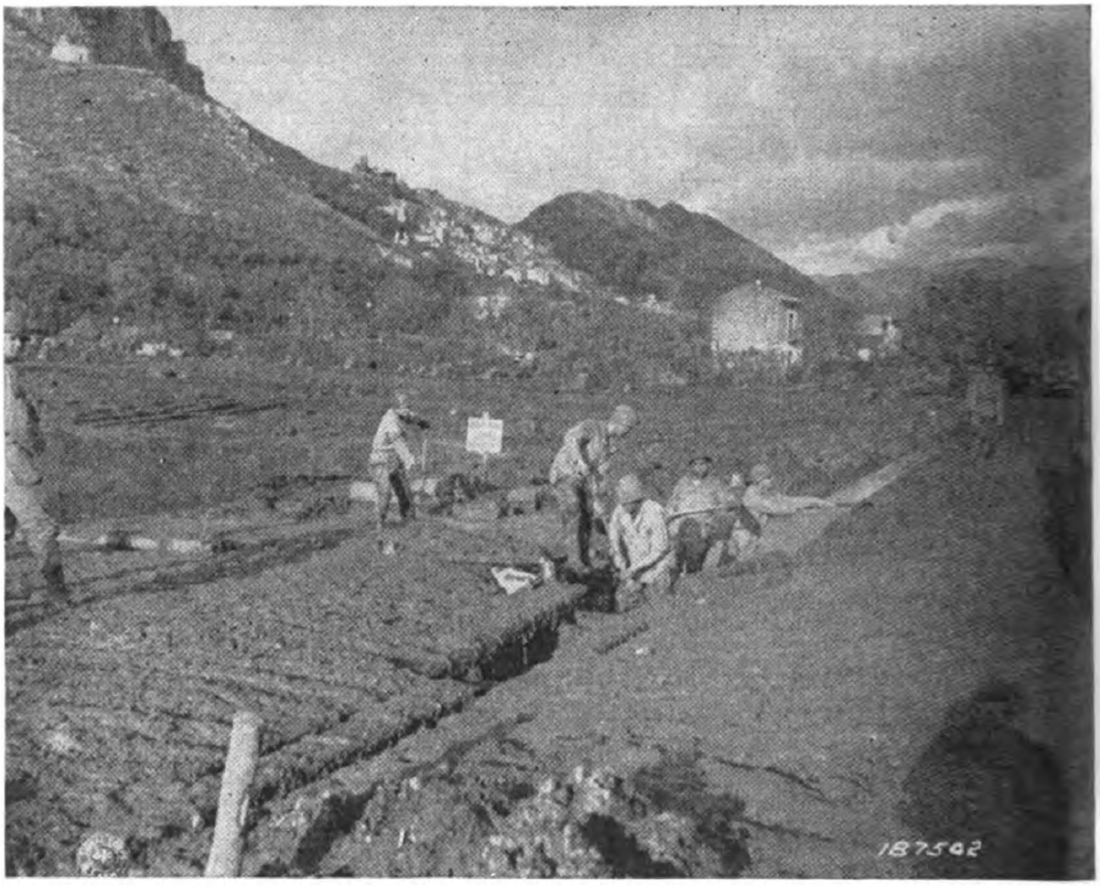


Figure 11. Drainage Canals are Being Built to Drain Off Water in a Field to be Used as an Ammunition Depot, in Italy, Dec. 1, 1943.

Transportation Facilities. Movement of ammunition ordinarily will be by motor transportation. Consequently, the area must be accessible to the using arms as well as the rear area sources of supply. Location of the area on a main supply route, however, is not advisable, for traffic congestion will reduce efficiency of operation. The best practice is to select an area on a secondary road which connects with the main line of communication from front to rear.

Rail facilities are not to be overlooked, but it should be borne in mind that railroads are obvious targets for enemy artillery and aircraft.

Terrain. Care should be taken to select the most advantageous terrain. Low, marshy ground or ground likely to be flooded should be avoided. The area should be dry, well drained, and accessible in all types of weather. An interior network of usable roads is essential if the ground itself is not solid enough to support the weight of loaded trucks. Very hilly country should be avoided, if possible, or else difficulty will be found in making level and stable stacks. (Fig. 11.)

Natural Features. If water is not to be drawn from a water supply point, an accessible source of drinking and washing water is all-important.

Natural cover to conceal the ammunition from enemy observation is highly desirable but not always possible. However, isolated trees and small wooded areas should be avoided as they attract attention. Dense woods provide good cover in spring or summer, but are damp in winter and carry a great fire risk in autumn. An area covered with pines is always dangerous because of the highly inflammable pine needles which blanket the ground.

Figure 12. Looking Northwest from Approximately 1,500 Yards Inland from the Middle of the Beach is the Ammunition Dump Which is Located Farther up the Valley. Another Ammunition Dump is Located Just Behind the Beach Along the Creek. In the Background Can be Seen Other Supplies Stored Along the Creek Bed, Which is Being Used as a Road. Massacre Bay, Attu, Alaska, 31 May 43.

Size. In selecting the site, consideration must be given to the possible necessity for subsequent expansion. It is good practice to allow for ultimate expansion to at least twice the expected initial stockage.

Protection from Enemy Attack and Artillery Fire. Protection of the ammunition area from attack or artillery fire is, of course, desirable. Tactical considerations, however, may require that this factor yield to the necessity of having the ammunition close to the using arms. In any event, wherever possible, full use should be made of existing defilades.

Alternate Site. An alternate site should always be selected in the same general area in which the ASP or depot is located. This may be used either for expansion or evacuation as circumstances require.

Arrangement of Area. The interior arrangement of the area will depend, in large measure, upon the type of installation and its mission. An Army depot, for example, distributing principally to other supply points might well be laid out in a different manner from an ASP supplying nearby using units. Certain basic factors apply however to all ammunition supply installations.

Chemical ammunition, rockets, and bombs should each be stored in separate areas away from other munitions. Gas shells, in the chemical area, should be stored on the lowest ground, and should be down wind if a prevailing wind exists.

Firebreaks in and around the ammunition area should be constructed. They can consist of cleared areas of sufficient width to prevent the spread of fire along the ground or of bunkers or revetments which will serve the same purpose.

An interior network of roads connecting with all parts of the ammunition area and yet so planned as to prevent traffic congestion is essential. Narrow roads are not to be overlooked, as one-way traffic can be organized and turn-arounds constructed.

Ammunition should be stored by groups according to the hazards presented with sufficient dispersion so as to prevent widespread destruction due to uncontrolled fires or sympathetic detonation. Pending revision of FM 9-20 (July, 1942 edition) the provisions of TC 47, 20 July 1944, will control the grouping and dispersion of ammunition in the theaters of operation.

Adequate facilities to fight fires and to prevent catastrophes due to exploding high explosive or chemical ammunition or leaking gas shells should be available at all times for instant use. Gas masks and protective equipment should be maintained ready for issue in the chemical area. A supply of shovels and sand or earth, of filled water barrels or buckets, and other materials suitable to prevent the spread of fire should be interspersed throughout the ammunition area.

Exact and detailed planning of the layout of the entire ASP or depot area in advance of its occupation is a cardinal requisite. This can only be accomplished by a suitable personal reconnaissance, as a result of which a sketch of the area should be prepared. Among other things, the sketch should show the location of the various areas within the site and should provide for a system of traffic control over existing roads and roads or turn-arounds to be constructed.

ASP's. In general, an ASP layout will include the following areas:

An entrance and exit;
Vehicle parks or assembly points for entering and departing vehicles;
An ASP office site;
An ammunition area;
A bivouac area;
A salvage area;
A renovation area.

These will be discussed in the order mentioned.

Entrance and Exit. As has already been stated, the ASP must be accessible from main highways connecting with the using units in the forward area and sources of supply in the rear. Ordinarily, traffic will be one-way throughout the area. Wide roads in certain parts of the area may make it possible at those points to allow for two-way traffic, provided however that there is no danger of traffic congestion.

Vehicle Parks or Assembly Points for Entering and Departing Vehicles. In order to reduce confusion, an area at which ammunition truck trains may be held until the ASP is prepared to serve them should be selected at a suitable distance from the ammunition area on each road of approach to the installation.

Similarly, a park should be selected at each exit where trucks may assemble until the entire train has passed through the ammunition area and is ready to leave in convoy as a unit.

These holding areas should be well drained, on hard ground, and well concealed or camouflaged. They should be situated off the main road running through the ASP, so as not to interfere with traffic. Each holding area should be connected by field telephone or other means of communication with the ASP office.

Office. The ASP office should be located at a suitable distance from the entrance and from the vehicle parks for incoming vehicles. It should be connected with entrance, exit, and vehicle parks by telephone. It should be well covered or camouflaged and prepared to operate under blackout conditions.

Ammunition Area. The ammunition area should be divided into at least three sections, each section containing approximately an equal amount of each type of ammunition stored. This arrangement minimizes the possibility of destruction of the entire ASP stock by a single fire or explosion. When sufficient space and personnel are available there should be enough sections to permit loading of the maximum number of unit trains expected at any one time.

Each section should have a road or roads which can be used without passing through any part of another section. All roads within a section, of course, should connect with the main entrance and exit.

Bivouac Area. This area should be located as near the ammunition area as is practicable, considering the factors of safety, accessibility, and camouflage. However, it should never be located nearer than 350 yards from the nearest ammunition stack. If water is not to be procured from a water supply point, the bivouac area should be located near a water source which has been approved by a medical officer. Such water must be purified in an approved manner before use.

Salvage and Renovation Areas. A salvage area should be established where returned ammunition and components are sorted and stored prior to renovation or removal to the rear.

An area should also be set aside for such renovation operations as may be performed by the ammunition company.

Each of these areas should be at least 350 yards from the ammunition area.

DEFENSE AGAINST ENEMY ACTION

General. Plans for meeting any type of attack must be prepared, and constant readiness for attack must be maintained. (See FM 5-15.) These plans must be coordinated with adjacent installations and troops.

A reconnaissance of the vicinity must be made to establish a plan for local defense. The reconnaissance information should be noted on a map and should include all passable roads, load limit of bridges, and dry creek beds which might fill with water in case of heavy rains or flash floods. The type of road surface and its condition should be noted.

A distinct type of alarm system should be established for each of the following types of attack: air raid, ground attack, gas attack, paratroop attack.

Outpost positions should be established and manned immediately upon occupying the area. Loitering near the area by persons not having business in the ASP should not be allowed.

Slit trenches or fox holes must be prepared immediately and barricades, if necessary, should be constructed. These measures should be taken with a view to protection of personnel from explosions within the magazine sections and from enemy artillery fire, if within range, as well as for protection from ground attack.

Prevention of light glow from tents or buildings is especially important in forward areas. All operational tents or buildings must be lightproof to prevent detection by enemy observation at night.

Air Attack. The best defense which an ASP can make against air attack is a passive one by means of camouflage and cover. A.A. weapons should be employed as additional defense measures as the situation requires.

Ground Attack. In the event of ground attack, all personnel should protect the ASP with the weapons available and in conformance with the defense plan. Higher headquarters and any nearby friendly troops should be notified immediately. (See page 396 for methods of destruction of ammunition to prevent capture.) The ASP should not be abandoned except in the case of a general withdrawal of friendly troops in the vicinity.

Gas Attack. All guards, guides, and traffic directors should be familiar with the location of gas alarms, and all personnel should be drilled in defense against chemical attack. (See FM 21-40.) If the ASP is neutralized by persistent gas, assistance of chemical troops should be requested through channels. Ammunition exposed to gases should be decontaminated as prescribed in TM 9-1900. Decontamination materials must be available and all personnel trained in their use.

Camouflage. *Definition.* Camouflage is work done to provide protective concealment of materiel, troops, or military works from enemy observation. Natural concealment may be combined with artificial means of disguise to form camouflage. Where no natural cover exists, artificial means of concealment must be depended upon entirely.

Effectiveness. The effectiveness of camouflage is dependent on camouflage discipline, which is a continuous process. Camouflage discipline is the prevention of any change which might be noted by enemy air observation.

Maintenance. All new construction, such as roads, must be kept to a minimum. All idle equipment, such as trucks, must be kept hidden during daylight.

All unnecessary movements of personnel must be eliminated during daylight.

Where natural cover is not available, regular outlines and shadows must be avoided.

A full discussion of the methods of camouflage is contained in FM 5-20 and TM 5-267.

ARMY AND COMMUNICATION ZONE DEPOTS

Depots are larger installations than ASP's, located farther to the rear, and are more permanent in nature. Army depots are usually intermediate points in the chain of supply, located in the Army service area between communication zone depots and the various ASP's. Communication zone depots may either be at a port or in the base section of the communication zone or at a more advanced point. Ordinarily more selectivity can be practiced in selecting a depot storage site, and more time is available to build or improve the existing road nets and, perhaps, to construct railroad spurs and sidings. Moreover, depots are usually well staffed as far as labor is concerned and are equipped with labor saving and materiel handling devices. Many depots, particularly in the communication zone, have facilities for covered storage. (See Fig. 2 and Fig. 13.)

TYPES OF ASP STORAGE

Depending on the type of area in which laid out, ASP's may be classified as wooded area, open area, and roadside ASP's.

Wooded Area. The great advantage of an ASP in a wooded area is the cover and concealment afforded by the trees. It is not meant to imply, however, that most ASP's are located in wooded areas, for other factors very often compel a different choice. Many wooded areas are not of sufficient size to accommodate the ASP's stockage. Often the ground will be soft and muddy, preventing the passage of heavily laden trucks, and existing trails may not be adequate. The hazard of fire, as has been mentioned before, is usually serious, particularly in autumn or in forests of pine.

Open Area. Frequently an ASP will be established in an open area, without cover. The area may either be on hard sand, as in North Africa, or on hard rocky ground, as in some of the hills of Sicily and Italy, or in farm country, as in parts of Italy and in France.

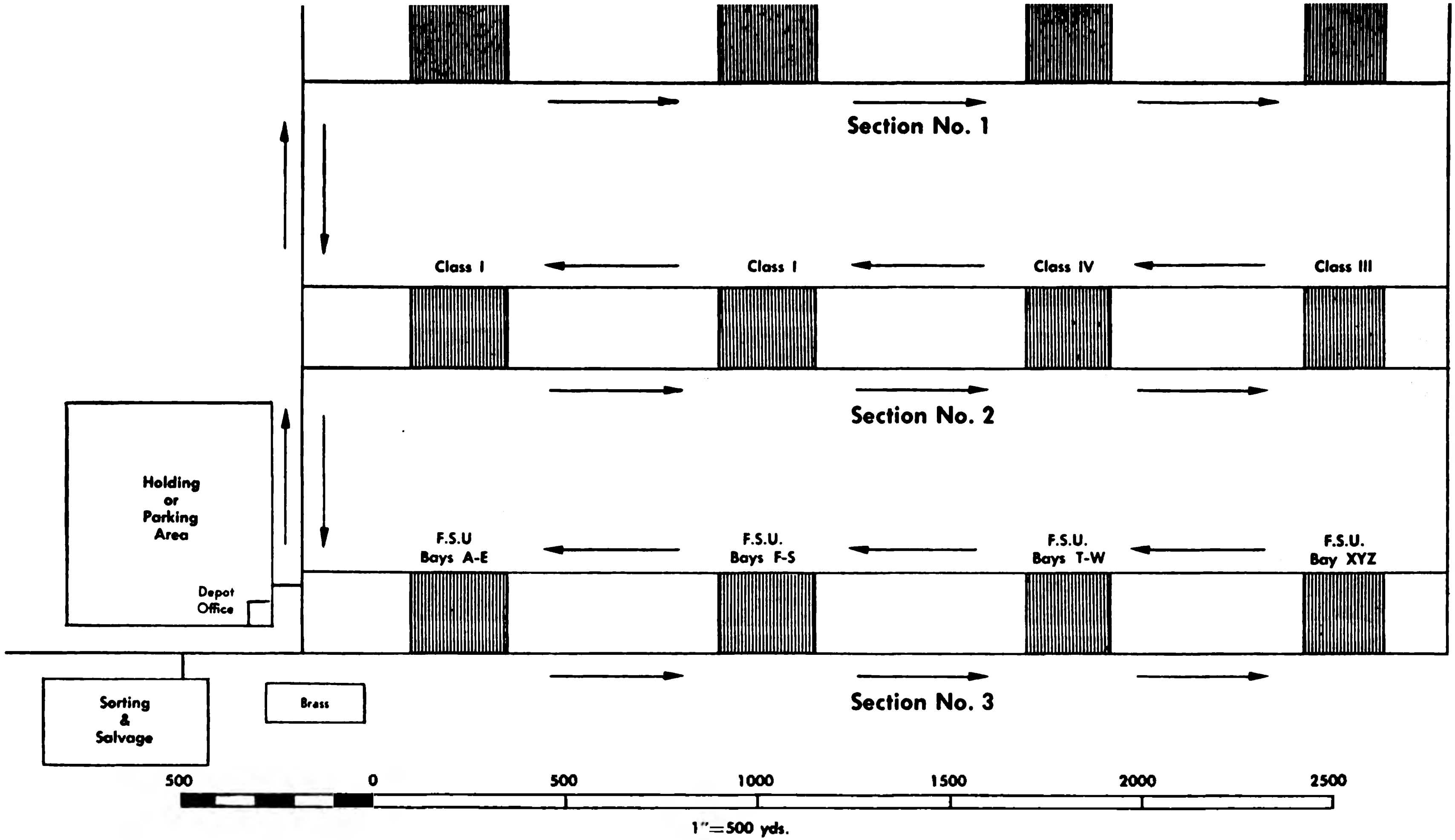
Where the ground is hard with a solid substructure of rock or gravel and only a thin layer of topsoil, the ammunition area can be laid out in a symmetrical pattern and a well integrated road net established for ideal traffic control within the area. In farm country, however, consisting of ploughed fields and pastures, it may be impossible to run roads through the fields. In such cases it will be necessary to limit traffic, for the most part, to existing roads and trails. In such a situation the ASP is likely to be spread over a larger area than otherwise would be required.

Roadside ASP. A roadside ASP is usually a small installation of temporary duration which is set up along existing roads. Because of the relatively small amount of ammunition that will be stocked, few problems are met in establishing its layout. A distinction should be drawn between roadside ASP's an such and larger ASP's of other types, where storage is placed along existing or newly made roads.

SAMPLE LAYOUTS

Drawings will be found in the following pages illustrating various principles in connection with ASP layout.

Drawings 1 and 2 are schematic layouts, one in an area which may be completely



Each Identical Section Will Contain All Types
—Stored in Four Field Storage Units.
Total Storage—2000 to 4000 Tons.

Figure 14A. Sample A.S.P. Layout in Location Suitable for Open Area Storage (Schematic). Traffic Routing as Shown—All Parts of Storage Areas Accessible to Trucks.

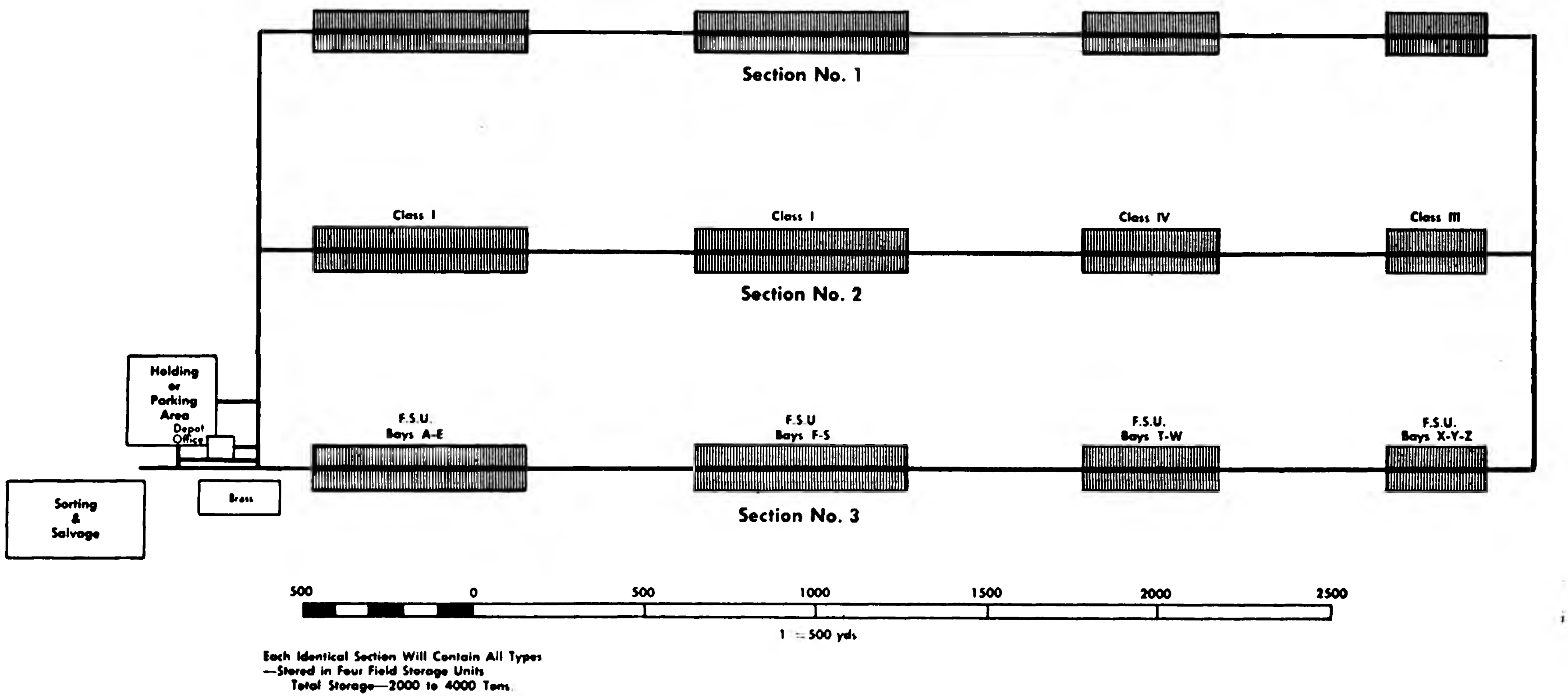
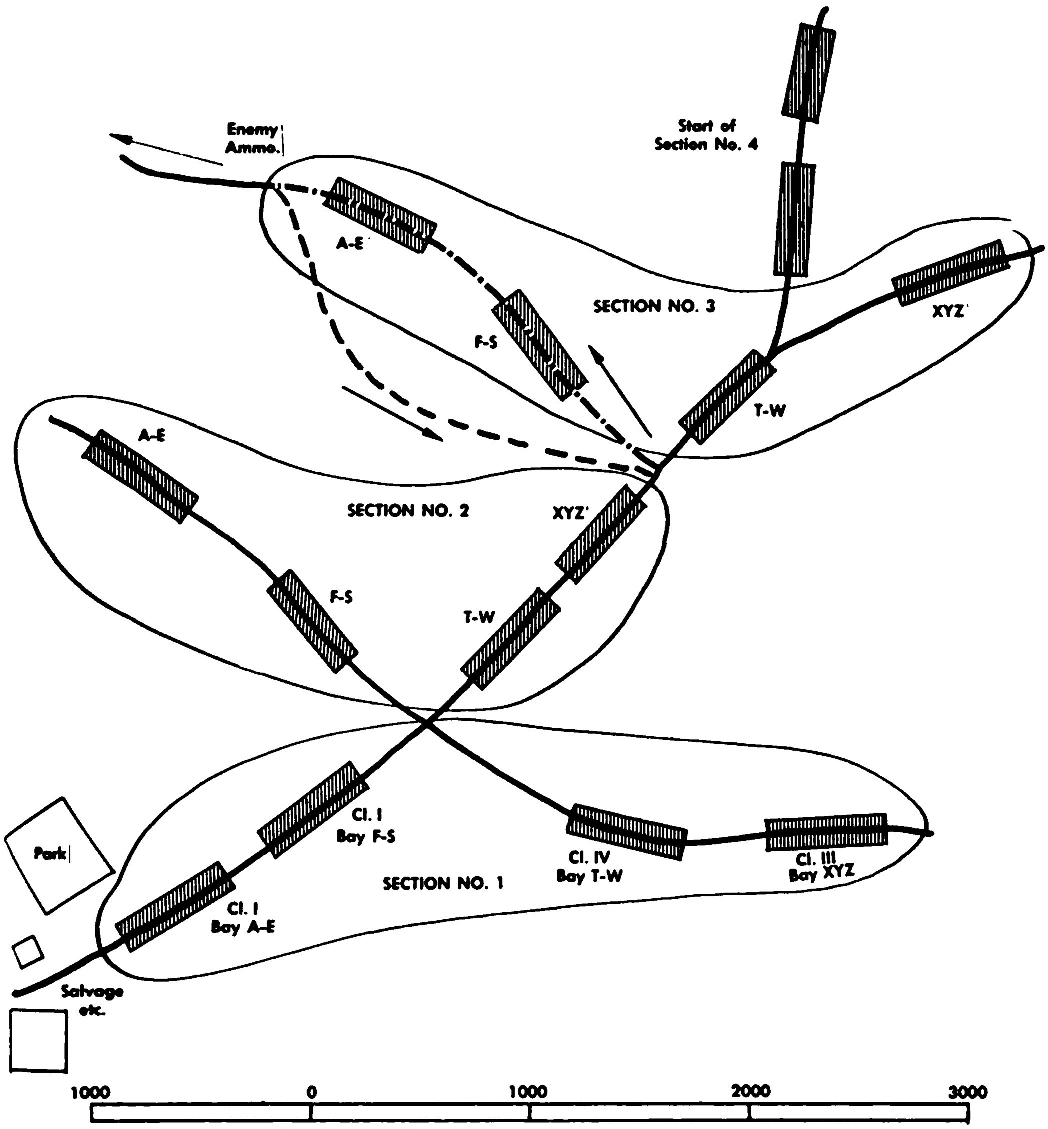


Figure 14B. Sample A.S.P. Layout—Roadside Storage (Schematic).
Ideal Road Network—Storage Limited to Area Very Close to Road—Both Sides Used.
Roads Suitable for Two-Way Traffic.

Limited to Roadside Storage



Adaption of Sample A.S.P.

Figure 14C. Adaptation of Sample A.S.P. Layouts to Typical Road Net-Works.

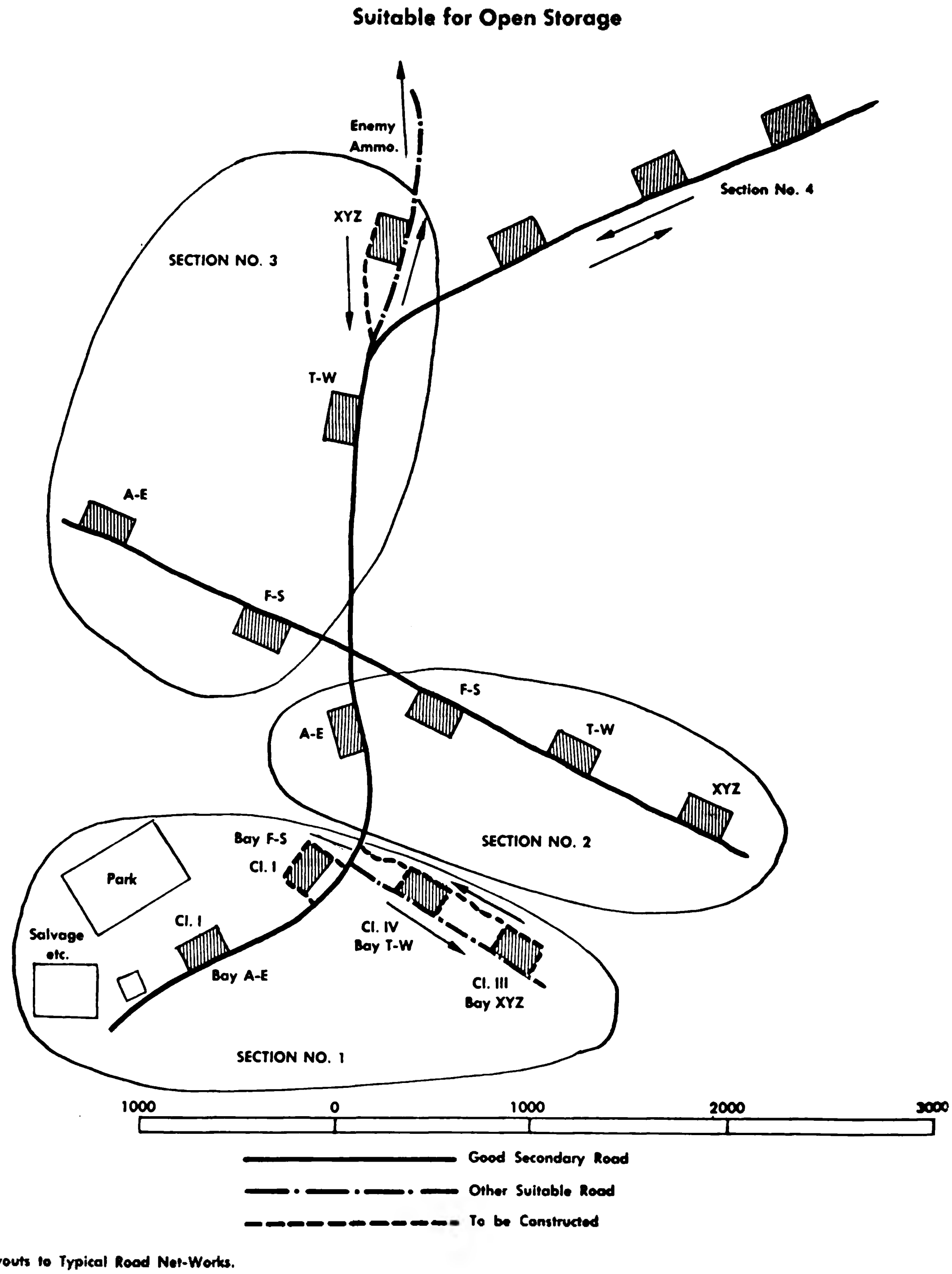


Figure 14C. Adaptation of Sample A.S.P. Layouts to Typical Road Net-Works—Continued.

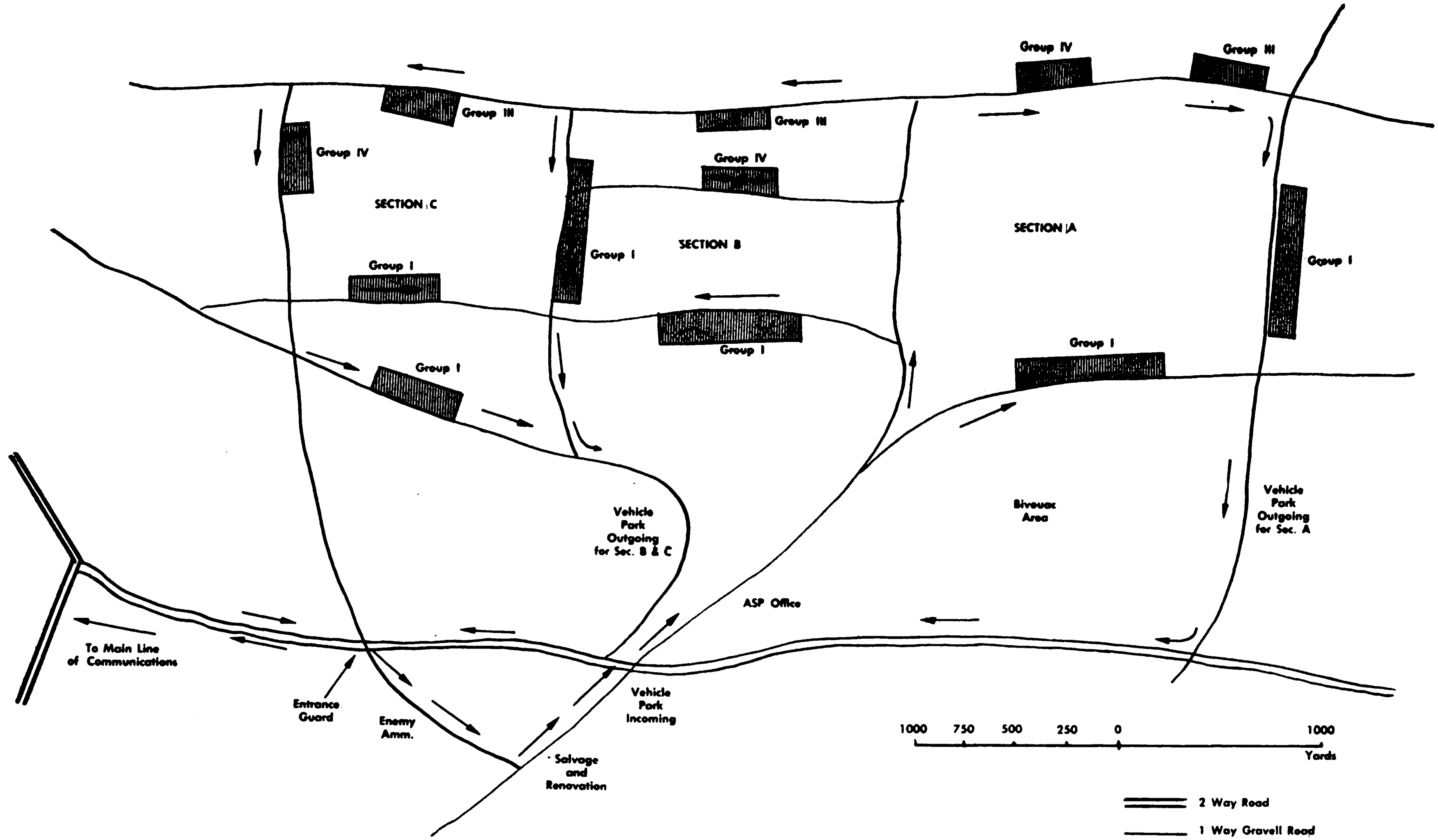

Group IV
Group III
Group III
Group IV
Group III
Group IV
Group III
SECTION C
SECTION B
SECTION A
Group I
Group I
Group I
Group I
Group I
Group I
Vehicle Park Outgoing for Sec. B & C
Vehicle Park Outgoing for Sec. A
Bivouac Area
ASP Office
To Main Line of Communications
Entrance Guard
Enemy Amm.
Vehicle Park Incoming
Salvage and Renovation
1000 750 500 250 0 1000
Yards
2 Way Road
1 Way Gravell Road

Figure 14D.

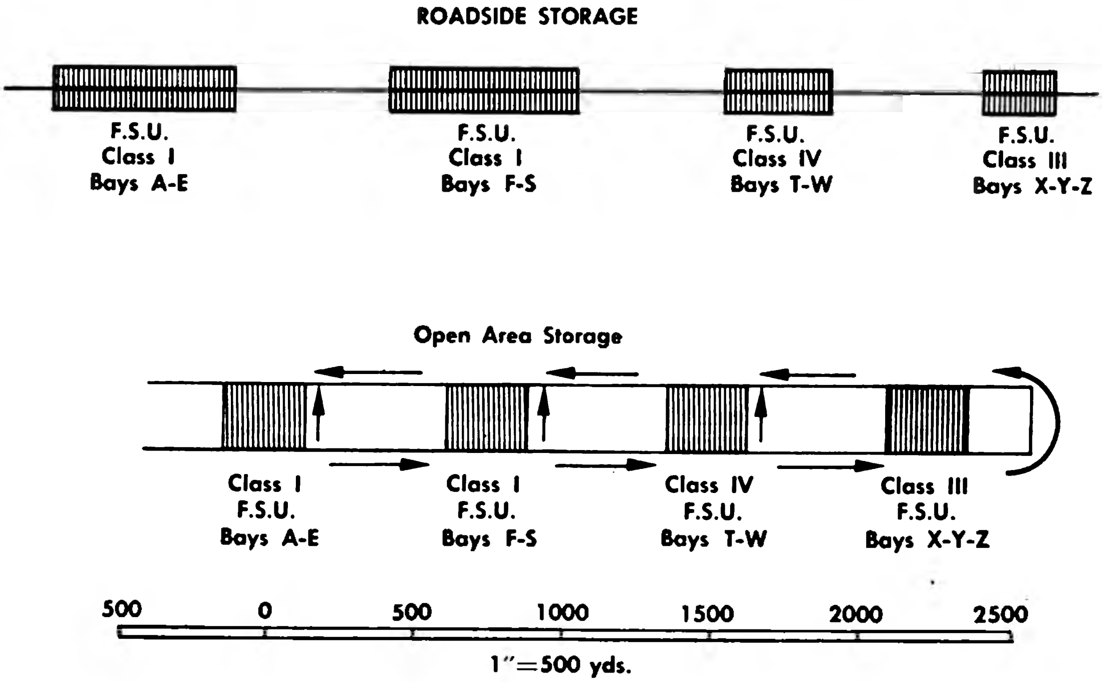


Figure 14E. Sample Section in Preceding A.S.P. Layouts.

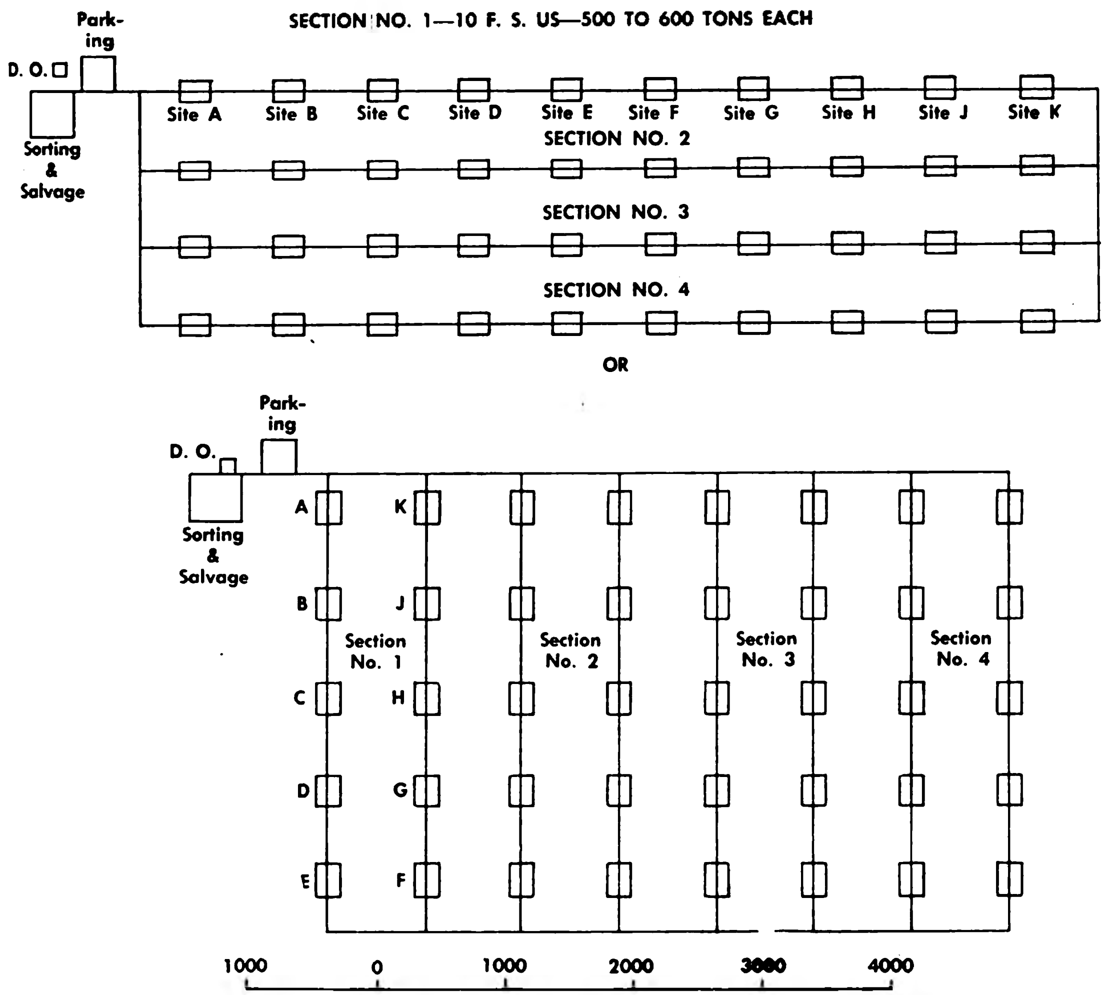
CONTENTS OF BAYS

		Max. Tons Est.*
A.	105 How M1, HE, WPDF M48	240
B.	105 How M1, HE, WTSQ M54	90
C.	105 How M1, Heat & 105 How M3	60
D.	155 How ALL TYPES (Ex. Smoke)	120
E.	155 Gun ALL TYPES (Ex. Smoke)	30
F.	75 Gun ALL TYPES (Ex. Smoke)	60
G.	3″ Gun ALL TYPES (Ex. Smoke)	60
H.	75 How ALL TYPES (Ex. Smoke)	60
I.	Not used or Miscellaneous	—
J.	57 mm Gun Miscellaneous	30
K.	37 mm (Tank & AT)	30
L.	A.A. Guns All Caliber	60
M.	.50 Cal MG	60
N.	.30 Cal MG	60
O.	.30 Cal Rifle, Carbine, Cal .45	60
P.	Grenades	10
Q.	Mortars	60
R.	Mines, Demolition	50
S.	Miscellaneous Class I	30
T.	155 Smoke	30
U.	105 Smoke	30
V.	75 Gun & How Smoke, 81mm Mortar	30
W.	Bulk Small Arms Tracer	30
X.	2.36″ Rockets	20
Y.	4.5″ Rockets	10
Z.	Miscellaneous—Rocket Components	—

TOTAL ESTIMATED TONNAGE (Maximum)*

Bay A-E	540
Bays F-S	570
Bays T-W	120
Bays XYZ	30
Total Section	1260

* Section will normally be filled to ½ these figures. See TC47, Sec. II ¶ 4.



Each section will contain all items to be stored in 10 field storage units—Total 5000 to 6000 tons per section.

Figure 14F. Sample Layout for Depot of 20,000 to 24.000 Tons.

traversed by trucks, and the other in an area where traffic must be confined to existing roads.

Drawings 3 and 4, are adaptations of the schematic layouts to typical road networks.

Drawing 5, with table annexed, presents in more detail the layout of a single section in an ASP.

Drawing 6, is a suggested layout of a depot as distinguished from an ASP.

The storage in all of the layouts is based upon the requirements of TC 47. The groups marked with common numerals refer to the field storage group set up in that circular.

The suggested bay breakdowns for both ASP's and depots are adapted from the S.O.P. of an ammunition company which has operated since November, 1942, in the Mediterranean theater. They now conform to the provisions of TC 47, but have been changed very little from the actual S.O.P. The distances allowed and the expected tonnages of each type are based on average stock levels as actually encountered in North Africa and Italy.

These plans can be adapted to a great variety of ASP or depot layouts with appropriate changes as they apply to a particular situation. The important feature of these plans is the fact that a planned layout is essential to good operation. It must be decided in advance where each item must go.

The company which used this ASP plan used it for all ASP's and the men became familiar with it. They knew, for example, that 105 Howitzer with M48 fuze would always be in bay A, and the time spent in looking for items was cut to a minimum. It was possible to transfer men from one ASP to another even at night. If the man had his bay list and could find bay A, he could properly place or instantly find any and all ammunition with no help or supervision from the section chief.

Traffic must be planned and controlled for each ASP or depot. If the roads are suitable for two-way traffic with no congestion, it is best that traffic be allowed to remain two-way with only the control necessary for proper dispatching. If the roads are suitable only for one-way traffic, then the flow must be kept one-way and any necessary measures to reduce congestion must be taken. If the roads are suitable for one-way traffic only and the network requires two-way traffic, passing spots must be built and their use rigidly controlled.

AMMUNITION STORAGE

Stacking. Boxed, crated, or bundled ammunition is usually stored horizontally in stacks or piles. Separate loading shells (usually uncrated and unboxed) may either be stacked horizontally, or stored vertically on their bases. Hereafter in this chapter the terms 'stacks' or 'stacking' will be applied indiscriminately to either kind of storage.

Methods of storing will vary depending on the quantity to be stored, the facilities available, and the distance of the storage area from the enemy—proximity to the enemy requires dispersion and cover. Installations more to the rear, unhampered by such considerations, may make more economical use of the available space. The facilities available also are important in determining the storage plan. Storage within a building may be quite different from outdoor storage.

Storage Facilities. Let us first consider the facilities that may be available for storage:

Igloos are arch type, earth-covered magazines. They are made in three standard lengths: approximately 40 feet, 60 feet and 80 feet. Their interior width is approximately 26 feet. Usually they are constructed of reinforced concrete. This type of magazine is standard for depots in the zone of the interior and may also be found in the theaters of operations at large installations. At such installations, they may be constructed of reinforced concrete, steel, or wood, and may vary in length.

Fireproof Warehouses. Various sizes of fireproof magazines may be found. One of the most common is the 'standard' magazine. It is approximately 51 feet wide and 218 feet long. The walls are hollow tile, the frame is steel, and the floors and foundations are concrete. These and similar magazines are standard at depots in the zone of interior and will also be found at large installations in the theater of operations.

Corrugated Iron Shelters of varying sizes, usually arch-type in shape. These will be found at installations in the theater of operations as well as in the zone of the interior. (See Figure 13.)

Ordinary Warehouses, Buildings, and Sheds. Existing buildings will be used when available. Specially prefabricated wood huts and shelters are also made available at many installations.

Principles of Ammunition Storage. Where none of the above facilities are available for storage, shelter either will be improvised, or the ammunition stored in the open.

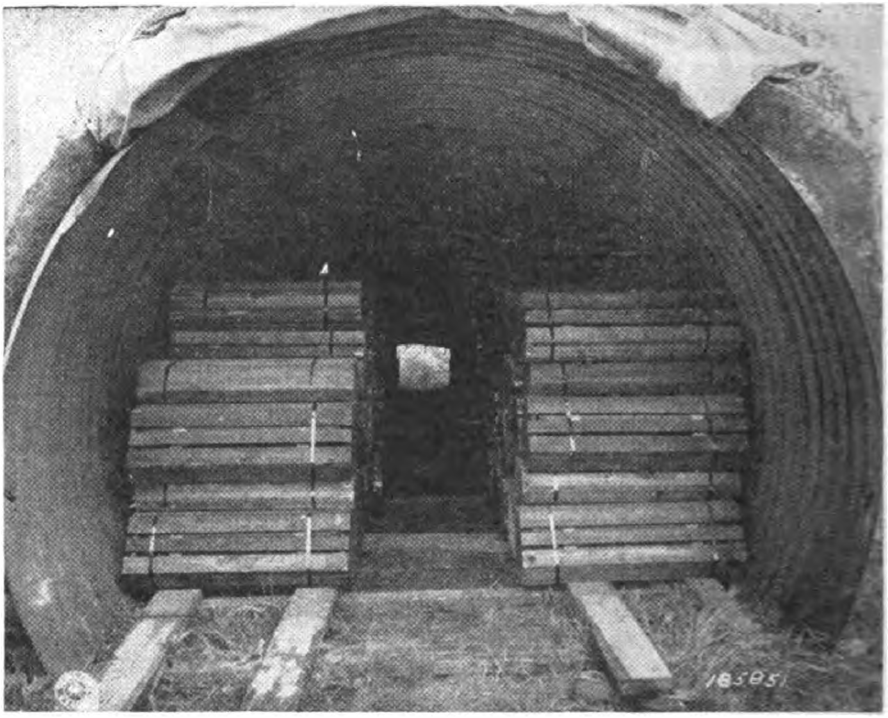


Figure 13. Camouflaged Steel Shelter Used to Store 105mm How. Ammunition, Somewhere in England, June 9, 1943.

It cannot be repeated too often that the primary object in the storage of ammunition is to keep it readily available for issue in a serviceable condition. But ammunition cannot be stored in such a manner as to remain serviceable and to permit rapid issue unless certain general rules are observed. These are basic, and apply to every type of ammunition supply installation, wherever located.

Ammunition must be stacked by type and caliber.
Ammunition must be stacked by lot number.
Stacks must be of a manageable size so as not to impede storage or issue.
Stacks must be built so that the contents may be readily inspected.
Ammunition must be protected from the elements.
Ammunition should not be stored unless it is in good condition.
Safety rules for dispersion must be observed.
Good housekeeping must be practiced.

These rules will be discussed in the above order.

Ammunition Must Be Stacked By Type and Caliber. Separate stacks must be made of each type and caliber ammunition. Obviously, speedy and accurate issue could not be made if two or more different kinds of ammunition were mingled in the same stack. Generally speaking, in the theater of operations separate loading ammunition stacks should contain complete rounds, with fuzes and primers in one pile, propelling charges in another, and projectiles in a third.

Ammunition Must Be Stacked By Lot Number. Segregation of lots is important, not only because issue of one lot to the using unit helps to limit dispersion of fire, but also because of the control it affords over unserviceable or dangerous ammunition.

Stacks Must Be of Manageable Size. It would not do, of course, to build a stack of ammunition 50 feet high. Quite apart from other considerations, the time and labor consumed to build such a stack and to make withdrawals therefrom would forbid any such practice. The size and type of stacks, however, depends, within reason, on the factors mentioned at the beginning of this section. To repeat: stacks in an arch-type igloo or corrugated shelter will differ from stacks in a warehouse with straight walls. Stacks in a building may differ from stacks in the open. Moreover, stacks in an area sheltered from enemy action will be built differently from stacks in an area under enemy observation or fire.

A few examples will illustrate the point. In an area under enemy fire, outdoor stacks should be small so as to present an unprofitable and dispersed target. For stability and to make camouflage easier, they are built in a pyramidal shape, each layer one box narrower and one box shorter than the layer under it. The stacks should not be too high for convenient loading. Four or five feet is ideal.

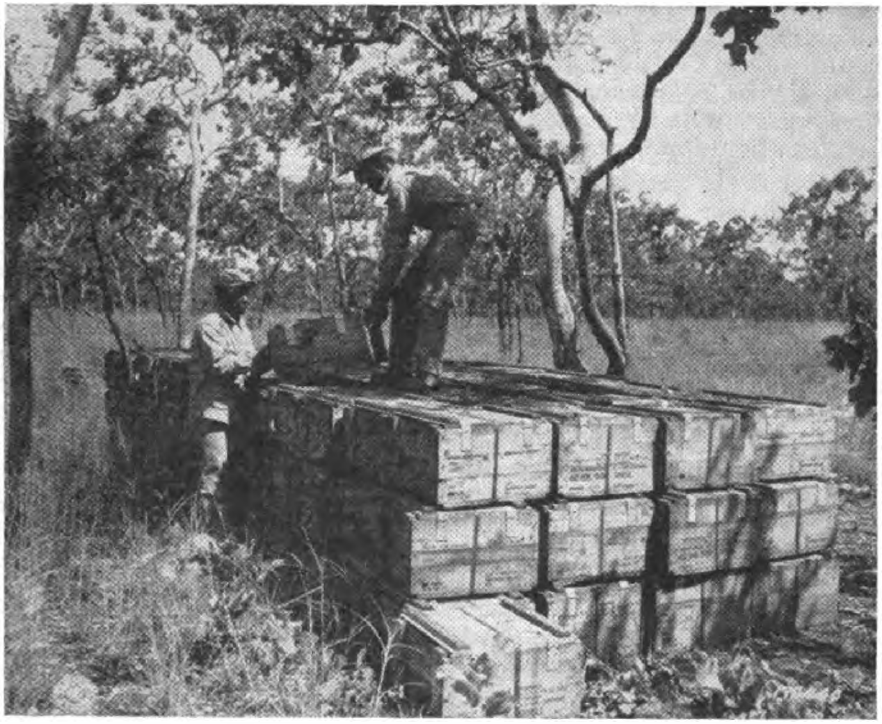


Figure 14. Open Storage Section of an Ammunition Dump, Somewhere in New Guinea.

In rear areas protected from the enemy, where camouflage is not a consideration and where more handling facilities are available, outdoor stacks need not be pyramided, and may be larger. The size and shape of a stack, in such circumstances, will depend in a large measure upon the degree of stability obtained, and the time and labor elements involved in building the stack and making withdrawals therefrom.

Stacks in buildings will vary according to the size and shape of the building, the number of doors and the pounds per square foot which the flooring will support.

In every case however, stacks must be stable and raised off the ground or floor by means of dunnage.

Stacks Must Be Built So That The Contents May Readily Be Inspected. Every ammunition officer is responsible for the inspection of his storage, in order to determine the condition and serviceability of stocks in hand. Ideal storage requires that stacks be built so that this inspection may readily be conducted. The extent of departure from the ideal depends on circumstances; the kind of installation, the time, labor, and space available, the rate of turnover, the climate, etc. It should be borne in mind, though, that chemical shells must be stored so that a leaking container can be readily detected and removed.

Ammunition Must Be Protected From The Elements. Ground water and moisture, rain, sun and heat are the enemies of ammunition. They cause deterioration, and, if conditions are not improved, will make it unserviceable. All stacks, indoor or outdoor, should be built on dunnage thereby raising the bottom layer off the ground or floor. A good general rule is that bottom dunnage should be at least 6 inches high—and higher, if necessary. Dunnage should be level; if necessary use shims or wedges. Where needed, drainage ditches should be built around the stacks. If available, light dunnage should be used between layers to insure circulation of air. Where possible, tarpaulins should shield the outdoor stack from sun and rain but they should be supported away from the top and sides of the stack to allow circulation. In windy climates, they must be securely fastened to avoid their destruction.

When ammunition is stacked in buildings, the stacks should never touch the walls or be built above the eaves, in order to assist circulation of air and prevent sweating.

Ammunition Should Not Be Stored Unless It Is In Good Condition. Wherever possible, ammunition should be clean and dry when stacked. Broken boxes or crates should be repaired before they are placed in storage. Defective rounds, when found, should be removed. Loose rounds or components should be boxed. Partly filled boxes will be marked plainly and placed in conspicuous places on top of the stack containing the lot to which they belong.

Whenever repair is necessary to ammunition or container, the work should be done at least 100 feet away from the nearest stack or magazine.

Safety Rules For Dispersion of Ammunition Must Be Observed. In order to reduce to a minimum the hazards and risks due to fire and explosion, quantity-distance tables and storage charts have been prepared for the use of the ammunition officer. The tables and chart found in O.O. Form No. 7224, Ordnance Safety Manual, govern storage in depots in the zone of the interior. Similar tables, somewhat less rigid, published in TM 9-1900, Ammunition, General, are applicable to posts, camps, and stations.

Generally speaking, these regulations divide ammunition into groups for storage, each group showing similar hazards as regards:

The results of an explosion. For example, separate loading propelling charges stored near high explosive shells would be endangered by fragments if an explosion occurred. This has been demonstrated with disastrous results during fires in field ammunition dumps.

The ease of deterioration. For example, smokeless powder is subject to spontaneous combustion if sufficiently deteriorated. If this should happen, materials stored with the powder would of course be destroyed.

The sensitivity of initiation. For example, detonators and fuzes may be initiated by a slight jar. Demolition bombs stored in the same magazine would be subjected to the same hazard.

Action in case of fire. Fire fighters would not attempt to put out a fire in a magazine containing black powder because of the extreme heat and danger of explosion. Any materials stored in the same magazine would be lost in case of a fire.

The quantity of explosives in each unit. For example, demolition bombs are regarded as extremely dangerous because of the large amount (30 to 75 percent of total weight) of explosive contained. A high explosive shell contains approximately 15 percent of explosive filler. They should not be subjected to additional hazard by storing them with bombs.

Tables also establish the maximum quantity beyond which it is not safe to store explosives in magazines, and the distances by which the magazines must be separated from other magazines and from general purpose buildings or public property. The method of applying these tables and charts is described in the references mentioned above. A good description is also found in TM 9-1904, Ammunition Inspection Guide.

In the theater of operations, pending revision of FM 9-20 (July 1942 edition), the provisions of TC 47, 20 July 1944, apply. This circular is based on recent experience in the various theaters and because of its importance is reprinted herein in full.

Training Circular No. 47 (Effective until 20 July 1945, unless previously rescinded.)

I. **Rescission of Training Circular.** Training Circular No. 96, War Department, 1942, is rescinded. See TM 20-300.

II. **Storage of Ammunition in the Field.** Pending revision of FM 9-20, the following is published for the information and guidance of all concerned, and supersedes those portions of FM 9-20 which are in conflict herewith.

1. General. a. The principal hazard in the storage of ammunition in the field, and the factor responsible for the loss of large quantities of ammunition in the present war, is fire. Fires are usually spread by hot missiles resulting from explosions in one stack igniting the packing material of nearby stacks, and by the travel of the fire along the ground through grass, undergrowth, weeds, dry woods, etc.

b. A large degree of protection from this hazard is obtained from the use of protective covering for stacks, such as concrete or metal shelters which effectively stop the penetration of these missiles, and by the clearance of fire breaks by burning over or by the use of bulldozers. In the absence of adequate shelters, dispersion of the ammunition beyond the range at which missiles are sufficiently hot to ignite packing materials is the only effective means of protection against the spread of ammunition fires. In any event, adequate fire breaks will always be necessary.

c. There is prescribed herein the minimum distance which will give protection against the spread of fires, in addition to basic planning data for the establishment of all types of ammunition supply points in theaters of operations. This information applies to the storage of ammunition in open storage, not in magazines or igloos. Where these latter structures are available, the storage principles prescribed in TM 9-1900 will govern.

d. As the purpose of these regulations is to reduce to a minimum losses of personnel and ammunition stocks, the intent of the regulation will be complied with as far as practicable. In any event, any reduction in the safety distances prescribed herein will materially increase the hazards involved and will be made only by authority of the commanding general concerned.

2. Definitions. a. Field storage groups. (1) These groups are the subdivisions into which ammunition is divided for the purposes of this discussion. The grouping was developed after consideration of the desirability of storing components of complete rounds in adjacent stocks, and the following hazards:

(a) Explosive.
(b) Missile.
(c) Fire.
(d) Chemical contamination.

(2) The groups are as follows:

(a) Group I. Small arms ammunition except bulk tracer and incendiary ammunition packed in cartons; all types of fuzed and unfuzed ammunition and components, except those listed in groups II, III, and IV. (See par. 3a.)

(b) Group II. Unfuzed general purpose and depth bombs, aircraft mines, and torpedoes.

(c) Group III. Rockets.

(d) Group IV. Chemical and smoke ammunition of all types, incendiary bombs, bulk small arms tracer and incendiary ammunition packed in cartons, and pyrotechnics.

b. Stack. (1) A stack is the smallest unit for storing ammunition in the field.

(2) For ammunition in groups I and IV, a standard stack will contain a gross weight of 30 tons, or outside dimensions of: length—40 feet; width—9 feet; and height—4 feet.

(3) For group III ammunition, a standard stack will have a gross weight of not more than 5 tons.

(4) The smallest unit for the storage of group II ammunition is the field storage unit (see d below).

c. Interstack distance. The shortest distance between the nearer edges of adjacent stacks. The distances prescribed herein are the minimum safe clear distances to prevent sympathetic detonation should the total explosive content of one stack detonate at once. For groups I, III, and IV ammunition, interstack distances should not be less than those indicated in Table I.

Table I. Minimum Interstack Distances (Feet)
(Ammunition in field storage groups I, III, and IV)

Gross tons	Interstack distance (feet)	Gross tons	Interstack distance (feet)
2.5	23	15.0	57
5.0	33	20.0	65
7.5	40	25.0	73
10.0	46	30.0	80

NOTE. Components of separate loading ammunition may be stacked at an interstack distance from unfuzed projectiles equal to one-half the distance prescribed above, based on the weight of the projectiles.

d. Field storage unit (FSU)—(1) A field storage unit is a group of stacks and the surrounding area required to provide protection for adjacent FSU's. Only the ammunition belonging to a single field storage group will be stored in any FSU.

(2) For groups I, III, and IV ammunition, 20 standard stacks are the maximum that may be contained in any one FSU.

(3) For group II ammunition, an FSU is the smallest unit for storage in the field. Such an FSU will contain not over 40,000 pounds of explosive. For purposes of estimation, in group II ammunition, 50 percent of total weight of general purpose bombs may be considered as explosive, except for the 4,000-pound light case bomb, in which 84 percent is explosive.

e. Inter-FSU distance. The distance between the nearer edges of the nearest targets of the nearest stacks in adjacent FSU's. The inter-FSU distance for groups I, III, and IV ammunition is designed to provide protection against the spreading of fires from one FSU to another. For these groups, the inter-FSU distance is 500 yards. Under circumstances where this distance cannot be attained, extraordinary care in the establishment and maintenance of fire protection, fire guards, and fire fighting measures must be exercised. The inter-FSU distance for group II ammunition is based on the sympathetic detonation hazard. For this group the inter-FSU distance is 150 feet.

f. Outside safety distances. The minimum allowable distances from the nearest stack of explosive to an establishment outside the depot. This distance will vary with the type of establishment to be protected and the explosive content of the stacks in the depot. (See table II.)

Table II. Outside Safety Distances

Installation	5-ton stack	30-ton stack	Group II stack
Gasoline storage, airfields, permanent radio transmitters and installations requiring protection from missiles.[1]	2,000 ft.[1] ...	1 mile[1]	1½ miles.[1]
Camp areas, storage facilities, headquarters, railroads, highways, and other installations requiring protection from structural damage.[2]	1,000 ft.[2] ...	1,500 ft.[2] ...	3,100 ft.[2]

[1] These are the farthest distances which it may normally be expected that a missile will travel upon the simultaneous detonation of all explosive in a single stack. If the attainment of these distances is impracticable, those prescribed for protection against serious structural damage will be considered as minimum distances.

[2] This is the outside limit of serious structural damage to buildings in the event of the detonation of a single stack containing the amount of ammunition indicated. If safety from missiles is required, the figures given for gasoline storage, etc., must be used.

3. Additional notes. a. Demolition explosives, bulk high explosives, antitank mines, Bangalore torpedoes, and similar types of ammunition containing a correspondingly high ratio of explosive content to gross weight, will be stored as for group I ammunition, but will be limited to 6,000 pounds of explosive per stack. The interstack distance for this amount of explosive will be the same given for a gross weight of 30 tons of other types in table I.

b. All ammunition should be stacked so that all rounds of a given lot will be stored together.

c. Ammunition and explosives may be mixed in stacks only as authorized by the storage chart in paragraph 117, TM 9-1900. Paragraph d below is an authorized modification of this table.

d. Propellants, fuzes, and primers should be stacked separately from the projectiles to which they pertain. However, when it is necessary that all components be stacked together, the gross weight of the stack should not exceed 30 gross tons. Fuzes and other components for group II ammunition may be stored in the intervals between the FSU's.

e. Each stack of group III ammunition (rockets) will consist of single rows per tier, and should be barricaded at both ends and at the sides to insure that if a motor element is ignited, the projectile will strike a strong artificial or natural barrier of not less than 3 feet of sand or earth.

f. It is extremely important that standings for ammunition storage be as hard and well drained as possible. Topsoil should be as thin as possible and should be supported by a solid substructure of coral, sandstone, rock, gravel, or other hard strata that will support the weight of the ammunition and the heavy vehicular traffic.

g. All ammunition should be stored out of the direct rays of the sun. However, if this is impracticable, priority should be established as follows:

(1) All separately packed fuzes.
(2) Groups III and IV.
(3) Group I.
(4) Group II.

h. (1) Smoking or the carrying of flame-producing devices must be prohibited within the storage area.

(2) Adequate fire fighting equipment must be maintained at all times for instant use.

(3) Firebreaks of sufficient width to prevent the spread of fire along the ground will be maintained.

i. Where tarpaulins are used, adequate provision for stack ventilation must be assured. The top of the tarpaulin must not rest directly on the top of the stack, nor be supported in such a manner that missiles will be held in contact with the canvas, but should be raised from the stack at least 6 inches. The bottom edges of the tarpaulin should be staked out from the bottom of the stack. Tarpaulins constitute an additional fire hazard in connection with the spread of fires. This fact must be constantly borne in mind when they are used.

j. Heavy, well supported dunnage must be used to keep the bottom tier of the stack off the ground, and to prevent its sinking into the ground. Wherever possible, dunnage should also be used to separate the individual tiers of the stack. (This is not necessary for cleated boxes.) Boxes should be placed in the stack so as to allow an air space of 1 inch between each individual box.

k. It must be remembered that the purpose of the inter-FSU distance is to provide insurance against the spread of fires throughout all the ammunition in storage. Therefore, when sufficient space is not available to permit storage strictly in accordance with the instructions contained herein, it is preferable to increase the density of stacks in each FSU rather than to decrease the prescribed inter-FSU distance. This, of course, will place a larger quantity of ammunition in immediate jeopardy in the event of a fire.

l. Captured enemy ammunition must not be stored with United States ammunition, but in separate dumps at least one-half mile from any storage installation containing United States ammunition.

4. Planning Storage Areas. In planning the lay-out of a depot area, the Ordnance officer should normally plan on dividing each kind of ammunition so that it is stored in three or more FSU's. Each stack should be considered initially to cover the full area of a standard stack, and be set down with the interstack distance prescribed for a full standard stack, but to contain only one-half the quantity of ammunition in a standard stack. This will allow for ultimate expansion in each FSU to twice the initial stockage.

5. Barricades. a. Barricades within FSU's are effective principally for the reduction of the hazard of sympathetic detonation. They also provide protection against missiles traveling at low angles of departure or fall. Where effective barricades are erected, or exist, the inter-

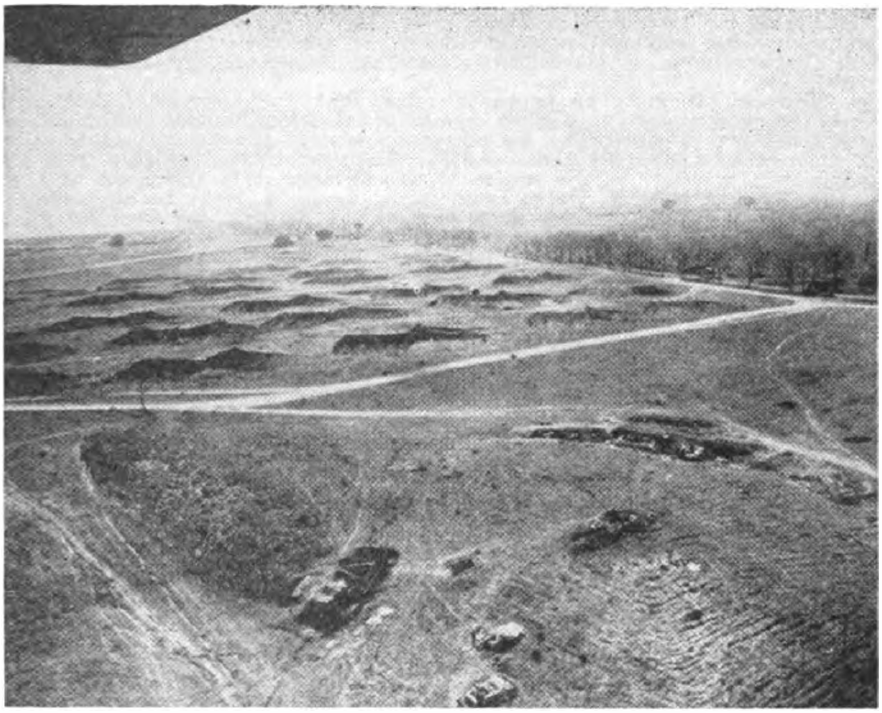


Figure 15. Air View of Ammunition Dump Showing Barricades (Anzio).

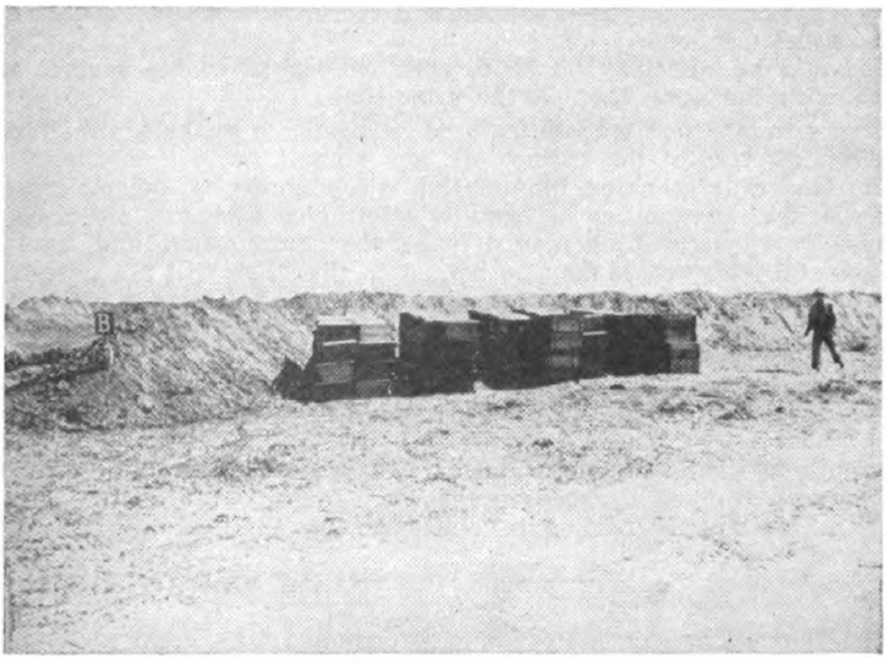


Figure 16. Close-up View of Barricades (Anzio).

stack distance may be reduced to one-half that prescribed in table I. For this purpose, barricades should consist of no less than 3 feet of sand or earth, measured at the top of the barricade, to be at least 1 foot higher than the stack, and be placed not closer than 4 feet from the edge of the stack. Barricades should be erected not to interfere with handling operations.

b. Barricades will provide only partial protection against the spread of fire due to hot missiles. Therefore, the inter-FSU distances prescribed herein for groups I, III, and IV, are the minimum allowable and will not be reduced by the use of barricades. For group II ammunition, the provisions of (a) above referring to interstack distances are applicable to inter-FSU distances.

6. Safety Distances. It must be borne in mind that the interstack distances prescribed herein merely provide protection against sympathetic detonation of adjacent ammunition. They do not constitute safe distances for protection against the hazards of missiles and fire. The hazard from missiles, and the corresponding hazard from fires resulting from hot missiles, varies approximately inversely as the square of the distance from the point of the explosion, that is, if the distance between stacks is increased from 30 yards to 60 yards, the missile hazard will be only ¼ of what it was at 30 yards. The limiting distances for missile hazard and serious structural damage are given in table II. It is, therefore, important that the distances prescribed herein be recognized as minimum allowable and that wherever possible they be increased as much as practicable. The prescribed inter-FSU distance, which is based on experience, is sufficient to protect against the spread of fires by means of hot missiles. However, it is to be noted that any reasonable safety distance will prove ineffectual against fire hazard unless adequate firebreaks are maintained.

Good Housekeeping. Cleanliness runs hand in hand with safety. Dirty containers will not make a stable pile. Explosive dust may be mixed with ordinary dust; therefore rags, scrap, and other inflammable material in the ammunition area are fire hazards. Good housekeeping is a "MUST" in ammunition handling and storage.

The above discussion is general in nature and applies to storage at all types of installations. The following applies particularly to stacking in an ASP or combat zone depot.

Usually, stacks should be laid out with the largest dimension parallel to the road. An exception to this should be made when two men are required to lift the container. In that event, the stacks should be perpendicular to the road with the largest dimension of each container parallel to the road. If road length is insufficient, road frontage may be conserved by building revetments between stacks or by laying out stacks of all types of ammunition perpendicular to the road. When perpendicular stacks are used, provision should be made for a greater number of shorter piles for the same total tonnage, in order to reduce the length of haul by hand from stacks to trucks. Stacks should be back from the road far enough to prevent the danger of trucks colliding with them.

Efficient operation can be facilitated by making standardized stacks for each caliber. Each stack of a certain caliber will therefore contain a specified number of rounds and truck loads.

There should be sufficient stacks of each caliber to enable several trucks to be loaded with the same item at the same time.

Handling. Ammunition is manufactured primarily to explode, either in practice fire or when directed at the enemy. If not abused, it will not explode *until* it is fired. Generally speaking, ammunition is functioned by impact; consequently, it is essential that ammunition be handled carefully if accidents are to be avoided.

Moreover, careless handling may damage the ammunition and make it unserviceable. Cartridge cases may be dented so that they will not chamber in the weapon; rotating bands may be cut so that they will not form a gas-tight seal in the bore; or containers may be broken allowing moisture to attack the ammunition and cause its deterioration.

Ammunition always should be handled under the supervision of a competent person who understands the hazards involved. The following precautions must be observed:

1. Ammunition should be lifted and carried or moved on roller conveyors. It should never be dropped, dragged, or thrown.

2. Ammunition must be packed in vehicles so that the load will not shift during transportation.

3. Grommets must be kept around the rotating bands of separate loading projectiles.

4. Fuzes, primers, and detonators must be handled with great care. The forces which arm fuzes in flight may be simulated by rolling or dropping.

General Safety Precautions. A study of accidents which have occurred in the past indicates that in practically every instance where the cause could be determined, the accident was due to circumstances which were avoidable. Much has been written about safety precautions. Here, however, we will touch only upon the high spots. It is suggested that before the ammunition officer assumes his duties he reads with care the pertinent parts of the following publications:

O.O. Form No. 7224—Ordnance Safety Manual.
T.M. 9-1900—Ammunition, General.
T.M. 9-1904—Ammunition Inspection Guide.

Causes of Accidents. Most accidents in ammunition areas can be traced to one or a combination of four major causes. They are:

Fire
Unauthorized tampering with ammunition
Bad handling of ammunition
Chemical 'leakers'.

They will be discussed in the order named.

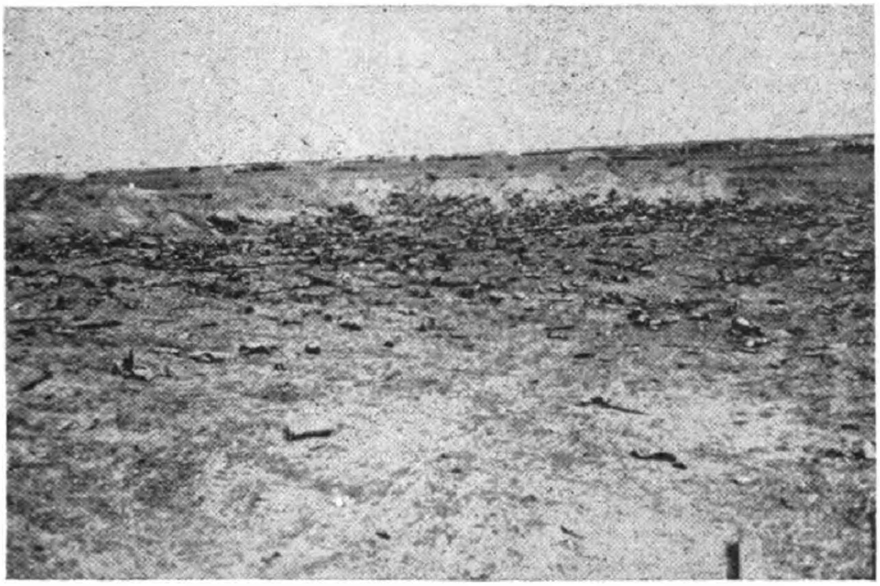


Figure 17. Ammunition Stack After a Fire.

Fire. Fire, by far, is the most frequent cause of accidents. Except when caused by enemy shelling or bombing, fire is usually avoidable; and yet, small fires, if unchecked, have caused untold losses in lives and property. The following are the principal causes of fire in ammunition areas:

1. Enemy shellfire or bombing will cause fires but their spread from stack to stack and from area to area may be prevented by adequate dispersion and by the construction of firebreaks.

2. Smoking and the carrying of matches and other flame producing devices. This is absolutely prohibited in the ammunition area except in pre-designated special smoking areas sufficiently removed from the dumps.

3. Dry grass, leaves, brush, waste, etc., ignited by sparks from cook fires, automobile exhausts, etc. The antidote for this is good housekeeping in the area. Where camouflage or other considerations do not forbid, fire-breaks in and around the area should be built.

4. Electric transmission lines blown down or in contact with inflammable materials. A good general rule to apply to prevent this type of fire is to select an area for storage not crossed by transmission lines.

5. Sparks caused by striking nails or metal containers with iron or steel tools, or by nails in shoes striking flint, pebbles, sand grains, or nails in the floor. Such sparks have often caused disastrous explosions of explosive dust. When working with ammunition it is desirable to use non-sparking tools made of brass, copper, or wood, and to cover the exposed nails on shoes by adhesive or friction tape.

Unauthorized Tampering with Ammunition. Many accidents are caused by curiosity of personnel concerning the ammunition they are handling. Unauthorized tampering should be absolutely prohibited. No one, except in the line of duty, should be allowed to disassemble any components.

Bad Handling of Ammunition. This subject already has been covered. (See page 360).

Chemical 'Leakers.' As we have already seen, chemical ammunition must be stored in a special area designated for that purpose. Frequent inspections should be made and leakers should be removed immediately and destroyed. Every man working in the area should carry a gas mask and must be instructed in methods of decontamination and first aid for gas casualties. Gas detection kits should be available and used periodically. Phosphorus-filled ammunition should be stored alone, and water-filled tubs should be kept nearby for submerging leaking shells.

General Security. 1. Fire fighting equipment should be kept available for immediate use, and all personnel should be instructed as to their fire fighting duties and stations.

An adequate, but simple fire plan should be prepared for each ASP site. The plan should be divided into two parts, namely, the precautions to be observed for the prevention of fires, and the procedures to be followed in event of fire. All personnel of the ASP must be familiar with their respective fire stations and the proper manner of giving the alarm. They must be thoroughly trained in preventing, reporting, and extinguishing fires, in accordance with the plan and with approved methods of extinguishing ammunition fires. (See TM 9-1900.)

Many brush or grass fires may be prevented or controlled by proper discipline and training. Brush fires may be extinguished, or their spread prevented, by beating with wet sacking, covered with dirt, or digging of fire breaks in their paths. Discipline and training must extend not only to ASP personnel, but to all personnel who may enter the area, even though only for a short time. Regulations for the prevention of fire should be published by the ASP commander after careful consideration of the subject, and should be posted in such conspicuous places that they will come to the attention of all persons concerned. They should cover such matters as:

(1) Smoking.
(2) Use of matches and other open fires.
(3) Use of gasoline or other highly inflammable substances.
(4) Burning of brush and trash, and policing of areas.

Fires and explosions in ammunition due to carelessness are inexcusable. All personnel in an ASP should be fully conversant with proper methods of handling ammunition and the dangers incident to improper handling. All ordnance personnel should be constantly alert to observe the manner of ammunition handling employed by others, and should instruct them in the proper methods. As far as possible, ammunition should be left in original containers, as they afford considerable protection against fire. Powder, when ignited, is extremely difficult to extinguish. If a fire cannot be controlled with the personnel and equipment available, the ammunition should be abandoned and personnel withdrawn to a place of safety. However, not every fire or explosion should be the cause of a general exodus. Many serious accidents have occurred to personnel running from a fire, while others much nearer to the danger have escaped injury because they were protected by cover which might seem slight, such as a tree or shallow ditch. In any case, every effort must be made to restrict the fire to a given area.

2. Every man should be instructed as to his duties in the event of an enemy gas attack or leaking gas from the storage area. All necessary equipment for protection and decontamination must be readily available.

3. An interior guard must be posted at all times. The guard should not only be trained in security measures but also in methods of fire fighting. Unless the fire is small it should be definitely understood that the guard will give the fire alarm before he attempts to fight the fire.

Special Fire Fighting Equipment. During an ammunition fire in a depot in North Africa tanks were brought in to attempt to check its spread. They pushed burning stacks apart before the fire could get to all of its parts and in most cases prevented the entire stack from burning. The grass fires were extinguished by running the tanks over them or by skidding the tanks to shower dirt on the

Figure 18. Bulldozer Blade Mounted on Medium Tank M4.

Figure 19. Ammunition Fire Extinguished With Tank-Dozer.

burning grass. Although a considerable quantity of ammunition was lost the tank had shown definite possibilities as a fire fighting agent.

Frequent fires at the Anzio Beachhead necessitated the use of special equipment and the fire in North Africa and the effective use of tanks in fighting it was recalled. The next step was a tank equipped with a bulldozer blade. With this tank-dozer a burning stack could be broken apart and partially buried in a single operation and the fire would be instantly exteinguished. (Fig. 18 and 19.)

INSPECTION AND SURVEILLANCE

As far as general usage is concerned, the terms 'inspection' and 'surveillance' are synonymous. The primary purpose of inspection or surveillance is to see that ammunition in the hands of troops or in storage is serviceable and stored under safe and favorable conditions.

Inspections should be frequent, particularly in hot or damp climates. It must constantly be borne in mind that the ammunition officer is responsible, not for the issue merely of ammunition, but of serviceable ammunition. The number and extent of the inspections will vary, of course, with the circumstances.

Generally speaking, the inspection will be made in several phases. Attention should be given, not only to the ammunition itself, but to the stacking; the magazine if any, in which the storage is placed; and the magazine or stack in relation to the surrounding area.

The summary given below is merely a rough outline of the more salient items to be observed. Before making an inspection, the references listed herein should be carefully examined.

Inspection of the Ammunition Area. Is the area at a safe distance from general purpose buildings and other army installations?

Is an interior guard properly posted and acquainted with its duties?

Is there an adequate fire fighting plan?

Is there an adequate plan to combat poison gas?

Is the chemical area segregated from the remainder of the ammunition area?

Inspection of the Magazines. Is the area around the magazine properly drained?

If the temperature in the magazine is excessive, have the doors been opened at night to cool it off?

Is there a fire break around the magazine?

Are there any leaks in the roof or breaks in the floor or walls?

Is fire fighting equipment readily available?

Are mixed storage and quantity-distance regulations being complied with?

Is the housekeeping inside the magazine satisfactory?

Additional Points To Be Watched For If The Magazine Contains Chemical Ammunition Are:

Is the magazine marked, as required, by FM 3-15, (Chemical Warfare Service Field Manual, Supply & Field Service)?

Is the auxiliary equipment, such as protective clothing, and barrels of water for immersing leaking WP ammunition, available?

Inspection of Stacking.

Are the stacks stable?

Is there sufficient dunnage?

If the stacks are not in magazines, is the area around the stacks properly drained?

Is the ammunition stacked by lots?

Is the ammunition protected against weather, and does it have sufficient circulation?

Are the containers clean and in good condition?

Inspection of the Ammunition. This subject is too detailed to permit treatment in the Field Guide. References listed at the beginning of this chapter contain detailed information on ammunition inspection. TM 9-1904 is particularly recommended to the reader. Generally speaking, it may be said that representative rounds will be minutely examined for serviceability of all components. If defects are found they should be reported to higher echelons. Dangerous rounds will be segregated and, if necessary, destroyed.

Most of the ammunition inspection will be carried out as the ammunition is received. At this time every ammunition handler should be alert to detect evidences of unserviceability and this ammunition should be set aside promptly and removed from the magazine area to a designated spot. The most common evidences of unserviceable ammunition are to be found in damaged packing. All ammunition received in damaged containers must be rechecked for serviceability.

SHIPPING

General. The shipment of ammunition involves two separate problems: the physical loading of the ammunition into the conveyance, and compliance with the various applicable shipping regulations.

Loading. In Continental United States, the standard references for blocking and bracing ammunition in freight cars are the Bureau of Explosives Pamphlets, 6 and 6 A and Ordnance Department drawings of the 19-48 series. A good discussion of these references is found in TM 9-1904. The general principles (as distinguished from the details) illustrated in these references will be of aid in loading ammunition into foreign freight cars, which have a much smaller capacity than ours.

There is no standard reference for the loading of ammunition into trucks but data in this regard may be found in FM 101-10.

Generally speaking, all loading (in freight car or in truck) will be accomplished in such a manner as to prevent a shifting of the load in transit. Boxes and crated bundles will be loaded lengthwise in the car or truck. The full end areas will be butted up compactly against each other so as to better resist the high pressures that are developed. Excess lateral and longitudinal space will be taken up by blocking. Separate loading projectiles are loaded on their bases. Movement between projectiles is prevented by the use of separators, placed laterally and longitudinally, so as to provide a sort of 'egg-crating' for each shell. Grommets are required to protect the rotating bands from injury.

Loading of trucks in the combat zone usually will be done without blocking. Boxes and crated bundles will be loaded lengthwise in the truck. Separate loading projectiles will be loaded on the sides, lengthwise in the truck. The first row, farthest forward, will be placed so that the bases of the shell are against the forward wall. The shells in the second row will have their noses pointing forward. Succeeding rows are loaded base to base and ogive to ogive.

The extent, if any, to which a truck will be loaded beyond its rated capacity, will depend on circumstances and on the standing operating procedure prevailing in the area. In one theater 6x6 cargo trucks (2½ ton) were limited to a 3½ ton load of ammunition. During certain desert operations, five tons of ammunition was a successful S.O.P. for 2½ ton trucks.

Shipping Regulations. Shipments of ammunition in Continental United States, whether by rail or by truck, are subject to the regulations not only of the Interstate Commerce Commission, but also of the ports, states, and municipalities through which the ammunition passes.

A resumé of the ICC regulations will be found in IOSSC-(i). A good discussion is also found in TM 9-1900 and TM 9-1904.

Overseas, standing operating procedure is issued to cover the pertinent regulations.

RENOVATION

In the recent past the renovation of ammunition has assumed paramount importance. Huge stocks of unserviceable ammunition have been accumulated in the various theaters of operation and common sense requires that as much as possible be reclaimed in the field, rather than be destroyed or returned to the zone of the interior for reworking.

Echelons of Renovation. The following echelons of renovation or maintenance have been established:

1. Surveillance Responsibilities of the Using Arm (such as gun crews or the men using the ammunition):

   Proper handling and storage of ammunition.

   Inspection for serviceability.

   Removal of minor rust and corrosion.

   Return of unserviceable ammunition to unit reserve, ASP, or other immediate source of supply.

2. Surveillance Responsibilities of the Using Arm (such as Munitions Officer):
Inspection of ammunition both in unit reserve and gun position.
Proper handling and storage of reserves.
Supervision of gun crews in handling and storage.
Removal of minor rust and corrosion.
Minor repairs of containers, boxes, and other packing materials.
Repacking.
Evacuation of unserviceable ammunition to ASP after inspection.

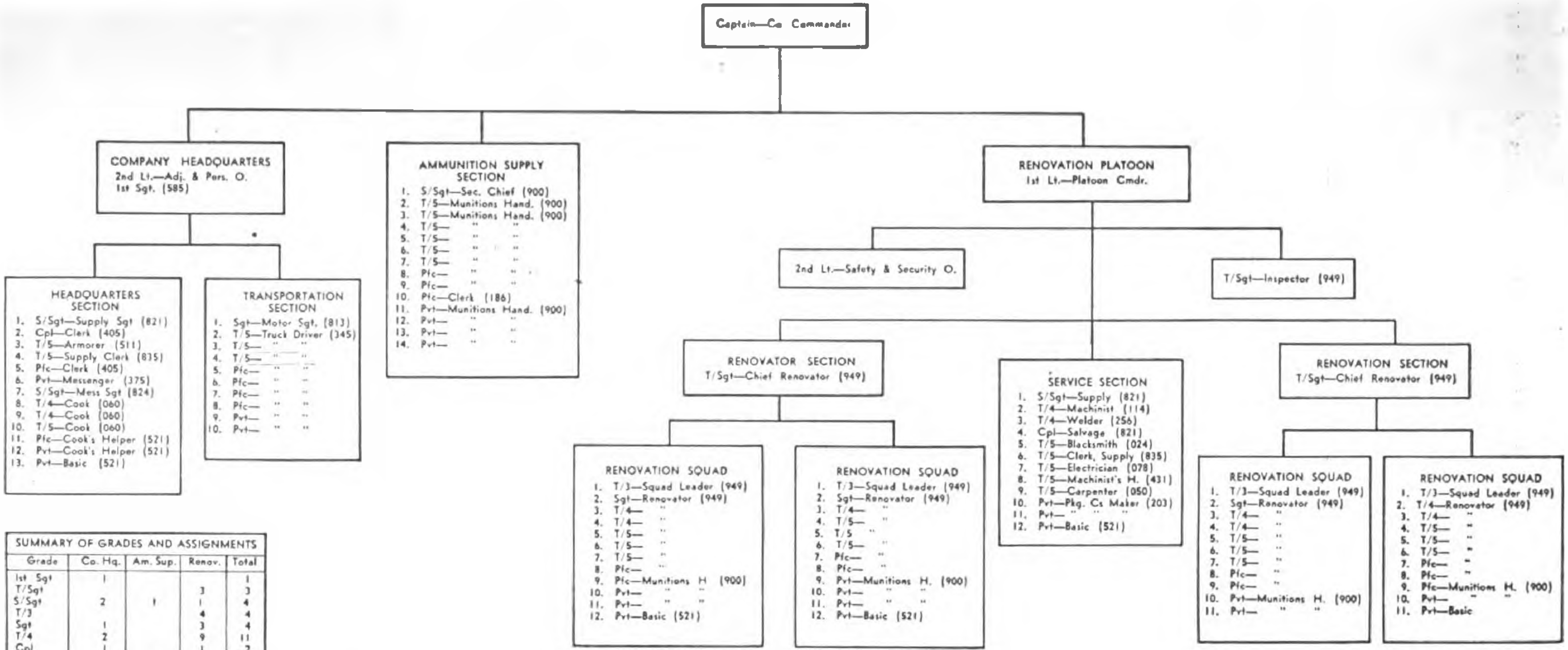
3. Surveillance and Reconditioning Responsibilities of the Ammunition Companies:
Proper handling and storage including segregation to preserve lot identity.
Inspection of stocks prior to issue.
Repair and renovation of unserviceable ammunition within the capabilities of the equipment listed in the SNL N-17 and T/O & E 9-17, and the personnel listed in T/O & E 9-17.
Repair containers, boxes, and other packages, repacking of ammunition, remarking of ammunition and ammunition containers.
Inspection and disposition of captured enemy ammunition.
Evacuation to ammunition depots of unserviceable ammunition.
Destruction of unserviceable ammunition which is dangerous.
Destruction of unserviceable components which cannot be salvaged and is incapable of renovation.
Collection and disposition of serviceable ammunition.

4. Surveillance, Recorditioning and Renovation Responsibilities of Ordnance Ammunition Renovation Company:
100% inspection of all unserviceable ammunition received.
All repair, reconditioning and renovation not accomplished by the Ordnance Ammunition Company including:
(a) Reshaping of cases (unfired cases only).
(b) Replacing primers.
(c) Reloading.
(d) Repairing and remarking of containers and other packages.
Inspection and modification of captured enemy ammunition for use in our weapons, or enemy captured weapons being used by our own troops.
Perform field modification of domestic ammunition as directed by the Chief of Ordnance.
Destruction of dangerous ammunition and components which are not considered feasible of renovation or reclamation as directed by the Theater Ord. Officer.
Disposition of unserviceable ammunition.
Furnish instruction and inspection teams for using arms and Ammunition Companies, as defined above.

5. Renovation beyond the scape of an Ammunition Renovation Company is to be handled at such bases as are established under the Chief of Ordnance.

The mission of the Ordnance Ammunition Renovation Company is the performance of surveillance, reconditioning and renovation of all types of ammunition issued by the Ordnance Department, within the capacity and limitations of the skill of the personnel and the equipment and the time available. Additional functions may also be performed such as modification of enemy ammunition for use in our own weapons, field modifications of U. S. ammunition as directed by the Chief of Ordnance, necessary destruction of ammunition, responsibility for disposition and evacuation of unserviceable ammunition, and such overflow of work that the Ammunition Company cannot perform, and furnish inspection and instruction personnel for use of the using arms and ammunition companies.

Ordnance Ammunition Renovation Company. In order to perform its mission successfully renovation companies (4 officers and 99 enlisted men) have been organized embracing the following sections:
Company Headquarters.
Ammunition Supply Section.
Service Section.
Renovation Section.
Company Headquarters is the administrative unit of the company. This in-



SUMMARY OF GRADES AND ASSIGNMENTS

Grade	Co. Hq.	Am. Sup.	Renov.	Total
1st Sgt	1			1
T/Sgt			3	3
S/Sgt	2	1	1	4
T/3			4	4
Sgt	1		3	4
T/4	2		9	11
Cpl	1		1	2
T/5	6	6	17	29
Pfc	6	3	9	18
Pvt	5	4	16	25
Total	24	14	63	101

NOTES

1. Am. Supply Section is attached to Co. Hq. for formations.
2. Transportation Section is formed from the following
   - 4 from Co. Hq.—1 Motor Sgt, 1 driver (T/5), 1 driver (Pfc) and 1 driver (Pvt)
   - 1 from Am. Supply—1 driver (T/5)
   - 5 from Renov. Platoon—1 driver (T/5), 3 drivers (Pfc) and 1 driver (Pvt)
3. Renovation Platoon is organized to operate in any of the following ways
   - a. One job on one shift—each squad to perform different step of work.
   - b. More than one job, one shift—sections or squads assigned to jobs as required.
   - c. Two shifts—one section, one officer and half of Am. Supply Sec. per shift.
   - d. Detachments (preferably squad or section) may be sent out as required.
   - e. Civilian labor may be employed for less skilled operations.

Figure 20. Ordnance Ammunition Renovation Company, T/O 9-500.

cludes personnel records, mess, supply, and other miscellaneous duties normally found in a company headquarters.

The ammunition supply section is the unit which will draw, record, store, and transport ammunition as required to supply the renovation sections. Personnel in this unit are specially trained in ammunition supply procedures, storage methods, identification of ammunition and allied subjects which are necessary for the efficient operation of this unit.

The service section includes machinists, carpenters, blacksmiths, welders, electricians, and other specialists similar to those found in the service section of a maintenance unit.

The renovation section is composed of highly trained ammunition specialists—men who know ammunition, its characteristics, and its properties, and who have been trained in the latest renovation methods so they will be able to perform their mission smoothly and efficiently. This section is so organized that it can send out advance units to perform renovation operations at ASP's or other installations, as desired.

One of the most difficult problems in considering the organization and work to be performed by a renovation company was that of designing and procuring equipment that would be adequate and still render the unit mobile. Owing to the fact that these companies are new in their particular field, and as a result of their experiences, unquestionably, there will be constant redesigning of some of the equipment currently being made available.

A brief description of some of the special items of equipment thus far available to these units should prove helpful in obtaining a clearer understanding of some of the operations they will be called upon to perform.

Assembly and Disassembly of Ammunition. One of the operations in the renovation of ammunition is the breakdown of the complete rounds so that the various components may be inspected and reconditioned if necessary. In this operation the complete round is placed in the cradle of the the assembly and disassembly machine so that the cartridge case engages a movable shoulder near the base of the device. An adjustable vice is clamped on the projectile just below the bourrelet, holding it in place. The operator then turns the wheel on the base of the breakdown machine drawing the cartridge case away from the projectile. The projectile and cartridge case are then removed from the machine.

In the assembly of rounds an adjustable crimping attachment is fastened to the bed of the breakdown machine. The projectile is set properly into the cartridge case and the round is placed in the machine in the same manner as described in previous operation; then the crimping attachment is adjusted. Four crimping dies fit through a circular sleeve which fits over the case. Operation of a handle by the operator causes a cammed outer cylinder to pass over the dies forcing the dies down and creating the crimp. Springs allow the dies to return to their normal position after the outer sleeve has been moved back. This machine is equipped with fixtures for all caliber ammunition.

Defuzing and Deboostering of Ammunition. The defuzing and deboostering of ammunition in renovation work has always been a hazardous operation. In some instances where the nature of the fuze is not fully known, the use of barricades as safety precautions are recommended; the barricades can be made of various materials as governed by the quantity of explosives undergoing the renovation operation. In this operation a defuzing and deboostering fixture is used. This fixture is a light hand-operated machine. It is fitted with a shaft which passes through an aperture in the barricade and joins a coupling on which defuzing and deboostering wrenches are attached. A vise is set in line with the defuzing or deboostering wrench. The projectile is inserted and the fuze is set in place. The operator in front of the barricade turns the wheel attached to the shaft of the machine thus drawing the fuze from the projectile. The operator by means of a mirror notices when the fuze is unscrewed, enters the barricade, removes the fuze, and sets it aside for storage.

In defuzing and deboostering operations where a barricade is not required a number of fuze wrenches have been furnished the renovation company for both base and point detonating fuzes. In operation the projectile is secured in a vise and the fuze wrenches are inserted into the holes or grooves provided in the fuzes. The fuzes are then removed by hand.

Cartridge Case Reconditioning. The reconditioning of cartridge cases is an operation of major importance to a renovation unit. Due to the amount of handling that ammunition is subjected to, cartridge cases are often dented or damaged in some way or other. The reconditioning of cartridge cases is broken down into the following categories:

1. Cleaning and inspection.
2. Dedenting.
3. Primer firing.
4. Depriming.
5. Repriming.

The inspection of cartridge cases consists of a visual inspection to determine whether or not the cartridge case is serviceable or unserviceable. If serviceable the cartridge cases are cleaned and set aside for future use.

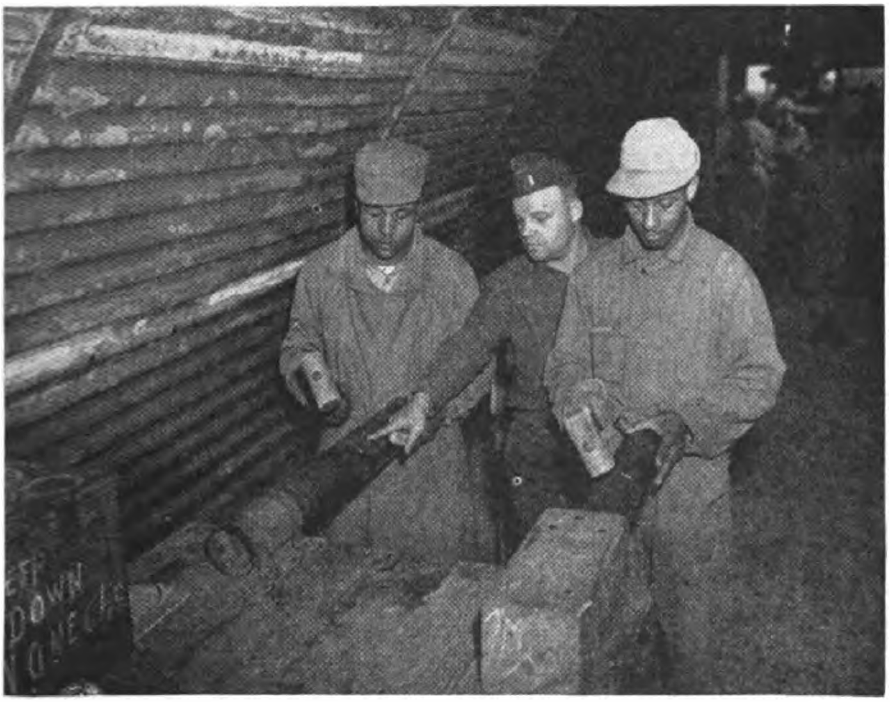


Figure 21. Removing Dents from Shell Cases.

In the dedenting operation the dented cartridge cases are placed on mandrels. These are metal bars curved at one end to conform to the contours of the cartridge case and extending out into a welded base plate which is used for securing the mandrel to a table or stand. The cartridge cases are held on the mandrel and the dents are removed with a rawhide hammer. The mandrels have various size replaceable units to correspond to the various size cartridge cases.

The primer firing operation and the depriming operation are concurrent operations and are accomplished in the following manner:

The cartridge case is placed on a primer firing fixture. This simple fixture consists of a metal "A" frame three sides of which are covered with iron plates and an iron pipe which passes through the top of the fixture and extends down through the frame in such a manner that the end of the pipe faces the open side of the fixture. The primer of the cartridge case is so placed that it will be inside the iron pipe of the fixture. The operator places a primer hammer, which is shaped to fit the primer cap, over the primer cap and strikes it a sharp blow with another hammer thus firing the primer. Then he strikes the primer hammer a few sharp blows driving the primer out of the cartridge case.

Another method of depriming in the field is by means of a depriming fixture.

This instrument is a steel rod fitted at one end with a T handle and at the other end with a steel knife blade which passes through a slotted sleeve. In this operation the primer of the case must have been fired and the case itself should be securely fastened. The rod is inserted into the open end of the case passing the sleeve of the body of the primer. The knife blade grips the primer as it turns and unscrews the primer body from the primer head. A steel rod is then inserted against the primer head and the head is driven out of the cartridge case.

In renovation work in which a repriming operation is necessary the renovation company has been equipped with a small arbor press. This is a light weight, hand-operated press which can easily be mounted for any repriming operation. It is equipped with a number of collar fixtures to conform to the various size cartridge cases in use. The cartridge case is placed in the arbor press and the primer is inserted hand tight. The ram of the press is brought into contact with the primer. A slow steady pressure on the lever arm, seats the primer correctly.

Propelling Charges. In renovation operations involving the separation of a projectile from its cartridge case and the removal of the propelling charge, an accurate check must be maintained to insure that the correct propelling charge weights for the various ammunition lots do not vary, as any mistakes in this check weighing might result in incorrect ballistic information. To determine the accuracy of the propelling charge weights the renovation company is furnished with a set of balances with which they can at all times keep an accurate record of the necessary weights.

Repainting, Restenciling. The renovation company is amply supplied with marking devices, stamps, rollers, ink and other items necessary to insure correct stenciling of nomenclature on ammunition components, boxes, and bundles. Stamps are of various sizes so that any type restenciling necessary can be reproduced. For repainting purposes each company is supplied with a spray gun which makes it possible to do painting quickly and efficiently.

Precision Equipment. Due to the great degree of accuracy needed in reconditioning and renovation of ammunition and its components, the renovaton company has been supplied with a great deal of precision instruments including the following:

1. Chamber and alignment gages.
2. Go, no-go, gages.
3. Ring gages.
4. Snap gages.
5. Primer plug gages.
6. Micrometer calipers.
7. Height, depth, and vernier gages.

These precision instruments are used frequently to check renovation work and to insure the accuracy of the operations performed by the renovation company.

Safety Tools. As in most installations where explosives are handled frequently the renovation company has been supplied with safety tools. These safety tools are made of beryllium copper and are valuable inasmuch as they are nonsparking—a characteristic which is a requirement whenever explosives are handled and used.

Auxiliary Equipment. Auxiliary equipment necessary to the successful accomplishment of its mission has been supplied the renovation company. For power they have been furnished with 2—2kw generators. An air compressor is available for their use, and they have been supplied with machine shop tools, carpenter tools and other general equipment deemed necessary for their maintenance in the field.

In conclusion it should be repeated that every consideration has been given the equipment of the renovation company to insure their self sufficiency and mobility at all times.

Time and time alone will dictate the changes and modifications in organization, equipment and mission which may become necessary. However this much can be said—these renovation units, properly trained, (and this training cannot be overstressed) outfitted with equipment which is both flexible and highly mobile. and with the knowledge of their work and the mission they are to perform will be in a position to successfully perform renovation jobs when and where needed.

OPERATION OF SUPPLY POINTS

Most of the storage and handling principles previously mentioned are applicable to any type of ammunition installation, regardless of size or mission. There are, however, several characteristics of operation peculiar to certain types of supply points. These differences will be amplified here.

Depots. Depots are defined as those ammunition installations whose principal issues are made to other ammunition installations. They range from the size of A.S.P.'s in the combat zone to large communications zone depots of 50,000 tons or more. Often the army depots start as A.S.P.'s and are expanded and made into army reserve depots as the troops move forward. Often the stock level becomes no greater than when it was a forward A.S.P., and other features of operation also change very little. To point out the real differences it is better to consider a typical depot in the communications zone and to analyze the army depots strictly according to their individual situations.

Figure 22. A Large Shipment of Ammunition Being Hoisted from a Shiphold at Attu in the Aleutions (1943).

Depots in rear areas store ammunition in large quantities and although daily issues and receipts may be appreciable they are small compared with the total ammunition in the depot. Ammunition is usually stored for an appreciable length of time prior to issue, and in some depots certain items might be static over long periods. Storage principles for a depot should be based upon this small rate of turnover in regard to dunnage and protection. Some slow-moving items in a large depot might remain in storage as long as the depot itself stays in operation.

Receipts will usually be large and much of the ammunition received will be badly mixed. Many depots receive their ammunition directly from incoming ships, the ammunition being transported to the depot by truck or rail or a combination of both. In this case it will all be badly mixed, most truckloads containing at least 2 or 3 types and often 8 or 10 types. (Fig. 22) A sorting area will be needed for the worst of this, and after sorting, other transportation must be used to move this ammunition to its regular place of storage.

Liaison with the agency shipping the ammunition is often helpful in reducing the quantities of mixed ammunition received. If a depot receives ammunition from another depot or from any installation employing trained ammunition personnel, the difficulties encountered due to mixed ammunition will be negligible. Every effort should be made to reduce the amount of mixed ammunition coming in since sorting and restacking is a very time-consuming and tedious job. Excessive time or effort spent on this cuts deeply into the efficiency and morale of the unit operating the depot.

Issues will be large as compared to those of A.S.P.'s. A transportation order will rarely call for less than one truckload of any given item. Sometimes it will call for one or two items only, and shipments of these items will be of fairly large quantity. This is usually what occurs when one or two items are badly needed at a forward installation. Intelligent staff planning will usually make the volume of issues fairly constant. Under some conditions it is even possible to plan on shipping a definite tonnage each day.

In many communications zone installations, additional labor will be necessary for efficient operation. With a semi-permanent depot the problem is best solved by hiring civilian labor from the immediate vicinity. Soldier labor will usually be unavailable or available for very short periods only and should be used only in emergencies, reserving the use of civilians as a permanent and long-term solution. If the civilians live nearby, administrative problems will be at a minimum since the only consideration should be payment for services.

In practice, the questions of food, clothing, shelter, and transportation to and from work may become a vital part of a specific civilian labor situation. The language difficulties and possible lack of interpreters will often add an additional problem to all phases of handling these additional men. Coordination of the hiring and administrative details will be handled by the theater Ordnance officer or his representative in conjunction with the appropriate civil affairs officer.

ASP's. ASP's are those ammuntion installations which make the majority of their issues directly to combat troops and all operation characteristics are influenced by this principle. The size of the installation is relatively small, usually ranging from 300 to 1,500 tons, and the ammunition is well dispersed.

The ASP is as close to the troops as deemed practicable, usually just out of possible heavy artillery range. It may be subject to aerial observation or attack so that camouflage, camouflage discipline, and security measures are likely to play a larger part than in the operation of a rear area depot. (See 'Security' in Ordnance Troop Units.)

Receipts are from ammunition depots farther to the rear, and as a result of handling by trained ammunition personnel, the receipts are usually in homogeneous truckloads. Sorting presents very little problem except where lot numbers are involved, and in such circumstances a sorting area may be necessary. Incoming trucks containing badly mixed loads will rarely be encountered except when ammunition is being turned in by the troops or where some agency has collected and in returning has abandoned ammunition to the ASP. A combination sorting and salvage area is usually set up at all ASP's to take care of such ammunition.

The turnover of ammunition in an ASP is very great compared to the total stock. During peak operation many stacks may stay for just a few minutes before they are issued and often the daily tonnage handled will exceed the tonnage in the ASP. It is only in the instance of a few slow-moving items, which will be stocked in order that all weapons will have a suitable reserve, that the extremely rapid turnover will not be encountered.

Additional labor is often not available although it is often badly needed. Soldier labor may be obtained only from nearby units, and in combat soldiers are badly needed in their own organizations. Consequently soldier labor will be available only for short emergency periods. Civilian labor is difficult to hire and keep in the combat zone, and in a rapidly moving situation the labor problem is further complicated by frequent ASP moves and an unstable state of civil affairs.

Combat troops returning for ammunition almost always bring their own men to load their trucks. All that is necessary is a man to take them to the right place and check the ammunition to be sure that it is what the loading chit calls for.

Figure 23. Use of Roller Conveyor in Communications Zone Depot—Typical of Labor Saving Expedients Often Used in Such Installations.

Figure 24. Civilian Labor Used in Loading Ammunition in Truck.

This is only a partial solution to the labor problem, but it takes care of the majority of issues.

In the Mediterranean theater the labor problem for ASP's has been solved by the hiring of civilians on a permanent basis. Each ammunition company hired about 200 civilians to be kept with the company at all times. Their food was obtained by local purchase and shelter was provided by the company in the form of salvage tents and tarps. By assuming all these administrative responsibilities on a permanent basis, the companies were able to overcome the difficulties encountered in frequent moves and changing local conditions since their laborers were almost like a part of the company.

In each ASP there is a certain amount of restacking and reconsolidation to be done. Ammunition from the sorting and salvage area must be taken to the magazine area as soon as practicable. Then critical items must be consolidated when the stock level gets low in order to insure efficient handling of convoys. Otherwise the trucks coming in for ammunition must go to many parts of the ASP to pick up a complete load. Carrying out this consolidation in a conscientious manner will greatly increase efficiency in handling issues.

Certain army depots will have many features of operation similar to those just described as well as the characteristics outlined under the operation of depots. Individual circumstances will determine which characteristics of operation will be the governing ones.

Transfer Points. Transfer points are points at which ammunition is unloaded and reloaded for reshipment and issue. At these places ammunition is stored for very short periods of time, seldom longer than one day, and the unloading and reloading may often be done in one operation. Transfer points include railheads, truckheads, and navigation heads.

Under some conditions using units may draw from these installations rather than from ASP's or depots. In some of those instances the issues will be made directly from the incoming trucks or railroad to the using unit's vehicles. To insure efficient operation, save time, and minimize handling, the movements of the incoming ammunition and the unit trains must be coordinated.

If the ammunition is not issued directly to troops or reloaded immediately to another means of transportation it will be held in storage for a short time. This storage will be at the point of unloading and will be kept to a minimum so that it will not hamper further operations.

In many instances this stored ammunition will not be issued or reshipped as planned, and in such a situation a storage area should be set up nearby. What now exists is a small ASP or depot with a transfer point in conjunction. In such a case issues will be made directly from the incoming transportation medium, where possible, but much of the ammunition will come into the transfer point, be taken to ASP or depot, and stored until issue or reshipment. This will be the most common type of railhead or truckhead encountered.

In any transfer point operation, trained ammunition personnel must be used. If issues are made directly to troops they must be present to insure issue of the correct items. If the transfer point is used solely for reshipment, ammunition personnel must be utilized to insure the ammunition being reshipped in unmixed carloads or truckloads. Failure to utilize trained ammunition personnel will result in undue confusion, unnecessary work and costly delay at some date or place.

DIVISION AND SMALLER UNIT DISTRIBUTING POINTS

After ammunition is drawn from the ASP, it is normally taken to the combat positions of the unit where it replaces a like quantity of ammunition recently expended. The unit's basic load furnishes the reserve with which the unit enters combat, and the ammunition supply system functions to replace the ammunition which has been expended from this basic load. (See 'Ordnance Staffs'.)

During combat two things might occur to cause small ammunition dumps to be started. Units may dump their basic loads on the ground or at their gun positions while the unit vehicles which originally carried the ammunition are used for something else or they may dump their basic loads on the ground and send the trucks to fill up with more ammunition in anticipation of heavy future operations. Any dumping of the basic load will usually cause ammunition issues at the ASP's in excess of combat expenditures, and this excess ammunition will be found in small dumps operated by any unit from a battalion to a division.

These dumps will be operated and manned by the units which started them by drawing ammunition in excess of their basic load. This will usually be the service companies of the infantry regiments or the service batteries of the artillery battalions. The personnel will be whatever men can be spared from other duties. Records probably will not be kept and the very few men needed as operating personnel will be used mostly as labor. These dumps will be small and will require very little supervision.

In some instances the divisions will start a dump to establish a handy reserve for an impending operation. This type of installation will usually be smaller than an ASP, but in some cases it will exceed 500 tons. The division ammunition officer will be responsible for the operation of this dump. He will maintain a stock level as he sees fit by drawing from Army's ASP and will control the issues to his own combat units as necessary. Direct supervision and some labor will be furnished by enlisted personnel of the division Ordnance officer's section as they can be spared from other duties. As the combat units come in to draw ammunition they will bring sufficient men to load their own trucks.

When these dumps are established it often happens that the tactical situation changes very rapidly and the units move with little notice. Transportation is usually short and the ammunition is abandoned. It must then be picked up at a later date by somebody else. Often the lapse of time and the conditions in which the ammunition was abandoned render it unserviceable by the time it is finally returned to an ASP since much of it may have been removed from its containers preparatory to firing.

As a result of the above occurring much too often, First Army, II Corps, Fifth Army, and other large units have taken every step possible to discourage unit dumps. The following is quoted from the Ordnance Standard Operating Procedure for combat of the First United States Army:

"Ammunition is a critical item of supply and will not be wasted with indiscriminate fire or by being abandoned at gun positions or bivouac areas. If the situation calls for dumping ammunition on the ground in anticipation of expenditure, the Division or separate unit will be responsible for its protection and evacuation and a report will be made to the Ordnance Officer of the next higher Headquarters within 24 hours giving the exact location and contents of the dump."

Other measures taken by Fifth Army to discourage unit dumps include the placing of ASP's by Army as close to the troops as practicable so that there will be no reason for units to establish their own dumps. Coordination with the division ammunition officers further reduces excessive withdrawals since all divisional units will have their transportation orders signed by their D.A.O. The unit ammunition dump is permitted only in special situations.

THE ORDNANCE AMMUNITION COMPANY

Mission. The Ordnance Ammunition Company has as its mission the operation of such ammunition supply installations as may be assigned. It will receive, store, and issue ammunition in accordance with established principles, adhering to prescribed storage and quantity—distance regulations, keeping adequate records, and rendering reports as required. (See Records and Reports, Storage Principles, Layout, Operation of Supply Points.)

Capabilities. An ammunition company is capable of handling 500 to 750 tons of ammunition per day without the use of additional labor. This means either 500 tons issued or 500 tons received, but not both. 500 tons received and then issued would constitute a total handling of 1000 tons. These figures of 500 to 750 tons are long term planning figures since the tonnage handled by a company during a day under peak conditions will often far exceed this. A company in North Africa without additional labor once handled 2400 tons in one day. A detachment of this same company handled between 1000 and 1800 tons per day for a period of ten days—also without additional labor.

A company is capable of operating a depot up to 50,000 tons if plenty of outside labor is available and if other conditions are also favorable. Usually it becomes

ORDNANCE AMMUNITION COMPANY

Designation: †...... **Ordnance Ammunition Company**
Company ‡......, †...... **Ordnance Ammunition Batttalion**
Company ‡......, **Ammunition and General Supply Battalion,** †...... **Ordnance Regiment (Base)**

	1	1	3	4	5	6	7	8	9	10	11	12	13
						Service platoon							
1	Unit	Technician grade	Company headquarters	Depot office	Magazine platoon (4 sections)	Platoon headquarters	Receiving section	Shipping section	Guard, guide, and traffic section	Total platoon	Total company	Enlisted cadre	Remarks
2	Captain		1								1		† Insert number of company battalion or regiment. ‡ Insert letter of company. [a] Additional ammunition sergeants, when depot is located where camouflage is necessary. [b] May be hired from local civilian labor when practicable. The equipment listed in this T/O is for a tactical organization. It may be materially reduced for a base organization if circumstances warrant it. The serial number symbol shown in parentheses is an inseparable part of the specialist designation. A number below 500 refers to an occupational specialist whose qualification analysis is found in AR 615-26. A number above 500 refers to a military occupational specialist listed in Circular No. 14, War Department, 1942.
3	First lieutenant			1	1						2		
4	Second lieutenant				2	1				1	3		
5	Total commissioned		1	1	3	1				1	6		
6	Master sergeant, including			1							1	1	
7	Chief clerk (502)			(1)							(1)	(1)	
8	First sergeant (585)		1								1	1	
9	Technical sergeant, including			1	4	1				1	6	2	
10	Platoon sergeant (651)					(1)				(1)	(1)		
11	Section chief (139)				(4)						(4)	(1)	
12	Superintendent of storage (810)			(1)							(1)	(1)	
13	Staff sergeant, including		1	3	[a] 1		1	1		2	7	2	
14	Camouflage technician (804)				(1)						(1)		
15	Clerk, requisition (186)			(1)							(1)		
16	Clerk, shipping (195)			(1)							(1)		
17	Clerk, stock record (323)			(1)							(1)	(1)	
18	Mess (824)		(1)								(1)	(1)	
19	Section chief (186, 195)						(1)	(1)		(2)	(2)		
20	Sergeant, including		1	1	7		1	1	1	3	12	2	
21	Camoufleur (800)				([a] 3)						(3)		
22	Clerk, stock record (323)			(1)							(1)		
23	Section chief (677)								(1)	(1)	(1)		
24	Section chief, assistant (805)				(4)		(1)	(1)		(2)	(6)	(1)	
25	Supply unit (821)		(1)								(1)	(1)	
26	Corporal, including		1		8				3	3	12	2	
27	Ammunition (505)				(8)						(8)		
28	Clerk, company (405)		(1)								(1)	(1)	
29	Section chief, assistant (677)								(3)	(3)	(3)	(1)	
30	Technician, grade 4 } including										10	4	
31	Technician, grade 5 } including		13	10	78	4	6	10	20	40	16	4	
32	Private, first class } including										50	1	
33	Private } including										65		
34	Carpenter, general (050)	4						(1)		(1)	(1)	(1)	
35	Carpenter, packer (203)	4						(1)		(1)	(1)		
36	Carpenter, packer (203)	5			(2)		(1)	(1)		(2)	(4)		
37	Carpenter, packer (203)				(4)		(2)	(3)		(5)	([b] 9)		
38	Chauffeur (345)	5	(1)								(1)		
39	Chauffeur (345)		(1)			(1)				(1)	(2)		
40	Checker, receiving and shipping (186)				(4)		(2)	(2)		(4)	(8)		
41	Clerk, general (055)	4		(2)							(2)	(1)	
42	Clerk, general (055)	5		(1)			(1)	(1)		(2)	(3)	(1)	
43	Clerk, general (055)			(4)							(4)	(1)	
44	Cook (060)	4	(2)								(2)	(1)	
45	Cook (060)	5	(2)								(2)	(1)	
46	Cook's helper (521)		(2)								([b] 2)		
47	Laborer (590)				(48)				(18)	(18)	([b] 66)		
48	Mechanic, automobile (014)	5	(1)								(1)	(1)	
49	Messenger (675)		(1)								([b] 1)		
50	Munition worker (139)	4			(4)						(4)	(1)	
51	Munition worker (139)	5			(1)						(4)		
52	Munition worker (139)				(4)						(4)		
53	Orderly (695)		(1)								([b] 1)		
54	Painter, general (144)					(1)				(1)	(1)		
55	Painter, sign (145)					(1)				(1)	(1)		
56	Stenographer (213)	5		(1)							(1)	(1)	
57	Basic (521)		(2)	(2)	(8)	(1)		(1)	(2)	(4)	([b] 16)		
58	Total enlisted		17	16	98	5	8	12	24	49	180	19	
59	Aggregate		18	17	101	6	8	12	24	50	186	19	
60	O Carbine, cal. .30		12	8	70	3	5	8	18	34	124		
61	O Pistol, automatic, cal. .45		3	6	8	2	1	1		4	21		
62	O Rifle, cal. .30		3	3	23	1	2	3	6	12	41		
63	Q Trailer, 1-ton, 2-wheel, cargo		1								1		
64	Q Trailer, 1-ton, 2-wheel, water tank, 250-gallon		1								1		
65	Q Truck, ¼-ton		1			1				1	2		
66	Q Truck, ¼-ton, command and reconnaissance, with winch		1								1		
67	Q Truck, ¾-ton, weapon carrier					1				1	1		
68	Q Truck, ¾-ton, weapon carrier, with winch					1				1	1		
69	Q Truck, 2½-ton, cargo		1								1		
70	Q Truck, 2½-ton, cargo, with winch		1			1				1	3		

[A. G. 320.2 (6-13-42).]

Figure 25. T/O and E 9-17.

necessary to use more than one ammunition company. The tonnage to be handled daily is the determining factor rather than the size of the depot.

The company is capable of operating 2 to 4 ASP's at one time, depending on the size of the installations and on the turnover of ammunition. The number of ASP's which can be successfully operated depends to a great extent on the state of training of the company.

Assignment. Ammunition companies are normally assigned to:

Ammunition battalions, T/O 9-15 (two to six companies per battalion; companies assigned to army, independent corps, or task force on a basis of one company per 500 to 750 tons of ammunition per day).

Theater reserve (one company per 500 to 750 tons of ammunition per day).

Communication Zone (two companies per 15 days' supply per army).

In addition to the above, ammunition companies may be assigned to the support of, or attached to task forces to supplement those shown above.

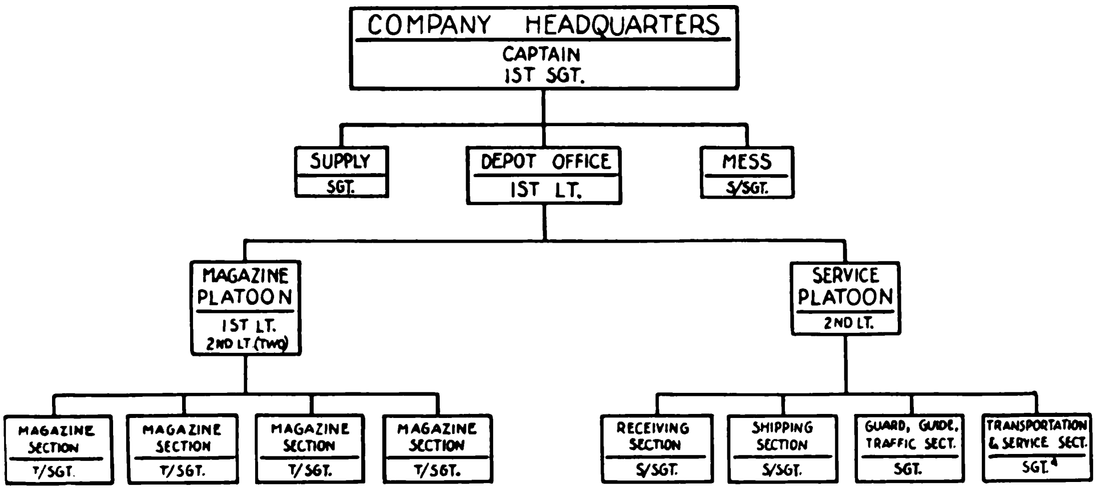


Figure 26. Schematic Diagram of Ordnance Ammunition Company.

Additional Items. In special situations, with the approval of the theater commander, additional vehicles may be authorized for companies operating forward ASP's in order to make them completely mobile. During ASP operation they are used for inter-dump consolidation, restocking, and sorting to facilitate the handling of issues. Another valuable function is the replenishment of low stocks of critical items when other transportation is not readily available. In places where these additional trucks have been authorized, they have often prevented serious shortages from developing because they could be dispatched immediately to the nearest depot to pick up the critical item.

Other items not authorized by T/E but vital to the company's operation include a water trailer, needed to insure an adequate water supply for the company. Additional tentage is needed when the company operates several ASP's. A small generator is needed for light with all the necessary night work; adequate light will reduce undue fatigue, headache, eye-strain, and mistakes. It may be possible in active operations to secure special authorization for one or all of these items.

KEY PERSONNEL

The following is quoted from the S.O.P. of the —nth Ordnance Company and was written by Major James F. Fisher.

Assignment of Officers. "When the company operates as a unit, officers will normally be assigned as listed below. If the company is short of officers, or detachments are sent out, adjustments will be necessary.

Captain—Company Commander.
Lieutenant—Depot Officer.
Lieutenant—Commander Magazine Platoon.
Lieutenant—Section Leader, Magazine Platoon.

Lieutenant—Section Leader, Magazine Platoon.
Lieutenant—Service Platoon Commander.

All officers are subject to assignment as Detachment Commander, or on special missions, at short notice. Consequently, subordinates should be kept well informed as to what is going on in order that there will be no interruption in depot or company activities.

A detachment commander exercises almost complete control over his detachment. Normally, administrative matters are taken care of by the company headquarters; the amount of administration necessary depends on the distance by which the detachment is separated from the company. The detachment commander normally must perform all the duties in a company, such as Depot Officer. Magazine Officer, Mess Officer, etc., for his detachment. He may arrange for separate rationing, water and gasoline, etc. Orders and information concerning the ammunition handling frequently come direct from higher headquarters rather than through the Company Commander.

Other necessary assignments are; Mess Officer, Supply Officer, Motor Officer, Personnel Officer, Graves Registration Officer, War Bond Officer, and Life Insurance Officer.

Duties. The Company Commander is of course responsible for all activities of the Company. Following the wishes and regulations of higher headquarters, he plans and directs both the administrative activities of the Company Headquarters, and the various phases of ammunition handling and depot operation. He is responsible for the training and discipline of the company. His duties are mainly supervisory, the various activities being assigned to subordinates insofar as is possible. The company should be organized in such a manner that it will function properly whether or not the Company Commander is present, as his duties will often require his presence elsewhere.

The senior First Lieutenant is normally assigned as the Depot Officer or Depot Commander, and his post is the Depot Office. He is responsible for all phases of ammunition handling, performing his duties in accordance with instructions from higher headquarters and recognized principles of depot operation. He supervises the operation of the depot officer, insuring that proper, accurate, and adequate records are kept, and that reports are made promptly as required. He is responsible for the smooth operation of the Depot Office. He is responsible for the general depot layout of main roads, and the location of the Depot Office, Magazine Area, and parking areas. He exercises general supervision over the Magazine Platoon, informing the Platoon Commander of all matters concerning the Magazine Area, and checking to see that his instructions are carried out. He is responsible for the efficient and prompt handling of incoming and outgoing ammunition. He must continually be on the alert to inform higher headquarters of situations which require action or decision on their part (such as shortages of certain types of ammunition, or requests on the part of combat units for abnormally large quantities of ammunition). He must anticipate to the greatest degree possible the difficulties that may arise in order that corrective action may be taken; in this he must have the fullest cooperation of his subordinates. When deemed advisable, he will have inventories made of any or all of the ammunition in order to insure the accuracy of the records, particularly when the stock of any type becomes low. He is also the Company Executive Officer, and takes command when the Company Commander is absent.

The magazine platoon commander has two assistants, each of whom normally command two Magazine Sections. The two assistants directly supervise the sections under their control, assisting the Platoon Commander in carrying out his mission. The Platoon Commander is responsible for the safe and proper handling and storage of ammunition. Assisting the Depot Officer and Company Commander in picking out the Magazine Area, he lays out the locations of the various types of ammunition according to established orders and rules. He insures that sufficient personnel are always on hand to handle the ammunition promptly and efficiently. Since there is usually a shortage of labor, he distributes the available labor and arranges for shifts when needed. When possible he arranges for an officer to be present at all times when work is being performed in the Area. He is responsible that sufficient men are always present at the Depot

Office or Sub-Depot Offices to take care of issues or receipts. He must make continual inspections to discover and correct errors and unsatisfactory conditions. He must check to see that the work is evenly distributed, that ammunition handling is prompt and efficient, and that all receipts and issues are accurately tallied and that the tallies are promptly sent or taken to the Depot Office. He is responsible for traffic control within the Magazine Area, insuring that truck drivers maintain safety distances and prevent traffic tie-ups. When necessary, he may request guards from the Service Platoon, for this purpose. He is responsible that the area is protected from fire and the spread of fire as adequately as is possible. He will keep alert to report unusual situations to the Depot Office so that action may be taken. He will inventory any or all of the ammunition as required, or at any time he deems necessary in order to insure that the Depot Office records are correct. He will post such signs as are necessary within the magazine area. He will prohibit smoking within the area, and will take steps to enforce the rule. Smoking areas will be designated.

The lieutenant in command of the Service Platoon has numerous duties. He is usually assigned as Motor Officer and Personnel Officer. Other lieutenants are assigned as Mess Officer and Supply Officer, but he must be prepared to function in those capacities when the assigned officer is absent temporarily. He normally remains with the Company Headquarters when the company is split into Detachments.

1. As personnel officer he is responsible for the proper maintenance of the personnel records. He supervises preparation of payrolls when the company is operating separately. He is responsible that all reports are made promptly and accurately, including the Morning Report. He prepares the necessary correspondence. Obviously he must consult the Company Commander frequently, especially as many reports and letters must be signed by the commanding officer.

2. As Motor Officer he is responsible for the company vehicles. He supervises the activities of the Motor Sergeant and Company Mechanic, and the drivers. He checks to see that the vehicles are properly maintained and that proper records are kept. He signs trip tickets and assures himself that the vehicles are not improperly used. He tests drivers and issues driver permits.

3. He sees that the Communications Section installs the Depot Phone system promptly, and arranges for outside connections when necessary. He is responsible for 24-hour switchboard operation when necessary.

4. He sees that the guard is promptly established and guard posts properly located. He sees that proper signs are erected wherever needed. He is responsible for the proper performance of the guard, although all officers present are normally placed on an Officer of the Day list. When necessary, guards may be used as guides also.

General: All officers will continually cooperate in the performance of their duties. When activities under the control of various officers supplement each other, requests or recommendations will be made direct to the officer concerned for appropriate action. Conflicts of duties will be settled amicably by conference or by reference to senior officers.

Normal channels of command will be followed except in emergencies, so that each officer may retain control of the men under his command. Each officer is responsible that the personnel under his control are definitely organized so that no one is in doubt as to his next superior commissioned or non-commissioned officer. Chain of command must be established so that in the event of the absence of anyone in authority, the next man in line will automatically take command.

Each officer must take a personal responsibility for the men under him. He must see that the non-commissioned officers perform their duties properly. He must check to see that his men are properly equipped, trained and disciplined and that proper care and police is taken of their clothing, equipment, and bivouac areas.

Duties of Enlisted Men. *Chief Clerk.* The chief clerk is responsible for all the activities of the depot office. He will see that adequate and accurate records are kept and that reports are prepared on time. He keeps himself and his clerks constantly on the alert to detect shortages of certain types of ammunition so that the Depot Officer may take timely action. He recommends the taking of inventories to the Depot Officer when he feels that they are warranted so that the Depot Officers will have them in order to check the accuracy of the records. This is especially vital when the stock of a given item becomes low. Although the Depot Officer is responsible for operations of the Depot Office it must be remembered that he is also responsible for other phases of operation and will not be in direct touch with the records or the Depot office at all times every minute. The Chief Clerk must act to keep the Depot Officer informed of any condition requiring action or decision and must have the office and records so organized that any desired information is instantly available.

Superintendent of Storage: This job is the enlisted link between the Depot Office and the magazine area. The Superintendent of Storage is in the Depot office and is indeed an understudy to the chief clerk and takes over his duties in his absence. On the other hand, his duties are just what his title implies. He is concerned with the storage, stocking, and handling of the ammunition in the ASP mainly as it affects the operations or jurisdiction of the Depot office. He exerts no direct control over the operations of the magazine sections and yet is partly responsible that the ammunition is stacked properly and located easily. He is an enlisted assistant to the Depot Officer in matters pertaining to the magazine area and any control over the magazine sections would be exerted through recommendations of the Depot Officer and subsequent action on his part.

One of the principal duties of the Superintendent of Storage is the establishment and maintenance of a locator record. It may take many forms and might be very simple and informal, but efficient operation requires that one be kept. In keeping this record, he is vitally concerned with activities in the magazine area. A locator record which can be set up as part of the stock record card is recommended. The designations and locations of the various storage areas should be simple and understood by all personnel so that chits returned to the Depot office will be properly marked. Without this a locator has no value. A large map of the area, prominently displayed and with the area designations plainly shown, should be prepared as soon as possible. All this should be the job of the Superintendent of Storage. In getting the information necessary to set up such a locator system and keep it up to date and functioning properly, he will necessarily perform most of the duties expected of him.

Section Chief; Magazine Section: There are four sections of the magazine platoon, each identical in its function and the section chiefs act as directed by the officer in command of their section of the Magazine Platoon, the orders having been those of the platoon commander originally. Although the officers are responsible for the proper functioning of the four sections the four section chiefs are those who are directly in charge at all times and who have the closest contact with the men.

They will then be responsible to their officers that the handling and storage of ammunition is carried out in the manner prescribed. They will be in direct charge of their sections at all times when they are working and will have them available as required. When their officers are elsewhere, the section chiefs will assume all of their officers' responsibilities and duties.

Platoon Sergeant; Service Platoon: The platoon sergeant of the service platoon supervises the activities of the platoon and sees that the orders issued by the platoon Commander are properly carried out. He is indirect supervision of the communications system, carpenters, motor guards, and guides and will see that they perform their duties in the prescribed manner.

When renovation is undertaken, the service platoon will normally perform most of the work required and the platoon sergeant will usually supervise the job even if men from other sections are used to do some of the work. Repair of crates or boxes is usually carried out under his direction even in normal operation.

Signs must be put up and kept in repair for proper traffic control and guides must be properly placed and available for such other duties as might be required. Due to the large variety of functions it performs, much of the platoon's work will be done with little supervision by the platoon commander. Additional supervision and attention to details must be given by the platoon sergeant.

General. The organization of the ammunition company, as prescribed in T/O 9-17, has been designed with a view to having within the company sufficient trained personnel to handle from 500 to 750 tons of ammunition a day. The organization must be sufficiently flexible to permit combining with other companies for operations when the ammunition to be handled is more than 750 tons a day. or to enable it to be divided when the load is less than 500 tons per day.

The internal organization of the ammunition company, as outlined herein, or as given in T/O 9-17, should be considered a guide rather than a rule, since situations vary widely.

In the combat zone, the ammunition company must be prepared to operate on a 24-hour basis, receiving and issuing ammunition at all hours. Reliefs must be organized and personnel, especially technicians, must be assigned to reliefs in accordance with fluctuations in the volume of work and to provide balanced teams. Moreover, the company must be prepared to meet sudden and unexpected demands without confusion. In addition, adequate security measures must be maintained, and organizational duties performed at all times.

Multiple Operation: Usually, two or more ASP's will be operated by one ammunition company. In this event, sufficient personnel must be detached from the company to perform all of the functions ordinarily performed by the company, with the possible exception of company administration and company supply. The distance between installations, transportation, and communication facilities will usually be the guiding factors in determining how independent the operation of each installation must be. Ammunition companies in North Africa have operated as many as five ASPs at one time.

The company must be prepared to supervise additional labor, soldier or civilian, and to operate efficiently with them, including the solution of any problems relating to their operation, administration and control.

It cannot be emphasized too strongly that the ammunition company must be completely flexible in organization, mind, and spirit. No two situations will be alike and the company organization and operation must be changed accordingly. They must be prepared to operate any size installation from 100 to 50,000 tons. They may operate alone, in combination with other companies, or split into several detachments. Labor will be scarce in many cases, or available for uncertain periods. The same can be said for transportation. Situations may change radically in a few minutes and the company must still be prepared to carry on with no confusion or lack of operating efficiency.

Company or Detachment Headquarters. The company or detachment headquarters is charged with the housekeeping duties necessary for the operation of the company or detachment. It includes the company or detachment office, the company or detachment supply office, and the mess section. The functions of these subsections are as follows:

Company or Detachment Office: This section is responsible for the administration and training of the company or detachment. In the case of a detachment, these duties will usually be limited to inspections and execution of policies prescribed by the company commander or higher authority, and the rendering of reports necessary for the company headquarters to maintain its records properly. The company office will be responsible for the following:

(1) Maintenance of personnel records including service records, morning reports, sick reports, duty rosters, and other routine reports pertaining to administration and training required by higher headquarters.

(2) Maintenance of correspondence files.

(3) Preparation of training programs and schedules, in connection with the ASP office, for the technical training of the organization. Reference may be made to Mobilization Training Program 9-100.

(4) Conduction of inspections of all phases of the activities of the organizations.

(5) Preparation of plans in connection with changes in the location of the company. Such plans will usually be initiated by higher headquarters but much detailed planning will devolve upon the company headquarters, such as messing arrangements, truck loading schedules, police of old bivouac, selection and preparation of new bivouac, conduct of motor march, etc. Such plans will be coordinated, where necessary, with the ASP office.

(6) Preparation and supervision of training programs for the military training of the organization, as required by higher authority.

The company headquarters must have additional personnel trained so that it will function properly when the company is operating several ASP's. This is especially true when the detachments of the company are at a considerable distance from the company and from each other and they must handle all of their administration with no outside assistance.

Company Supply Section: The functions of company supply are usually performed by a noncommissioned officer and one assistant, under the supervision of the company commander. This section is responsible for:

The presence of all authorized equipment which has been issued to the organization or a validated requisition for its replacement.

Maintenance of the company property book and file of all necessary vouchers pertaining to it.

Maintenance of all records of individual equipment.

Preparation of requisitions for organizational and individual equipment.

Preparation of all property forms, such as Report of Survey, Statement of Charges, Inventory and Inspection Report, and other forms required in the property administration of the company.

Maintenance of a file of memorandum receipts for property other than individual equipment which is held by members of the company.

The company supply must be prepared to operate in several sections when the company is split into detachments. There should be additional personnel available to act in the capacity of the supply sergeant for these detachments. They should be trained in supply procedures and forms, since they may often draw supplies without contacting the main company. Above all they should be thoroughly conscientious.

Mess Section: This section is responsible for:

Obtaining, transporting, preparing and serving rations (including those for attached personnel) as well as police and maintenance of sanitary conditions in all matters pertaining to mess equipment and serving of the mess.

The mess section is usually subject to some unusual condition in its operation. Additional personnel are usually attached to the company for varying periods and are often attached or detached on short notice. These fluctuations in strength make the mess sergeant's job more difficult both in food preparation and in drawing rations or maintaining reserve stocks.

Meals may be delayed by a sudden rush of work in the magazine area, often for periods of an hour or two. The work in the area usually necessitates having the company eat in two or more shifts even in normal operation. The food must be kept hot and yet palatable while the meal is delayed or until the second or third shift comes in to eat. A fourth meal at midnight or at least hot coffee should also be provided when the company is working at night.

Detachments are also a major problem. There may not be enough cooks for satisfactory operation unless there are other men in the company who can be used. There should be at least two cooks with each detachment, especially if the detachment is drawing its own rations. Kitchen equipment as authorized by T/E will not be adequate for more than three detachments. In such a case steps should be taken to procure any additional equipment needed.

Depot Office. The depot office should be organized to accomplish the following duties:

1. To prepare such plans as may be necessary to insure efficient operation in connection with initial stockage, replenishments, issues, inspections, disposition of ammunition returned by units, and related duties.
2. To supervise and coordinate the work of the magazine and service sections.
3. To maintain a layout chart of the area and a situation map showing the location of the ASP, the division ammunition office (or other appropriate office), and the tactical units served in the ASP.
4. To keep such records and prepare such reports as are required by higher headquarters, and to keep such additional records as are deemed necessary for the efficient operation of the ASP.
5. To take timely action in notifying proper authority when certain shortages start to develop so that prompt measures may be taken to prevent them from becoming critical.

To discharge this last duty efficiently, it is necessary that records be kept as up to the minute as possible so that any question concerning the ASP stock can be answered on demand. Some few companies in active operation, under the guise of cutting down paper work, keep no stock record. They submit a Status of Stock Report daily, and once each day they post all vouchers to yesterday's copy to get their new balances which are now the balances of the Status Report for the current day. As a result of such bookkeeping a shortage will never show up until a particular item runs out and then it is too late to take effective action. Anticipation of shortages and intelligent planning is impossible unless adequate records are kept.

The depot office may be found to contain too many men for efficient operation if the company operates one ASP. It must be remembered that much of the company's operation will call for detachments and trained depot office personnel must be instantly available.

Magazine Section. Magazine sections are the operating part of the ammunition company. All other sections of the company contribute to the end that the magazine sections will efficiently accomplish their mission of receiving, storing, and issuing ammunition. The operations of the magazine sections will include the following:

Preparation of Site: In the establishment of a new ASP, the magazine section, coordinating with the superintendent of storage, is responsible for:

Proper layout of the magazine area to provide the necessary number of sections, and stacks in the proper location to facilitate storage and issues.

Clearing, leveling, and ditching of stack sites, if necessary, in accordance with the stacking plan.

Receipt of Ammunition: During initial stocking and at such other times as large quantities of ammunition are received at the ASP, magazine section personnel will be concerned chiefly with supervision and checking. They will see that ammunition is properly handled and that stacks are properly built up. This will include the segregation of ammunition as to type, caliber, and lot number.

Inspection: At all times, and especially during stocking, magazine personnel will be on the alert to detect damaged containers, dented shell cases, damaged or unprotected rotating bands, and all other defects in ammunition. Such defects should be reported to the ASP office for action.

Storage and Issue: The magazine section is responsible for the correct storage and for the issue of ammunition from the ASP.

The magazine sections must be prepared to function independently in the operation of small ASPs. In larger installations, a particular section of the ASP or Depot should be assigned to a magazine section and made their sole responsibility. This will not only train them for independent operation, but will induce competitive spirit. Their familiarity with their own area will expedite the handling of receipts and issues.

Attached labor, civilian or military, must be handled by the magazine platoon in the direct supervision of their work. Although the service platoon operates the labor pool, the actual supervision of the men while they are working and the responsibility for the work they do remains that of the magazine section. Each man must be prepared to take charge of attached labor and properly direct its activities.

Service Platoon. The service platoon of the ASP is organized to perform the following functions:

Shipping and Receiving. The service platoon assists and augments the magazine section during receipts and shipment of ammunition. In connection with receipt or shipment of ammunition by rail, the service platoon usually conducts the operations at the railhead, including checking, segregation, and supervision of loading or unloading.

The shipping and receiving sections will usually be used as labor in the magazine area when the company is not operating a railhead. In many situations the company will not be connected with a railhead and in such a case the personnel of these sections will be temporarily assigned to a magazine section.

Guard, Guide, Traffic, and Labor. The service platoon is charged with the following:

Maintenance of a guard and alarm service for protection against fire, gas attack, ground attack, air attack, prowlers, loiterers, or other unauthorized persons. (See FM's 5-15, 24-75, and 26-5.)

Traffic direction, including traffic at train holding areas. (See paragraph 14-e.)

Furnishing of guides for ammunition trains to and within the ASP.

Operation of a labor pool when required, and supply of labor as needed by the other sections.

General handling and all administrative problems of civilian labor. This will include pay, food and clothing, transportation to and from work or any other problems applicable to a particular labor situation. Dispatch of labor to the various sections will be coordinated.

Transportation. The service platoon furnishes transportation as required by the various sections, or as directed by the company commander. It is responsible for:

Maintenance of all records and motor books pertaining to the motor vehicles of the company. (See FM 25-10 and TM 21-300.)

Transportation of organizational equipment and supplies.

Dispatch of all organic vehicles.

Training of organizational drivers.

Repair and maintenance of organic vehicles, to the limit of the tools, time, labor, and skill available. Such repairs are limited to first and second echelon work.

Miscellaneous. The miscellaneous operations of the service platoon include:

Packing of ammunition for shipment.

Repairing of ammunition containers.

Renovation of ammunition, when necessary, and within the limits of tools and skill available. (See Section IV, Chapter 3.)

Miscellaneous carpentry and painting. (See TM 5-226.)

Installation and operation of the ASP telephone system.

The supervision and installation of necessary camouflage.

Miscellaneous operations of the service platoon will vary with the situation. If there is plenty of suitable material for repair of containers and time is available, the platoon will do quite a bit of this work. Under other conditions the carpenters may be better used as labor in the magazine area. Renovation will be the responsibility of this section. If there is plenty of time and suitable tools and facilities it may well become a major part of the platoon's operation. At other times the miscellaneous operation of the platoon may consist of only a few small carpentry and painting jobs.

The communications may become a very busy section. In North Africa one of the ammunition companies gave its switchboard 24 hour use and often had other units hooked into its board as well as its own phones in the area.

The entire platoon will be subject to sudden changes in its operation at short notice. If a rush occurs in the magazine area, it must be remembered that the service platoon will be more valuable as labor at that particular instant than they would be in their normal function. They will often be used to provide the necessary flexibility needed for periods of peak operation.

Training. The personnel of the ammunition company should be trained so that each individual can perform essential duties in addition to those normally assigned to him. All personnel should be thoroughly trained in security measures and defensive tactics as well as technical operations involved in the supply mission of the company.

Company officers should be thoroughly trained in military subjects in order to increase their efficiency and effectiveness in the combat zone, and in their relations with the combat branches. Such training should cover the following matters:

Ordnance service operations in the combat zone, including the capabilities and functions of all ordnance units.

The art of small maneuvers and terrain evaluation, including alternate locations and routes.

Security measures and defense against ground and air attacks.

Thorough knowledge of demolition techniques and safety precautions.

Map reading and use of compass.

Motor movement at night, relying on odometer readings and a compass.

Hand weapons, machine guns, and anti-tank weapons.

Ability to make a logical and concise estimate of the situation, and to write logical and concise orders.

Military and staff terms.

First aid.

Fire prevention and fire fighting.

The ability to render approximate reports promptly when the rendition of more accurate reports will cause such delay as to make them useless.

The administration of separate detachments.

The fact that it is better to use initiative and act, even if wrong, than to do nothing.

TABLE OF ORGANIZATION No. 9-15 — WAR DEPARTMENT, WASHINGTON, April 1, 1942.

ORDNANCE AMMUNITION BATTALION

Designation: † ...... Ordnance Ammunition Battalion

	1	2	3	4	5	6	7
1	Unit	Headquarters and headquarters detachment	6 ammunition companies (each) (T/O 9-17)	Total battalion	Attached medical (for details see p. 2)	Aggregate	Enlisted cadre
2	Lieutenant colonel	a1		1		1	
3	Major	b1		1		1	
4	Captain	c2	1	8	1	9	
5	First lieutenant		2	12	3	15	
6	Second lieutenant		3	18		18	
7	Total commissioned	4	6	40	4	44	
8	Master sergeant	d1	1	7		7	7
9	First sergeant		1	6		6	6
10	Technical sergeant	e4	6	40		40	14
11	Staff sergeant	f2	7	44	1	45	14
12	Sergeant	g2	12	74		74	14
13	Corporal		12	72	1	73	12
14	Technician, grade 4	h1	10	61		61	24
15	Technician, grade 5	h1	16	97	3	100	26
16	Private, first class	i5	50	305	9	314	6
17	Private, including	i7	65	397	10	407	
18	Basic	(2)	(16)	(98)	(2)	(100)	
19	Total enlisted	23	180	1,103	24	1,127	123
20	Aggregate	27	186	1,143	28	1,171	123
21	O Carbine, cal. .30	12	124	756		756	
22	O Pistol, automatic, cal. .45	11	21	137		137	
23	O Rifle, cal. .30	4	41	250		250	
24	Q Car, 5-passenger, light sedan	1		1		1	
25	Q Trailer, 1-ton, 2-wheel, cargo		1	6		6	
26	Q Trailer, 1-ton, 2-wheel, water tank, 250-gallon		1	6		6	
27	Q Truck, ¼-ton	2	2	14	1	15	
28	Q Truck, ¾-ton, command and reconnaissance, with winch		1	6		6	
29	Q Truck, ¾-ton, weapon carrier	1	1	7	1	8	
30	Q Truck, ¾-ton, weapon carrier, with winch		1	6		6	
31	Q Truck, 2½-ton, cargo		1	6		6	
32	Q Truck, 2½-ton, cargo, with winch	1	2	13		13	

Remarks (column 8):

† Insert number of battalion.

a Battalion commander.

b Executive officer.

c 1 battalion adjutant; 1 battalion supply officer.

d Sergeant major (502).

e 1 communication (542); 1 operations (intelligence) (814); 1 personnel sergeant major (816); 1 supply (821).

f 1 camouflage technician (806); 1 motor (813).

g 1 assistant supply (821); 1 message center chief (674).

h Clerk, general (055).

i 1 chauffeur (344); 3 clerks, general (055); 2 orderlies (696); 4 truck drivers, light (345); 2 basics (521).

The serial number symbol shown in parentheses is an inseparable part of the specialist designation. A number below 500 refers to an occupational specialist whose qualification analysis is found in AR 615-26. A number above 500 refers to a military occupational specialist listed in Circular No. 14, War Department, 1942.

* This table supersedes T/O 9-15, November 1, 1940.

MEDICAL DETACHMENT, ORDNANCE AMMUNITION BATTALION

Designation: Medical Detachment, † ...... Ordnance Ammunition Battalion

	1	2	3
1	Unit	Technician grade	Total
2	Captain		1
3	First lieutenant		(a 2) 3
4	Total commissioned		4
5	Staff sergeant (673)		1
6	Corporal (673)		1
7	Technician, grade 5 (including)		3
8	Private, first class (including)		9
9	Private (including)		10
10	Chauffeur (345)		(1)
11	Dental technician ([illegible])	5	(1)
12	Dental technician ([illegible])		(1)
13	Medical attendant ([illegible])		([illegible])
14	Medical technician ([illegible])	5	(1)
15	Medical technician ([illegible])		([illegible])
16	Orderly ([illegible])		(1)
17	Surgical technician ([illegible])	5	(1)
18	Surgical technician ([illegible])		([illegible])
19	Basic (521)		([illegible])
20	Total enlisted		24
21	Aggregate		28
22	Q Truck, ¼-ton		1
23	Q Truck, ¾-ton, weapon carrier		1

Remarks (column 4):

† Insert number of battalion.

a Dental.

The serial number symbol shown in parentheses is an inseparable part of the specialist designation. A number below 500 refers to an occupational specialist whose qualification analysis is found in AR 615-26. A number above 500 refers to a military occupational specialist listed in Circular No. 14, War Department, 1942.

[A. G. 320. 3 ([illegible])]

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:
J. A. ULIO,
Major General,
The Adjutant General.

Figure 27. T/O and E 9-15.

Enlisted men should receive training in such matters above as would apply to them in the performance of their duties. (See MTP 9-100.)

Technical training for both officers and men should include all phases of technical ammunition including explosives, ammunition components and complete rounds, and all their functions, characteristics, and properties. In addition, they should be thoroughly familiar with the weapons in service and must know which weapons will be able to fire the various types of ammunition and what the effect will be under various battle conditions. They must be able to identify all types of ammunition, components, and packings, even under blackout conditions.

It is just as important for the enlisted men to have this high standard of training as it is for the officers. Ammunition companies overseas have been able to increase their handling capacity by the use of additional labor only in those companies in which all of the men were fully qualified to give proper supervision. When the privates knew their ammunition as well as the NCO's, any man could be given a loading chit and be trusted to fill the order properly or seek help at the proper time. Each man became the equivalent of an entire squad if sufficient labor was available.

If the laborers and basics called for by the T/O are trained only as such, the company's mission will be unfulfilled under adverse conditions. Training of ammunition companies should be directed at producing a maximum number of ammunition specialists. Only by having every man an ammunition specialist will the company be able to attain and maintain the required degree of flexibility. Although there is plenty of hard labor to be done in an ammunition company, labor alone will not carry out the company's mission.

THE ORDNANCE AMMUNITION BATTALION

Mission. The mission of the ordnance ammunition battalion is to establish and operate ammunition supply installations as required. When the mission includes the operation of more than one installation, the battalion commander determines the distribution of personnel and equipment, and designates the commanding officer of each installation.

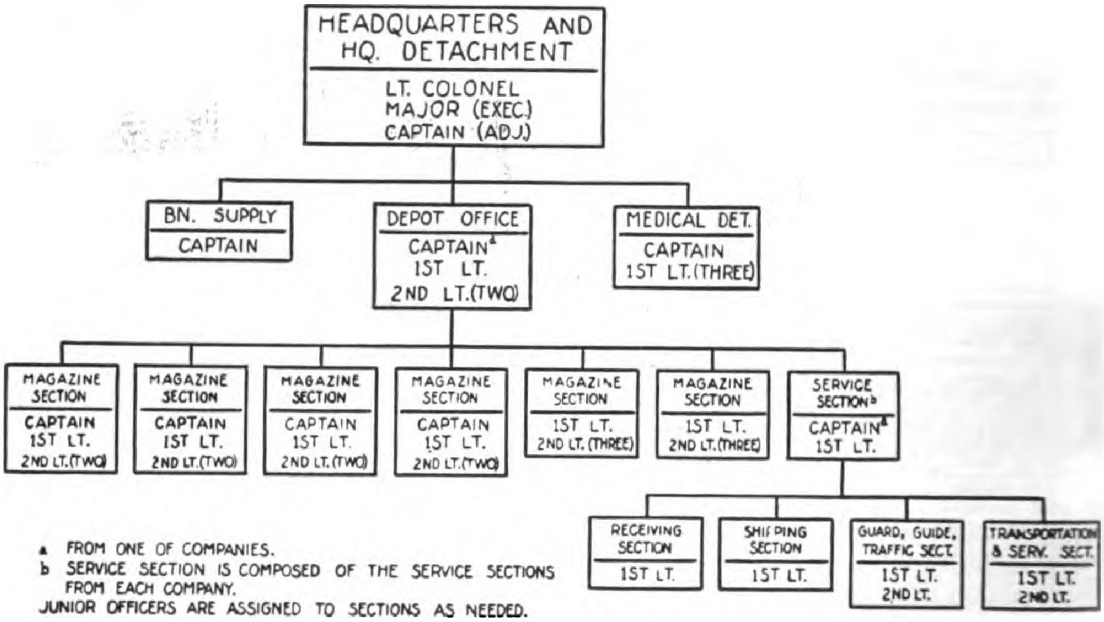


Figure 28. Ordnance Ammunition Battalion Operating One Depot.

Capabilities. The ordnance ammunition battalion is composed of 2 to 6 companies and is capable of handling 2 to 6 times as much ammunition as a single company. An ammunition battalion with all its companies could handle 3000 to 4500 tons per day or move under certain conditions

The battalion might operate one very large depot or many small ASP's depending upon the situation and the tonnages to be handled at the various installations. Any combination of depots and ASP's could be operated if the tonnage to be handled is within the capabilities of the companies involved. See "The Ordnance Ammunition Company."

Assignments. Ammunition battalions are assigned to a field army, independent corps, or task force, and to the communications zone.

Key Personnel and Section Operations. The commander of an ordnance ammunition battalion is responsible to the ordnance officer of the unit to which the battalion is assigned. These responsibilities include: Establishment and operation of ammunition supply installations assigned to the battalion. Maintenance of complete information concerning the area assigned to the battalion in order that the army ordnance officer may have immediately available all the information necessary to establish new ASP's. Close coordination with G-2 and G-4 through the army ordnance officer as to the disposition of captured enemy ammunition, and the preparation of instructions to ASP's under its control for the disposition of such ammunition, as well as lists of ammunition desired for use in captured weapons. The execution of command and administrative responsibilities.

Operations as a Unit. For a large depot of the type usually found in the communications zone, an entire ammunition battalion may be required. Figure 28 illustrates how a battalion serving an ammuunition depot may be organized, and Figure 29 illustrates a possible organization chart for a battalion operating two or

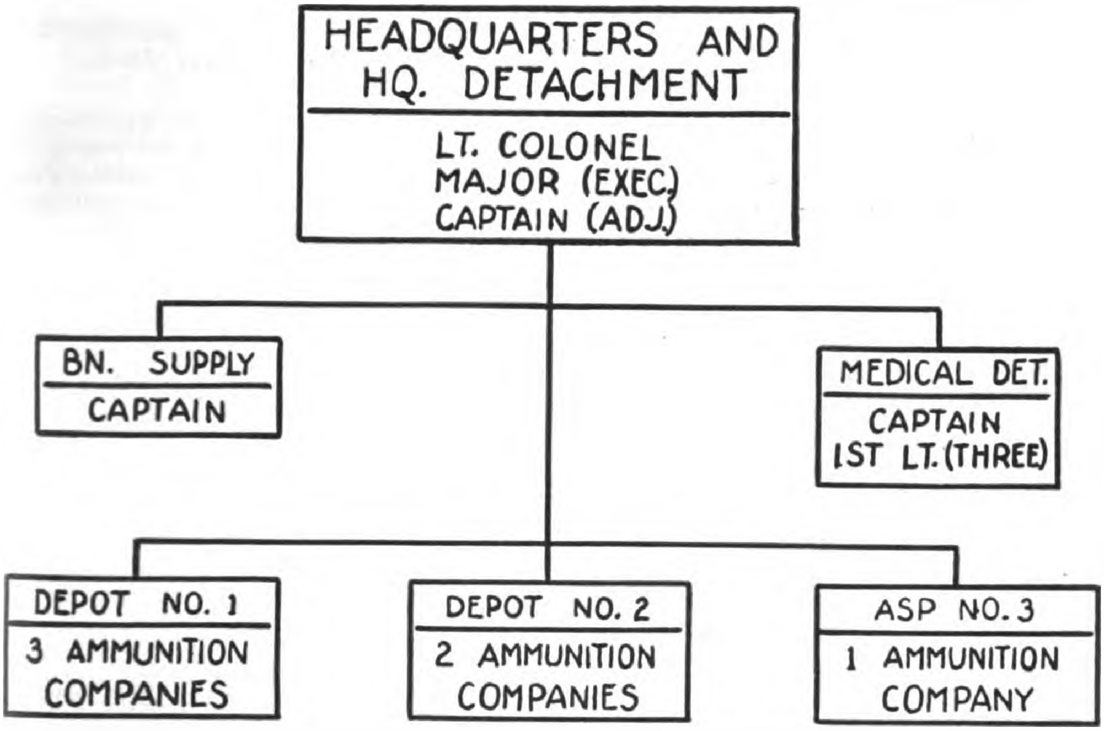


Figure 29. Ordnance Ammunition Battalion Operating Two or More ASP's or Depots.

more installations. In the fulfillment of the mission of the battalion, the installation and operation of the supply points will be effected by the companies assigned. The headquarters and headquarters detachment of the battalion will supervise and coordinate the activities of the companies and render such administrative services as may be necessary.

BATTALION HEADQUARTERS AND HEADQUARTERS DETACHMENT

The headquarters and headquarters detachment of an ammunition battalion is an administrative unit. (See T/O 9-15.) It will usually perform the following functions: Receive and transmit to the proper person or organization all orders and instructions from proper authority, issue necessary orders to subordinate units, perform such duties as are necessary in connection with personnel matters, when practicable coordinate Class I and other supply requirements of its companies with higher headquarters, arrange for the necessary transportation and other facilities required when a company or installation is moved from one site to another, in multiple operation, make a study of the possibility of, and make the necessary arrangements for, the supply of messing, transportation, and similar facilities by one company or installation to a nearby section of another company or installation, supervise the establishing and closing of depots, make such military inspections of companies as are required, make such technical inspections of depots as are deemed advisable.

Such inspections will be concerned with: General layout, conditions of storage, traffic situation, administrative procedure.

Prepare and consolidate technical reports, if required.

Military Section: The military section will perform all the normal functions of a headquarters and such other functions as may be assigned to it by the battalion commander. This section is responsible to the battalion commander for the military administration of the battalion. It will:

1. Receive and carry out the orders and policies of the commanding officer.

2. Receive and transmit to the proper person or section all orders and instructions from proper authority.

3. Issue necessary orders to subordinate units.

4. Prepare such reports from the battalion to higher authority as are required.

5. Perform such duties in connection with personnel matters as are required, that is, maintain files, conduct correspondence, and attend to other routine administrative details.

6. Prepare training programs and conduct such schools as may be practicable. These will be coordinated with the technical section, when deemed advisable.

7. Coordinate Class I and other supply requirements of its companies with higher headquarters; make any necessary arrangements with Class I and other railheads.

8. Arrange for Class I and Class III supplies for outside labor and transportation when necessary during ammunition movements.

9. Arrange for the necessary transportation and any other facilities when a company is moved from one company to a nearby section of another company.

10. In sub-ASP operation, make a study of the possibility of, and make the necessary arrangements for, the supply of messing, transportation, and similar facilities by one company to a nearby section of another company.

11. Make such military inspections of companies as are ordered by the battalion commander, these inspections to cover such matters as military training of personnel, guard, safety precautions, camouflage, sanitation, etc.

Technical Section: This section is responsible to the battalion commander for the correctness and adequacy of the technical operations of the battalion. It will:

1. Assign depot missions to ammunition companies.
2. Supervise the movement and establishment of depots.
3. Check all plans for transportation and labor.
4. Secure such additional transportation and labor as may be required.
5. Secure and forward to appropriate companies all bills of lading, train schedules, loading plans, truck movement plans, etc.
6. Make arrangements for services required in the establishment and operation of depots, such as spotting cars and moving trains, road construction, telephone installation, etc.
7. Supervise plans for traffic control and make such arrangements as may be necessary to carry out such plans.
8. Reconnoiter for and maintain a situation map showing any or all of the following: Present location of depots and ASP's, possible future location of depots and ASP's, appropriate rail sidings, and suitable road nets.

This situation map should show detailed information concerning all pertinent factors. Consolidate and post to the situation map all pertinent information received from the companies. Submit recommendations to the army ordnance officer for depot and ASP sites, when required. Recommend changes in depot and ASP sites to the army officer, when the situation makes such changes desirable. Transmit to other headquarters for concurrence schedules of issues, when such schedules are desirable and practicable. Make such technical inspections of depots as are required by the battalion commander. Such inspections will be concerned with:

General layout, conditions of storage, traffic situations, and administrative procedure. Prepare and consolidate technical reports, if required. Make arrangements with the salvage service for repossession of serviceable salvaged ammunition and repossession of serviceable salvaged components such as machine-gun belts and clips when desirable. Arrange for transmission to the rear of damaged ammunition from the companies. Prepare plans for the disposition of captured enemy ammunition. This will require coordination with G-2 and G-4 of the army through the army ordnance officer. In general, ammunition which can be used in our weapons will be reported to the army ordnance officer and may be stored in the ASP and issued to troops as required. Ammunition unsuitable for use in our own weapons will be stored pending instructions from G-2 and G-4 for its disposition. G-4 will have information as to what units of our own forces have enemy weapons and the types of these weapons, and will know where such captured ammunition can be used to best advantage.

Special Operations. Under certain conditions the Headquarters and Medical Detachments may have extra equipment and extra personnel to assist in their operations. One Battalion Headquarters in Italy procured extra equipment to enable them to operate their own mess and function independently of their companies and thus operate in a more flexible manner. Also included were 2 ¼-ton trucks to be used in maintaining proper communication and contact with the companies.

Additional personnel were added to this Battalion Headquarters by placing personnel of the various companies on Detached Service to the Headquarters Detachment for certain phases of operations. Most of the additional men were cooks, carpenters, sign painters or clerks.

The functions of both Military and Technical Sections were expanded. A special Guide and Reconnaissance Section was made responsible for the selection of all future ASP areas and for making, erecting and maintaining all necessary signs throughout the combat area so that any ASP operated by the Battalion could be easily found. In addition mimeographed sketch maps were prepared which showed locations of all ASPs and DAOs and all critical features of the roads and terrain which might have been of value in finding them. Any drivers hauling ammunition or troops drawing ammunition were given these maps upon request and they were periodically revised as new ASPs were opened.

In taking over the problem of additional civilian labor on a permanent basis the Military Section was also expanded. Food and supply of the laborers was a full-time problem for one officer and 3 men since most of this was procured by local purchase. Their pay was also a full-time job for an officer and three clerks. With 5 companies at widely separated spots it took one day at each place, one day to balance the accounts and one day to get more money from the Finance Office and to properly settle and turn in the payrolls. These additional duties were performed by officers and men on Detached Service from the Various companies.

If the Battalion is operating ASPs, the Medical Detachment will often operate an aid station or dispensary at each. This usually means that the Medical and Dental officers are also attached to the ASPs as they are available instead of all four officers remaining at the Detachment Headquarters. An ambulance is often available in lieu of or in addition to the ¾ ton weapons carrier authorized by the T/O.

The operation of a single depot or two depots by an entire battalion is the usual type of operation which will be encountered in the communications zone, see figures 28 and 29. In such a situation the battalion headquarters will supervise and guide the policies and operation of a composite Depot office which will in turn set up such Sub-Depot offices as it deems necessary for control and will also operate the magazine area with the magazine sections of whatever companies are available.

In the combat zone a Battalion will probably operate all ASPs. The Headquarters will supervise the operations of its companies which will function as complete and independent units. Each company will operate, one to three ASP's, depending on the situation. In addition the ammunition Battalion will take a vital part in executing all the details of the Army Ordnance Officer's Plan for ammunition supply. All ammunition movement, stock levels, transportation, locations and resupply then must become the responsibility of the Battalion Commander and Headquarters.

SPECIAL OPERATIONS

Amphibious Operations. The ammunition plans for amphibious operations will necessarily be based on the tactical plans of the landing teams. A full discussion of this is contained in Field Manual 31-5. It is essential that ordnance personnel be sent ashore to operate initital dumps, handle resupply of ammunition to the initial waves, and to set up ammunition depots as soon as the beachhead has been consolidated. ASP's will be established as soon as the tactical situation requires or permits them. Preliminary planning for the establishment of these

ASP's will consider the following points: designation of one or more tentative sites previously selected from study of aerial photographs or available maps of the area, reconnaissance of these tentative sites as soon as possible after the initial landing has been made. The site or sites finally selected must be readily accessible to the combat troops since road building equipment will probably not be immediately available. Island warfare or the initial phases of amphibious operations are conducted on limited terrain. The islands may be small, or the combat area may be restricted by enemy action; advance may be slow and difficult. The early stages of combat and all unloading operations will usually take place on beaches.

Combat troops going ashore will usually carry sufficient ammunition for the initial phase. Reserve ammunition will be put ashore in the latter waves. Ammunition personnel should be sent ashore with the first load of reserve ammunition.

Ship to Shore Movements. Prior to the unloading of the first load of reserve ammunition, the beachhead will have been established. Supervision by ordnance personnel is necessary during the unloading of ammunition from ships into small boats. An officer should be present to insure that the procedure is orderly and efficient and that the ammunition is not mixed.

Figure 30. Ammunition Being Properly Unloaded From Hold of Cargo Ship.

Crews of supply ships, since they form stationary targets for bombing attacks, are reluctant to stand off shore for long periods of time during unloading. Ammunition officers should, therefore, do everything in their power to expediate the unloading of ammunition from the ships and to move it quickly ashore. All available manpower should be used.

Equipment may not be available for moving ammunition from the landing boat to the beach. In the absence of roller conveyors, the ammunition is moved by the human-chain method. Under such circumstances, the correct handling technique, careful supervision of the entire procedure, and provision of rest periods are of the utmost importance. Ammunition may be palletized prior to the movement if equipment is available at the landing point for handling pallets.

When ammunition is passed by the human-chain method, the end man nearest the stack must be cautioned not to throw, or carelessly drop containers on the ground or on the stack.

When boats are unloaded by the human chain method, there is a tendency for the men to stack ammunition in piles extending toward the water. Such a practice must be checked because it causes congestion on the beach, makes succeeding landings more difficult, exposes the ammunition to enemy air bombardment and danger of damage by action of the tide.

DUKW's or other amphibious vehicles may be used and driven directly to the selected ammunition areas. Unloading from these vehicles will be a difficult task due to their height and the inaccessibility of the cargo space. In some cases roller conveyors may be used to facilitate this unloading.

Stacking on Beach. Segregation of ammunition by types should be carried out to an extent which does not impair the success of the ship-to-shore movement. Trained ammunition personnel will be able to accomplish a great amount of this without appreciable loss of time or delay in the movement.

Figure 31. Men are Unloading 155mm Shells from Barge onto the Pontoon, Somewhere in New Guinea, March 3, 1943.

Complete sorting of mixed types should be accomplished when the ammunition is placed in the storage area. Confusion will arise if unsorted ammunition is allowed to accumulate on the beach or in the storage area. Every effort should be made to keep the amount of unsorted ammunition to a minimum.

Protective Measures. One of the first protective measures to be taken by personnel after landing is to dig slit trenches in the unloading area.

During the time ammunition is being moved ashore, segregated, and stored, personnel must be prepared to deal with snipers, enemy infiltration parties, and night patrols. They must know how to carry on their normal duties without panic or disruption, and how to defend themselves as well as the ammunition supply.

Enemy aircraft will attack not only the ships unloading in the harbor, but will attack all beach installations as well. All practicable protective measures will be taken.

Storage Areas. All ammunition must be moved as soon as possible from the beach to a storage area which has been selected by the ammunition officer, as indicated in above paragraphs. Final selection is made by a reconnaissance as soon as the situation will permit.

Ammunition which arrives after the initial load may be handled in a different manner if the tactical situation warrants it. For example, if the landing force, in its advance, has been split into two or more groups, it might be advisable to locate storage areas to the rear of each of these groups. This would make supply more efficient and, in many cases, shorten the distance over which ammunition must actually be carried.

For ammunition planning on amphibious operations see "Ordnance Staffs."

ISLAND SUPPLY INSTALLATIONS AND TROPICAL STORAGE

Sites. The nature of island terrain and climatic conditions makes the selection of storage sites extremely important. It will be almost impossible to find large storage areas because of steep slopes, swamps, and stream beds subject to flash floods. Even level stretches of firm ground will become seas of mud during the rainy periods. It will frequently be necessary to stack ammunition at some distance from trails or roads, thus complicating the problem of handling. Terrain should be studied continually, however, with the idea of relocating stacks so that they will be nearer to roads and paths.

Rain: A short, heavy, rainfall may be expected daily on many tropical islands. At some seasons of the year the rainfall is both heavy and prolonged through many days. At such time, streams, normally two feet deep, will rise to ten or twelve feet overnight. These flash floods are not infrequent and should be kept in mind when choosing sites for ammunition storage.

Heat and moisture: In the tropics, heat is a constant factor to be considered. Rain followed by intense sunlight, the presence of swamps, and the thickness of jungle growth combine with the heat to produce conditions of humidity and moisture seldom experienced before by many of the army personnel.

Storage Problems. Surveillance must be continuous and thorough. Moisture, temperature, and salt water cause extensive deterioration, which must be detected immediately and counteracted. Conditions of storage and climate make it imperative that a thorough check of all ammunition be made daily. Good sites and adequate dunnage will normally prevent stacks of ammunition from sinking into the ground. Stacks that have settled into wet ground or have become unstable must be restacked. All containers should be examined and damaged containers should be repaired. Lack of dunnage has caused considerable quantities of ammunition to become unserviceable in several of our island campaigns.

Protection of containers. Ammunition must be protected from moisture and sunlight as much as possible. Tarpaulins should be suspended over stacks, leaving room for the circulation of the air. Palm leaves are valuable rain shedders when spread on stacks of ammunition.

ASP commanders should make strong representation for the inclusion of dunnage with the ammunition load aboard cargo ships. If no dunnage is received, and ASP personnel are forced to provide it themselves and they may be faced with a very serious problem. There may be no large or suitable growth of trees near the beaches, and in many cases it will be impossible to cut down the quantity of timber required, without seriously jeopardizing camouflage.

Climatic conditions and presence of termites make it imperative that ammunition should not be allowed to remain on the bare ground more than a minimum of time before being stacked on dunnage. Stunted trees are most suitable, since their removal will least disturb the aerial pattern. Where timber is unprocurable, dunnage must be improvised from native growth or stones. If empty small arms boxes or fiber containers are available, they can be filled with earth and used as the foundations of stacks. If ammunition is to be entrenched, jungle undergrowth and the lower branches of trees will frequently provide sufficient dunnage.

Corrosion, mold, and rust will collect on opened ammunition even in a day's time, and must be removed. It will also be necessary to assign personnel every day to the task of delinking, cleaning and relinking metal-link machine gun belts.

When beachheads and storage areas are subject to frequent bombing, it may be necessary to entrench ammunition. Artillery ammunition should be buried deeply, and the trenches either drained or provided with duckboards. No more than 50 rounds of 75mm or 105mm ammunition should be put in one trench.

Supply to Combat Troops. In island warfare, the function of the ammunition supply installation is at times much different from functions performed by the same type of installation in continental warfare. The supply installation is near the enemy; this fact requires a change in its methods and procedures. The supply installation may not only receive and issue, it may also deliver ammunition to the combat troops at the gun positions. In some cases, supplies will move directly from beachhead to weapon. Records should be few and simple.

During the early phases of fighting in island warfare, much of the action may take place at night. The enemy counterattacks usually at night; this means that the bulk of the ammunition will be brought forward during the day.

Figure 32. Removing Ammunition from the Beach.

Ammunition may be expended in excess of estimates, and fresh supplies will have to be delivered at night to the crucial area. The difficulties of transporting ammunition at night over island terrain can be met in a variety of ways. An ammunition officer should insist that his noncommissioned officers be familiar with the combat area. They can then be assigned to guide and command ammunition carriers moving between the dumps and the combat units. Ammunition carriers must be warned of the importance of correct handling under such conditions. When forwarding ammunition in an emergency, it will frequently be advisable to send an advance party with a light load of ammunition, as a stop gap. A party with a regular load can then follow, taking more time. As ammunition parties approach the forward areas, vigilant watch must be kept for enemy patrols and precautions taken so that friendly troops are not mistaken for the enemy and fired upon. Combat units should be requested to provide guides for ammunition parties, particularly in cases where such units are shifting their positions.

Ammunition is, of necessity, heavy and bulky. The weight and bulkiness of ammunition are factors of particular significance in island warfare, inasmuch as ammunition will, for the most part, be handled and moved entirely by hand. Every effort should be made to maintain the efficiency of ammunition personnel.

Harnesses, litters, slings, and other devices should be made available to the men so that this equipment can be used to conserve energy whenever possible. In forward areas, where ammunition must be man-handled over long distances, relay stations should be established to allow ammunition carriers a short haul and a short unburdened walk.

A system of rotating labor shifts, designed to prevent the overtaxing of personnel, will help to reduce casualties as well as damage to ammunition containers resulting from careless handling.

Roller conveyors can be used to great advantage if available. In initial operations it can be used in unloading or in moving the ammunition off the beach to its more permanent storage area. It can also be used in sorting mixed ammunition.

Transportation. In island warfare, the site of the ammunition supply installation may be no more than 1,000 yards from the forward fighting lines and is frequently less. Transportation is not usually available until after a position has been consolidated, and even then may not be suitable for hauling large quantities of ammunition. The terrain of many islands limits motor transportation to use of ¾-ton and ¼-ton trucks with trailers.

Figure 33. Ammunition Storage in Cold Climate.

It is the responsibility of the organization ammunition officer to make certain that ammunition arrives where it is needed on time and in serviceable conditiion despite obstacles imposed by climate and terrain. In island warfare, such obstacles are frequently encountered. In order to meet and overcome these conditions successfully, ammunition personnel must receive the most thorough and careful training possible.

Training in the proper use of harnesses and slings should be given to ammunition handlers. The carrying of ammunition will thus be simplified and made less burdensome. Men using harness will also be able to defend themselves more easily and quickly against enemy attack.

Snipers. Ammunition carriers are vulnerable to attacks by snipers. If it is known that snipers, or other troops are in the areas through which carriers must pass, armed guards should accompany ammunition parties. Wherever possible, carriers should also be armed.

Care of Ammunition. Personnel of the ammunition supply installation should inform using troops of the proper methods of caring for ammunition in extreme climates. Gun crews will seldom need all the ammunition with which they are supplied for a night's firing; if all of it is exposed ready for firing, the unused rounds will be unserviceable in the morning.

STORAGE IN COLD CLIMATES

Ammunition stacked in the open should be kept well off the ground by use of dunnage. Bottom dunnage should be designed to prevent the stack from sinking into thaw-softened ground, and should be high enough to allow surface water to flow under the stack without wetting the ammunition. Stacks should be covered to keep out snow and water. In regions where high winds occur, the covering must be securely fastened at all points to prevent damage.

If huts or similar shelters are used for storage, the floors must be designed for easy drainage, and dunnage must be provided.

Ventilation of stacks and huts must be maintained to reduce condensation.

If available, stone or gravel should be used liberally for construction of roads. Culverts should be provided for cross-drainage to avoid washouts during thaws. Stacking of ammunition on frozen ground away from well-ballasted roads must be avoided, as sudden thaws may isolate the ammunition.

Thaws will usually be accompanied by a considerable quantity of surface water. The layout must provide drainage for this water. This condition may also result in the formation of temporary ponds or even lakes. Therefore, depressions where surface water might accumulate must be avoided in locating roads and stacks.

All special measures which will be taken are aimed at keeping the ammunition containers in good shape and the protection of the ammunition and containers from the elements. The ammunition should not be allowed to freeze into the ground. The cold itself should cause no serious difficulty if the ammunition containers hold up and thus properly protect the ammunition.

DESERT STORAGE

Cover rarely exists in the desert. Isolated groups of cover are conspicuous, and will invite special attention from the enemy. Roads are seldom necessary in desert ammunition storage areas, as the only limiting factor for transportation is the presence of sand or rocks. Open storage is therefore the rule, and camouflage and dispersion are all important.

Shadows and regular shapes and patterns are most conspicuous in the desert. They must be avoided by the use of sloping traverses or small irregular stacks, and avoidance of regular lines and rows. Typical means of camouflage are:

In flat scrubby country, low irregular stacks may be covered by brush or stone, and small pyramidal stacks may be garnished to resemble bushes.

In broken, stone-littered country, low irregular stacks are surrounded and covered with stone, or containers are painted stone color.

Every effort should be made to protect the ammunition from the direct rays of the sun. Tarpaulins should be used wherever available if there is no other cover. If a choice exists as to what should be covered, rockets should be covered first. Smoke shells must not be exposed to the hot sun if they are out of their containers. Several fires have occurred in North Africa as a result of smoke shells lying in the hot sun, although there has been little difficulty encountered when they have been left in their original containers.

Work during the heat of the day will probably be confined only to those very necessary issues or receipts. To conserve manpower and raise the efficiency of the men, sorting or restacking should be carried out only in the early morning or late afternoon while it is relatively cool.

Demolition work in the desert should not be attempted during the heat of the day. Accidents occurred in North Africa which were attributed to heat alone. All work should be done during the very early morning.

The dust will be very heavy and very annoying to all personnel, but if a stack of ammunition is allowed to stand for 2 or 3 days, the dust covering will make it blend in with the surrounding landscape. Judicious use of a shovel will often speed up this natural process.

Desert warfare is often very fluid and fast-moving with little definition between friendly and enemy forces. All security measures must be undertaken, since the ammunition installation might be subjected to local attack upon short notice.

Dispersion of the ammunition may often far exceed the quantity-distances prescribed by TC 47, and the installation will be spread over a very large area. Such a large area may make operation and control difficult.

SPECIAL SITUATIONS AND FIELD EXPEDIENTS

Relocation and Evacuation of Site. Because of the tonnage and transportation involved, ASP stocks in general will not be moved. The usual procedure is the opening of another ASP at a new site, accompanied by depletion of the stocks of the old ASP by issues to troops as required. The new ASP may be operated by personnel from the same organization who operated the old ASP, or a different unit may be assigned to it. The new ASP should be opened before the old ASP is completely closed out.

In an advance, it may be desirable to retain the old ASP as a base or intermediate installation. The procedure in this case will depend upon the situation and will be determined by the army ordnance officer. In a retirement, however, it may not be possible to close out the old ASP. In such a situation all available transportation will probably be used in moving troops and equipment and will not be available for moving ammunition.

The presence of enemy troops in the vicinity and the imminent capture of the ASP by them does not necessarily call for destruction of the ASP. If the operation is only a raid, the enemy will have neither the time to accomplish complete destruction of the ammunition nor the transportation to carry it off. The decision for destruction rests with the army commander and should not be carried out without his orders unless communication with him is impossible. In this latter situation, the decision must be made by the senior ordnance officer present.

Destruction of Ammunition to Prevent Capture. When it has been determined by the army ordnance officer or higher authority that destruction of an ASP is advisable to prevent its capture, no time must be lost in execution of the plan for the actual operation. Such plan should be prepared as soon as a site is occupied, and all personnel should be familiar with it. The chief factor to be considered is the time for preparations. Normally, when it has been decided that an ASP must be destroyed, there will be no time for extensive preparations for the destruction. First considerations are the safety and evacuation of equipment and personnel, and the warning of friendly troops. If additional time is available, the following preparations should be made:

Chemical ammunition filled with poisonous or toxic gases should be evacuated if possible. If not evacuated, this ammunition will never be destroyed without specific orders from the theater commander. Destruction of this ammunition will contaminate the area and if gas is not already in use in the theater, such action might be the basis for a claim by the enemy that its use had been initiated by our troops.

Items which burn or explode easily should be mixed with other items requiring an initiator. Propelling charges may be opened and the powder spread on containers of small arms ammunition, minor caliber fixed artillery ammunition, and opened containers of propelling charges, semi-fixed ammunition, grenades, and rockets. Gasoline or oil may be poured on containers of the same types of ammunition.

Demolition blocks, if available, should be placed against medium and large caliber shell and should, if possible, be fused for delayed detonation. All equipment not actually being used in destruction operations should be evacuated to the rear, when possible. Friendly troops in positions near the ASP must be notified in advance of the proposed destruction, and actual demolition must be restrained until such troops and ASP personnel are safe.

The following methods of destruction are listed in order of preference from the standpoint of safety to all concerned and for the completeness of destruction:

Fire, explosion, or a combination of these methods may be used by ASP personnel. Fuses should be prepared with sufficient delay to permit retirement of personnel to a minimum distance of 200 yards for small arms ammunition destruction and 1,000 yards for large caliber shell. Miner's fuse, if available, is the best source of delay. Thin trails of oil, smokeless powder, or other inflammable substances may be used as fuses, but the rate of burning must be considered and a sufficient length of trail must be made to permit the required delay. In this connection, used motor oil may be stored in a safe place and retained for this purpose. Trails of inflammable substances should be laid in such a way that they will burn up wind. Under no circumstances should black powder be used for this purpose as its rate of burning is much too rapid for use as a delay element.

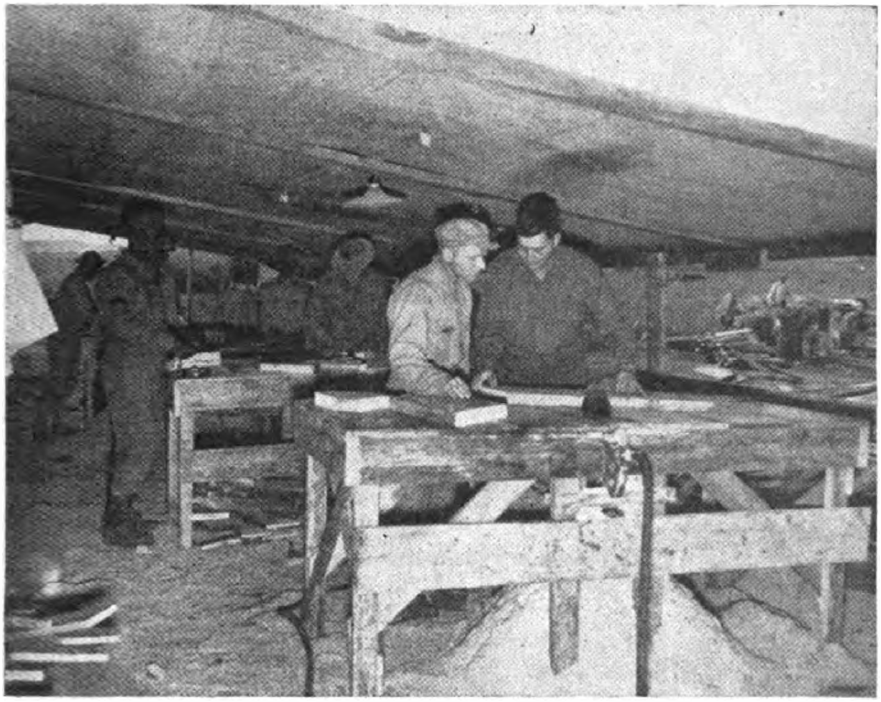


Figure 34. Set-up for Manufacturing Ammunition Crates.

Friendly artillery, if emplaced to the rear or flank of the ammunition area, may be called upon to lay down a barrage on the installation.

Infantry may be called upon for mortar fire concentrated on the area. They should be notified in time to determine the quantities of ammunition they will require for the operation. This quantity can be removed from the ASP and placed on a road to be used by the infantry. This will relieve the infantry of the necessity of reserving and transporting their own ammunition for the destruction.

Modification and Packaging of Ammunition. An excellent example of field improvisation is the crating and marking of 150,000 clover leaf bundles of 105mm howitzer ammunition. This job was done by an ammunition company and, despite a very short allotment of time, work was completed several weeks ahead of schedule. The accomplishment can be fully appreciated by anyone acquainted with the tools and equipment of an ammunition company. To accomplish this job, lumber, power saws, nails, stain, stencils, stencil paint, sprayer, wire, wire strapping machines, good old American ingenuity, and the resourcefulness and cooperation of the entire company were required. During peak production 12,500 units were completed per day. This meant 12,500 crates manufactured, the bundles inserted into these crates, the crates stained, marked, and wire bound. The educational value of this job lies in an appreciation of the planning and ingenuity that went into it.

Lumber and power saws were obtained from the Engineers; painting materials, spray guns, etc., from the Quartermaster. The saws were set up so that the entire operation could be accomplished with assembly line efficiency. In the first set-up the crates were stained after they had been built. As this was found to be too slow, staining became part of the assembly line operation. At the particular point in the assembly line where the lumber had been cut to the proper sizes and shapes, the conveyer line was broken and the boards tumbled into a large oil drum cut in half to form a vat which contained the staining material. Thus the boards rolled off the conveyer into the vat. These boards were then removed from the vat and replaced on the roller conveyer. The stain was also improvised. The main purpose of the stain was to darken the wood. In the absence of a standard paint or stain, gasoline mixed with tar was used in proportions of 100 to 1, 50 gallons of gasoline to ½ gallon of tar (as much as 600 gallons of gasoline were used in a single day), these materials being obtained from the Quartermaster.

The marking on the crates became the next problem. Stencils and stencil cutters were available but no sprayers. A call on the Quartermaster resulted in the acquisition of a number of flit guns and these, in the absence of a standard sprayer, permitted the job to roll on with no loss in production. One additional problem resulted from the lack of wire strapping material. Round steel wire was used in its place, one loop around each end of the bundle. It later developed that this wire wrapping was not strong enough, many of the wires breaking during shipment. It was felt that a double wrapping at each end would have successfully completed the job.

The steps in the completed operation were, first, the stripping of the boards to the proper width. These boards traveled on roller conveyers to other saws that cut them to the proper lengths and sizes. Roller conveyers then carried the boards to the staining vat, operated by one man who removed the boards, a handful at a time, and placed them on the roller conveyer to continue their trip to the classification bins. Here the boards of the various shapes and sizes were removed from the conveyor and placed in their proper bins. This completed the first phase of the operation. We now had a number of boards of the proper size, shape, and already stained. At a number of long tables the crates were assembled, all but the two side boards. A number of men were used to keep a supply of boards available at the assembly table. The partially finished crates were then stacked ready for removal to the bundle crating area. The third phase was the insertion of the bundles into the partially finished crates followed by the nailing of the two side strips which were obtained from the classification bins. We now had the crated bundle. The next step was the stenciling of the proper identification data. This was done, as has been mentioned before, by the use of a flit gun, a very satisfactory way of marking projectiles, crates, boards, or boxes. The final step was the wire wrapping. The finished crate was then ready for shipment.

This was a single job, yet the ingenuity and resourcefulness required for its successful completion have been duplicated many times by ammunition units operating in all theaters. The stain and the spray guns are tips well worth remembering. But more important is the challenge of achievement in spite of the absence of tools and blueprints.

Another example of devising ways and means to do a job arose from a well-nigh impossible assignment. Thousands of unpainted boxes and crates, suitable for use in desert operations, but entirely too light in color for use in terrain with much vegetation, had to be stained O.D. The ammunition personnel operating the depot where this stock was located had also to conduct their regular business of receiving and issuing ammunition. Obviously, therefore, the staining could not be done stack by stack. Flit guns and sprayers were resorted to and as soon as notice was received of a shipment due out, crews would head for the stacks of ammunition involved and, with a fifteen crate or bundle lead, were able to keep ahead of the loading crews. The paint had to be thin so as not to make the markings illegible and also so as to permit rapid drying because of the immediate handling. Extracurricular tasks such as these are not difficult in themselves, but they require American resourcefulness and organizing ability to make efficient use of the materials and men available.

Repainting and marking of separate loading projectiles is an ever recurring job in ammunition installations in the field. No doubt every ammunition company has a story to tell in this regard. Rotary tables have been built, running the gamut from simple mechanical devices to elaborate power operated contrivances capable of mass production. Again the flit gun has been the answer to the stencilling problem. A faster, more efficient job can be done with a spray than with a brush and stencil paint.

Another renovation job which somewhat taxed the ingenuity of an ammunition company was the request made of them to provide 3-inch HE shells with a smoke (HC) spotting charge. This request was made because the artillery observers were unable to spot the shell impact area as completely as desired. To accomplish this aim, the ammunition company adopted the following technique. The fuze was removed, the booster was removed, and the TNT was bevelled out by approximately a one and one half (1½) inch cutting tool to a depth of about 3 inches. The excess TNT dust was then blown out by air pressure and the HC smoke was tamped in. A hammer handle and mallet were used for tamping in the HC smoke. The next operation was to replace the booster and fuze in the shell.

The best method of accomplishing this operation was by the establishment of an assembly-line process:

Boxes containing shells were opened.

Rounds were removed from boxes and fiber containers.

"Smoke" was added to the nomenclature of the shell by stencilling.

Fuzes were removed from the shells.

Boosters were removed from the shells.

One and a half inch cutting tools were used to bevel out the TNT to a depth of about 3 inches.

TNT dust was blown out by air pressure.

HC smoke was tamped in by means of a hammer handle and a mallet.

Boosters were replaced in the shells.

Fuzes were replaced in the shells.

Rounds were placed in the fiber containers and boxed.

This type of renovation job can be adapted for all sizes and types of ammunition. Also, the renovation line, as outlined, can be set up in any building or area when necessary.

Demolition Expedients. In the demolition of duds or of large quantities of unserviceable ammunition there are many expedients that have been used. Perhaps the most satisfactory means of disposing of large quantities of ammunition is to dump them at sea. If the proper spot is selected, the dumping ends all further problems and eliminates much handling as well as being the safest method.

Destruction of large quantities has been carried out in many instances during overseas operations. The procedure one company used was as follows:

Several pits about 15 feet deep were blown with unserviceable mines, set off by a small TNT charge, and these were used for subsequent detonations. Unserviceable ammunition in quantities of one to ten tons was loaded into the pit and covered with mines about 3 layers thick—usually around 200 to 300 mines, depending on the type. The pit was then set off with an electric blasting machine from the safety of a hole about 200 yards away. Pits were never loaded immediately after any blast or burning because of the risks involved. There were usually enough pits so that 2 or 3 days would elapse before the same hole was used again.

Small arms ammunition was burned in the same pits. When the pits became 30 feet deep or more due to several blasts they were loaded with small arms ammunition, scrap wood, unserviceable propelling charges and any other inflammable substance available and the entire contents would be ignited and burned. A long smokeless powder train as an igniter allowed the personnel involved to reach a place of safety.

Other destruction expedients include:

155mm shells. Shaped charge from an M9 rifle grenade.

General purpose bombs. Remove the nose plug and insert composition C plus two blasting caps.

Fuzes. Wrap primacord around the fuzes.

Mines. Four to six blasting caps taped together and placed in the fuze well. Usually mines are a good source of TNT to be used for other demolition and will be destroyed by themselves only if so damaged as to be dangerous.

Hand grenades, detonators, blasting caps, smoke pots. Burn in deep pit with unserviceable smokeless powder.

Many of the special jobs which will be assigned to the ammunition company from time to time will be something new and different. The preceding examples have been included to illustrate tasks which have been given to ammunition companies in the past. The indicated solutions may suggest probable answers to the problems which will arise in the future.

CHAPTER 5

ORDNANCE GENERAL SUPPLY

Throughout the services during World War II more attention has been accorded supply, its relation to speedy victory, and its inseparable nature in the logistics of modern warfare than for any prior time or campaign in our history. Continuing War Department traditional policies, supply consciousness has been impressed repeatedly upon all military personnel from private to general. Properly speaking however, supply discipline is one element of, and reflects the status of, overall discipline, which in command is the fixed responsibility of every commissioned officer.

During First U. S. Army operations in France, Lieut. General Omar N. Bradley issued "Notes on Supply Discipline." As you read General Bradley's supply directive which follows, bear in mind that each officer of the First U. S. Army received a copy addressed to him personally.

Today, considerable emphasis is given to actually pushing supply service right up to the 'door step' of the using units—particularly those units in combat. Likewise, stock identification and full use of the ASF Catalog are technical functions of high priority in the field supply officer's 'must' list. In consequence, new publications and forms are tied-in to former Ordnance publications and War Department forms since many of these are still widely used in the field.

The data in this chapter is intended to assist supply officers with maintenance organizations, those engaged in ordnance general supply at depots, and in planning sections on Ordnance staffs. Field commanders have followed somewhat different supply operating plans in overseas operations according to problems peculiar to their areas. Although appreciable latitude, in this respect, is provided by existing manuals and directives, such plans frequently vary widely from policies established by the War Department. Therefore, in the sections following, wherein supply principles, stock control, and the operations of communication zone and field depots are discussed, the object is to present the basic elements in working plans which were derived from experiences of officers operating Ordnance General Supply in the various theaters of operation. Much of the debatable supply doctrine herein is taken from a current project of the Ordnance Department Board, which, it is hoped, will establish uniform policies and procedures for Ordnance General Supply in the communications and combat zones. Irrespective of the specific plan followed, officers must always keep in mind that the mission of Ordnance service in the field is to insure that our fighting forces have serviceable weapons, tanks, trucks, spare parts, and other materiel in the right place when needed.

CLASSIFICATION, PROCUREMENT AND FLOW OF SUPPLIES

All property is classified as *property real* or *supplies* and comprises all items procured from funds appropriated by Congress:

Real property consists of fixed and immobile things, such as lands, buildings, roads, docks, and other structures and moveable objects, such as equipment, apparatus, machinery, and fixtures which have been permanently placed or incorporated into real property. Such property is carried on *Real Property Records,* maintained by Post Engineers.

Supplies consist of raw materials, commodities, unit assemblages, and units of equipment which are procured, stored, and issued for the Army. Supplies are divided into two classifications:

1. *Expendable supplies* are materials which are consumed, or which lose their identity as a result of permanent incorporation in, or attachment to real property or other supplies.

2. *Non-expendable supplies* are materials which retain their identity over a prolonged period of time and are worn out rather than consumed in the public service.

Classification. Supplies are grouped in five classes which, in FM 100-10, are defined as follows:

HEADQUARTERS
FIRST UNITED STATES ARMY

To: ....

"A UNIT CAN GO ONLY AS FAR AS ITS SUPPLIES WILL ALLOW"

I desire that you study and remember these

NOTES ON *SUPPLY DISCIPLINE*

and use your influence and example to instill in every man the habit of

CONSERVING SAFEGUARDING MAINTAINING SALVAGING

food, clothing, weapons, fuel, motor transportation, materiel and supplies of all kinds.

O. N. Bradley

Lieut.-General, U.S.A. Commanding.

GENERAL

1. No plan of operations, however good, will succeed unless administration has been emphasized from the start. Supply Discipline goes hand in hand with military discipline.

2. The production of our equipment involves enormous efforts on the part of workers in our homes in the United States and United Kingdom and it all has to be transported across seas at great risk to our seamen and ships.

3. In any operation, transportation, whether by sea, rail, motor vehicle or air, will never be adequate to meet all our requirements.

TO REQUEST MORE THAN YOU NEED IS INEFFICIENT

TO WASTE WHAT YOU HAVE IS SABOTAGE.

TRAINING

1. The training of the individual in Supply Discipline is as important as any other form of training. Your training program will set aside regular periods for this. Prepare what you have to say, your demonstrations, your practical work, as you would for any other training. The support of the men must be won. Ingenuity will be required. Emphasize protecting property in guard duty. Remind each man that he is a taxpayer, quoting prices.

2. a. Food. It is a standing order of the ETO that no one should help himself to more food than he needs nor leave any on his plate. Greases and bones are used in manufacturing explosives; teach your men the various uses for which garbage is saved.

b. Clothing. Impress your men that a "stitch in time saves nine," and that laundering of socks, fatigues, etc., increases the life as well as the cleanliness of clothing. In battle it is more important to use transportation for ammunition than clothing.

c. Weapons. Teach your men that "for want of a nail a horse can be lost" and that in combat a missing rifle part means not loss of pay or K.P. but immobilization of a weapon.

d. Fuel. Train all handlers of gasoline and oil to avoid spilling a drop when making transfers.

e. Motor Vehicles. Have your drivers do 1st echelon maintenance at stops and periods of waiting instead of only at "motor stables." As long as 1st and 2d echelon maintenance is kept up, our vehicles will keep rolling.

f. Hygiene and Sanitation. Get your men to observe the principles instinctively. The best fighter is no good if he gets sick; unnecessary sickness must be avoided.

3. Administrative directives are not the sole concern of the supply services. Learn about their contents yourself.

IT IS NOT SUFFICIENT TO HAVE A GOOD "S-4" OR SUPPLY SERGEANT – EVERY MAN MUST BE SOMETHING OF AN S-4 OR SUPPLY SERGEANT HIMSELF.

IN COMBAT

1. The hoarding of supplies and equipment by individuals results in overloading of vehicles and undue wear and eventual breakdown of transportation.

2. The throwing away of prescribed equipment by individuals to lighten personal loads involves resupply at a later date and unnecessary demands on transportation. To prevent this, give thought to confining personal loads to what is necessary for the mission.

3. The formation of unauthorized reserves and dumps at battery and other positions will result in shortages of supplies where most needed.

4. To abandon a supply of ammunition however small may be equivalent to disarming yourself or your fellow-soldiers at a later date.

5. Vehicles, tools and spare parts are always short of demand. Units which retain more than they are entitled to prevent the speedy re-equipment of other units.

6. Cannibalization of tanks and vehicles prevents these tanks and vehicles from becoming quickly available as replacements and disorganizes repair and replacement services.

7. There must be no unnecessary use of transportation.

8. Gasoline and oil represent a very large percentage of tonnage to be moved. Trucks and vehicles cannot advance a yard without it. Uneconomical use and spilling is sabotage.

9. It is of the utmost importance that damaged valuable equipment such as Radio Sets, Weapons and Spare Parts be salvaged for repair and reissue. New stocks cannot be provided in sufficient quantities without the assistance of efficient salvage.

10. It is important that captured enemy material and supplies of all sorts be reported and brought under centralized control, intact, without pilfering or cannibalization. Such supplies may prove the greatest value in assisting planning and speeding an advance.

11. Administration must win the confidence of troops by its efficiency. Organizations and Units, on their side, must show confidence in their administrative service. Then there can be no excuse for the forming of unauthorized reserves and dumps, holding of excess equipment and hoarding and overloading of vehicles.

NO MATTER HOW HARD THE FIGHTING, OUR BATTLES WILL NOT BE WON WITHOUT GOOD SUPPLY DISCIPLINE.

Figure 1. Notes on Supply Discipline.

Class I. Those articles which are consumed at an approximately uniform daily rate irrespective of combat operations or terrain and which do not necessitate special adaptions to meet individual requirements. Examples: Food, forage, and water.

Class II. Those authorized articles not included in Class IV, for which allowances are established by tables of basic allowances, tables of allowances, and tables of equipment. Examples: Rifles, pistols, wacthes, trucks, clothing, camouflage nets, first aid kits and gas masks. (Tables of equipment prescribe that for further allowances of supplies, spare parts, components of sets and kits, etc., other publications, such as the ASF Catalog must be consulted. In this regard, since ORD 7 and 8 of the catalog apply, the SNL's are thus properly considered authorization for allowance of Class II supplies. No 'fine line' is usually drawn for differentiating Ordnance general supplies as groups in either Class II or IV).

Class III. Fuels and lubricants for all purposes except aviation, including gasoline for all vehicles, Diesel oil, fuel oil and coal.

Class III(A). Aviation fuels and lubrication.

Class IV. Supplies and equipment for which allowances are not prescribed, or which require special measures of control and are not otherwise classified. (Normally such supplies include items not specifically listed in tables of organization and equipment, tables of basic allowance, and tables of allowances. Example: maintenance spare parts and assemblies, and supplies for care and preservation not included in class II).

Class IV(E). Complete airplanes, airplane equipment, spare parts and supplies required to maintain the complete airplane in commission.

*Class V. Ammunition, pyrotechnics, antitank mines, and **chemicals.***

PROCUREMENT OF SUPPLIES—ZONE OF INTERIOR

Class I. Ration requirements of the organization are submitted daily as an estimate of needs three days prior to issue. The quartermaster is then enabled to consolidate demands and order sufficient stocks to meet day-to-day ration issues. Class I stocks generally are procured by the QM from local contractor's bids or bulk transfers of both perishable and non-perishable stores from central distribution points.

Class II and IV. The reader is referred to the Requisitioning Procedure Section of this chapter. Reference: Volume I Chapter 2, Administration.

Class III. Normally organizations submit monthly reports on estimated 30 day requirements of fuels and lubricants based upon past experience, contemplated operation needs and the authorized vehicles on hand. The quartermaster consolidates all requirements for units supplied, adding a safety reserve thereto to avert shortage. Vehicle operators are issued fuel and lubricants at post service stations as needed, signing a hand receipt therefor. Unit motor officers maintain consumption records to enable the commanding officer to plan and report activity in Class III supply.

Special oils and lubricants for maintaining Ordnance material are procured in the same manner as Ordnance General Supplies.

Class V. Ammunition supply is a command function. Several procurement plans are used, in one of which unit commanders submit an ammunition requirement report to the post commander. The quantities cited are based upon needs for training and will show the type and number of weapons to be fired and ammunition on hand and expended since the previous reporting period. Such reports of various units on the post are consolidated by S-3 and are submitted to the Post Ordnance officer for initiation of procurement, or in some cases directly to the Service Command for approval. In either event, the approved quantities of ammunition are shipped to the Post Ordnance depot from an arsenal, or other Ordnance Supply Point. Ammunition credits to the various units concerned are established at the Ordnance office and are based upon training requirements established by S-3. The method of storage procedure for ammunition is discussed in Chapter 9 of this volume. The organization will draw ammunition upon credits thus established. In certain plans of Class V operation ammunition credits for specific organizations or posts are established by the Service Command and notification thereof is transmitted to the post commander. The latter plan is used for Armies, divisions and large training centers in the service command.

PROCUREMENT OF SUPPLIES—THEATERS OF OPERATION

Supply planning plays a large part in procurement procedures for theaters of operation. Requirements necessarily will be anticipated well in advance, making adequate allowances for proposed tactical operations, time required for delivery of the materiel on requisition (turn-around time), previous supply consumption experience, special needs where applicable, and the effect of climatic changes during the period in which use of the supplies is contemplated. Generally, theater requirements are consolidated by the special staff officers concerned at Service of Supply Headquarters. From the staff estimate, and based upon experience, a 'slate' listing complete description data tor each item and separately submitted for each class of supply is prepared and forwarded for supply to the commanding officer of the post of embarkation concerned. Since, in this chapter, we are primarily concerned with Ordnance Class II and IV supplies, and a reasonable treatment of the other classes is not within the scope of this text, Ordnance general supplies only are considered below.

Ordnance Class I and IV Supply Procurement in Theaters of Operation.

Theater ordnance officers obtain periodic stores replenishment requisitions, broken down into SNL groups for armament and delete automotive parts, from the various communications. Zone depots within the theaters. In one operation plan such data is furnished on a modified stores report which in addition to required stock also shows: stock levels; receipt and issues resulting from action on requisitions filled or stock received from turn-ins and depot transfer; dues-in and dues-out. In the general supply section of the theater Ordnance office the various depots' requirements are consolidated on a single requisition and periodically forwarded to the port of embarkation.

Since parts and major items consumption rates are frequently not available from any other source to the Ordnance oversea supply officer at the port of embarkation, it has been found highly advantageous to show directly on theater requisitions issues based upon definite periods of time. The latter is further augmented by an attached break-down list showing the quantities of major items on hand in use and hence gives an excellent supply consumption figure. That phase of zone of interior procurement planning as concerns overseas operations experience may well start with requisitions received from theater of operations.

PROCUREMENT OF SUPPLIES—COMBAT ZONE

Class I. Units draw rations from the Class I depot designated in their administrative orders. Normally a ration strength report on short form is submitted daily by each unit commander for organizations authorized to draw directly from the DP (distribution point). In a battalion set-up, S-4 consolidates Class I requirements based upon morning report data and draws rations for the entire organization. In the latter case a DP is organized in the battalion area where rations are broken down and issued daily to the various units of the battalion. In both types of operation, *i. e.*, units drawing rations separately or through battalion headquarters, issues are made to and receipted for by the mess sergeant.

Class II and IV. Reference: Requisitioning Procedures Section which follows in this chapter.

Class III. The judicious consumption of fuel and lubricants in the combat zone is a responsibility of command. In many situations Class III consumption reports will be compiled by QM gas supply companies operating field SP's rather than using arms and services. Quantities sufficient for weekly needs are normally drawn on a direct-exchange 'full-for-empty' container basis from the Class III SP. Lubricant may be drawn either on requisition or on a request receipted for at the time of issue.

Class V. Reference: Chapter 4, Ammunition Supply.

FLOW OF ORDNANCE SUPPLIES—ZONE OF INTERIOR

Supplies properly originate at their point of production, that vast structure of manufacturing plants and concerns which constitute the industrial facilities of the United States of America. Here, in the Ordnance Field Guide, we are not primarily concerned with the design, development, government contracting and production control procedures which precede the actual movement of supplies from manufacturing establishments into the chain of depots which will ultimately deliver literally millions of different items to using arms and services operating in combat missions in foreign theaters throughout the world. A chart listing Ordnance Department Basic Procedure is furnished in the pocket at the back of this volume for the information of officers concerned with this aspect as well as other ordnance maintenance and supply procedures in the army as a whole.

The distribution and flow of Ordnance supplies normally will involve four major types of supply depots:

Master Depots. Supplies from manufacturers located all over the country flow into master depots, each of which stocks or assignes specific types of ordnance materiel. In scheduling Ordnance materiel from factories and arsenals into the supply system, master depots are given first priority in order that every item required for maintenance of vehicles and weapons will be available at these points for immediate movement to foreign theaters and domestic agencies as needed. Master depots are the first and principal sources of supply for ordnance distribution depots.

Distribution Depots issue Ordnance materiel against requisitions from using organizations. There are three groupings of this type depot:

Distribution or Retail Depots handle domestic supply by direct issue, serving Ordnance service command supply points and posts, camps and stations, within a designated distribution area. All requisitions for the prescribed materiel will be submitted within each area to the appropriate depot upon schedules established by the depot.

Filler Depots handle oversea supply and are located near ports of embarkation which they are designed to supply. They receive parts and tools in large shipments either from suppliers direct, or from master depots. They issue them in smaller quantities in accordance with requisitions from overseas theaters and bases through supply officers at the ports of embarkation.

Special Stock Depots are used to store and issue items for maintenance and repair of minority groups and obsolescent materiel, as directed. Obsolescent materiel depots and excess materiel depots fall into this category.

Storage Depots are assigned to distribution depots for 'advance' or 'back-up' storage so that the distribution depots can use their warehouses and sheds exclusively for the rapid movement of current stocks.

Reserve Depots handle only bulk or unit reserve stocks of materiel.

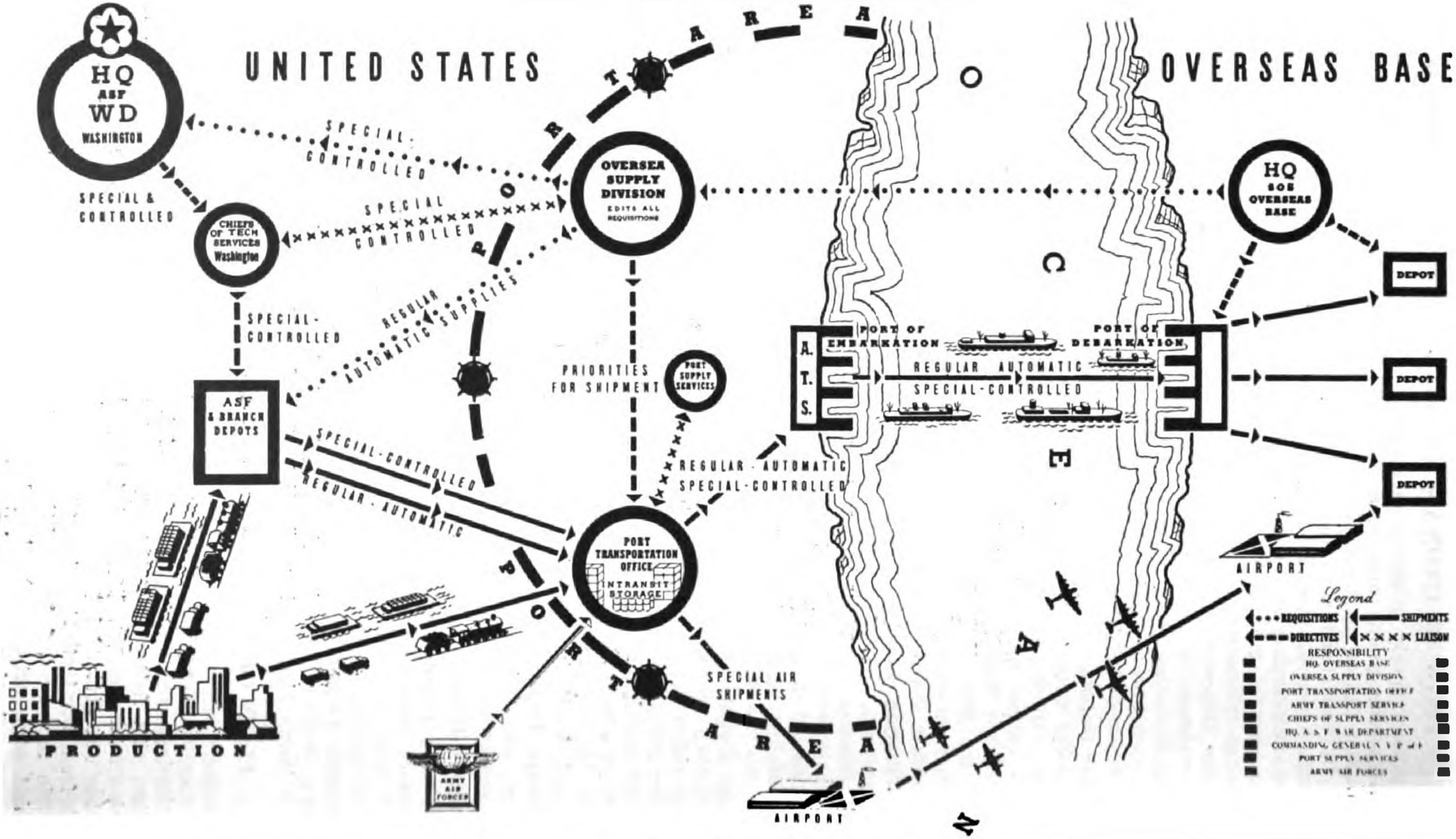
Advance Depots are Ordnance sections in jointly occupied depots, or selected Ordnance depots in which parts and tools, boxed or crated for overseas shipment, may be located temporarily until released complete by ports, as called for in movement orders.

Arsenal Depots. Located at Industrial division installations, arsenal depots process distribution of parts, supplies, tools and equipment which accompany major items supplied through such arsenals and proving grounds.

FLOW OF ORDNANCE SUPPLIES—THEATER OF OPERATIONS

Theaters of operation are geographically broken down into the Communications and Combat Zones. In theaters of large area or large scale operations the communications zone is further sub-divided into the Base section, intermediate section, and Advance section, each of decreasing size and scope of activity and located from the rear toward the front in the order named. The combat zone is further sub-divided into the army service area, corps area and divisional areas, both from the tactical and administrative viewpoints. Theaters of Operation may contain four or five base sections, each constituted as above, and one or more combat zone set-ups. In island warfare, one or more islands may constitute the communications zone and the elements thereof. The combat zone, under these

NEW YORK PORT OF EMBARKATION
OVERSEAS SUPPLY



conditions, will receive a similar break-down and may consist solely of a divisional area for small operations or an army in large scale campaigns. Boundary designations for the theater are made by the War Department whereas, normally, boundaries within the theater are designated by the theater commander.

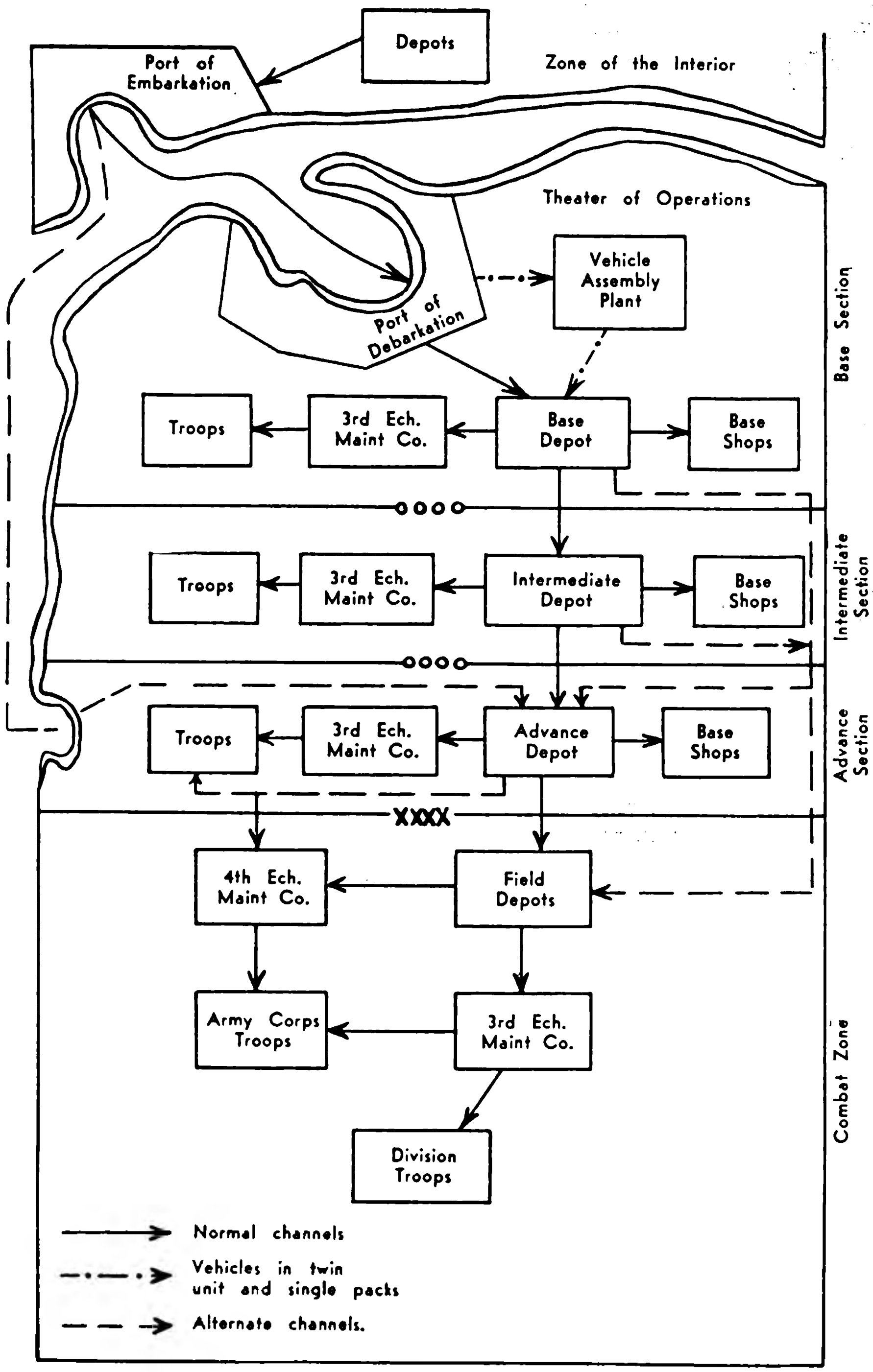


Figure 3. Flow of Ordnance Supplies in a Theater of Operations.

Strictly speaking, supplies flow from ports of embarkation in the Zone of Interior to Base Sections at the port of debarkation in the Communication Zone. The sketch shows that Ordnance Class II, IV and V Supply depots and maintenance service are located in each element of the communications zone although in some operations it may be found that the advance section is utilized for traffic regulations only, rather than for a service of supply function. The flow chart is for normal flow of ordnance supplies and does not serve to impede (by red tape) direct negotiations where expeditious handling is necessitated by the tactical situation.

Communications Zone. Normally, stores for the various services are segregated in stowing ships, off-loaded at ports of debarkation and delivered to the base section depot by the Transportation Corps. In island warfare, all service units present have pooled facilities and performed unloading, segregation by service, and movement of stores to their respective depots as necessitated by exigencies of the situation.

Base section depots in some cases have been segregated with separate sites for each service; however, officers will expect a general depot set-up wherein each service operates in a designated area of one large installation known as a general depot. Ordnance will consist of from two to five depot companies, of base or regular depot company type (T. O. & E. 9-57 and 9-377 respectively), which normally constitute a battalion with the Ordnance Section Officer (Lt. Col.) as battalion commander. Hereinafter the ordnance section of the depot only is considered.

The base depot orders, receives, stores and issues all supplies required in its particular area of the threater. Separate set-ups within the depot normally operate for handling spare parts and unit assemblies, wheeled and towed artillery and vehicles of all types. It may be expected that upward of 100,000 different ordnance items will be handled although perhaps only 10 percent of the total will be considered active—further, daily receipts and outgoing shipments will total in excess of one thousand tons. Where advance depots are operating, the base section functions as a feeder for stores replenishment. In some situations the base depot may issue directly to depot companies operating with the Army or to an Army depot in the Army service area. The Base depot may back up two or more field Armies and supporting troops according to the tactical situation. Supplies may be forwarded via water, rail or motor transportation. The latter may be furnished by the Transportation Corps, or on vehicles being delivered to forward areas from the depot pool. Supply flow to the front is initiated by requisitions from Army Ordnance general supply. Such requisitions may come from the Army depot or depot companies, rather than the Army Ordnance office, depending upon the Army Ordnance Standing operating procedure. Base section ordnance units such as local 4th echelon and 5th echelon shops will be sources of considerable incoming and outgoing shipments of materiel to the base depot. In this connection, repaired items from the base ordnance is turned back to the depot. Base policies will emphasize the requirement of delivering serviceable units and assemblies to forward areas rather than parts, thus permitting expeditious handling of serviceable materiel, reducing downtime of defective major items and pooling maintenance in rear areas near the bulk of spare parts supplies.

In large theaters of operations various situations will necessitate transfers of stores within the theatre from one base section to another. It is for this reason, as well as stores control and ordering, that the theater ordnance officer will operate centralized detailed records of stores activity for each item handled. Initial instructions for routing shipments to the desired base section also originate with the theater ordnance officer.

Combat Zone. Supply operation is normally located near the rear boundary of the combat zone and conducted on an army basis regardless of the number of armies operating. Several plans for general supply procedures in Army have been used in the field which we will consider briefly. Plan A. Four depot companies assigned to Army will draw supplies directly from Comm. Z depots coordinating stock levels, movements and rationing of issues, according to policies of the Army Ordnance Officer. Plan B: An Army depot manned by two depot companies is established near the Army rear boundary for receipt, control and ordering of all supplies furnished the army. The army depot supplies local 3rd and 4th echelon maintenance spare parts and further acts as a feeder depot for the other two depot companies which in turn support ordnance service units with divisions and assigned organizations. Plan C: Ordnance supply will be broken down into separate set-ups for serving the forward and rear portions of the combat zone. Highly mobile depot companies operating in the forward area are stocked according to the type of unit supported. For example; armored vehicle parts stock would predominate the stores for a depot company supporting armored divisions on other mechanized units while a general depot company would store parts for general automotive and armament maintenance. The rear area supply organization is basically a rear echelon of supply with the functions of supporting the forward depots, serving 3rd and 4th echelon maintenance units and the receipt of supply replenishments from communications zone depots. The depots in the latter group are relatively immobile.

Irrespective of the supply plan used in the combat zone, supply flow is through depot companies assigned to Army, to ordnance maintenance companies. Contact parties distribute such parts normally carried in 2nd echelon to the various units served at the same time as maintenance is effected. On this basis it is unlikely that maintenance company stocks carried will normally exceed 10,000 different items.

Army depots may stock in the vicinity of 40,000 different items of Ordnance general supply, a large quantity of which is necessitated by 4th echelon maintenance located in the Army service area. Mobile field depots served by Army will stock approximately 20,000 different items, in both casse about 15 per cent of which will be active or moving materiel. Daily receipts and issues at the Army depot will total several hundred tons but may fluctuate widely as reflected in tactical or any special ordnance activity.

PRINCIPLES OF SUPPLY

Introduction. Supply principles encompass the following fundamentals: the mission; plans and the use of logistical data; dissemination of policies and safeguarding information; reconnaissance; communication and liaison; security of stores; improvisation and the training of officers and men. Ordnance general supply includes approximately 2,200 major items and 488,000 component parts which are stored and issued as individual items as well as in various unit assemblies, sub-assemblies, and unit and standard packs. In the field, officers will encounter only a small portion of these items and assemblies; however, a careful observance of the points discussed below will assure that an ordered and efficient supply service will be furnished to the arms and services.

Mission. To provide serviceable U. S. Army Class II and IV supplies in the required quantity and type at the proper place when needed.

Plan. Standing operating procedures (SOP) includes the ordnance general supply plan and are normally published in advance of operations. Usually an SOP will continue in effect through an entire campaign. A simple, straightforward plan, properly disseminated, understood by personnel concerned, and executed in an efficient manner is the first requisite to succes of the supply mission. The following will be incorporated in the plan;

The mission.

Channels of command including the tactical and administrative control of units.

Situation: showing units of the command and assignments of ordnance organizations.

Operational policies. Herein will be directed the level of supply; base of supply; control of stock; supply rationing (where applicable); types of stores to be stocked by the various depot companies; stock replenishment procedures; handling and control of major items issues; channels of evacuation and salvage; disposition of captured materiel and submission of reports.

Mobility of units.

Flexibility of Operations.

Economy of troops, equipment, storage facilities, and supplies.

Logistical data will be employed in planning unit assignments and basic loads to be carried by maintenance and depot companies.

Sample Ordnance Plans are included in Chapter 6 Volume I, Staffs.

Dissemination and Safeguarding Information. Organization commanders, junior officers, and men must receive complete up-to-date information. Informed troops work with a 'sure-fire' knowledge and hence do a spirited and expeditious job.

Considerable classified information in the form of maps, situation estimates, status of materiel reports, planning and stock control directives, and movement plans are used in supply work. Such information must receive controlled distribution and be properly safeguarded.

Reconnaissance. Movements of supplies and men to new locations are preceded by a careful, detailed reconnaissance of road and rail nets and the terrain to be occupied.

Communication and Liaison. Phones and messengers, both inside the depot and operating to and from the forward and rear echelons, enable sure stock control as well as speeding receipts and issues. Abundant numbers of marker signs on the road net permit using units to easily find the depot.

Supply officers will regularly contact the units served and the next higher echelon. Liaison, front and rear and side-to-side, is a continuous job. It must be spirited and thorough, advisory as well as coordinating, and render consistent attention to detail. Liaison is the first step in the so-called 'impetus' of supply.

Security. From the supply standpoint, stores must be safeguarded against damage from enemy action, misappropriation, weather, and fire.

Improvisation. When not obtainable in time from normal re-supply points, supplies are procured from any other source available. Ordnance, Quartermaster, and Engineers carry many common items. Coordinate supply problems with these allied branches; assist them, and through channels have them assist you. Where needs are unobtainable in the Army (including Air Force depots), the Navy, Marine Corps and all nearby supply branches of the allied military forces, or local purchase through the depot P. & C. officer are each exploited. At the outset, when a shortage occurs, every opportunity of substitution will be followed up, such as; breaking down large quantities into small and conversely; issuance of next larger unit assembly; re-check of storehouse for quantities not indicated by stock record, and the use of interchangeability.

Training. Officers and men must be technically trained for the supply mission prior to going into the field. Supply has progressed beyond that technical and administrative stage permitting the assimilation of knowledge and experience on the job. Hence, training programmes must be thoroughly and realisticly pursued emphasizing the content and use of SNL's, stores handling and identifications, warehousing, complete and accurate recording and ordering procedures, and the employment of reports. Officer training will stress the formulation and interpretation of standing operating procedures and reports, inter-cooperation of maintenance and supply as well as stores groups within the depot, independent team-operation of groups in handling assigned sections of the depot, and the leadership of men. Obviously most training programs will not be tailored to fit a specific field operation and will therefore be sufficiently flexible to enable officers and men to carry out whatever supply mission is assigned the organization.

SOURCES OF INFORMATION

It is necessary that Ordnance men comply with the rules and regulations of the Army, and more particularly necessary that they comply with the rules and regulations of the Army Service Forces and the Ordnance Department. Naturally enough, they must know what these rules and regulations are before they can abide by them. All the information for this, as well as information of a technical training or supply nature, can be found in various publications. It is the intention of the writer to set forth herein a key to the use and contents of these publications.

There are, in a broad sense, two types of publications to be dealt with: War Department publications and Army Service Forces (including Ordnance) publications. They will be further sub-divided according to their purpose and subject matter.

Publications of the War Department are printed and distributed by the Adjutant General's Office, and publications of the ASF are under the jurisdiction of the Commanding General, ASF.

No one of the above groups of publications is sufficient, as there is very little duplication of information. Therefore, it will be necessary for the Ordnance man to be familiar with both groups.

Perhaps the simplest way to distinguish between the two types of publications is to look at the last page of any particular pamphlet. If it says "By order of the Secretary of War" and is signed and countersigned by the Chief of Staff and the Adjutant General, it will certainly be of War Department issue. If it says "By command of Lieutenant General Somervell," is signed by the Chief of Staff of the ASF, and countersigned by the Adjutant General, then it will be on ASF publication.

The majority of the publications included here are of the 5¾-inch x 9-inch size, and are punched in the left margin for inclusion in a regular strap binder; however, some are large enough to be separately bound so we can make no positive rule about their form.

War Department Publications. The War Department distributes a variety of publications for the guidance of all army personnel. These publications do not cover one branch of the service, but are applicable to the Army as a whole. These publications may be broken down roughly into three groups: (1) Administrative, (2) Training, and (3) Supply.

War Department Administrative Publications. *Army Regulations.* Before Army Regulations can be discussed clearly, it is important that their legal status be thoroughly understood. On the whole, they are inferior to statute law, but insofar as army personnel and certain other individuals subject to military jurisdiction are concerned, they have the same effect as statute law does on civilians. Since these regulations are going to have to cover so many people doing so many different things, it becomes obvious that they will be rather voluminous.

The numbering of these AR's is comparatively simple. A system known as the 'Double Arabic Numeral' system is used. The system involves the assignment of two titles and two numbers to each regulation. Although this sounds rather complicated, it is not. Using AR 45-75 as an example, the 45 is the base number and the 75 is the subnumber. The base number applies to the general title of the regulation (Ordnance Department), the subnumber applies to the specific title, Sale of Ordnance Property. All AR's having a base number of 45 can be identified as having something to do with the Ordnance Department. Other base numbers are assigned in the same way; for example, all AR's having a base number of 35 apply to Finance in one way or another. For a complete index of base numbers see AR 1-10. To identify a specific AR properly you must give both the base number and the subnumber.

There are three means by which an AR can be changed. One is by War Department Circular, another by printed change sheet, the third, by re-publication. In the case of the War Department Circular, the change will be general. The circular will set forth a certain policy, and if it is in conflict with any regulation, it will take precedence over that regulation.

If a printed change is used, it will be published under the same number as the regulation to be changed and will be marked to identify it as the first, second, or whatever change it may be to the regulation. The printed change will change specific parts of a regulation, perhaps a paragraph, or maybe just one word. When this method is used, there is a specific way of handling it, known as 'posting'.

To 'post' a change to a regulation, the part of the regulation being changed will be crossed out, and a marginal note inserted, "See Change 1," (or the appropriate change number). Then the change sheet will be inserted directly preceding the regulation in the strap binder. If there is more than one change to a regulation, change 1 will precede the regulation, change 2 will precede change 1, etc.

Indexes to Army Regulations. There are, generally speaking, three indexes to AR's. Perhaps the most important is AR 1-5. This is an alphabetical index by subject matter. The completeness of this index is the best part about it. It lists everything in several different ways for ease of location. It gives the AR in question and even the paragraph number in the AR where the information desired may be located.

The next index is AR 1-10. This lists the regulations by numbers, their title, distribution, latest date of publication, and any changes thereto.

The last is AR 1-15. Although not an index in the strictest sense of the word, it is a valuable complement to the indexes because it gives general information about AR's.

War Department Circulars. Circulars are printed by the War Department to clarify or to give advance notice to Army Regulations. They apply to administration and supply and are temporary in duration. Unlike AR's, War Department Circulars may cover more than one subject. A simple index by section is always at the top of the first page, so that the whole circular will not have to be read to find the few items that may be of importance to you. WDC's are numbered by the calendar year. Each January 1st the number of WDC's goes back to 1. So, when referring to a WDC, you must always give both the individual number of the circular, and the year published. Example: WDC 170/43.

War Department Training Publications. War Department training publications are printed by the War Department for all arms and services and include such publications as field manuals, training circulars, technical bulletins, and lubrication orders.

Field Manuals are books designed for use in the field. They are made so as to be easily carried in a pocket, so that the latest information of field training is always handy. The index of field manuals is Field Manual 21-6, which gives all the latest information on numbering, titles, and dates of publication. Latest changes and distribution are also shown. FM 21-6 is indispensable to any officer or non-commissioned officer who is concerned with training. The numbering system explained in FM 21-6 is called the branch numbering system. This system uses a base number, which refers to the general subject, or more usually to the arm or service which wrote the book and with which the manual is primarily concerned, and a subnumber, which is given in sequence to distinguish one manual in the same series from the other. For example, '9' is the base number assigned to Ordnance, '25' is that assigned by Ordnance to the Ordnance depot company, so FM 9-25, is ordnance depot company. The same system follows through for each branch of the service. For example, '7' is the base number assigned to Infantry. The base numbers that are most important to Ordnance are '9' and '23'. The latter number is assigned to the operation and 1st echelon maintenance of basic weapons. The subnumbers for field manuals will never go over 199. For a complete listing of all base numbers and subnumbers refer to Field Manual 21-6.

Technical Manuals are a series of manuals which supplement field manuals, and cover subjects which require special technical attention. TM's contain the technical information not found in FM's. For example, FM 23-5 deals with the employment and first echelon maintenance of the M1 rifle, whereas TM 9-1275 deals with the 3d and 4th echelon (ordnance) maintenance. TM's are numbered by the branch numbering system, the same as FM's. TM's of the '9' series are especially numbered for ordnance personnel. The use of FM 21-6 is imperative in the understanding of TM's.

Training Circulars are issued by the War Department to make general amendments to FM's and TM's. They are more general in application than a change to a FM or TM would be. TC's are numbered consecutively by the calendar year, a new series starting each January 1st. When referring to a TC the year of issue as well as the specific TC must be given. Change sheets are not issued for TC's. They may be changed by TM's, FM's, or a new TC. TC's of interest to Ordnance are indexed in OFSB 1-1 Vol. 2.

Lubrication Orders were formerly issued in the OFSB 6 series. They were changed to separate guides and issued in the SNL for the weapon or vehicle. Then they were changed again and may be found listed in FM 21-6, lubrication orders. If there is any difference in the orders the date on the lubrication orders will rule.

The Technical Bulletin is an ordnance publication taken over by the War Department. They were orginally OFSTB's or Ordnance Field Service Technical Bulletins. They contain information of a technical nature, usually maintenance. TB's are used to publish advance notices of changes to TM's and FM's. They are designed by the number of the FM or TM affected. Example: FM 23-85 is the FM on the 60 mm mortar and TB 23-85-1 tells what to do when the mortar is loose in the mount.

The same system applies to all TB's. Example: TM 9-225 is on the .50 cal

MG M2, and TB 9-225-2 tell how to paint the water jacket to prevent rusting. A complete listing of TB's and their status may be found in OFSB 1-1 Vol. 2, and FM 21-6.

War Department Supply Publications. The placing of a publication in the supply category is sometimes a difficult job. For example: a Table of Organization and Equipment is only half concerned with supply. But, that half is so essentially a part of supply that the entire publication can best be considered here.

In general, supply publications are concerned with either procedures of supply or allowances of supplies and materiel.

Leading the list of supply publications dealing with allowances are:

Tables of Organization and Equipment. These are printed by the War Department as an authority for unit commanders in organizing and equipping their units. They are numbered to indicate the branch in the base number and the subnumber is assigned by the arm or service.

The inside page of every T/O & E indicates that the T/O & E does not list all the equipment necessary for complete equippage, but that it is supplemented by catalogs for the different services. The T/E section is broken down by supplying services in alphabetical order and under each are listed the items which each service issues to the unit represented by the applicable T/O & E, the amount, and basis of issue. The T/O section gives the breakdown of the personnel of the unit for every man. After each man's title are listed his specification serial number, his grade, in what section of the unit he should be located, what he is to be armed with, and his extra duties if any. Also listed is the cadre section, which tells which men will be sent out on a cadre to form new units. The T/O section also lists the major items of equipment for the unit. A T/O is not variable, although it is the practice of unit commanders to change tables slightly to suit local conditions. They are indexed in an Index of T/O & E's printed by the War Department.

The Table of Equipment section of a T/O & E is a breakdown of the appropriate *Table of Basic Allowances* (T/BA). These T/BA's are printed by the War Department for each arm or service and they list the equipment that the various units of an arm or service are authorized to have. They are numbered by the branch numbering system, so T/BA 9 would be for Ordnance.

Before the advent of the T/O & E these T/BA's were the only publications listing the equipment that could be drawn by an organization, and it was often difficult to root out this information. This publication now takes a secondary position to the T/O & E, and is used for planning purposes only. They are indexed in "List of Tables of Organizations and Equipment, Tables of Allowances and Tables of Basic Allowances," of 1 February 1944.

Tables of Allowances are next on the list of allowance publications. These are special tables listing equipment for various schools and training centers of the arms and services. The base number of the T/A tells the branch to which it pertains; subnumbers are assigned as needed for additional pamphlets pertaining to an arm or service. T/A 20 gives general allowances for all posts, camps, or stations.

War Department Supply Bulletins. Moving from the allowance to the procedure group we find War Department Supply Bulletins, which are used to pass on information prepared by the technical services pertaining to supply. They will cover a variety of material such as packing, crating, etc. The branch numbering system is used. SB's of the '9' series are of particular interest to Ordnance personnel. The following former Ordnance publications are now part of WDSB's:

OEC's. The Ordnance Department formerly published OEC's or Ordnance Equipment Charts. They were used to help larger units plan their Ordnance requirements. They listed the breakdown of organization into smaller units and showed the amount of Ordnance equipment used by each. The major items were all listed, although SNL's had to be consulted for a complete breakdown. They were used largely for planning purposes and were never an authority for requisitioning. They are now published by the War Department as supply bulletins in the '9' series and are numbered SB 9-OEC (Subnumber). They were originally numbered in the branch numbering system so that OEC-7 was for an Infantry division. But that has been discontinued, and as SB's the subnumbers are assigned in numerical sequence and have nothing to do with the branch numbering system or the T/O & E numbers.

IOSSC's (Introduction to Ordnance Storage and Shipment Charts) are other Ordnance publications taken over by the War Department. They are used in conjunction with Ordnance storage and shipment charts, though they cover general subjects pertaining to all SNL groups. They were called IOSSC (b) or (c), etc. The lower case letter does not refer to SNL group. It merely distinguishes one IOSSC from another. They cover a variety of subjects such as "Instructions for marking Ordnance Supplies." A complete listing of IOSSC's may be found in OFSB 1-1, Vol. 1.

OSSC's or Ordnance Storage and Shipment Charts published by the Ordnance Department are now issued by the War Department. They give information necessary for proper crating and shipment of major items of ordnance materiel. Hardly any publication is less known than the OSSC, yet there is hardly another one so widely used. Herein are listed item weight, freight classification, freight rating, minimum carload pounds, type of shipping container with a design of each, number of items per container, length, width, and height of the container plus square and cubic ft. of the container. It also gives the maximum number of containers that can be loaded on various trucks and box cars. The value of such a publication may easily be seen. Formerly, the publication was identified by placing the SNL group letter concerned after the title, as OSSC-B, the 'B' standing for the SNL group of the major item listed in the pamphlet. One OSSC was printed for each SNL letter group of the general supply section. Under the present set-up, as War Department Supply Bulletins, they are numbered SB 9-OSSC (letter pertaining to SNL Groups) and are indexed in OFSB 1-1 Vol. 1, and FM 21-6.

OFSB's or Ordnance Field Service Bulletins, are now published by the War Department. The OFSB's as now published by the War Department are somewhat different from those formerly published by Ordnance. First, they are no longer identified by the same name. They are simply titled 'War Department Supply Bulletins' and are numbered with the ordnance base number and a serial subnumber. For example, WDSB 9-3, 'Distribution and Issue of Ordnance General Supplies', replaces OFSB's 2-11, 2-15, 2-18, and 5-9.

The old OFSB's, many of which have yet to be replaced, were designed to contain administrative, supply, and various other information for ordnance field service personnel. They were broken down into seven series: 1. General, 2. General Supply, 3. Ammunition, 4. Maintenance, 5. Miscellaneous, 6. Lubrication, and 7. Ammunition Operation Depot. The numbers listed above were called the base numbers, or general subject. They were then assigned subnumbers or titles, for various subjects within the general subject. For instance, within the number 3 group (ammunition) the subnumber 5 was assigned for 'Small Arms Ammunition', thus OFSB 3-5 was printed on small arms ammunition. Superseding the OFSB 3-5 the same manual now becomes SB 9 Amm-3. The old OFSB's on lubrication were in the six series, with the SNL group letter and number of the item added for complete identification. Thus, the lubrication OFSB for the 37 MM gun was OFSB 6-A-44. These however have been superseded and are now appearing as War Department Supply Bulletins which do not pertain to special subjects such as OEC's or OSSC's and are numbered on the branch numbering system. Thus, SB 5-1 is supply information of a general nature, being the first SB published for the Engineer Corps. Similarly, SB 9-11 is the eleventh SB published for Ordnance.

Field Service Modification Work Orders have been taken over by the War Department. They are now called WDMWO's or War Department Modification Work Orders. WDMWO's serve as instructions for modifying equipment used in the field. They give a complete classification of the modification, how to accomplish it, the tools needed, time required, new parts needed, and the priority with which the modification is to be accomplished. They are numbered by using the SNL of the item to be modified. Example: MWO-ORD-C 502-W3 tells that the MWO is ordnance materiel, that the item to be modified is the 4 x 4 Dodge weapons carrier, (SNL 6-502) and that it is the 3d modification (W3). Modification Work Orders have a color band on the top which denotes the priority with which the modification will be accomplished: red—at once, blue—to be started when all the red MWO's are finished, green—to be accomplished when sent to arsenal or at time of complete overhaul. MWO's also serve as authority for requisition of materiel required to do the job.

It is well to remember that the usefulness of these valuable sources of information is dependent upon knowledge and full use of indices. The use of indices cannot be stressed too heavily.

For AR's, AR 1-5 Alphabetical Index
AR 1-10 Numerical Index
For FM's, TM's and War Department Lubrication guides see FM 21-6.
For TC's and TB's see OFSB 1-1 Vol. 2, and FM 21-6.
For IOC's IOSSC's, OSSC's, OFSB's see OFSB 1-1 Vol. 1, and FM 21-6.
For T/O & E's, T/BA's, T/A's and OEC's see list of T/O & E's.

ARMY SERVICE FORCES PUBLICATIONS

The Army Service Force Catalog. In dealing with A.S.F. publications we must place first and foremost the A.S.F. catalog. This extensive publication is divided into sections, one for each of the supply services (i.e. Ordnance, Medical, Signal, Q.M. etc.). Of primary importance to us, naturally, is the Ordnance Section. The principal divisions are as follows:

Section 1, (called ORD 1) Introduction, known as IOC. (Introduction to the ORD Catalog).

Section 2, Index, or OPSI (Ordnance Publications for Supply Index).

Section 3, List of Major Items. This includes SNL's A-1, B-1, C-1, D-1, D-2, E-1, F-1, F-2, F-3, G-1, J-101, L-1, L-3, and L-7.

Section 4, Expendable items. (Does not apply to Ordnance).

Section 5, List of Standard Hardware, Common Tools, Cleaning and Preserving, and Miscellaneous common items with certain additions such as numbers lists.

Section 6, Tools and tool sets.

Section 7, Organizational Spare Parts and Equipment (OSP&E). Formerly in Ordnance SNL's)

Section 8, Higher Echelon Spare Parts and Equipment. (Corresponds to former Addendum with a new name).

Section 9, List of all parts.

Section 10, Tool and Load Lists for Ordnance Units. This will include a basic load of parts for type units, such as heavy maintenance companies assigned to field armies, as well as lists of special tools and equipment.

Section 11, Ammunition, including SNL's, P, R, S, & T.

Section 12, Obsolete General Supplies, (formerly OGS of the SNL's).

Section 13, Parts Common.

Section 14, another newcomer: Unit Manufacturers Parts Interchangeability Lists.

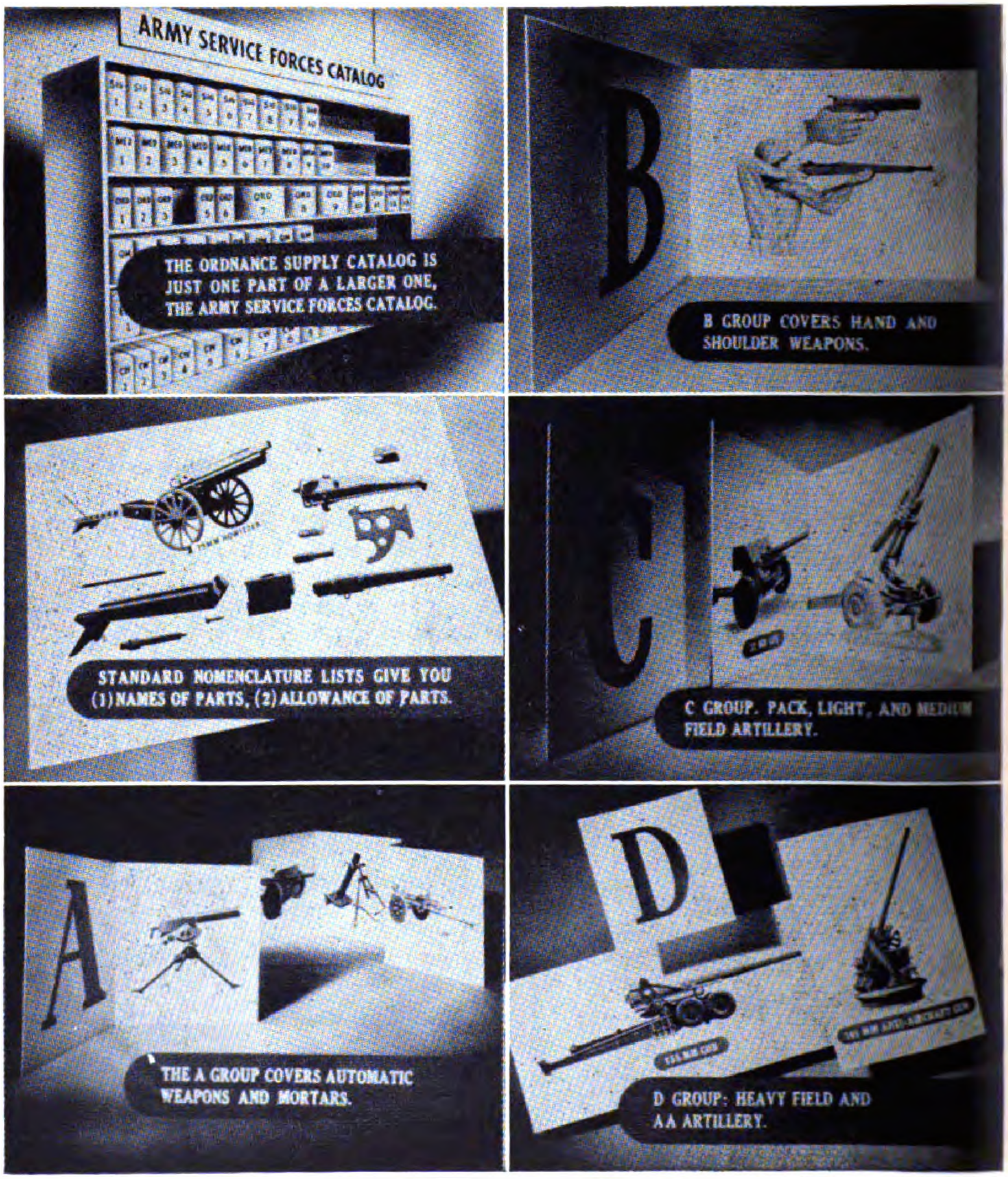
Section 15, Cross-Reference, (Ord 15-1 and Ord 15-2).

This Ordnance Section of the ASF Catalog is nothing more nor less than the old SNL's with a few additions, so it is recommended that they be treated in the same manner.

To begin with, what are these SNL's? The name, Standard Nomenclature Lists, gives that away. When you consider that the Ordnance Department handles about 2200 major items and 488,000 spare parts it becomes obvious that we must have a system of cataloging the various items in a logical manner which will provide a complete reference and further insure that one designation (Standard Nomenclature) is used by all concerned in procuring and requisitioning the same part.

The first consideration was subdividing these lists according to some plan, whereby a single item could be run down with a minimum of trouble. All items whose functions were similar were placed together in one group, and the various functional groups were designated by a letter of the alphabet. The grouping, roughly, is as explained in Figures 4, 5 and 6.

To further the identification of the publication pertaining to one single major item, the SNL's under a given letter group are further broken down by number. For example, the M-1 rifle is a semi-automatic shoulder weapon. By its function it is placed in the "B" group, then since it is desirable to have one pamphlet for each major item, the number 21 is assigned to the M-1. The result is a pamphlet



Group A—Automatic Weapons through 40mm.
Group B—Non-Automatic and Semi-Automatic Hand and Shoulder Weapons.
Group C—Light and Medium Field Artillery.
Group D—Heavy Field Artillery, Heavy AA Artillery.

Figure 4. The Ordnance Supply Catalog Showing Grouping of Standard Nomenclature Lists.

entitled "SNL B-21", pertaining to parts and equipment for the M-1 rifle and nothing else.

It would be well to note here that for convenience the number 1 section of each letter group 'A' through 'G' contains a list of the major items in the group and their current prices. In some cases the number one section is inadequate; in the 'D' group this list extends through both 'D-1' and 'D-2' and in the 'F' group it is 'F-1', 'F-2', and 'F-3'.

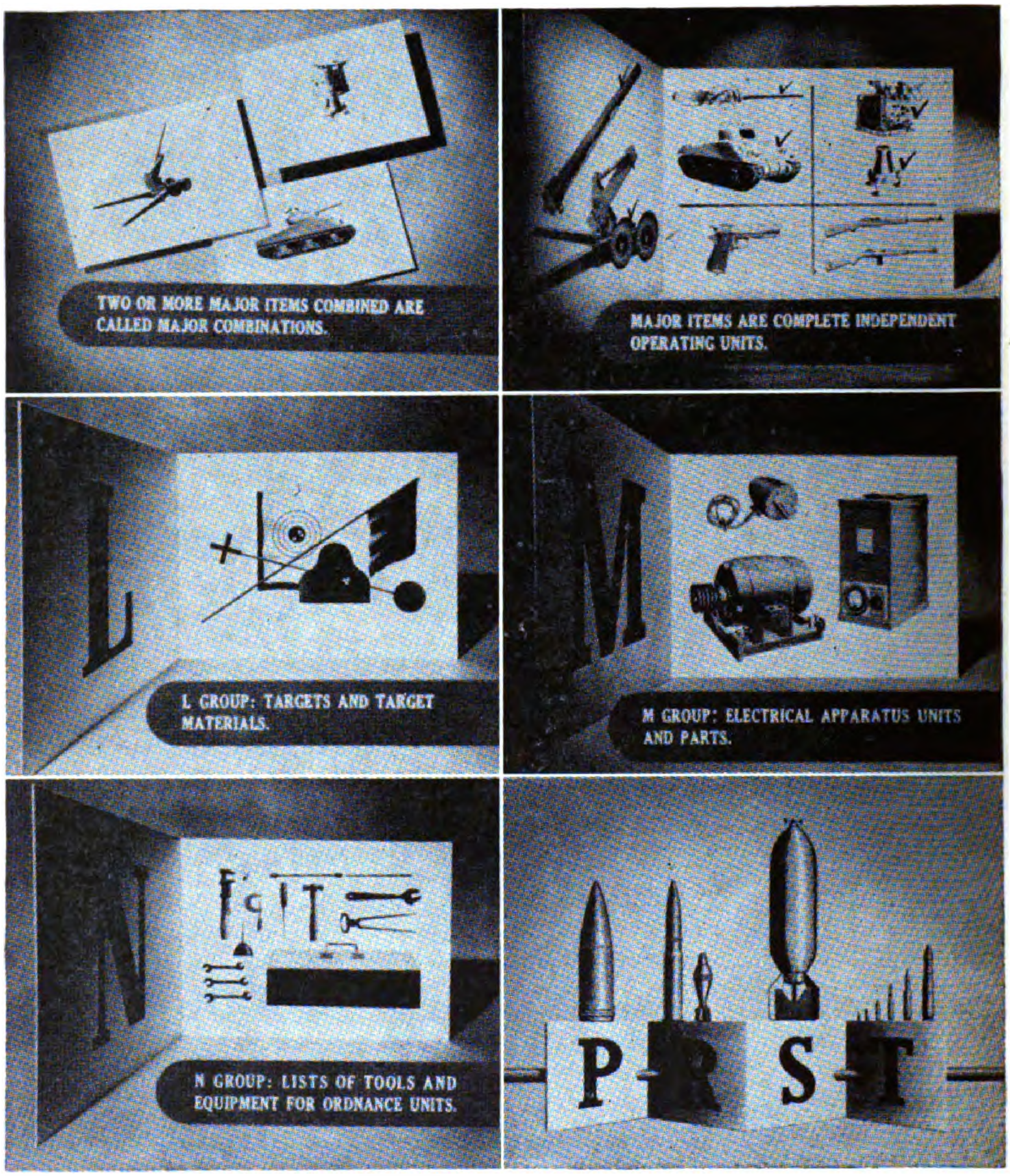
Now since we have the pamphlets broken down this far, let us consider some of the things the pamphlets should do. In the first place, they set forth the name and identifying number of each part included in a major item, and give additional information on the part. First, we need a list of all the parts involved in a major item; next, we need a list of parts for which the using unit, for example

Group E—Railway and Seacoast Artillery.
Group F—Sighting and Fire Control Equipment.
Group G—Automotive (Including Tanks)
Group H—Standard Hardware.
Group J—Standard Tools.
Group K—Cleaning, Preserving, and Welding Material.

Figure 5. The Ordnance Supply Catalog Showing Grouping of Standard Nomenclature Lists.

an Infantry Company, should be authorized to draw materiel for first and second echelon maintenance. Now we have three sub-divisions of each SNL dealing with one particular major item. For example, SNL B-21, for the M-1 rifle, is divided into: (a) List of all parts section, (b) Organizational spare parts and equipment section, and (c) Higher echelon spare parts and equipment (Addendum) section.

Since we have this array of subdivisions and breakdowns, we will have to select a means by which we can use the catalog with a minimum of confusion. Since it is easier to operate on the basis of the rule than on a basis of the exception to the rule, let us do it that way.



Group L—Targets and Target Materials.
Group M—Electrical Apparatus, Miscellaneous Kits, and Some Common Items.
Group N—Sets of Special Use Equipment, Such as Tools, and Also Tool and Load Lists for Various Ordnance Units.
Groups P, R, S, and T—Ammunition.

Figure 6. The Ordnance Supply Catalog Showing Grouping of Standard Nomenclature Lists.

First we have pamphlets in alphabetical order, then numerically within the letter groups, and the bulk of the numerical pamphlets divided into the LAP, OSP & E, and HESP & E. Scattered throughout we have number sections assigned by ASF.

To build a usable file of SNL's we must first assemble the alphabet groups put them in order, then put the numbers and sections in order. When this is done we have stock of SNL's running from 'A-1' through (if we have them all, 'T6', not counting groups Z or OGS.

Now the exceptions. Scattered through our file are some pamphlets that are not of the same type as others. The first exception would be that the first number section of each letter group A through G, as 'A-1', 'B-1', etc., will be a list of major items within the group and their prices. (Remember, the bulk of the SNL's, as 'B-21' etc., are divided into the LAP, OSP & E, and HESP & E listing parts and equipment for one major item.)

Figure 7. Catalog Breakdown Showing OSPE, HESP & E and LAP.

The next exception will be SNL A-19, which, instead of listing parts and equipment for a particular 'A' group item lists parts common to two or more 'A' group major items. Incidentally, there is such a section for each letter group 'A' through 'G', although it will not always be 19. For example, parts common for the 'B' group is SNL B-15.

We find no further exceptions until we reach the 'H' group. Here instead of

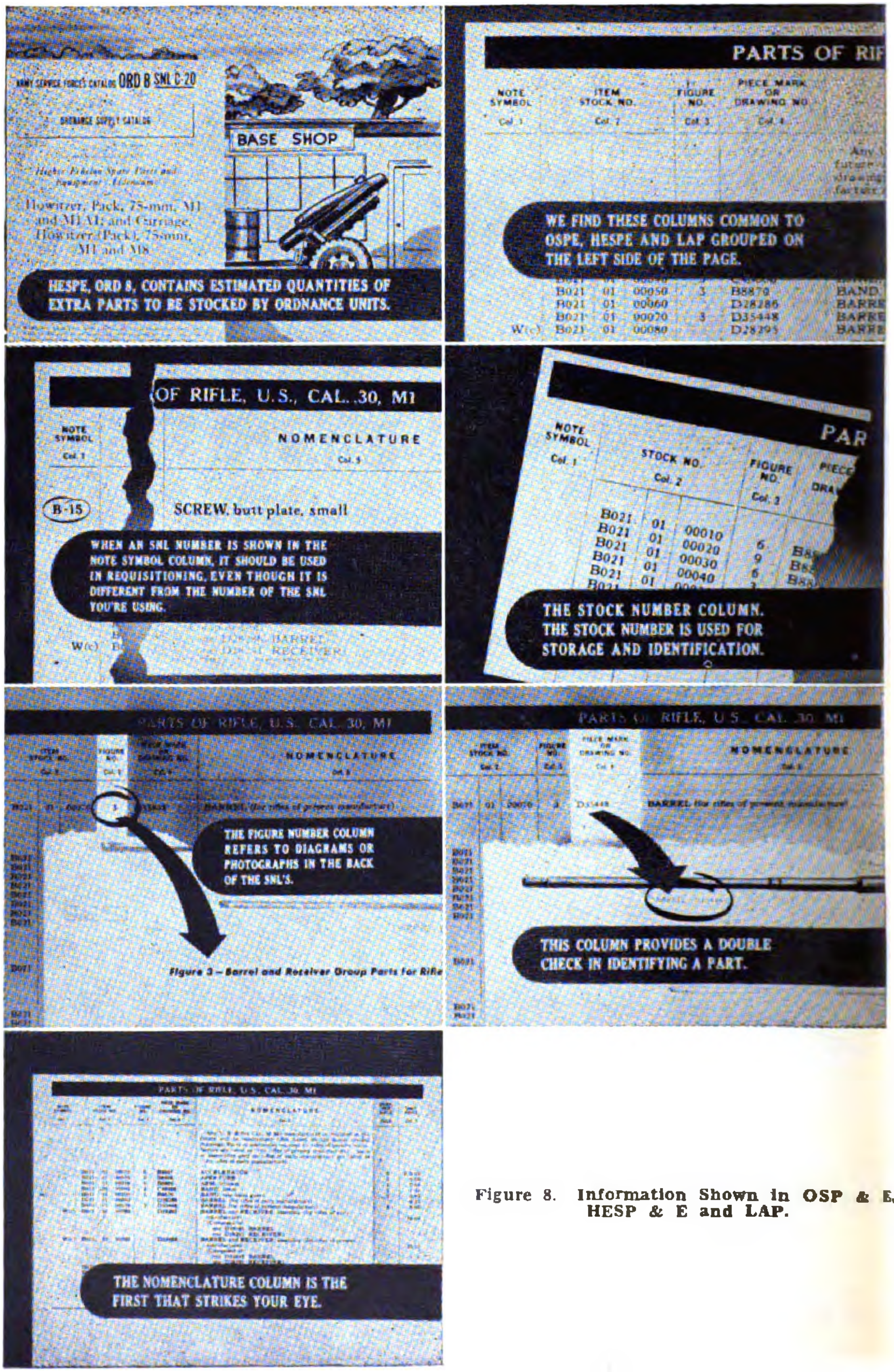


Figure 8. Information Shown in OSP & E, HESP & E and LAP.

listing major items and parts, we find only a list of standard hardware. This practice of listing various small items will be continued through the 'J' group, this being SNL's for various types of standard tools.

The 'K' group lists cleaning and preserving materials and a basis for issue of each item. The 'L' group lists targets and target materials and the 'M' group electrical apparatus and miscellaneous accessories such as rifle cleaning brushes etc.

The 'N' group lists a variety of things such as N-8 with a tool and load list for a Light Maintenance Co. The best way to see the diversity of this group is to examine the index which we will take up later.

The P, R, S, & T groups are ammunition and include shipping information for ammunition.

Group 'Z' is reserved for captured enemy materiel held as trophies.

Group 'OGS' is a little different, not being numbered in the regular way. There are eight groups, running from OGS 1-1 for obsolete group 'A' materiel through OGS 8-1 for obsolete miscellaneous items.

The last section is known simply as 'ORD 5', is divided into sections 'A' through 'R', and is nothing but a stock list, section 'A', listing all items beginning with the letter A, etc., cross-referring the items.

List of All Parts. Here is what the publications look like. Using SNL B-21 for the M-1 rifle, we can get some idea of what it all means. Starting first with the List of All Parts, the important thing to remember is that this is an information publication. It lists all the parts necessary to make one complete M-1 rifle. However, just because they are listed here doesn't mean that they are available for issue.

Looking at Figure 8 you see several columns. On the left you observe a column headed "Note Symbol." In this column is listed additional information about a part. For example, *barrel* and *receiver* assembly has a note W (c) in this column. If you turned to the end of the SNL an explanation of this symbol would show that the parts were non-expendable, and only available to manufacturing establishments. Also, if the part were stored under another SNL you would find a note referring you to the proper SNL.

Next, from left to right, you find the Item Stock Number (the official Ordnance number), and the figure number which refers you to the figure in the pamphlet showing this part. It might be well to add that these figures can not be improved upon, it being possible to assemble or dissassemble the rifle from them. Going on, we find the piece mark number, and the official nomenclature followed by the quantity of this part per rifle, and the unit price of the part.

Organizational Spare Parts and Equipment List. Moving from the List of All Parts we come next to the Organizational Spare Parts and Equipment section. Looking at Figure E 6, we see that in make-up it is about the same as the LAP, the first five columns being identical. However, when we reach column six we see that it is headed 'Basis of Issue.' This shows us that this is not simply an information publication but is an authority for issue. It lists those parts that are available to the using arm for first and second echelon maintenance and the basis on which those parts are issued.

To see it a little more clearly, look at Figure 9. You see listed a spare parts set for the M-1, its components, and a reference in column six to 'Note 1'. Looking at Note 1 (at the bottom of the page), you see that this set is available to any organization armed with the M-1 on the basis of one set for each 100 rifles or major fraction thereof. These parts sets may be requisitioned on that basis using this section of the SNL as the authority.

The OSP & E also lists the equipment that goes along with a major item. For example, if you were to turn further on in the OSP & E of B-21 you would find such items as slings, bayonets ,gun cleaning tools, and even the field manuals covering the major items, as well as the basis for issue of the above item.

The Higher Echelon Spare Parts and Equipment (Addendum) section is covered under the section on 'Basic Load,' and to avoid repetition the reader should refer to it there.

Catalog Index. Having covered the SNL's, it is now important to consider an index. The index has been mentioned previously, but in no detail. It was shown that it was the second section of the Ordnance part of the ASF catalog. More clearly, it is a separately bound publication known as 'ASF Catalog, ORD 2, OPSI'. The OPSI part tells you that it is the Ordnance Publications for Supply Index in a new form.

Figure 9. Information Shown in OSP & E, HESP & E and LAP.

This publication is in two principal sections, the first being a list of SNL's in order, giving their status (what they cover, or whether they are printed or assigned), date of publication, and any changes to them. The second section is an alphabetical list of items covered in SNL's and the SNL covering any particular item.

In the design and manufacture of vehicles, changes and new vehicles come so fast that in some cases it has been impossible to compile SNL's as rapidly as the new vehicle is furnished the field. To fill the time lag, a 'Service Parts Catalog', published by the manufacturer is delivered with the vehicle. This, for a time, will be the only parts manual available. From necessity, it must be one of our sources of information. Let us take, for example, the Service Parts Catalog for the Chevrolet medium armored car, M-6.

On the cover sheet is listed the vehicle, the manufacturer, and the contract numbers concerned. The manual contains pictures of all parts, and all parts are divided into their functional groups. In addition it gives an alphabetical listing of all parts and where they can be found in the manual. Finally, at the back of the book, a listing of parts by item stock number and where they are located in the manual. It might be well to note that all through the manual all parts have an item stock number (the official Ordnance number), the Ordnance piece mark or drawing number and the manufacturer's number listed.

War Department Technical Manual. We have one other type of automotive parts manual to deal with. These manuals, known as War Department Technical Manuals, are published in the style of Service Parts Catalogs, including the same features, but are for all the models of one type vehicle made by a single manufacturer. For example, TM 10-1185 covers all 4x2, 4x4, 6x4, and 6x6 truck models made in 1940, 1941, and 1942 by General Motors. At the end of the manual is listed the prices for the parts in the manual.

The contents of the ASF and Ordnance Department Orders, and Ordnance Field Service Directives are divulged by their titles. Another is the Ordnance Daily Activity Report, dispensing new information to the field almost as soon as it becomes known.

Training Manuals. From a training viewpoint the ASF puts out a series of manuals known simply as Army Service Forces Manuals. These manuals are something new in the line of army publications. They are eight by ten and one-half inches in size, very clear and concise, cover every detail, and use charts or graphic forms to put across all procedures to the reader.

Numbers are assigned in blocks of one hundred and all numbers are preceded by the letter 'M'.

The series assignment is:

M1 -M99 Basic and Advanced Training
M100-M199 Army Specialized Training and Pre-Induction Training
M200-M299 Personnel and Morale
M300-M399 Military Law and Enforcement, Organizations, Civil Affairs
M400-M499 Supply and Transportation
M500-M599 Fiscal
M600-M699 Procurement and Production
M700-M799 Administration
M800-M899 Miscellaneous
M900-up Equipment, Materiel, Housing and Construction.

These manuals have the force of regulations on all Class I and Class II installations, regardless of whether any other publication may appear to be in conflict with them.

INTERCHANGEABILITY

The Interchangeability Problem. The 'numbers racket' has plagued more than one Ordnance man dealing with automotive parts. To a lesser degree there is a problem of interchangeability of parts in all of general supply which is gradually being worked out through SNL's. Such a problem is inevitable in dealing with large quantities of parts from numerous manufacturers.

Briefly, as far as automotive parts are concerned, the Ordnance department has found that many parts used by one firm in producing its machinery and vehicles are identical with parts manufactured by other firms and used in other machinery. Because of competitive trade and independence of all manufacturers concerned, each firm has its own system of identifying parts. As such parts were adopted for Ordnance use, they were in many cases receiving additional numbers, and further confusing the issue. A concerted effort is being made at present to set up charts on these interchangeable parts and to distribute information to key points. It has been found that countless items on requisitions have been 'no stocked', when actually substitute parts were occupying nearby bins under different numbers.

Publications. Perhaps the oldest and one of the most indispensable references for interchangeability is the Parts, Interchangeability Manual, published by OCO-D.

It is a large, loose-leaf volume which cross-refers parts numbers of one manufacturer to all known manufacturers and vehicle manufacturer numbers.

Automotive parts are grouped according to assemblies, and each unit manufacturer's parts are listed. Each part name, with its number, is identified with all models of vehicles in which it is used. A cross reference sheet then converts the particular manufacturer's number to other numbers which identify parts that are identical or interchangeable.

This manual is a 'must' item for any organization dealing with parts, whether its mission be primarily maintenance or supply. To the man whose vehicle is deadlined, it is a boon in leading him to another vehicle or manufacturer's part number for replacement. To the man who is editing and attempting to fill a requisition it means the difference, in many cases, of no-stocking an item and back ordering, or furnishing a substitute item.

The reference is kept up-to-date by addenda issued periodically. Each manual is numbered serially for the purpose of maintaining accurate and prompt distribution of additional sheets upon publication. A complete index of assemblies and brief instructions for using the manual precede the actual catalog of parts.

To further simplify the numbers problem where more than one number exists for an item or similar items, one number is being designated as an official stock number. Thus, while a part, or number of similar parts, might be identified by one or more unit manufacturers' numbers, one or more vehicle manufacturer's numbers, old official ordnance drawing numbers and item stock numbers, one of these numbers will be designated for stocking and reporting purposes. As such numbers are designated, all numbers assigned to the parts are cross-referenced to the selected number.

The results of this step are contained in a twelve volume cross reference entitled, Ordnance Piece Mark and Manufacturers Part Numbers to Official Ordnance Numbers, published by OCO-D, and in interchangeability lists, published in the ORD 15 series of ASF publications and mentioned elsewhere in this section. The cross reference volumes simply convert various numbers to the official stock numbers. All types of manufacturers' and ordnance numbers for general supply have been screened in this list.

The ASF Interchangeability Lists are published according to unit manufacturer. Divided into two sections, they list all manufacturers' numbers cross referenced to official stock numbers. The second section catalogs official numbers and refers them to manufacturer designations.

Parts Common Manual. Parts common to more than one group of items identified by Federal Standard Stock Numbers are indexed in a parts command manual published by OCO-D with much the same format and arrangement as the Parts Interchangeability Manual. (The Parts Common Manual is smaller). Parts are classified in groups and indexed. Groupings include general headings such as 'Fuel,' 'Motor Vehicles,' 'Oils,' 'Electric Cable and Wire,' etc.

These manuals are authorized only for reference purposes and information. For setting up official stock numbers on stock records and for reporting purposes, specific advice from OCO-D in the form of master cards and code lists is necessary.

In conclusion, let it be admitted that there is a large number of publications, but a general familiarity with their contents, and an understanding of their indices can save the Ordnance officer, at home and abroad, a world of work and confusion.

DEFINITIONS

Terms commonly used in Ordnance General Supply are defined below to fix the meanings implied by their use in the field and in the text following.

Backorder.—The term applied to requisitions, to property issue slips, or to parts thereof, requesting supplies which are not shipped pending their availability.

Deadline requisitions.—A deadline requisition is an emergency request for items required for the repair of a vehicle, weapon, or other major item which cannot be used until the repairs are made.

Depot.—A depot is an establishment for the reception, classification, storage, preservation, and issue of supplies.

Depot control level.—The depot control level is the level of stock on hand plus dues-in, at which routine requisitions for replenishment purposes are submitted. It is a reorder point.

Dues-in.—Dues-in represent supplies which have been requisitioned or scheduled for shipment from a supply point according to prior arrangements, but which have not been received and for which no notice of cancellation has been received.

Dues-out.—Dues-out represent supplies for which requests have been received and which are not available for issue at the time of the request.

Emergency order point.—An emergency order point is the stock-on-hand level equal to the anticipated expenditures during the time required for receipt of items requested by emergency requisitions submitted by phone, radio, cable, or other emergency methods.

Extract requisition.—An extract requisition is a request for items which the extracting organization has been unable to issue when requested; it contains only items included in a single request upon the extracting organization.

Field depot.—A field depot is a supply establishment located in the combat zone and supporting combat units.

Railhead (Truckhead).—A railhead (truckhead) is a point to which supplies are transported by rail (truck), unloaded, and reloaded for transportation to designated points.

Replenishment period.—The replenishment period is the time elapsing between the preparation of a requisition and the actual receipt of the items requested by that requisition.

Requisition.—A requisition is an itemized request for supplies, usually written on a form designed for that purpose.

Stores unit.—The stores unit is a small operating unit within a depot, responsible for storage and issue of stock, and related operations.

Stock level.—A stock level is a prescribed limit upon stock, stated in terms of units of measure (each, gallon, pound, etc.).

Supply level.—A supply level is a prescribed limit upon stock on hand stated in terms of days.

Tally-in.—A tally-in is an itemized list of supplies received; it may be compiled from packing lists, invoices, or actual inventory; these documents may be used as tally-ins when suitable.

Tally-out.—A tally-out is an itemized list of the items included in an issue or shipment.

REQUISITIONING

The procedure of procuring supplies upon a request, which may be orally or in writing, is termed "requisitioning". Practically every commissioned officer in the Army will, at some time, require a knowledge of the few simple procedures which apply in making up and processing a requisition. An intelligent requisition will do more toward getting you the property needed than perhaps any other device applicable to the supply field. Therefore, make no mistake about the importance of knowing how to requisition correctly.

Normally, prepared forms are used for requisitioning but the absence of forms is not a bar to making your needs known. Simply labelling a blank sheet "Requisition" and adding the desired information will be adequate where forms are not available. Oral requests are acceptable and proper when required in special situations, but, to keep your own and the depot records straight, follow-up oral requests with a written requisition. The type of form is unimportant but the data shown is most important. Each of the various forms discussed below was designed for a specific purpose. Before studying the forms in detail let's decide on the 'simple procedures.'

Procedure. The requisition is prepared by you or your supply sergeant in a sufficient number of copies such that one can be kept in file and two (for combat zone) or three (for communication zone) can be taken to the depot. Basically, the following is shown on the requisition:

1. Designation of Organization: Example, 991st Ord HM Co. (tank) APO 600, USA.
2. Designation of Depot: Example, 1st Army Ordnance Depot
3. Requisition Number—From your unit requisition file

4. The Date
5. Standard nomenclature of property required

For this data consult the ASF Catalog and break-down the items required into the same grouping shown in the catalog. Normally one group only is shown on each requisition. For example, requisitioning gun parts and truck parts on a single requisition will delay issue of parts at the depot. Further, it will confuse your records and those at the depot. Also, separate requisitions must be prepared for each service from which you need supplies. Part numbers must be absolutely accurate.

6. The unit applying to each item. Example, dozens, lbs, each, etc.
7. Quantity needed.
8. Basis—Normally will be 'Initial issue' or 'Replacement'.
9. Authority—Examples, SNL, T/O & E, Verbal Order, Special Authority, etc.
10. Your signature. In combat zone supply, your signature as an officer frequently obviates a need for showing basis and authority but also makes you responsible that all requests shown are authorized. However, the basis is one place where you can put punch into the requisition and should be exploited to give the depot a story as to just why you require the supplies.

REQUISITION FORMS

Property Issue Slip (W.D., A.G.O. 446). Old timers will note that the Property Issue Slip is a new War Department Form designed for all using organizations which will draw property from a depot. Formerly, property was requested on a "400", received on a Tally-out and finally the depot supply officer shipped it to the C.O. on a shipping ticket. All the foregoing takes place in one action—when you submit the 446. If the procedure above and the example form shown is followed, the supplies will be forthcoming if available.

Property Turn In Slip (W.D., A.G.O. 447). The property turn in slip is made out for all unserviceable supplies to be turned in to the depot on the 'direct exchange replacement' basis. Excess stocks are also turned back on this form.

Requisition (W.D., A.G.O. 400). The new forms above are to save you work. However, depots everywhere are accepting the old '400' form from using units. When the 400 form is used the columns should be modified as shown in the accompanying illustration.

Requisition (W.D., A.G.O. 445). Don't confuse this with the QMC 400 form which is also termed a requisition form. The 445 is normally used by the Post Ordnance Officer in requisitioning from depots and arsenals. You probably won't see any of these in the field, but if some should turn up unexpectedly feel free to use them.

Parts Requisition OO 7365. This is the form generally used within a maintenance company. Formerly it was chiefly for automotive parts and a repair section would request parts from the supply section to perform necessary repairs. Use it to requisition from your supply point if you have nothing else handy. As a good field man you improvise and use what you have.

Preparation of Requisition. The correct manner and information required to fill in a requisition properly must be considered. On the property issue slip shown, each line and column to be filled in is numbered so refer to that number in the explanation. One other point, don't regard this information as pertaining only to property issue slips. Essentially it must go on all requisitions, although the headings may be slightly different.

(1) At the very top of the form is the line which reads To: Here's where you enter the next higher echelon of supply, which we call the 'supply point.' The only thing that can be added here is an admonition to make sure that you get the right numerical designation and be sure that the supply point gets it. Some examples of a supply point might be, Post Ordnance Officer, Fort Bragg, N. C., 377th Ordnance Base Depot Co., or Reg'tl Supply Offices, 980 Infantry.

(2) The line after "To": Your unit designation must be entered here *correctly*.

(3) You will notice 4 small boxes at the top of the property issue slip under Types of Issue. The first one is titled Initial Issue. If the circumstances are such that you are requesting the items for the first time, not having previously stocked

or been issued the item, you merely mark an X in the box. This may seem relatively minor but the supply point sometimes needs this information, so help them out.

(4) This has been the same purpose as the entry discussed immediately above. If your request is not for Initial Issue, it must be Replacement Issue. Either you are replacing stock which you have issued previously, or you are replacing an item which you had received previously but which you now lack. If it is replacement issue, place an 'X' under the word 'Replacement'.

Figure 10.

(5; 6) In addition to its other uses the property issue slip may be used as a memorandum receipt. It actually serves in a dual capacity—both requisition and memorandum receipt. If you request property on temporary loan your supply point may issue it to you and mark the box marked Debit Memo with an X. As far as you are concerned, it does not make too much difference except that the property is not yours. When you return this property the supply point will make out a property issue slip and mark the box called Credit Memo. A validated copy of this property issue slip will act as your receipt.

(7) This line is for the voucher number just as it states. Actually the voucher number doesn't directly concern our problem of requisitioning, although sometimes requisition numbers are derived from the debit voucher number. The best thing to do is leave this blank and fill in your voucher number, if you use them, when the property is issued and you are returned the duplicate copy of the property issue slip.

(8) This box is for the requisition number although it is labeled Issue Slip Number. Numbering requisitions is an extremely important factor and the requisition number itself must always be entered. It becomes a means of identifying the

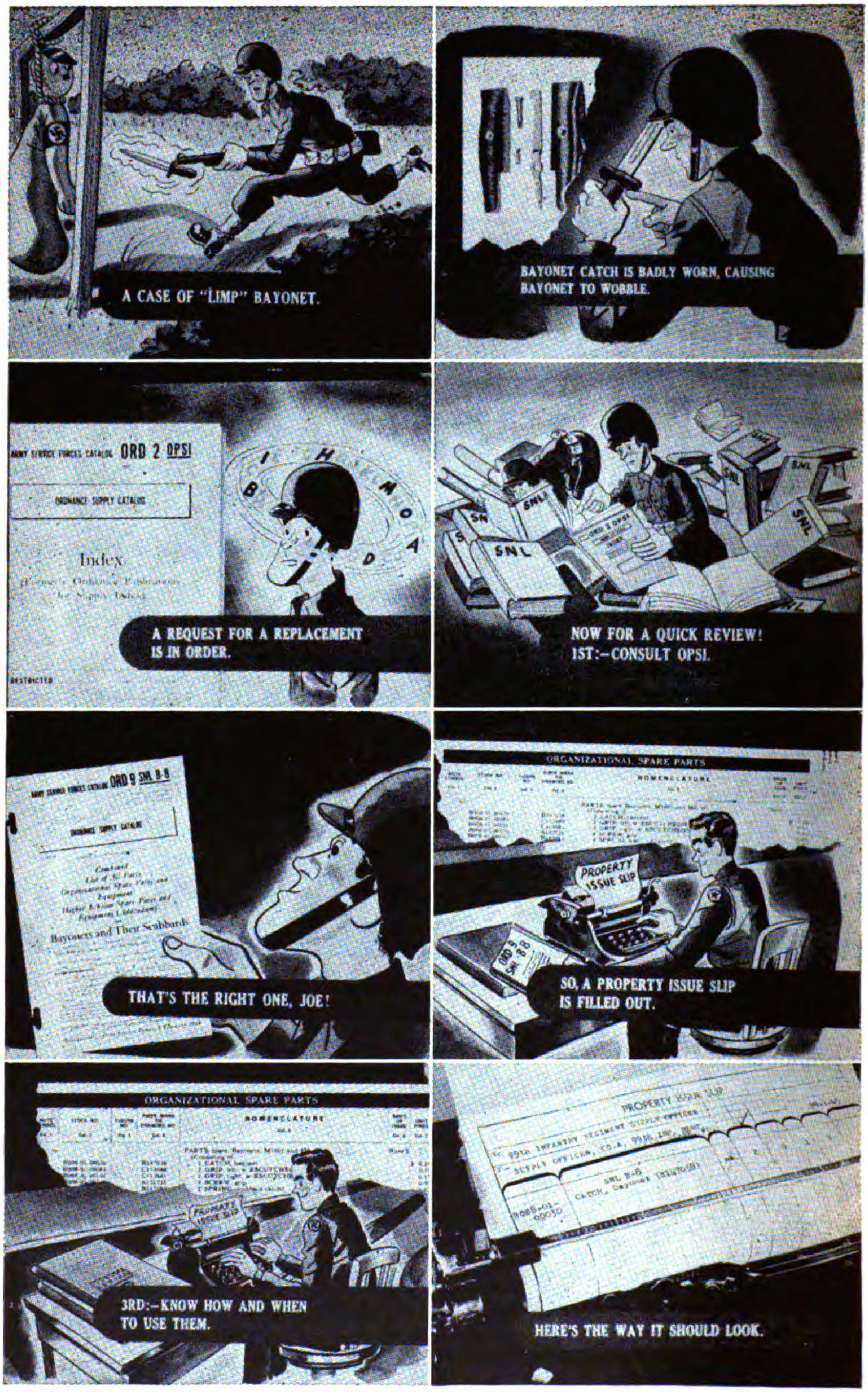


Figure 11. Preparation of the Property Issue Slip.

property issue slip not only for yourself but for your supply point. You are probably wondering just how you will arrive at a requisition number. There are two ways and you can use either. A requisition number consists of three parts:

(a) Unit designation number
(b) Serial Number
(c) Fiscal year (last two digits)

Figure 12. Request Shortages Immediately.

For the unit designation you need only take the number of your unit. If you are the 30th-Co. the first part of your requisition number is 30. Remember that the serial numbers of requisitions always begin with the first of the fiscal year. Consequently, the first requisition on 1 July 1944 will be NO. 1 and the requisitions that follow will be numbered serially until 30 June of the following year. You would then start with number 1 all over again. Let us go back to the two records that are kept to number requisitions. The first is the Requisition Register QMC 479. The form is self explanatory and you doubtlessly will be able to get them in the field. You start a new register every fiscal year and number all requisitions consecutively. To get a number for a new requisition consult the register and take the next number. Do not forget to enter the new requisition in the register.

The second method is a little different inasmuch as the requisition number comes from the Voucher Register QMC 480. When you eventually receive the property which you have requisitioned you will use your copy of the property issue slip as a debit voucher and it would be entered in the voucher register. Under the system being discussed, instead of waiting until the property is received, we prepost the voucher in the voucher register. Hence, if the last number in the voucher register was DV-7-45, when we received the stock on our property issue slip we would use the next voucher number DV-8-45. But instead of waiting until

PROPERTY ISSUE SLIP

To: (1) 77th. Ordnance Depot Co. — Supply Officer

For: (2) 55th. Ordnance MM Co. (Organization unit)

Type of Issue: Initial (3) | Replacement (4) X | Debit Memo Receipt (5) | Credit Memo Receipt (6)

Voucher No. (7)

Issue Slip No. (8) 55-10-45

Stock No.	Nomenclature	Unit	Auth. or Max. Level	On Hand	Due In	Quantity Desired	Action
(9)	(10) SNL B-21	(11)	(12)	(13)	(14)	(15)	(16)
B021-01-00360	HAMMER (C46008)	ea.	12	2	2	8	
	SNL B-28						
B028-01-00100	BOLT, assy (C57156)	ea.	10	3	0	7	

LAST ITEM

(17)

BASIS: To bring stock up to maximum level

AUTHORITY: Addendum SNL B-21 dated 10 August 194
" SNL B-28 " 11 August 194

Issuance or acceptance of quantities shown in "Action" column is authorized. Items marked "Ext" will be ordered. Zeroed items will be available on the dates indicated hereon. When received, items will be issued on presentation of this slip. Inquiries must refer to No. (19)

(Date) ______, 194 (20) — For Station Supply Officer

For the Commanding Officer:

(Date) (18) 7 July, 1944 James P. Smith — Organization Supply Officer.

Quantities shown in "Action" column have been received.

(Date) (21) ______, 194 ______ Authorized Representative.

W.D., AGO Form 446—4 August 1943

Figure 13. Property Issue Slip (W.D., A.G.O. 446).

the stock is obtained we post the debit voucher at the time the requisition is made up. The debit voucher number is DV-8-45. We get our requisition number from this debit voucher number. We use the unit numerical designation 30, the serial number of the debit voucher which is 8, put a 'D' in front of it and add the last two digits of the fiscal year. Thus the debit voucher number DV-8-45 becomes requisition and voucher numbers for reference purposes.

(9) This column is headed Stock Number. There shouldn't be too much difficulty in understanding what goes here. It may be any identifying number—item stock number, the so-called Taxi number, piecemark or drawing number, manufactures number, or Federal Standard Stock Catalog number. If you get your item from an SNL you won't have any trouble finding a number; the item stock number, if available, is the one to be inserted. If you don't have an item stock number, one of the others listed in the SNL will be used instead. The importance of the stock

number cannot be overemphasized. It is one of the vital necessities of requisitioning. On requisitions for property issued by supply branches other than Ordnance, you may not be required to have a number. This is usually true of QM property. In a case like this do not worry about your lack of numbers.

(10) The nomenclature column is reserved for the description of the items you wish to requisition. Always verify and check your nomenclature to make sure you will get what you want. SNL's are a perfect basis for correct nomenclature; use it. Whatever publication you use, the nomenclature therein can usually be considered as correct. Note closely the way of arranging your items as shown in the illustration. The SNL number is always listed first and should be underlined. Arrange your SNL numbers numerically and the items within one group numerically. Always capitalize the first noun of the nomenclature. If you have inserted an item stock number in the stock no. column include the piece mark after the nomenclature in parentheses. Always double space your items. The supply point will appreciate this because it enables them to edit your requisition more easily. It may very well be the difference between having your requisition filled or having it rejected.

WAR DEPARTMENT
Q. M. C. Form No. 400
(Revised Apr. 6, 1931)

REQUISITION

To: .... No. of Sheets .... Sheet No. ....

Requisition No. .... Date .... Period ....

SHIP TO ....

REQUISITIONED BY (show Signature, Rank, Organization, Destination. If different from "SHIP TO" include address):

APPROVED BY:

STOCK No.	ARTICLES	UNIT	ON HAND AND DUE	CONSUMED	REQUIRED	APPROVED

Figure 14. Requisition (W.D., A.G.O. 400).

(11) Simply insert the unit by which the item is normally requisitioned—ea, qt, lb., barrel, etc.

(12) There are several sources for filling in the information in the 'Authorized or 'Maximum Level" column.

If you have a regular informal stock record account the figure will appear on the stock card. If it is organizational equipment the authorized amount is that given by the appropriate T/E. For allowances of spare parts and equipment on your weapons and vehicles you will be the authority on your own allowances from the SNL.

(13) 'On Hand' means just what it says, and the figure to be inserted comes right from the balance column of the stock record card or the page of the company property book. Here is something that's always well to remember—the amount you request is always the difference between the sum of 'due' in and 'on hand' and maximum or authorized level. If your maximum level was 6 and you had 1 on hand and 1 due in, the amount requested would be 4.

(14) Due-in means that a certain item is owed to you and has not, as yet, been

received. It represents stock that was previously requisitioned and has been back ordered for you. Don't forget to add this to your on hand figure to compute the amount you want.

(15) We have finally reached the main point of our discussion—what we actually want. Quantity Desired represents our requirement and the amount we hope the supply point will issue to us.

(16) This column is reserved exclusively for the supply point to indicate just what action they will take on the items you want. This may be any of the follow-

REQUISITION

TO

SHIP TO

Page of Pages

Period

Requisition No.

Item No.	Stock No.	Nomenclature	Unit	1 Control Level	2 On Hand	3 Due In	4 Due Out	5 Quantity Req'st'd	Act Sym.
				Column 1−2−3+4=5					

The Action Symbol Column Is for Depot Use Only

For the Commanding Officer:

_____ 194____ __________ ____________________
(Supply officer)

W. D., A. G. O. Form No. 445
1 May 1944
(This form supersedes W. D., A. G. O. Form No. 445, 6 August 1943, which will not be used after receipt of this revision)

☆ U. S. GOVERNMENT PRINTING OFFICE

Figure 15. Requisition (W.D., A.G.O. 445).

ing: backorder, extract, cancellation. They may honor the requisition for the amounts you desire.

(17) You will never find any publication which definitely states that a basis and authority must be shown on requisitions; nevertheless, all authorities strongly recommend the use of these two items. Basis merely means a statement telling why you want the item. Authority is the publication which permits you to stock the item or have it in your possession. There are so many different publications which authorize you to request property that we'll list only a few.

OSP&E and HESP&E sections of the SNL's pertinent T/E's or T/O & E's, Modification Work Orders, Tool and Load Lists, allowance publications such as SNL K-1, T/A 20, T/A 23, etc. Actually there are many hundreds of these and it is obviously impossible to list them all. Just make sure you use the right one and let the authority fit the situation. If you put a basis and authority on your requisition you are really presenting the situation as it exists and giving the supply point a picture of the situation so that it can determine the validity of your request. It almost always happens that a request with a basis and authority will be given preference over one with no explanation. This is particularly true if there is a limited amount of the item requested available. If possible, always include a basis and authority.

WAR DEPARTMENT
Q.M.C. Form No. 479 (old No. 60)
Revised August 9, 1934

OUTGOING **REQUISITION REGISTER**

55th. Ordnance LM Co. *Fiscal year* 1945

Date of Req.	REQUISITION NUMBER	ROUTED TO	REMARKS	COMPLETED
1 Jul 1944	55-1-45	19th. Ord. HM Co.	Replacement	
1	55-2-45	77th. Ord. Depot Co.	Initial	
2	55-3-45	77th. Ord. Depot Co.	For Stock	
3	55-4-45	19th. Ord. HM Co.	Replacement	
3	55-5-45	77th. Ord. Depot Co.	Deadline	
4	55-6-45	77th. Ord. Depot Co.	Reissue 97 Ord. LM Co	
5	55-7-45	77th. Ord. Depot Co.	Replacement	
5	55-8-45	77th. Ord. Depot Co.	MWO ORD B3-W15	
6	55-9-45	19th. Ord. HM Co.	Replacement	
7	55-10-45	77th. Ord. Depot Co.	Stock	

Figure 16. Requisition Register (W.D., A.G.O. 479).

(18) When the requisition is made up, you first put down the date that you completed it on the line indicated. On the line marked 'organization supply officer' either the organization commander, supply officer or any other authorized officer or warrant officer may sign. The signature on this line actually certifies that the request is correct and that authorized allowances have not been exceeded.

(19 and 20) This is the box at the lower left of the property issue slip. This is filled in only when the requisition is validated. If you should present a requisition to your supply point, and they cannot fill it because they have no stock on hand, they will validate it. This validation acknowledges receipt of the requisition, the correctness of the request and furnishes a basis which enables you to receive the property when the supply point receives it. The signature, on the line For Station Supply Officer, constitutes the validation and will be the signature of the Supply Point's organization commander, supply officer or designated officer or warrant officer. The line marked No. will be filled in with the credit voucher number of the supply point. In any correspondence with the supply point in regard to this requisition you refer to it by this number.

(21) This is never filled in until the property you ask for is received. When it is, your representative will date and sign, acknowledging receipt of the property. This is only done on the original copy which is used by the supply point as a credit voucher. As far as your copy is concerned, it is blank.

1. When To Make Separate Requisitions

There are three or four cases where separate requisitions are necessary. Each alphabetical SNL Group will get a separate requisition. For instance, A-4 items and B-6 items cannot be put on the same request. For automotive items you have a separate requisition for each different make and model. Separate requisitions are required for different supply branches, i.e., QM, Med, Ord, etc.

2. Local Standard Operating Procedure

Regardless of what may be said here, there are different ways and methods of accomplishing a process like requisitioning. You will sooner or later come under a local SOP or perhaps even one by a corps or army commander. In all cases their provisions will be complied with even though what we learn here might not agree. In any case apply what you learned here to your specific problem.

ACCOUNTABILITY AND RESPONSIBILITY

Zone of Interior

Accountability devolves upon any person to whom public property is entrusted and for which a formal stock record account must be kept. All commissioned officers and warrant officers, when duly appointed by proper authority, may be held accountable. In addition, in certain cases, a noncommissioned officer of the first three grades, subject to the approval of the chief of the branch may also be held accountable.

Responsibility devolves upon any person who has public property in his personal possession or entrusted to his care. It infers well-being of property, in contrast to a paper record of disposition.

Transfer of Accountability. Complete transfer of accountability occurs when an officer is relieved from accountability and responsibility by competent authority and another officer is appointed to assume the same accountability and responsibility.

Ordinary Transfer occurs when property is issued by the station supply officer to another station supply officer.

Normally accountability ceases when property is issued to an organization or a unit by the station supply officer.

Stock Record Account. In order to reflect equipment available for issue and materiel for which a property officer is accountable, a *stock record account* is maintained. In the case of a post, camp, or station installation, this account includes not only records of receipts and issues, but also a record of property which has been issued temporarily on memorandum receipt. The latter usually consists of T/A property which is not removed from the post by the unit upon change of station.

The stock record account is not a ledger or a single listing of stock. It consists of three parts: the *voucher register, stock cards,* and a *voucher file.* While, as a rule, specific forms are used for each of these three portions of the stock record account, expedients may be adopted for any one or all of the papers and cards.

The voucher register (Form No. 480). On this form will be listed all incoming and outgoing vouchers pertaining to the account. Vouchers are debit or credit, depending upon whether they reflect receipt or issue of property. Memorandum receipt transactions are also recorded on this form. Numbers of the vouchers are determined from the register itself, which runs through the fiscal year, from 1 July.

Stock cards, or *stock record cards.* The stock record account contains one card for each type item in stock, and to these cards will be posted all information pertaining to activity on individual items. There are various stock card forms—from the punch card used by depots with machine records to the AGO Form #421 and the Kardex file employed by some outfits. Regardless of the kind of card used, it must contain sufficient information to identify completely the item, and it must contain space for the entries reflecting traffic in the particular item.

Vouchers and Voucher File. A voucher is a document which guarantees accuracy of an account. There should be a voucher to correspond to, or explain, each entry on the stock record cards or the voucher register. After vouchers have been given numbers and posted to the voucher register and the pertinent stock ecord cards, they are retained in a file which contains vouchers in serial order ɔr the fiscal year. Vouchers are audited periodically.

Memorandum receipts are termed debit and credit. They are used to transfer esponsibility for equipment—usually T/A property. An accountable officer keeps ıemorandum receipts catalogued according to organizations holding property esponsibility.

Any voucher reflecting an increase in amount of property on hand is a *debit oucher*, and those which decrease balances are *credit vouchers*. Papers which ıay be accepted as vouchers include:

1. Tally-In
2. Property Issue Slip
3. Property Turn-In Slip
4. War Department Shipping Document
5. Report of Survey

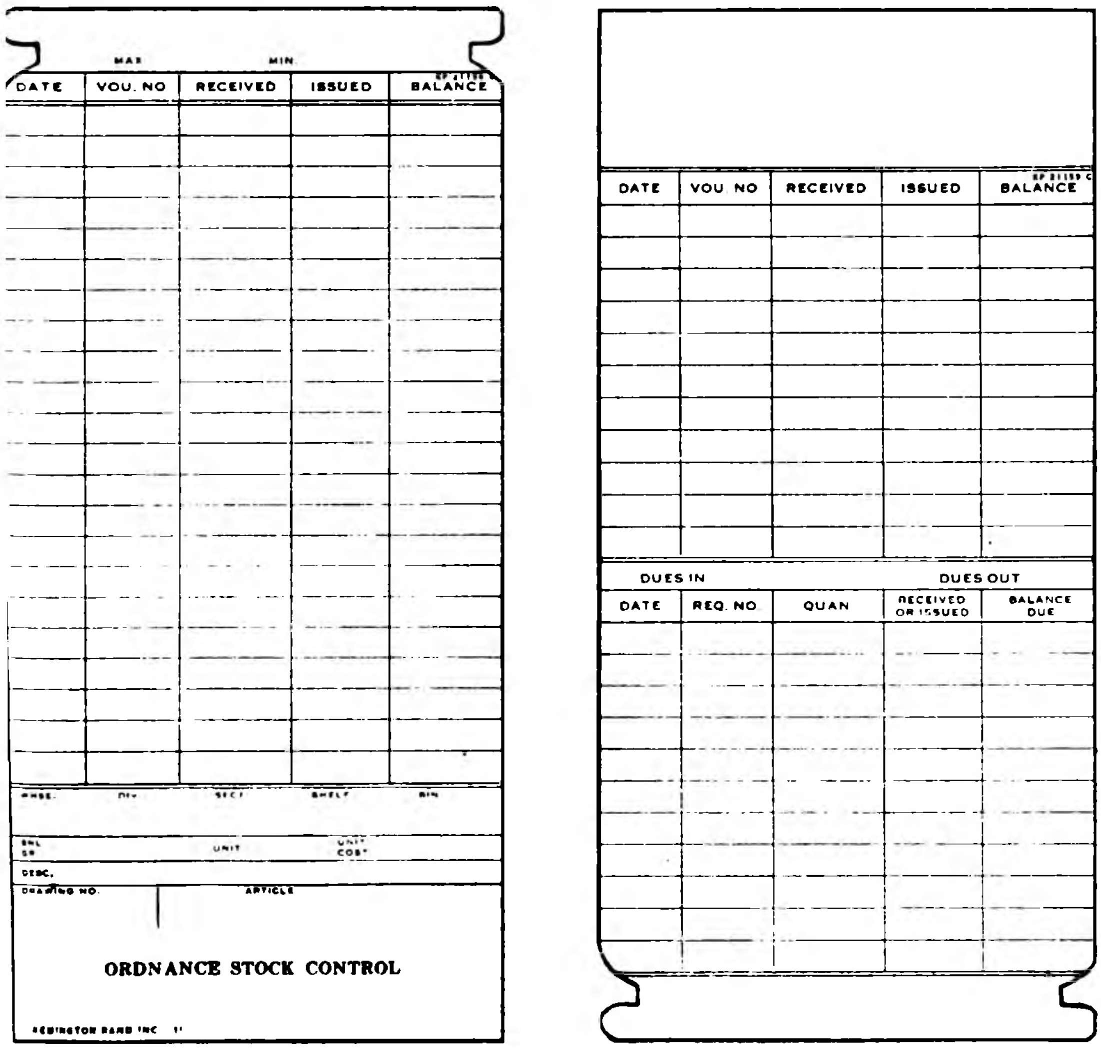


Figure 17. Ordnance Stock Record Card (W.D., A.G.O. Form No. 9-72).

6. Statement of Charges
7. Purchase Order and Voucher

The process of recording information on stock record cards is known as *posting*.

Receipt and Issue of Property. While the primary mission of Ordnance supply installations is the constant issue of property, in order to fulfill that mission, it

Date	9/1/44			Interchangeability		Description	Class	Stock No.	
Maximum Level	40					ARM, follower B8869	B-21	8021-02-00030	
Reorder Point							Unit	Standard Pack	Order Schedule
							ea.	10	10th each mo

DUE IN AND DUE OUT							RECEIPTS AND ISSUES							
Date	Order No.	Depot or Organization	Quantity Ordered	Received / Balance	Received / Balance	Received / Balance	Date 1944	Quantity Received	Voucher No.	Initial Issue	Replacement Issue	Transfers	Balance on Hand	AR
9/10	77-D377-W	911th Arty	23	23 / 0			9/1	Balance brought forward					40	
							9/3		O-230		5		35	
							9/5		O-262	12			23	
							9/8		O-274		6		17	
							9/11		O-291		2		15	
							9/12	23	R-297				38	

Date				Interchangeability		Description	Class	Stock No.	
Maximum Level	(1)			(2)		(3)	(4)	(5)	
Reorder Point							Unit	Standard Pack	Order Schedule
							(6)	(7)	(8)

DUE IN AND DUE OUT							RECEIPTS AND ISSUES						
Date	Order No.	Depot or Organization	Quantity Ordered	Received / Balance	Received / Balance	Received / Balance	Date	Quantity Received	Voucher No.	Initial Issue	Replacement Issue	Transfers	Balance on Hand
In this section of the card will be entered all DUE IN and DUE OUT quantities.							(9)	(10)	(11)	(12)	(13)	(14)	(15)
(16)	(17)	(18)											

(1) The maximum allowable on hand and due in.
(2) Here will be entered the numbers of any items that may be substituted for the article.
(3) The complete nomenclature of the item to be entered on this card.
(4) The actual storage group in which this article is to be stored.
(5) The stockage number of the article on this card.
(6) The unit of the article - pound, each, pair, assembly.
(7) The normal way that this item is usually packed for shipment
(8) The schedule that is usually set up by the supply point - depot or post.
(9) The date that the actual paper or voucher is assigned its number.
(10) The quantity actually received on the incoming paper.
(11) The actual number assigned to the paper will be entered here.
(12) The amounts issued initially to an organization or unit will be entered here.
(13) All issues to organizations or units except initial issues will be entered here.
(14) Any property to be shipped from one post to another will be entered in the column.
(15) The actual amount available for issue will be shown in this column.
(16) This column will show the number of the requisition- your own number in the case of DUE IN; and the requisitioning unit's number in the case of DUE OUT.
(17) The organization upon which requisition is made or the unit making the request will be entered here.
(18) The actual quantity shown on the requisition will be shown in this column.

SAMPLE ENTRIES

Figure 18. Stock Record Card (W.D., A.G.O. Form 421).

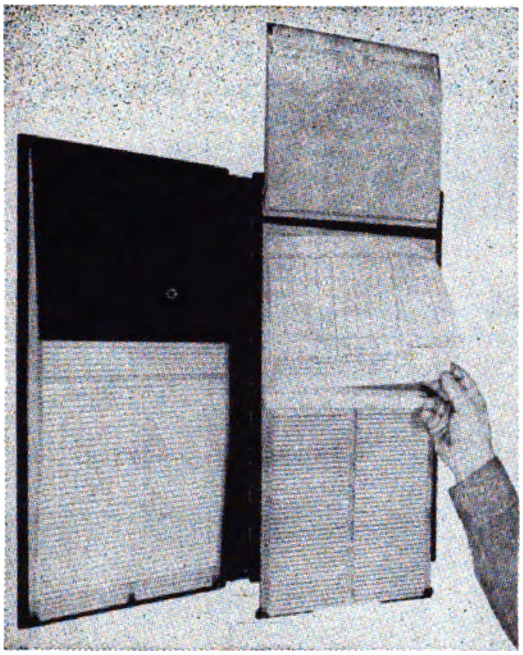


Figure 19. Assembled Bookfold.

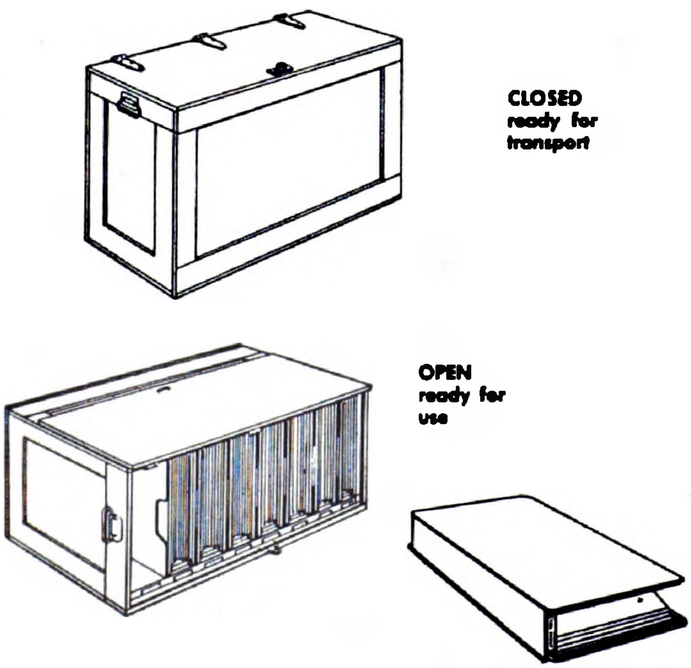


Figure 20. Book Unit Holding Cabinet.

will be necessary as well to receive and store property, and all incoming property should be covered by appropriate papers. These may take the form of:

(1) The Property Issue Slip—WD AGO Form 446

(2) Property Turn-In Slip—WD AGO Form 447

(3) Purchase Order and Voucher for Purchases and Services other than Personal—WD Form 383 and 383a.

(4) Tally Sheet Incoming—WD QMC Form 489

(5) War Department Shipping Document (Property Copy)—WD AGO Form 450-5-C.

Upon receipt of items on any of the preceding papers, entries will be made on stock record account, posted to quantity received, for:

(1) All shipments for stock.

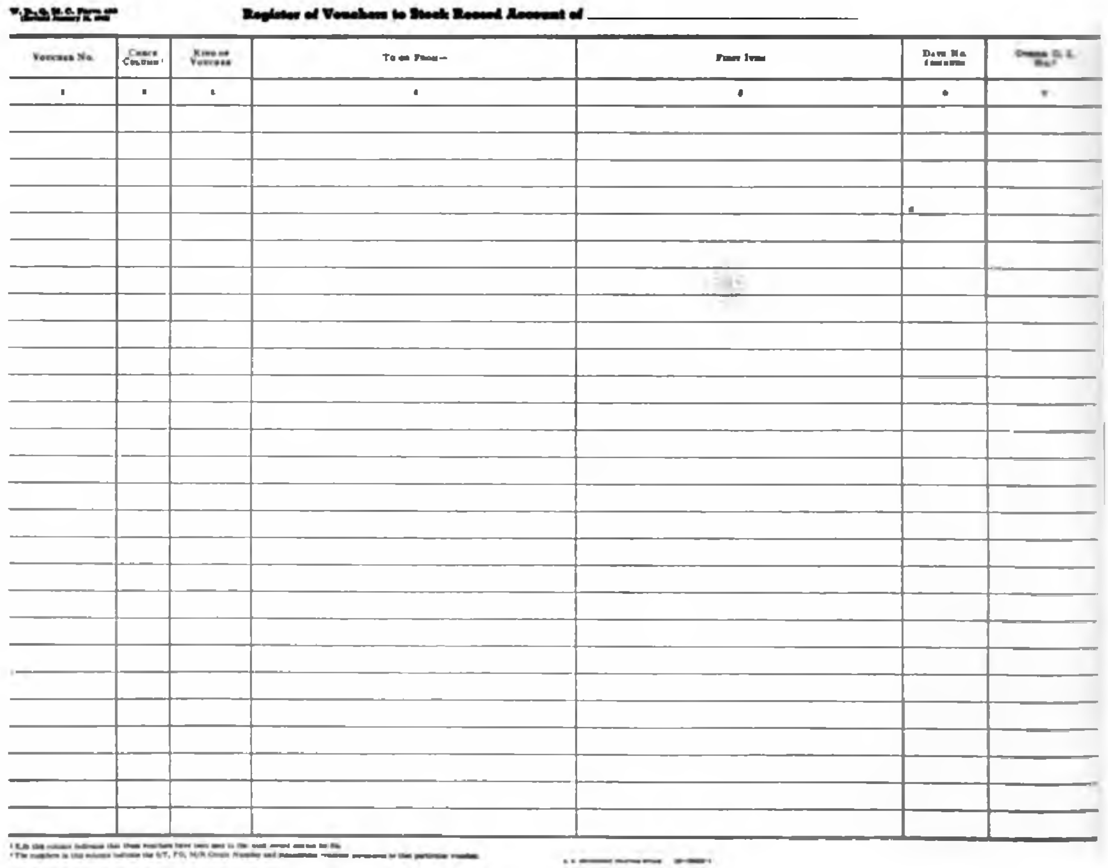


Figure 21. Voucher Register (W.D., A.G.O. Form 480).

(2) All shipments for organizations, the requisition for which was initiated or submitted through the station.

(3) All serviceable items returned to the supply officer from units, organizations, or repair shops.

Receiving Property for Stock. When local purchase of supplies is authorized by proper authority, the purchasing and contracting officer will take steps to have local vendors deliver required items to the receiving officer. The instructions given by the purchasing and contracting officer are contained in a purchase order and voucher for purchases and services other than personal (WD Form 383 & 383a). Normally three copies of this form are furnished by the purchasing and contracting officer to the receiving officer.

War Department
Form No. [illegible]
Form approved by Comptroller General, U. S.
[illegible] August 1943

13.

PURCHASE ORDER AND VOUCHER FOR PURCHASES AND SERVICES OTHER THAN PERSONAL

UNITED STATES WAR DEPARTMENT

[Lo]cation: (1)

To: (2)

Please furnish the following, subject to the conditions stated on both sides of this form:

Ship To: (3)

F. O. B. (4) Terms: (5)

VENDOR: Mail the original with vendor's certificate completed or the original with original certified invoice and (6) copies

To (7)

(8)
(Date)
(9)
(P. O. No.)
(10)
(Req. No.)
(11)
(Par. Auth.)

Negotiated under authority of the First War Powers Act, 1941, and Executive Order No. 9001, December 27, 1941.

D. O. Vou. No. ....

PAID BY

(12)

(For Use of Paying Office)

Payment will be made by finance officer at— (13)

Funds chargeable (14)
[illegible]

(15)
Purchasing and Contracting Officer.

Item No.	Articles or Services	Quantity	Unit	Unit Price	Amount: Dollars	Amount: Cents	Quantity Received
(16)	(17)	(18)	(19)	(20)	(21)		(22)
				Total.	(23)		

(Vendor must NOT use this space)
Differences
(24)
Account verified, correct for
(Signature or initials)

MEMORANDUM

RECEIVING REPORT: I certify that the items listed in Quantity Received column above were inspected and accepted by me, and that they conform to requirements, and/or that the services specified were actually rendered. (25)
(Date) Inspecting Officer.

PROPERTY VOUCHER NO. .... I certify that the items listed in Quantity Received column above were received by me in the quantities and conditions stated, and that the same have been taken up on the property accounts at this station. (26)
(Date) Accountable Officer.

ACCOUNTING CLASSIFICATION (for completion by Administrative Office)

Appropriation, Limitation, or Project Symbol	Abbreviated Appropriation Title	Allotment, Project, and Object Symbols	Station Code	Limitation of Project Amount	Appropriation Amount
	(27)				

[Pai]d by {Check No .... dated ...., 19.... for $........ on Treasurer of the United States in favor of Payee named above.
Cash, $........, on ...., 19.... Payee ....
(Sign original only)

Per .... (28)
Title ....

SPECIAL PROVISIONS AND CONDITIONS APPLYING TO THIS ORDER

1. PAYMENTS.—The Contractor shall be paid, upon the submission of properly certified invoices or vouchers, the prices stipulated herein for articles delivered and accepted or services rendered, less deductions, if any, as herein provided. Unless otherwise specified, payments will be made on partial deliveries accepted by the Government when the amount due on such deliveries so warrants; or, when requested by the Contractor, payments for accepted partial deliveries shall be made whenever such payments would equal or exceed either $1,000 or 50 percent of the total amount of the contract.

2. INSPECTION.—All material and workmanship shall be subject to inspection and test at all times and places and, when practicable, during manufacture. In case any articles are found to be defective in material or workmanship, or otherwise not in conformity with the specification requirements, the Government shall have the right to reject such articles, or require their correction. In the event public necessity requires the use of materials or supplies not conforming to the specifications, payment therefor shall be made at a proper reduction in price.

3. VARIATION IN QUANTITIES.—Unless otherwise specified, any variation in the quantities herein called for, not exceeding 10 percent, will be accepted as a compliance with the contract, when caused by conditions of loading, shipping, packing, or allowances in manufacturing processes, and payments shall be adjusted accordingly.

4. ACCEPTANCE.—In accepting this order the Contractor agrees that the terms and conditions stated on both sides of this purchase order are a part of the agreement between the parties hereto.

5. NOTICE OF SHIPMENTS.—In connection with any shipment hereunder of one carload or equivalent or more consigned to any unit or officer of the War Department, the shipper, at the time the equipment or supplies are ordered for loading for rail, motor, or water transport, will send consignee notice thereof by prepaid telegraph or teletype, including car number and initial, complete routing, size of shipment, and brief general description of the equipment or supplies comprising the shipment, including requisition or shipping order number, if any. When authorized by the purchasing and contracting officer, such notice may be sent by air mail, in lieu of telegraph or teletype, where secrecy is essential and where the use of air mail is practicable. This provision is not to be substituted for any other requirement, such as mailing bills of lading.

6. SHIPPING INSTRUCTIONS:
   (a) MARK EACH PACKAGE with complete destination, purchase order number, name of Contractor, commodity, quantity, purchase order item number, and package number.
   (b) PACKING LIST MUST accompany each shipment, showing package number and contents.
   (c) PREPAY all carrier charges to destination (unless otherwise instructed) forwarding shipping notices, bills of lading, and paid tariff bills.

7. TAXES.—Unless otherwise indicated in this contract (a) the prices herein do not include any of the following taxes in effect at the date of this contract: (i) Any Federal tax which is directly applicable to the completed supplies covered hereby (including component parts, articles, or units of which the Contractor is the manufacturer, importer, or producer) and as to which exemption from tax is available, or (ii) any State or local sales, use, or other tax from which the Contractor or this transaction of the procurement of these supplies is exempt, and (b) the prices herein include all other Federal, State, and local taxes (including without limitation of the foregoing all transportation taxes). Upon request of the Contractor the Government will issue tax-exemption certificates or furnish other similar proof of exemption with respect to all taxes excluded from the price.

8. EIGHT-HOUR LAW.—No laborer or mechanic doing any part of the work contemplated by this contract, in the employ of the Contractor or any subcontractor contracting for any part of said work contemplated, shall be required or permitted to work more than 8 hours in any one calendar day upon such work at the site thereof, except upon the condition that compensation is paid to such laborer or mechanic in accordance with the provisions of this article. The wages of every laborer and mechanic employed by the Contractor or any subcontractor engaged in the performance of this contract shall be computed on a basic day rate of 8 hours per day and work in excess of 8 hours per day is permitted only upon the condition that every such laborer and mechanic shall be compensated for all hours worked in excess of 8 hours per day at not less than one and one-half times the basic rate of pay. For each violation of the requirements of this article a penalty of $5 shall be imposed upon the Contractor for each laborer or mechanic for every calendar day in which such employee is required or permitted to labor more than 8 hours upon said work without receiving compensation computed in accordance with this article, and all penalties thus imposed shall be withheld for the use and benefit of the Government: *Provided*, That this stipulation shall be subject in all respects to the exceptions and provisions of U. S. Code, title 40, sections 321, 324, 325, and 326, relating to hours of labor, as modified by the provisions of section 303 of Public Act No. 781, 76th Congress, approved September 9, 1940, relating to compensation for overtime.

9. ANTI-DISCRIMINATION.—(a) The Contractor, in performing the work required by this contract, shall not discriminate against any worker or applicant for employment because of race, creed, color, or national origin. (b) The Contractor agrees that the provision of paragraph (a) above will also be inserted in all of its subcontracts. For the purpose of this article, a subcontract is defined as any contract entered into by the Contractor with any individual, partnership, association, corporation, estate, or trust, or other business enterprise or other legal entity, for a specific part of the work to be performed in connection with the supplies or services furnished under this contract: *Provided, however*, That a contract for the furnishing of standard or commercial articles or raw material shall not be considered as a subcontract.

10. CONVICT LABOR.—The Contractor shall not employ any person undergoing sentence of imprisonment at hard labor.

11. DELAYS—DAMAGES.—If the Contractor refuses or fails to perform this contract within the time specified, or any extension thereof, the Government may, by written notice, terminate the right of the Contractor to proceed with deliveries or with such part or parts thereof as to which there has been delay, and may hold the Contractor liable for any damage caused the Government by reason of such termination. The right of the Contractor to proceed with the performance of this contract shall not be terminated under this General Provision 1 if the delay is due to unforeseeable causes beyond the control and without the fault or negligence of the Contractor, including without being limited to, any preference, priority, or allocation order issued by the Government or any other act of the Government.

12. DISPUTES.—Except as otherwise specifically provided in this contract, all disputes concerning questions of fact which may arise under this contract, and which are not disposed of by mutual agreement, shall be decided by the Contracting Officer, who shall reduce his decision to writing and mail a copy thereof to the Contractor. Within 30 days from said mailing the Contractor may appeal to the Secretary of War, whose decision or that of his designated representative, representatives, or board shall be final and conclusive upon the parties hereto. Pending decision of a dispute hereunder the Contractor shall diligently proceed with the performance of this contract.

13. ASSIGNMENT OF RIGHTS HEREUNDER.—This General Provision 13 shall apply if this contract is for $1,000 or more. (a) Claims for monies due or to become due the Contractor from the Government under this contract may be assigned to a bank, trust company, or other financing institution, including any Federal lending agency. Any such assignment shall cover all amounts payable under this contract and not already paid, and shall not be made to more than one party, except that any such assignment may be made to one party as agents or trustee for two or more parties participating in such financing. (b) In the event of any such assignment the assignee shall file four signed copies of a written notice of the assignment, together with one copy of the instrument of assignment, with each of the following: (i) General Accounting Office; (ii) the Contracting Officer; (iii) the surety or sureties upon the bond or bonds, if any, in connection with this contract; (iv) the officer designated in this contract to make payments thereunder. (c) Any claim under this contract which has been assigned pursuant to the foregoing provisions of this article may be further assigned and reassigned to a bank, trust company, or other financing institution, including any Federal lending agency. In the event of such further assignment or reassignment the assignee shall file one signed copy of a written notice of the further assignment or reassignment together with a true copy of the instrument of further assignment or reassignment with the Contractor; and shall file four signed copies of such written notice and one copy of such instrument with each of the parties designated in the preceding paragraph. (d) No assignee shall divulge any information concerning the contract except to those persons concerned with the transaction. (e) Payment to an assignee of any claim under this contract shall not be subject to reduction or set-off for any indebtedness of the assignor to the United States arising independently of this contract. (f) Indication of the assignment of claim and of any further assignment thereof and the name of the assignee will be made on all vouchers or invoices certified by the Contractor.

14. OFFICIALS NOT TO BENEFIT.—No Member of or Delegate to Congress, or Resident Commissioner, shall be admitted to any share or part of this contract or to any benefit that may arise therefrom, but this provision shall not be construed to extend to this contract if made with a corporation for its general benefit.

15. COVENANT AGAINST CONTINGENT FEES.—The Contractor warrants that he has not employed any person to solicit or secure this contract upon any agreement for commission, percentage, brokerage, or contingent fee. Breach of this warranty shall give the Government the right to annul the contract, or, in its discretion, to deduct from the contract price or consideration the amount of such commission, percentage, brokerage, or contingent fees. This warranty shall not apply to commissions payable by contractors upon contracts or sales secured or made through bona fide established commercial or selling agencies maintained by the Contractor for the purpose of securing business.

16. DEFINITIONS.—(a) The term "Secretary of War" as used herein shall include the Under Secretary of War, and the term "his duly authorized representative" shall mean any person or board authorized by the Secretary of War to act for him other than the Contracting Officer. (b) Except for the original signing of this contract, and except as otherwise stated herein, the term "Contracting Officer" as used herein shall include his duly appointed successor or his authorized representative.

Figure 22. Purchase Order and Voucher for Purchases and Services Other Than Personal (W.D. 383a).

EXPLANATION OF THE PURCHASE ORDER AND VOUCHER

Space Number	Explanation and Samples of Entries on P. O. & V.	Office Making Entry
1	U. S. WAR DEPARTMENT, STATION SUPPLY OFFICER, FT. WAYSIDE, KY.	Pur. & Cont.
2	Name of vendor supplying the item, i.e. ACME HARDWARE CO., FRANKFORT, KY.	ditto
3	Office for whom purchase is being made, i.e. STATION SUPPLY OFFICER, FT. WAYSIDE, KY.	ditto
4	F.O.B. means the item is to be delivered to train or ship without extra charge. (Local purchases usually are delivered by the vendor or picked up by govt. vehicle.)	ditto
5	Cash or in case of discount the terms are quoted.	ditto
6	Vendor completes certificate on the original P.O.&V. or attaches original and two copies of invoice.	ditto
7	P.O.&V. or/and invoice mailed to the Purchasing and Contracting Officer by the vendor.	ditto
8	No explanation necessary.	ditto
9	Serial Number assigned to each P.O.&V.	ditto
10	Requisition number supplied by the Station Supply Officer. (This will also serve as Voucher No. for the Station Supply Officer)	ditto
11	Sub-Allotment or Purchase Authorization Advice Number may be listed herein.	ditto
12	Completed by the Finance Officer making payment.	Fin. Officer
13	Address of Finance Officer who will make payment.	Pur. & Cont.
14	Appropriation from which funds will be used, i.e., 212/4020502 7-2240 P490.	ditto
15	Signature of the Purchasing & Contracting Officer.	ditto
16	When more than one item is being purchased they are numbered consecutively, i.e., 1-2-3-4 etc.	ditto
17	Nomenclature of item being purchased. For automotive parts, the type, manufacturer, model and registration number must be indicated. For major items, the designation, type, model, and serial number must be indicated. (This information is on requisition from Station Supply Office.)	ditto
18	Numerical amount of each item being purchased.	ditto
19	Unit of measure, i.e., ft., gal., cu. ft., lbs., set.	ditto
20	Price for one unit.	ditto
21	Amount. (Quantity multiplied by the unit price).	ditto
22	Items actually received in the warehouse.	Warehouse Sect., Station Supply Office.
23	Total money value of the P.O.&V.	Pur. & Cont.
24	Shortages or variations will be accounted for, i.e., Item No. 2 short 4 each, 70c. Deduct the 70c from the total money value above to show the amount to be paid the vendor.	ditto
25	Officer receiving the property will sign here.	Station Supply Officer.
26	Accountable officer will have the voucher number entered and sign accepting accountability.	Stock Record Sect & Station Suppl Officer.
27	Accounting classification information is completed by the fiscal section except the appropriation amount which is entered by the Purchasing and Contracting Office.	Fiscal Section, Station Supply Office and Purchasin and Contracting.
28	Completed by the Finance Officer. The original only is signed by the vendor or his representative.	Finance Officer making payment.

One copy is filed with the retained copy of the requisition requesting the supplies. The other two copies are retained by the receiving officer until receipt o the supplies from the vendor. Upon receipt of the supplies these copies are completed by filling in the *Quantity Received* column, the *Receiving Report* section and the *Proper Voucher* section. One copy is then forwarded to the purchasin and contracting officer, and one copy is retained as a debit voucher to the stoc record account of the receiving officer.

War Department Shipping Document (WDSD). Property shipped on the Wa Department shipping document will be accompanied by two property copies of th shipping document (WD AGO Form). One copy stamped *Tally Copy* will be use to tally in the number of pieces received in the shipment. This copy will b signed by the inchecker and delivered to the transportation officer who will us it to complete the bill of lading for the shipment. The other copy, unstampe will be used to check the contents of the shipment. The quantities actually received will be entered in the *Quantity Received* column, and signed by the checke

›nly the quantities actually received will be picked up on the stock record account, using this copy of the shipping document as a debit voucher to the stock ccount. In the case of minor discrepancies between quantities listed in the shipping ocument and the quantities actually received, no action is taken.

Occasionally property will be received unaccompanied by any papers. In such ases a debit voucher must be made by the receiving officer to enable him to pick p the property on his stock record account. The tally sheet incoming (WD QMC 'orm 489) may be used for this purpose. The property is listed on the tally sheet ʻhich then becomes a debit voucher to the account. When the papers covering he property are subsequently received they are given the same debit voucher ıumber as the tally-in and filed with it as a supporting voucher.

. C. Form No. 489
I DEPARTMENT
ised June 20, 1938

TALLY SHEET
INCOMING

Tally-in No. B-443
Sheet No. 1
Number of Sheets 1

tion Camp Swayback, Md. Warehouse No. B-Group Date received 15 July 1944

nsignor Ordnance Property Officer Car No. ---- Car Seals No. -------

. Truck (Rail, truck, boat, parcel post, mail) Requisition, Purchase Order, or Shipping Ticket Requisitio

. 957-18-45 Bill of lading No. ------

Contents of packages { have / ~~have not~~ } been verified (strike out words not applicable)

[illegible]	[illegible]	CONTENTS	[illegible]	
			Unit	Total
		SNL B-21		
16	B021-01-~~[illegible]~~ 00200	EJECTOR, cartridge, assembly	ea	

hecker Joseph W. Connors
Joseph W. Connors,
Sgt., Ord. Dept.

3—10043

Figure 23. Tally Sheet Incoming (W.D., QMC Form 489).

Organizations and units will normally receive property on a property issue slip. The quantities as shown in the Action column of the property issue slip will be taken up on the account of these units carrying stock for maintenance or re-issue, such as ordnance maintenance and depot companies.

Property turned in to a station supply officer will be listed on a property turn-in slip (WD AGO Form 447). The receiving officer will enter the quantities actually received in the *Action* column of the property turn-in slip and receipt for same. In the case of serviceable property, the turn-in slip becomes a debit voucher and the supplies are picked up on the stock record account. All debit postings from receipt documents to stock record cards will be identified by dating the posting the same date as that used by the inchecker. The following items will not be picked up on stock record cards, and accountability will be maintained by matching shipping documents or obtaining the signature of the receiving officer:

(1) Shipments to newly activated organizations, based upon shipping orders from a source other than the station supply officer.

(2) Expendable items requisitioned or purchased for immediate consumption, which are not normally stocked.

When Property Is Not Required To Be Picked Up On The Stock Record Account

When expendable supplies which are not normally stocked, have been received for immediate consumption, they are not to be picked up on the stock record account. The following certificate is accomplished on the receiving document:

I certify that the expendable supplies listed hereon were procured for immediate use in current service, and will not be picked up on the stock record account; the unused residue thereof, if any, will be taken up and accounted for.

The document is given a debit voucher number and becomes a valid voucher to the stock record account. (TM 38-220).

Items not normally stocked, received for immediate reissue: Shipments received which have been requisitioned for immediate reissue, except those normally stocked or to be issued on memorandum receipt, will not be posted to the stock record cards, if immediately issued. In those instances where the items are not posted to the stock record cards, the following certificate will be placed on the receiving document:

I certify that the materiel and supplies as indicated hereon have been issued to .... (organization(s)), the signature(s) of whose representative(s) appears on this document; and that the unissued portion of this materiel and supplies, if any, will be posted to my stock record cards by the debit voucher number assigned this document.

Accountable Officer.

Such documents of receipt will be assigned a debit voucher number entered in the voucher register and filed numerically in the voucher file. The portions of such materiel and supplies, if any, not immediately issued, will be posted to the stock record cards.

Shipment received for newly activated organizations: Shipping documents received in connection with shipments to newly activated organizations based on shipping orders from a source other than the station supply officer will not be posted to the stock record cards. When the supplies have been delivered to the newly activated organization, copy No. 3 of the War Department shipping document, signed by the organization representative, will be assigned a debit voucher number and will be filed in proper numerical order in the voucher file.

Issue of Property

Property is issued to organizations or units by means of a property issue slip (WD AGO Form 446). Organizations will submit requisitions by means of a property issue slip in triplicate. The 3rd copy of the property issue slip is used as an Action copy of the requisition, if required. The 1st and 2nd copies are retained for use as an issuing document. When the supplies are available for issue, the quantities actually issued will be indicated in the Action column of the property issue slip. The receiving officer or his authorized representative receipts for the supplies, and one copy becomes a credit voucher to the supply officer's stock record account. When the supplies are issued for which no requisition was submitted, the issuing officer makes up the issue document and the transaction is handled in the same manner as stated above.

Frequently a property officer must issue expendable supplies for use by activities under his control. In such event he will execute a certificate on the document listing the supplies so issued, to the effect that the supplies have been expended in the public service. The issuing document so certified will constitute a valid credit voucher to the stock record account. When such issues are frequent, the work orders or memoranda on which the individual issues are made, may be retained until the end of the month and then abstracted on any form, upon which the accountable officer will execute the certificate of expenditure. The abstract when so certified will constitute a valid credit voucher to the stock record account, and the individual issue memoranda may be destroyed. (AR 35-6620.)

Tools of a unit value of approximately $2.00 or less which are lost or destroyed incident to the repair and maintenance of ordnance materiel may be dropped

WAR DEPT. SHIPPING DOCUMENT — **PROPERTY COPY**

VOUCHER NO.	STATION	REQUISITION NO.	MO.	DAY	YR	SHEET
C-108	44-072	17-023-D212-45	9	1	4	1

DATE SHIPPED	2 Sept 44
CAR NO. & INITIAL	B152461
SEAL NOS.	F113141792
B/L NO.	WQ 1721411
CARRIER	B&O

CONSIGNOR: Ordnance Supply Officer,
Fort Wayside, Va.

CONSIGNEE: Trans. O.,
For Ordnance Supply Officer,
Fort Webb, Md.

RECAPITULATION OF SHIPMENT

√	TOTAL PKGS	TYPE PKGS	SIZE	TOTAL WEIGHT	TOTAL CUBE
1	1	box	24 x 24 x 6	90	2
2	1	box	36 x 18 x 12	120	4.5
3	2	box	36 x 36 x 24	210	36
		TOTAL		420	42.5

CONSIGNEE VOUCHER NO.

VOUCHER DATE

TALLY NUMBER

STOCK NUMBER	DESCRIPTION OF ARTICLES	UNIT OF MEAS	NO. OF PKGS	TYPE OF PKGS	PKG NUMBER	UNIT WT	TOTAL WEIGHT	UNIT CUBE	TOTAL CUBE	ITEM NO.	STOCK COND	TALLY QUANTITY ACTUALLY SHIPPED	QUANTITY RECEIVED
	SNL K-1												
K001-10-12648	CLEANER, rifle bore (6-oz can)	can	1	box	1	90	90			1		72	
K001-10-13350	COMPOUND, rust preventive, heavy (5-lb can)	lb	1	box	2	120	120			2		90	
K001-10-78460	PATCHES, cut	M	2	box	3-4	105	210			3		200	

DATE — INCHECKER — ARTICLES SHOWN IN COLUMN HEADED "QUANTITY RECEIVED" WERE RECEIVED IN APPARENT GOOD CONDITION THIS DATE.

DATE — INCHECKER — PACKAGES SHOWN IN COLUMN HEADED "TOTAL PKGS." HAVE BEEN RECEIVED IN APPARENT GOOD CONDITION (EXCEPT AS NOTED ON REVERSE SIDE).

Figure 24. War Department Shipping Document (W.D., A.G.O. Form 450-5-c).

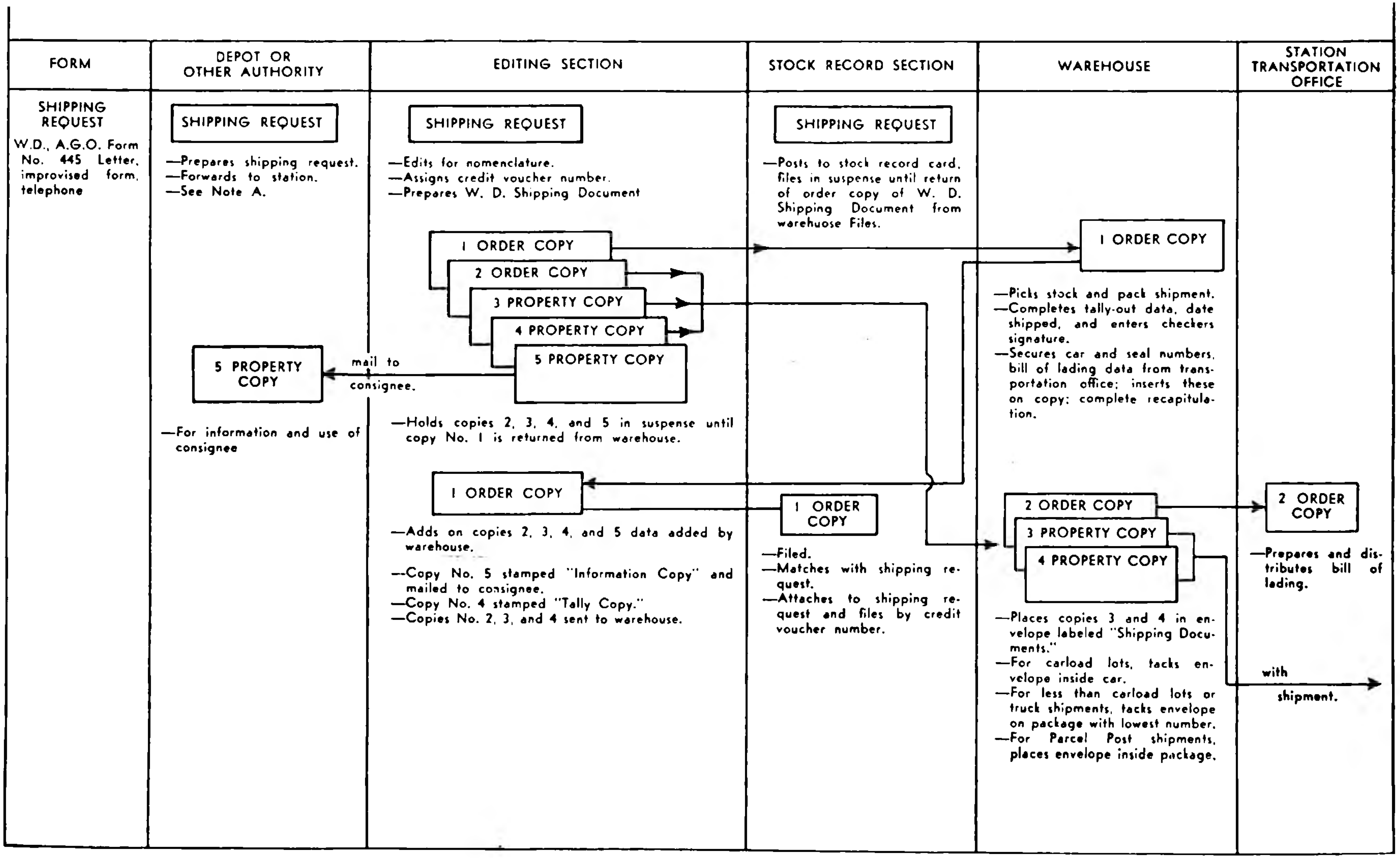


Figure 24A. Flow Chart of War Department Shipping Documents.

from accountability by post, camp, or station ordnance officers up to a total value not exceeding $30.00 each quarter. A list of tools bearing a certificate by the responsible officer that the items were lost or destroyed without fault or neglect, when approved by the commanding officer, will constitute a valid credit voucher to the stock record account. This $30.00 quarterly dropping allowance is not cumulative, nor may it be subdivided proportionately for periods of less than three months. (AR 35-6620).

Procedure For Shipping Property

Upon receipt of instructions to make shipment, the shipping officer prepares War Department shipping documents as follows:

War Department shipping document (Order Copy) W.D., A.G.O. Form 450-5-D, in two copies. If material is to be shipped in mixed packages, an additional copy must be prepared for each package.

War Department shipping document (Property Copy), W.D., A.G.O. Form 450-5-C in three copies.

These shipping documents will have the following information thereon:

a. Voucher number as determined from voucher register.
b. Station number.
c. Requisition or shipping request number.
d. Date.
e. Consignor.
f. Consignee.
g. Property to be shipped, listed by proper nomenclature, stock number, etc.
h. Quantity ordered to be shipped. (This will not appear on property copies).

The 1st order copy is sent to the warehouse where the property is picked and packed for shipment. If the material is to be packed in mixed packages, the additional order copies will be sent to the warehouse with the 1st copy. The warehouse completes the tally-out data on the order copy, entering thereon the number of packages, type of packages, package numbers, weights, item number, quantity shipped (actually), recapitulation of shipment and checker's signature. The warehouse also secures the following information from the transportation officer and enters same on other copy: Car number, seal number, bill of lading number, carrier and routing data. The completed order copy is then returned to the editing section which enters the added data on all other copies of the shipping document. If the material is to be shipped in mixed packages, the additional order copies are completed and one placed inside each package as a packing list. The three final or property copies of the shipping document are completed at this time.

After entry of all data added by the warehouse, the shipping documents are distributed as follows:

a. 1st order copy is filed as credit voucher.
b. 3rd property copy is stamped 'Information Copy' and mailed to consignee.
c. 2nd order copy and 1st and 2nd property copies are forwarded to warehouse.
d. 2nd order copy is forwarded to transportation officer who prepares and distributes bills of lading.
e. 1st and 2nd property copies are placed in envelope labelled 'Shipping Documents'. For carload shipments, this envelope is tacked inside the car at jamb side of door above the loading line. In less than carload lot or truck shipment, the envelope is tacked on package with the lowest number.

Shipment By Mail

Instructions may be given to make the shipment by mail. Government property may be shipped by parcel post provided that no single package weighs more than 70 pounds and is no larger than 100 inches in combined girth and length. A package not more than 4 pounds in weight may be shipped free under the franking privilege. In the event the package weighs more than 4 pounds, the entire weight must be paid for. (See paragraph 4, AR 340-10).

In the case of a shipment by mail, the processing and preparation of W.D. shipping documents is given above, except that no copy is required for the transportation officer. In this case the 2nd and 3rd property copies are placed inside the package and the package mailed.

An officer making a shipment is responsible for seeing that the material is serviceable, properly packed to prevent damage enroute, that the material is properly cleaned or oiled to prevent deterioration in storage. Each package to be shipped must bear the name and station of the consignor, the name and station of the consignee, the consignor's shipping document number and bill of lading number, the serial number of the package, the weight, the cubic contents if the shipment is to be made by water, and the list of contents which is placed on a packing list in an oiled envelope on the outside of the package having the lowest package number. (See IOSSC (b)). See flow chart of W.D. Shipping Documents.

ACCOUNTING FOR UNSERVICEABLE PROPERTY

Since a stock record account should indicate only stocks on hand available for issue, it will be necessary to keep records of unserviceable property in a separate file. This unserviceable property file will include a register of turn-in documents or other vouchers. All documents will be properly cross-referenced to show disposition of all unserviceable property received. W.D, Q.M.C. Form No. 423 or 424 may be used in keeping this record.

PROPERTY TURN-IN SLIP

To	SUPPLY OR CLASSIFICATION OFFICER Ordnance Property Officer, Camp Swayback, Md.	PAGE 1 OF 1 PAGES VOUCHER NO
FROM	ORGANIZATION OR UNIT 957th Ordnance Depot Co.	TURN-IN SLIP NO C-6

ITEM NO	STOCK NO	NOMENCLATURE	UNIT	QUANTITY	REMARKS	ACTION
		SNL B-21				
1.	B-21-01-00200	EJECTOR, cartridge, assy.	ea	4	FWT	

LEGEND FOR REMARKS

FWT—Unserviceable, due to fair wear and tear
R/S—Unserviceable, report of survey
S/C—Unserviceable, statement of charges
SER—Serviceable
EXS—In excess of authorized allowances
MR—Memorandum receipt property

W. D., A. G. O. Form No. 447
15 April 1944
(This form supersedes W.D., A.G.O. Form No. 447, 6 August 1943, which may be used until existing stocks are exhausted)

I CERTIFY that the articles listed herein are turned in under the circumstances indicated in "Remarks."

FOR THE COMMANDING OFFICER:

16 July 1944 C. W. Carter
(Date) Organization Supply Officer

QUANTITIES SHOWN IN "ACTION" COLUMN HAVE BEEN RECEIVED

(Date) 194__ (For station supply officer or classification officer)

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Figure 25. Property Turn In Slip (W.D., A.G.O. 447).

Unserviceable property will be listed on a property turn-in slip, W.D., A.G.O. Form 447, or other document, and turned in to the supply officer. This turn-in document will be a voucher to the unserviceable property record, and will not go through the regular stock record account.

Property for which a supply officer is accountable and which becomes unserviceable while in stock will be removed from accountability by transfer to the unserviceable property file. A copy of the turn-in slip or document affecting such transfer will be used as a credit to the stock record account.

When unserviceable property is shipped to higher echelon for repair, the shipping document will contain the following statement:

Unserviceable property. No accountability on the records of the consignor.

a. Property determined by the technical inspector as salvage will be listed on a property turn-in document, prepared in triplicate, with the applicable certificate on the reverse side thereof, as follows:

I certify that the items listed on the reverse side hereof have been examined by a technically qualified repair shop inspector furnished by ....
(Title of Repair Shop)
.... *who determined that this property is unserviceable beyond the*
(Station)
state of repair and has no further value to the Government except as salvage.

or

I certify that, to the best of my knowledge and belief, the items listed on the reverse side hereof are unserviceable beyond a state of repair, and are not covered under disposition instructions issued by a chief of technical service or other authority, and are properly disposable as salvage under authority contained in paragraph 4, Circular No. 7, War Department, 1944.

b. The unserviceable property is then turned over to the salvage officer if he is not accountable. The 1st copy of the property turn in slip, receipted by the salvage officer, will be used to drop the items from the unserviceable property record.

c. If the salvage officer is accountable, the unserviceable property will be presented to the disinterested officer appointed to receive salvage under the provisions of Section VI, Circular No. 170, War Department, 1943.

LOST, DAMAGED AND UNSERVICEABLE PROPERTY

Officers and other persons responsible for public property will be charged for any loss or destruction of or damage to property for which they are responsible, unless they are relieved from such responsibility by an approved report of survey or in some other manner in accordance with existing regulations. Property responsibility is not to be lightly assumed by officers. A review of Article of War No. 83 is sufficient to clear up any doubt in this regard.

Article of War No. 83—Military Property. *Willful or Negligent Loss, Damage or Wrongful Disposition.* Any person subject to military law who willfully, or through neglect, suffers to be lost, spoiled, damaged, or wrongfully disposes of, any military property belonging to the United States, shall make good the loss or damage and suffer such punishment as a court-martial may direct.

"When an officer, enlisted man or other individual is held financially liable for loss, destruction or damage to public property he will be required to pay the current price of the item or the cost of repair, except that when in the judgment of the commanding officer, credit should be allowed for depreciation in the value of the property at the time of loss, destruction or damage. This allowable credit will be determined by the surveying officer and approved by the appointing authority."

Initiation of Reports of Survey. When public property is lost, destroyed or damaged, except through fair wear and tear in the service, a survey is required to determine the responsibility and to recommend disposition of the property damaged. The exception to this rule, of course, is the case in which personnel admits the loss or destruction and accepts the responsibility.

In the event that an enlisted man accepts the responsibility of lost, damaged or destroyed property, a Statement of Charges (WD AGO Form No. 36) is prepared, and at the time the man signs the payroll, his commanding officer will see that he is informed that his signature on the payroll is considered an acknowledgment of justice of the charges. He will also be advised that he has a right to demand a survey, and that the approved recommendations of the surveying officer will be final.

Where an officer is involved, a Report of Survey (WD AGO Form No. 15) will be initiated to fix responsibility, and where it is so fixed, the officer will make payment to the appropriate fiscal officer on a Receipt for Miscellaneous Collections (WD FD Form No. 38.) Whether responsibility is fixed, or whether all concerned are relieved, the Approved Report of Survey will act as the property paper in

STATEMENT OF CHARGES[1] **against enlisted men for** ORDNANCE **Property**
(Name of supply arm or service to which property pertains)

On {[redacted] Pay roll[2]} of 957th Ordnance Depot Co. for month of July, 1944

ARTICLES CHARGED[3]	Price of article	Size of article	1	2	3	4	5	6	7	8	9	10	(A)[6] Total articles charged	(B)[6] Replaced	(C)[7] Not replaced
			ENLISTED MEN CHARGED—NAMED BELOW[4]												
PUNCH, drive pin, 0.12 in pt., 3 in long	.80	J-4	1		1								2	1	1
ROLL, tool, M6	1.43	M-8		1									1	1	
OILER, oval, 3-oz., (w/cap and chain)	.91	M-3		1	1								2	2	

Right to action of a surveying officer under AR 35-6640 is waived and correctness of the individual charges is acknowledged by the enlisted men whose signatures appear below:

Line[4]	Total charge[8]	Cause of charge[9]	Name, grade, and serial No.[10]	Signature of enlisted man
1	.80	Lost through neglect	John C. Martin, Cpl 36,001,001	John C. Martin
2	2.34	Damaged through neglect	Elwin M. Brooks, Sgt 6,438,110	Elwin M. Brooks
3	1.71	Lost through neglect	Millard C. Snodgrass, Pvt 32,800,811	Millard C. Snodgrass
4				
5				
6				
7				
8				
9				
10				

I CERTIFY that the statements hereon are complete and correct, and that the charges have been made for the reasons stated.[11]

ENTERED IN SERVICE RECORDS[12]

William C. Greenaway

WILLIAM C. GREENAWAY, Jr.
Captain, Ord. Dept.,
(Commanding organization)

JOHNSON, C. ~~GREY~~, 2d Lt., Ord. Dept.,
(Personnel officer)

W. D., A. G. O. Form No. 36
May 12, 1943

[OVER]

10—94780-1

Figure 26. Statement of Charges. (W.D., A.G.O. Form 36).

the case of company property, or as a valid voucher, in the case of a formal stock record account.

In the case that an enlisted man does not accept responsibility for a loss, a Report of Survey will be initiated to determine responsibility and to make disposition if damaged property is involved. If the man is found pecuniarily liable, a Statement of Charges will be prepared, and the man will be charged with money value on the appropriate unit payroll or final statement. (In this latter case, the Statement of Charges, with the Report of Survey attached, will become the property paper or the valid voucher and sub-voucher, depending upon the type property record.)

The articles listed as damaged, as shown by "Cause of Charge," have been received by me for salvage.[13]

Date 15 July 1944 Signature ______________
JAKE L. KEEPER,
Major, QMC,
(Salvage officer)

I CERTIFY that I have received the articles listed in Column (B) "Replaced," and that the articles drawn, together with such as are already on hand, do not exceed the prescribed allowance.[14]

Date 15 July 1944 Signature ______________
WILLIAM C. GREENAWAY,
Captain, Ord. Dept.,
(Commanding organization)

I CERTIFY that the articles listed in Column (C) "Not Replaced," were not replaced.[15]

Date 15 July 1944 Signature ______________
HERMAN C. STORES,
Major, Ord. Dept.,
(Accountable officer)

Voucher to stock record account of[16] HERMAN C. STORES (Name) Major, Ord. Dept., (Grade) [redacted] Credit[2]
the accountable officer of Ordnance Property (Organization or agency) VOUCHER No. C6
at Camp Swayback, Maryland (Station)

INSTRUCTIONS

1. This form will be used whenever property is to be charged against the pay of enlisted men and will be prepared in triplicate. See AR 345-300, AR 35-6520, and AR 35-6640.

2. Strike out word or words not applicable.

3. Description (proper nomenclature) of the item to be charged.

4. One column of columns 1 to 10, inclusive, will be used for each enlisted man. The number of each of the lines beneath the statement "Right to action, etc.," refers to the column of the same number (upper half of the form).

5. The total number of each article entered in columns 1 to 10, inclusive.

6. The total number of each article drawn for replacement from the accountable officer.

7. The total number of each article not replaced.

8. The "Total Charge" is the total cost of the articles listed in the column of the same number as the line.

9. The "Cause of Charge" such as lost through neglect, damaged through neglect, destroyed through neglect, etc.

10. Each line is ruled so that the enlisted man's name may be entered on the upper half of the space provided, and his grade and serial number on the lower half.

11. Certification to be made by commanding officer of the organization.

12. To be initialed by the personnel officer or other individual responsible for entries in service records.

13. Any articles listed as damaged will be turned over to the salvage officer who will acknowledge receipt.

14. When replacements are drawn, the commanding officer of the organization will sign for them.

15. When replacements are not drawn, the accountable officer will so certify.

16. To be used by the accountable officer for recording as a voucher to his stock record account.

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Figure 26. Continued (Back of Form).

Where civilian employees are concerned, and property is embezzled, lost or damaged, through neglect, value and damage are determined through a survey, if necessary, and deductions are made from pay due the responsible persons. If an article in process of manufacture or repair is spoiled through incompetency, the workman will have the cost deducted from his pay, provided that the amount so deducted for spoilage in any one day will not exceed the average pay of the employee for that day.

In making adjustments for lost, destroyed, or damaged property, the Statement of Charges or the Report of Survey will be used only as a credit paper to the

REPORT OF SURVEY

(1) ORDNANCE Property (2) ORDNANCE PROPERTY OFFICER, Fort Wayside, Kentucky
(Class of property, ordnance, medical, etc.) (Stock record account and station)

Accountable officer (3) Capt. Harry A. Getchel, Ordnance Department Date (4) 10 November 1943

STOCK NO. (5)	ARTICLES (6)	QUANTITY (7)	TOTAL COST (8)	DISPOSITION (9)		
				DESTROY	SALVAGE	[illegible]
	SNL B-1 RIFLE, U.S., cal. .22, M1922M1	1	$58.58			
3003-02 00146	SNL B-3 SLING, gun, M1907 (leather) (20-18-25)	1	1.11			
	SNL H-8 PADLOCK, 1½ in., keyed interchangeably with Chain, "F", 6-in., assembly	1	1.47		S	
		Grand total	$61.16	(10)		

(11) **DATE AND CIRCUMSTANCES**

10 November 1943. The rifle listed above was received at this station 1 September 1943, from Letterkenny Ordnance Depot, Chambersburg, Pa., with nine (9) other like items. Upon receipt it was unpacked, cleaned, inspected, and gauged, fitted with the sling listed, and stored in a properly secured and locked rifle rack in the strong room in Ordnance Warehouse No. 1. At 0700, 1 November 1943, M. Sgt. John E. Whirley 31274578, the warehouseman accompanied by his assistant S. Sgt. Earl M. Hastings, 31427307, both of the 185th Ordnance Co. (MM), discovered that the strong room door and rifle rack had been forcibly opened and the above listed rifle was missing. SEE EXHIBITS "A" AND "B" HERETO.

(12) **AFFIDAVIT**

I do solemnly swear (or affirm) that the articles of public property shown above and/or on attached sheets were lost, destroyed, damaged, or worn out in the manner stated, while in the public service.

JOHN E. WHIRLEY, 31274578
(Signature)

M. Sgt., 185th Ord. Co. (MM)
(Grade and organization)

Subscribed and sworn to (or affirmed) before me at Fort Wayside, Ky.

this 10th day of November 1943

RALPH L. LIPSCOMB
Captain, 100th Infantry
Adjutant.
(Grade and organization or title; if notary public, affix seal)

(13) **CERTIFICATE**

I certify that the loss, destruction, damage, or unserviceability of the articles of public property shown above, and/or on attached sheets, was caused in the manner stated and without fault or neglect on my part, and that each article listed with a view to elimination by destruction has been examined by me personally, has never been previously condemned, and is, in my opinion, worthless for further public use.

HARRY A. GETCHEL
(Signature)

Captain, Ordnance Department
(Grade and org., accountable or responsible officer)

Hq. (14) FORT WAYSIDE
Station Fort Wayside, Ky.
Date 11 November 1943
To Major RALPH I. SHERRARD, 100th Infantry.
who is appointed surveying officer.
By order of Colonel TOMACZIK
RALPH L. LIPSCOMB,
Captain, 100th Infantry
Adjutant.

(7) (15)

Property Voucher No. ______

W. D., A. G. O. Form No. 15
July 14, 1938

Figure 27. Report of Survey. (W.D., A.G.O. Form 15.

FINDINGS.[8]—I have examined all available evidence as shown in exhibits "A" to "B" and as indicated below have personally investigated the same and it is my belief that the articles listed hereon ~~and/or on attached sheets~~, total cost $61.16 was stolen by a person or persons unknown from the strong room in the Ordnance Warehouse No. 1, due to neglect and lack of care on the part of M. Sgt. JOHN E. WHIRLEY, 31274578, 185th Ordnance Co. (MM), in performing the required inspection of the warehouse prior to locking it up for the night at about 1705, 31 October 1943, this inspection being one of his properly ordered duties; that all available evidence indicates that the guilty person or persons were in the building at time it was locked for the night; that the loss was not sustained through intent or design on the part of Sgt. Whirley, since the rifle had been properly locked in an arms locker bolted to the floor in a properly locked strong room as prescribed by regulations. RECOMMENDATIONS: That the amount of SIXTY-ONE DOLLARS and SIXTEEN CENTS ($61.16) the value of the stolen and damaged property, be charged against the pay of M. Sgt. JOHN E. WHIRLEY, on the next payroll of his organization that the strong room door be repaired and fitted with a steel or iron barred type door and proper lock at government expense to prevent a recurrance of this type incident; that the damaged lock be turned into the salvage officer; that the accountable and responsible officer, Captain Harry A. Getchel, Ordnance Department, be relieved of accountability and responsibility for this property.

FORT WAYSIDE, KENTUCKY, 15 November 1943.

RALPH I. SHERRARD,
Major, 100th Infantry,
Surveying Officer.

I have ~~witnessed the destruction of the articles to be destroyed~~ and/or received the articles to be turned in to salvage.

(17)
Date 15 November 1943 CARL O. HOFFMAN, Captain, Q.M.C.
(Officer witnessing destruction, or salvage officer)

(9)(16) Hq. FORT WAYSIDE
Station Fort Wayside, Ky.
Date 15 November 1943

APPROVED: Any damaged property shown above and/or on attached sheets has been inspected by me, or by a disinterested officer of suitable grade and arm or service, and the disposal indicated is in the best interests of the public service.

THOMAS T. TOMACZIK,

Colonel, Infantry.
(Appointing authority)

(10)

Hq. ~~service command~~
Reviewed ~~for corps area~~ commander
Date
Number
Finance officer.

(11)

[1] If space is inadequate, list articles on suitably ruled and captioned attached sheets and recapitulate in this and Total Cost column as "Sheet 1, $147.60"; "Sheet 2, $234.30," etc.

[2] Estimate cost if not known.

[3] When disposition of articles is involved, the surveying officer will indicate same in proper column using abbreviated entries as follows: D—to be destroyed; S—to be turned in for salvage, V—to be sold; Rc—to be turned in for reclamation of component parts; C—to be continued in service; Rp—to be repaired; Ex—to be held for exchange.

[4] The grand total cost of all articles acted upon will always be shown.

[5] Enter a concise statement of date and circumstances together with a reference to certificates and affidavits submitted, as "Exhibits A to H herewith." Each exhibit will bear a reference to the report of survey to which it pertains as, "Ex. 'A'—R/S 3/4/34—$75.00."

[6] The certificate may be omitted if the oath is subscribed to by the accountable or responsible officer. In any event the oath must be subscribed to.

[7] For use of chief of arm or service or Secretary of War or both.

[8] Enter total cost as shown on the face of the report and continue with the findings in full. If any oral testimony is considered, the name of each witness and a clear, concise statement of the testimony given will appear in the findings. Opposite a caption "RECOMMENDATIONS", which should follow the findings without loss of space, enter appropriate recommendations. The recommendations should be complete in all details and cover all articles or subjects investigated. If space is insufficient, continue on additional sheets; the station, date, and signature to follow the recommendations in any case.

[9] Should the appointing authority disapprove the recommendations of the surveying officer, the disapproval with reasons or action recommended will be typed on the back of the report or on an attached sheet and reference made thereto in this space.

[10] For action or review of division, post, camp, or station commander if surveying officer is appointed by a subordinate administrative commander.

[11] For use of corps area commander.

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Figure 27. Continued (Back Side).

FORT WAYSIDE)
COUNTRY OF CLAYSIDE: Ss
STATE OF KENTUCKY)

Personally appeared before me, the undersigned, authorized by law to administer oaths in cases of this nature, one JOHN E. WHIRLEY, 31274578, M Sgt., 185th Ordnance Co. (MM), Fort Wayside, Ky., who, after being duly sworn, deposes and says:

"I am the storekeeper in Ordnance Warehouse No. 1, Fort Wayside, Ky. My daily duties include opening this warehouse at 0700 and closing it at 1700. At both times I make an inspection of the warehouse and strongroom and its contents. On 31 October 1943, prior to locking up, I made this inspection personally, checking the strongroom and its contents, then the warehouse and all doors through which property is received and shipped. These doors are of the double sliding type, locked with bars held in place with padlocks. Everything being in order, I locked the strongroom and left at about 1705 by the office door, which is locked by a Corbin spring lock, which I verified to be properly locked by "trying" the door. At 0700 on 1 November 1943, accompanied by S. Sgt. Hastings, my assistant, I opened the warehouse and proceeded to the strongroom to make the usual check, and noticed the door was ajar. It had been forcibly opened. This door is locked with a padlock through a hasp securely bolted through the door and frame, which had been pried off apparently with a large pinch bar or jimmy, no trace of which was to be found. Posting Sgt. Hastings as a guard, I immediately notified Captain Getchel, the Property Officer by telephone, and upon his arrival we started an inventory, which revealed that only one item was missing - the RIFLE, U.S., Cal. .30, M1922M1, Springfield Armory No. 13753, fitted with a leather sling, both of which are listed on the Report of Survey to which this affidavit is an Exhibit. This rifle had been locked in an arms locker securely bolted to the floor, and locked with a padlock which had been broken. This lock is also listed on the R/S. Keys to the arms locker and doors were in possession of only two persons, Captain Getchel and myself. I have no knowledge of who took this rifle, nor of its present whereabouts."

Further deponent sayeth not.

JOHN E. WHIRLEY, 31274578,
M. Sgt., 185th Ord. Co. (MM)
Chief Storekeeper.

Subscribed and duly sworn to before me this 10th day of November , 1943.

RALPH L. LIPSCOMB,
Captain, 100th Infantry,
Adjutant.

Ex. "A" - R/S, 10 November 1943 - $61.16

Figure 28. Affidavit to Accompany Report of Survey.

HEADQUARTERS FORT WAYSIDE
Office of the Ordnance Property Officer

GETCHEL/ha
4132

Fort Wayside, Ky.
10 November 1943.

C E R T I F I C A T E

I certify that on 1 November 1943, at about 0705, I received a telephone call from my Chief Storekeeper, M. Sgt. John E. Whirley, stating that the strongroom in Ordnance Warehouse No. 1, had been broken into. I proceeded there immediately, and noted that the outside door to the office through which entrance is made had not been tampered with - the lock being OK. I next examined the door to the strongroom and found that the entire lock, together with the hasp and staple had been pried off from the door and door frame. I immediately notified Captain Ralph L. Lipscomb, the Post Adjutant, and Captain Lewis T. Harmon, the Officer of the Day, who furnished a sentry to replace Sgt. Hastings, the assistant storekeeper, who had been placed as a temporary guard, pending repair of the strongroom door. Next I proceeded with aid of 2nd Lt. Joseph M. Moore, my assistant Ordnance Officer who had arrived, to conduct an inventory of all items in the strongroom to ascertain what if anything had been taken. This inventory when completed revealed that only one item was missing - the RIFLE, U. S., Cal. .22, M1922M1, S. A. Serial No. 13753, fitted with a SLING, gun, M1907 (leather) listed on the R/S to which this certificate is an Exhibit. This rifle had been locked in an M1 Arms Locker (49-1-91) which was locked with a 1½ in. Padlock. The lock had been broken open. A search of the entire post and surrounding community made in accordance with par. 10 i, A.R. 210-10, failed to reveal any trace of this weapon. I have no personal knowledge of who took this rifle, nor of its present whereabouts.

HARRY A. GETCHEL,
Captain, Ord. Dept.,
Ordnance Property Officer.

Ex. "B" - R/S, 10 November 1943 - $61.16

Figure 29. Affidavit to Accompany Report of Survey.

company property book, or as a valid voucher to a stock account. In no event will either be presented to a property officer as a method of obtaining replacements. The Requisition and Property Issue Slip are the only authorized means of obtaining replacements.

Whenever loss or damage is sustained, and a Report of Survey is required, such report is prepared by the responsible officer and submitted to the commanding officer or appointing authority, whichever is applicable. Reports should be prepared as quickly as possible after discovery of the discrepancy. In all cases, these reports should be compiled within 30 days following discovery of the loss, unless exceptional circumstances prevail, in which case they will be explained by the officer's certificate.

Preparation of Report of Survey. Separate Reports of Survey are prepared for property pertaining to different supply services and the Army Air Forces, and for subsistence stores, as distinct from other property of the Quartermaster Corps. They are prepared in triplicate by the responsible officer and fowarded to the commanding officer or appointing authority.

The responsible officer may rely upon supporting papers to relieve him from responsibility, in which case he will attach them as exhibits to the original copy only of the Report of Survey. (These papers may be WDSD; Bills of Lading; Certificates and Affidavits, and, in cases of accidental damage to government property, a copy of the approved report bearing on the accident which resulted in the damage.)

Such supporting papers will be referred to as 'Exhibits,' and will bear reference to the report, for example: 'Exhibit A' — R/S 3/4/44 $98.68.

Money totals on each sheet, in the column headed 'value' will be initialed by the responsible officer. No other money total will be initialed. Erasures, interlineations, and other alterations in the written matter of the report must be initialed by the officer making them.

It is not necessary for the accountable or responsible officer to execute the certificate on the face of the report. In all cases the oath on the report is subscribed to by the responsible officer. See reverse of form 15.

REFERENCES

W.D. Pamphlet No. 38-1.
W.D. Circular 75, dated 16 March 1943.
W.D. Circular 170, dated 24 July 1943.
A.R. 35-6640, dated 13 June 1942 including all changes.

NOTES ON PREPARATION OF A CLASS "II" REPORT OF SURVEY

Property lost, destroyed or rendered unserviceable from causes other than fair wear and tear in the service is classified as Class "II" unserviceable property and must be entered on a Report of Survey, WD AGO Form No. 15, to determine the responsibility, the actual amount to be charged against the individual held pecuniarily responsible, and to recommend disposition of damaged property. However, where criminal negligence or intent is not indicated, an enlisted man may be permitted to pay for property in this classification up to $25, in value on a Statement of Charges without the necessity of a survey. If intent or negligence is indicated action should be taken under the 83d or 84th A.W.

The Surveying Officer alone cannot determine the disposition of unserviceable property. Par. 2, WD Pamphlet 38-1 states: "The disposition of unserviceable property . . . will be determined by repair shops of various echelons operating under technical instructions furnished by the chief of service to which the property pertains. Therefore, the disposition recommendations must be obtained from the repair echelon and are limited to the following:

1. To be repaired and continued in service.
2. To be turned over to a salvage officer. (After spare parts have been removed.)
3. To be destroyed (but only as authorized by par. 10 c (6) (a), (b), (c), and (d), A.R. 35-6640, which states:

(a) Clothing infected with contagious diseases.

(b) Stores so deteriorated or defective as to endanger health or injure other stores.

(c) Medical supplies which The Surgeon General has determined to be unsafe for use.

(d) To be released to . . . vendor when so authorized or required by regulations."

STEP BY STEP PREPARATION OF THE REPORT OF SURVEY

Erasures, interlineations, and other alterations in the written matter of an R/S must be initialed by the officer making them.

(1) Self-explanatory—enter supply branch to which the property pertains.

(2) Here enter the proper designation of the account on which the property is carried. If the property is not on a S/R account, *i.e.*, has been dropped from accountability and is carried on a Co. Property Book or other record such as clothing on a Form 32, then the entry should be the unit designation and station.

(3) In this space record the accountable officer's rank, full name, and branch. If accountability for the property has been terminated and no accountable officer is involved, delete "accountable" and substitute "responsible" officer and enter the company commander's name.

(4) The Report of Survey ". . . will be prepared by the responsible officer and submitted to the commanding officer as soon as practicable and in every case within 30 days after discovery of the loss, destruction, or damage, unless exceptional circumstances, which will be explained by the officer's certificate, prevent such action within the prescribed period." (par. 8 a, AR 35-6640)

(5) In this column enter only the Item Stock No. or Federal Stock No. of the article or articles being surveyed.

After completion of the investigation by the Surveying Officer, and entry of his Findings and Recommendations, all copies of the Survey and evidence are returned to the Appointing Authority for his approval or disapproval. If he disapproves the findings and recommendations he may return it for further investigation, or approve it with exceptions. In any event it will be so worded as to leave no doubt as to its import with regard to property responsibility and accountability, pecuniary liability, and disposition of unserviceable property.

Upon approval—the copies of the survey are distributed according to the circumstances and in accordance with A.R. 35-6640 and WD Cir. 170,—various things being taken into consideration, such as:

a. Whether the property has been dropped from accountability, *i.e.*, carried on a Company Property Book or Clothing on Form 32, etc.

b. Whether an individual has been found pecuniarily liable—and whether he accepts or objects to the findings of the surveying officer.

c. Surveys covering Major Items—especially disposition of Major Items.

d. Whether or not the Appointing Authority or Commanding Officer (when authorized to approve the survey "By Order of the Secretary of War") desires that final approval be made by a higher headquarters.

In any event a survey covering damaged or unserviceable property recommended for salvage or destruction cannot be used as a voucher until the receipt of the salvage officer, or signature of the officer witnessing destruction, has been secured on the survey itself.

In the case of an enlisted man found pecuniarily liable the survey actually becomes a sub-voucher to the statement of charges on which the amount is deducted from the man's pay.

Action of Higher Authority on Receipt of Report of Survey. A surveying officer is normally of field grade. He may be appointed by the commanding officer of (1) any tactical organization higher than a company or similar unit (normally battalion or larger organization); (2) Post, camp, station, or fixed installation; (3) Any administrative organization (such as technical service, non-tactical command, district, or area.)

Reports of Survey initiated by units not under an immediate higher headquarters (battalion, regiment, or division) will be processed by a Board of Officers for Property Adjustment, located at the station furnishing such unit with Class 1 Supplies, e. g. rations.

Each station commander will appoint such a Board of Officers for Property

Adjustment, in order to relieve individual officers as far as possible of the paper work and detail incident to surveys and investigations. The assignment of an individual member of this board as surveying officer need not be recorded in space 6 on the face of the Report of Survey, if the order appointing the Board is cited in the report. The signature of any one member of the board will be sufficient to attest the action of the surveying officer.

Duties of Board of Officers. A Board of Officers for Property Adjustment will perform the following functions: (1) Take action required of surveying officers on reports of survey; (2) Prepare reports of survey from informal memoranda submitted by accountable or responsible officers when requested to do so; (3) Prepare reports of survey and act as surveying officer concurrently with preparation of Report of Claims Officer (WD Form No. 30), on those cases in which the immediate responsibility for the investigation rests initially upon the station commander. In appointing his board, a commanding officer may invest it with the authority to authenticate in his name reports of survey upon which he is authorized to take final action; those which do not require appointment of a surveying officer and upon which he may not be authorized to take final action; and those which must be forwarded to higher authority for final action, providing the member who authenticates the document in the name of the appointing authority is not the same individual who acted as surveying officer.

If the commanding officer receives a report concerning property, the loss or damage of which involves less than $500, and the loss of which is not classified as loss or damage in transit, or losses in sales accounts, and if the facts in space 5 of the report justify such action, the report may be accepted as submitted, to relieve all concerned from responsibility, and to dispose of damaged or unserviceable property as recommended in the report. Such reports are, of course, subject to review by higher authority, and they have the same value as valid vouchers (or property papers) as normal reports of survey.

When a report of survey of the above type is received, and in the judgment of the commanding officer all concerned should not be relieved of the responsibility, he will appoint a surveying officer, or turn the report over to the Board of Officers for Property Adjustment for investigation and proper action.

When the value of property in question exceeds $500, or in any case if in the judgment of the commanding officer, all concerned should not be relieved from responsibility for the loss or damage, he will appoint a Surveying Officer to investigate the case and submit recommendations.

Duties of Surveying Officer. The duties and responsibilities of the Surveying Officer can not be overemphasized. He must investigate fully all matters submitted. He will not limit his inquiries to proofs or statements presented by persons involved only. In cases of accidental damages or injuries to government property, reports of investigating officers and boards will be made available for his consideration, and he will include in his findings a file citation of the report and a statement to the effect that he has considered it in his findings.

The Surveying Officer will scrutinize rigidly the evidence, especially in cases of alleged theft and embezzlement. He will, under no circumstances, recommend relief of responsible parties until he is satisfied that they have performed their whole duty towards use, preservation, etc., of the property.

All persons concerned in the subject matter should be heard by the surveying officer, either in person or through deposition, and if the property has been acted upon previously, the officer will be advised, and he will have any reports in existence placed at his disposal.

If the damages are the result of fire, the Surveying Officer will investigate and report upon the origin of the fire and its extent. In the event that fire or other catastrophe was responsible for damage, and the occasion has already been the subject of an investigating board under provisions of AR 210-10, the report of the board will be made available for the Surveying Officer, and he will incorporate the findings in his report.

He will make inventories of property ordered to be abandoned. In the case of discrepancies in shipments, he will verify the discrepancy between shipping documents and the actual quantity and kind of property transferred from one officer to another, and he will fix definitely the amounts received for which the receiving officer must sign. He will ascertain insofar as possible where and how the discrepancy occurred.

The Surveying Officer will afford the officer responsible for the property an opportunity to examine all evidence, or copies thereof, which are a part of the survey report. If the officer involved has any additional exhibits, they will be attached to the survey. If the Surveying Officer, as a result of his investigation, determines that some officer or individual other than the one who instituted the survey is to be held pecuniarily liable, that officer will be afforded an opportunity to examine the report and submit a reply. (In all events, before a Surveying Officer makes recommendations concerning the responsibility of an individual, he will notify such individual and solicit any further information on the case.)

Action by Chief of Finance on Reports of Survey. Final action on reports of survey is reserved for the Chief of Finance in the following cases:

1 Where pecuniary charges are brought in any amount against any individual, partnership, association or corporation. When a charge levied against an officer or enlisted man is removed by appointing or reviewing authority, the report of survey need not be forwarded to the Chief of Finance for final action.

2 Those covering shortage or damage noted on government bills of lading, or incident to shipments thereon (see AR 55-150).

3 Those covering shortage or loss or damage of property where there may be any question as to liability of a contractor under the terms of contract or purchase order (AR 35-730).

4 Those which cover property pertaining to state guard or to national guard not in the federal service.

5 Those covering property pertaining to 'lend-lease' or 'international aid 'funds.

Except for cases in which Reports of Survey must be forwarded to the Chief of Finance for review and final action, the commanding general of the service command may exercise his right to review and take final action on surveys originating in his command. Provided that it isn't necessary to forward surveys to Chief of Finance, and provided that the commanding general of the service command does not reserve the right to review and take final action of surveys, commanding officers of posts, camps, and stations may review and take final action on reports. Such action will be "By authority of the Secretary of War."

Preparation and distribution of copies of Report of Survey will depend upon the acting officer. When final action is taken by the Chief of Finance, three copies are forwarded through headquarters of the service command to Chief of Finance. The original is filed in permanent records of the Chief of Finance. The duplicate is filed by service command finance officer, and the triplicate is returned through channels to the accountable or responsible officer involved.

If the commanding general of the service command takes final action, the three copies are forwarded to service command headquarters, where the original becomes a part of the permanent files. The service command finance officer receives the duplicate, and again the triplicate goes back to the accountable or responsible officer.

In the event that final action is taken by the commanding officer of a post camp or station, or other appointing authority, when the accountability of the property has been terminated and all concerned are relieved from responsibility, the original goes to the permanent files of the post, camp or station headquarters. The duplicate is filed as a credit paper to the company property book, and the triplicate is destroyed.

It is not sufficient to indicate action on a report of survey merely as "disapproved." When reports are found to be complete as to investigation and evidence, but otherwise satisfactory, they may be approved with reservations, or their findings may be amended in whole or in part. Such action will be authenticated by signature, and it will be so worded as to leave no doubt with regard to property responsibility and accountability, pecuniary liability and disposition of unserviceable property. Action in such cases will be indicated on all copies of the report, or copies of action will be attached to all copies.

Incomplete or unsatisfactory reports may be returned through channels received for further evidence, correction, reconsideration or other action warranted by circumstances.

Theater of Operations. The commander of the theater of operations will prescribe the extent of accountability records, based on policies announced by the War Department, which must be maintained to account for property issued by supply establishments of the communications zone, or transferred from one service to another within the communications zone. (See FM 100-10.)

Accountability in Combat Zone. In the combat zone, no formal accounting for supplies is required. When supplies are issued to troops or are transferred from one service to another, the receiving officer receipts for the supplies with a notation showing the organization or work for which the supplies are required. Property officers must honor authorized requests for supplies made in any manner by those responsible for filling supply needs of troops engaged in active operations. However, the normal method of requisitioning supplies is used whenever practicable. The same care is taken of all equipment, supplies, and materiel, and the same economy in their use is observed as in cases where a formal accounting is required. All commanders are charged with insuring that neither men or organizations of their commands waste or misuse supplies, materiel, and equipment furnished to them, or accumulate an unauthorized surplus thereof. (See FM 100-10.)

Responsibility. Responsibility for the proper care and use of property continues throughout the theater of operations, irrespective of whether there is accountability for that property. A depot commander is responsible for all depot property. Since it is impracticable for one person to exercise immediate supervision over property as widely distributed as that of a depot, each section chief is concurrently responsible for all property assigned to his section, and each individual soldier is concurrently responsible for all tools, equipment, materiel, or supplies in his possession. Personal financial liability attaches to any officer or soldier responsible for property. This liability is enforced in the combat zone in the same way as in the zone of the interior. The only difference is that omissions or acts which constitute neglect and result in enforcement of financial liability in the zone of the interior may be considered reasonable care in the combat zone because of the exigencies and conditions prevailing in the combat zone.

STOCK CONTROL

Purpose. The purpose of stock control is to correlate supply to actual requirements. This correlation is a continuous process and estimated requirements are projected into the future. Stock control has two phases:

1. Maintaining adequate, balanced stocks on hand in all supply installations at all times to the extent permitted by the available supply. Balanced stocks can seldom be maintained in base depots, due to the receipt of shipments from the zone of the interior at these depots.
2. Effecting the best distribution of the available supply in accordance with existing needs, future needs, and anticipated future supply.

Procedure. Stock control is accomplished by:
1. Determination of supply levels for each supply installation.
2. Computation of stock levels by applying replacement factors to supply levels.
3. Maintenance of stock levels by adequate and timely replenishment.
4. Revision of supply levels, replacement factors, and stock levels in accordance with accumulated experience and anticipated requirements.

Determination of Supply Levels. *General.* Supply levels are stated in terms of days and apply to *stock on hand.* The supply level prescribed by the War Department for the theater applies to the theater as a whole and is apportioned between the combat zone and the communications zone, by prescribing supply levels for each zone. The communications zone commander apportions the supply level authorized for the communications zone by prescribing supply levels for each depot and supply installation in the communications zone, and the supply level prescribed by the theater commander for the combat zone is apportioned among the depots and maintenance companies within each army by the army commander

Determining Factors. The factors to be considered in establishing supply levels for individual depots and supply installations are as follows:

1. The supply level prescribed by the theater commander for the communications zone or the combat zone, as the case may be.
2. The location of each supply installation.
3. The normal replenishment period for each installation, and the regularity or irregularity of resupply.
4. The character and relative importance of the combat missions of the tactical units being supported by each installation.

Maximum and minimum levels. A supply level should be prescribed with an allowance for fluctuations due to varying demands and irregularity of resupply. This may be accomplished by including in the standing operating procedure a provision that prescribed supply levels are maximum and that depots should make every effort to prevent stock falling below a given percentage of the maximum, or maximum and minimum levels may be prescribed.

Stock Levels. *General.* Stock levels differ from supply levels in that stock levels are stated quantitively in terms of units of measure, such as each, quart, pound, 2-ounce can, etc. Like supply levels, stock levels apply to *stock on hand.* They do not include dues-in. Stock levels are the objectives which replenishment action strives to attain. The maximum stock levels should never be exceeded, and diligent effort should be made to keep stock on hand above the minimum stock level by timely placing of requisitions and follow-up action on previous requisitions.

Computation. Stock levels are computed by the depot for each item. The estimated daily issue is multiplied by the number of days prescribed as the supply level. The replacement factor used as the basis for determining the estimated daily issue may be prescribed by the authority prescribing the supply level or by higher authority. The replacement factor may be SNL addenda, theater experience and mortality tables, or estimated requirements.

Replenishment Procedures. *General.* The commander of each depot is charged with maintaining stock on hand within the authorized maximum and minimum levels. Action taken to obtain resupply must be correlated to the expected replenishment period and anticipated demands. Requisitions should be timed so that a shipment will arrive before the stock on hand falls below the minimum stock level, and the quantities requisitioned should be fixed so that no receipt will raise stock on hand above the maximum stock level, provided normal issues occur.

Depot Control Level. A depot control level is established for each item handled by the depot. This depot control level is a requisitioning objective or reorder point. It includes both stock on hand and dues-in. Routine stock replacement requisitions are made whenever the stock on hand plus dues-in is equal to or less than the depot control level. Normally, the depot control level is established at the minimum stock level plus the estimated issues during the anticipated replenishment period.

Quantity Requisitioned. If the stock on hand plus dues-in is equal to the depot control level, the quantity ordered is the difference between the maximum and minimum stock levels. However, if the stock on hand plus dues-in is less than the depot control level, the quantity ordered includes that difference as well as the difference between the maximum and minimum stock levels.

Emergency Order Point. An emergency order point should also be established for each item stored and issued. Emergency requisitions are submitted whenever stock on hand falls below this point. It should be equal to or slightly greater than the anticipated issues during the time required for receipt of items requested by emergency requisitions, submitted by phone, radio, cable, or other expeditious methods. Dues-in are not involved in the emergency order point except that the quantities ordered by emergency requisitions are dues-in and are entered as such on stock control cards.

Examples. Examples of the determination of depot control levels, quantities to be requisitioned, and emergency order points are given at the close of this section.

Revision of Levels. *Stock Levels.* All depot personnel should be alert to detect the need for the revision of stock levels, either upward or downward. Whenever stock levels appear to be either inadequate or excessive, the depot commander informs the authority which prescribed the supply level of all pertinent facts and recommends a revision by changing either the supply level or the replacement factor . Revisions are made when approved by the army ordnance officer or the communications zone ordnance officer as the case may be. Routine revisions, consisting of adjustments and recomputations due to changes in the number of major items in the hands of or authorized to troops being supported, are made by the depot without approval of higher authority. However, such revisions will be reported to all interested authorities and to the higher echelons of supply supporting the depot.

Depot Control Levels and Emergency Order Points. Depot control levels and emergency order points must be revised whenever stock levels are changed. In addition, they are revised by the depot whenever the replenishment period changes or whenever the estimated replenishment period does not conform to actual resupply conditions.

Essential Information. *General.* In order to effectively accomplish stock control, each depot must maintain records making the following information immediately available for each item:

1. The quantity on hand and its location.
2. The quantity due out and the quantity allocated.
3. Maximum and minimum stock levels.
4. Depot control level and emergency recorder point.
5. The quantity and status of dues-in.
6. Nomenclature, stock number, and unit of measure.
7. Interchangeability.

Records. The stock control records of field depots are maintained on W.D., A.G.O. Form No. 9-72, formerly W.D., O.O. Form No. 7356A. (See Figure 17.) Those of the communications zone depots are maintained on this same form or on W.D., A.G.O. Form No. 421. (See Figure 18.) The use of Form 9-72 is discussed in the operation of communications zone depots. The use of Form 421 is discussed under Accountability and Responsibility.

Theater Control Point. *Functions.* The theater control point operates under the ordnance officer of the communications zone. It has the following functions:

1. Maintains theater stocks in accordance with supply levels prescribed by the War Department.
2. Makes recommendations concerning supply levels prescribed for the theater and concerning supply levels prescribed within the theater.
3. Advises the War Department of the status of ordnance general supplies within the theater and submits estimates of future needs.
4. Requisitions upon the zone of the interior and initiates local procurement within the theater.
5. Determines the distribution of theater stocks.
6. Exercises special control of critical items.
7. Keeps all interested commanders and supply echelons advised of the status of critical items.
8. Maintains such historical and statistical records as may be required for the compilation and analysis of supply data.

Records. In order to perform these functions, the control point must maintain records which will give, for each item, the following information:

1. Total quantity on hand in the communications zone.
2. Quantity on hand at each depot.
3. Quantity due in from the zone of the interior, and the sources of supply.
4. Quantity due out at each depot.

Reports. A schedule is established requiring all depots to submit reports giving the status of supply as of a given date and hour. Additional periodic reports may be required on major items and critical items. The schedule is arranged so that the time required by depot personnel for preparation of reports is evenly distributed, and so that the reports impose a minimum burden upon the depots. Normally, entire SNL groups are reported upon at one time. It is essential that all depots report upon the same items at the same time.

The control point may also receive periodic reports from army ordnance officers concerning the status of critical items in the army installations and periodic reports of dues-out at the army installations.

Dues-in. In order to have information concerning dues-in to the theater, the control point must maintain an accurate record of all requisitions submitted by the theater and of all local procurement action. If the supply to the theater is accomplished, entirely or in part, by prearranged shipments or by automatic replenishment based upon materiel status reports, accurate records must be maintained to show the quantities to be shipped. Unless the War Department has exempted the theater's requisitions from editing, the quantities requisitioned should not be considered as dues-in until notice of approval has been received and due-in quantities adjusted to conform to the editing.

Resupply of Communications Zone Depots. *In the Advance Section.* The resupply of advance communications zone depots may be handled by the following methods:

1. The advance depots may submit requisitions to designated depots in the intermediate and base sections.
2. The advance depots may submit requisitions directly to the control point, and resupply will be effected by means of shipping orders issued by the control point to depots in the intermediate or base sections.
3. The control point may issue shipping orders based upon the periodic reports.

In the intermediate zone. Resupply of intermediate depots may be effected by any of the methods set forth above.

Base depots. The resupply of base depots receiving shipments from ports is largely dependent upon requisitions against the zone of the interior. These requisitions are prepared by the control point and are based upon the periodic reports mentioned in the above discussion of the Theater Control Point. Emergency resupply of a base depot is accomplished by shipping orders issued by the control point and directing shipment from other base depots.

By return of excess stocks and reclaimed materiel. The stock of any depot may be augmented by reclaimed materiel turned in to the depot by maintenance units located near it, and by lower supply echelons returning excess stocks.

Receipts through ports. Frequently, advance depots are located at or near ports of debarkation. In this event, shipments may be received directly from the zone of the interior. Excess stocks, resulting from such shipments, are reported to the theater control point, which effects redistribution through shipping orders.

EXAMPLES OF STOCK CONTROL CALCULATIONS

A. **Basis for Computation.** 1. The administrative order authorizes a supply level of 15 days supply and directs that every effort should be made to maintain 60% of the authorized level in stock at all times. This means that the maximum stock level for the depot will be computed on the basis of 15 days and the minimum stock level on 9 days.

2. The administrative order also directs that the SNL addenda be used in determining the estimated daily or monthly issue.

3. The depot is supporting an armored division which has 5284 Carbines, 2036 M1 Rifles, and 27 M1903 Rifles.

4. The estimated time required for replenishment of depot stock is 10 days.

5. The depot commander directs that emergency order points are to be established at 3 days supply.

B. **Computation of Stock Level for Thong, Item Stock No. B003-02-00160.** 1. Cross reference data is examined to determine the major items to which the item pertains. This shows that the Thong (B003-02-00160) is an accessory for the Carbine, the M1 Rifle, and the M1903 Rifle.

2. The addendum to SNL B-28 shows that 24 thongs per 100 Carbines are required for a 12-month period. The addenda to SNL B-3 and B-21 show the same number are required for the M1 Rifle and the M1903 Rifle. The 15-day authorized level is 1/24 of the 12-month period used in the SNL addenda; therefore, 1 thong per 15 days is required for 100 weapons, or 0.01 per weapon for 15 days.

3. Since the requirements are the same for the Carbine and both rifles, the

computation of the maximum stock level will be the total number of Carbines and rifles (7347) multiplied by the number of thongs per weapon for 15 days.

7347 × .01 = 73.47 or 74 maximum stock level

4. The minimum stock level is 60% of the maximum stock level.

74 × .6 = 44.4 or 45 minimum stock level

C. **Computation of the Reorder Point.** 1. The replenishment period is 5 days or 1/3 of the maximum supply level. Therefore, the estimated issues for the replenishment period is 1/3 of the maximum stock level.

74 ÷ 3 = 24 2/3 or 25

2. The depot control level is the minimum stock level plus the estimated issues for the replenishment period.

45 + 25 = 70 depot control level

D. **Determining Quantities to be Ordered.** 1. Assume that after posting an issue to the stock control card for the thong, the balance of stock on hand is 50 and the balance due-in is 15.

2. Stock on hand (50) plus dues-in, (15) equals 65, which is below the recorder point of 123.

3. The quantity to be requisitioned is the amount that the stock on hand plus dues-in has dropped below the recorder point added to the difference between the maximum and minimum stock levels.

70 — 65 = 5
74 — 45 = 29

34 quantity to be requisitioned

E. **Computation of Emergency Order Point.** 1. The emergency order point is 3 days or one-third of the minimum stock level.

45 ÷ 3 = 15 emergency order point

COMMUNICATIONS ZONE DEPOTS

Ordnance general supply depots in the communications zone normally are located in the Base Section Service area as a section of the general depot and are under the administrative and technical control of the base ordnance officer. The ordnance depot companies may comprise all personnel working in the ordnance section, or be supplemented to an appreciable extent by civilian labor. The set-up and operation of depot companies is discussed at the close of this chapter. Accessibility of the depot by transportation, existing storage facilities, and proximity to other installations of the base section are primary considerations in selecting a location for the general depot. In island warfare it will be expected the depot site will incorporate few of the accessibility and storage features desired.

Layout of the Depot. The layout of each depot is a separate problem which must be evaluated from the overall operation standpoint considering the depot mission; existing land, air, water and rail transportation; whether either or both bulk and individual items will be stored and issued; anticipated volumes of receipts and issues; amount of covered area available; and finally means for doing the work, that is, men and handling machinery. The well-planned depot will conserve space; prevent lost motion in stores handling; minimize travel time and travel distance and further avoid congestion. A good test of the organization and lay-out efficiency of the depot is the time required to completely process a normal size requisition. Under average operating conditions each requisition received from the field should be ready for pick-up by the using arm or service, or for packaging within 24 hours after receipt.

Principal Operating Points. The depot layout must locate each of the following in such relation to each other as to aid and speed operations: depot office, receiving section, storage areas, packing section and shipping section.

The lay-out of a typical communications zone depot, based upon the assumptions listed below is shown in Figure 30.

The principles illustrated are equally applicable to both separate ordnance supply point and general depot operation:

1. Depot is located in a base section.
2. Materiel is received directly from the port of debarkation.
3. Mission is the re-supply of other sub-depots and direct issues to ordnance units in the base section area.

4. Shipments incoming and outgoing are delivered by the Transportation Corps except materiel transported in vehicles issued from the motor pool.
5. Warehouses are available.

A depot lay-out in an advanced island base is shown in Figure 26.

The organization and functioning for this type of depot are virtually the same as for the base depot shown in Figure 25, the principal differences being that improvised cover and storage are employed and neither conventional buildings or railroads are present.

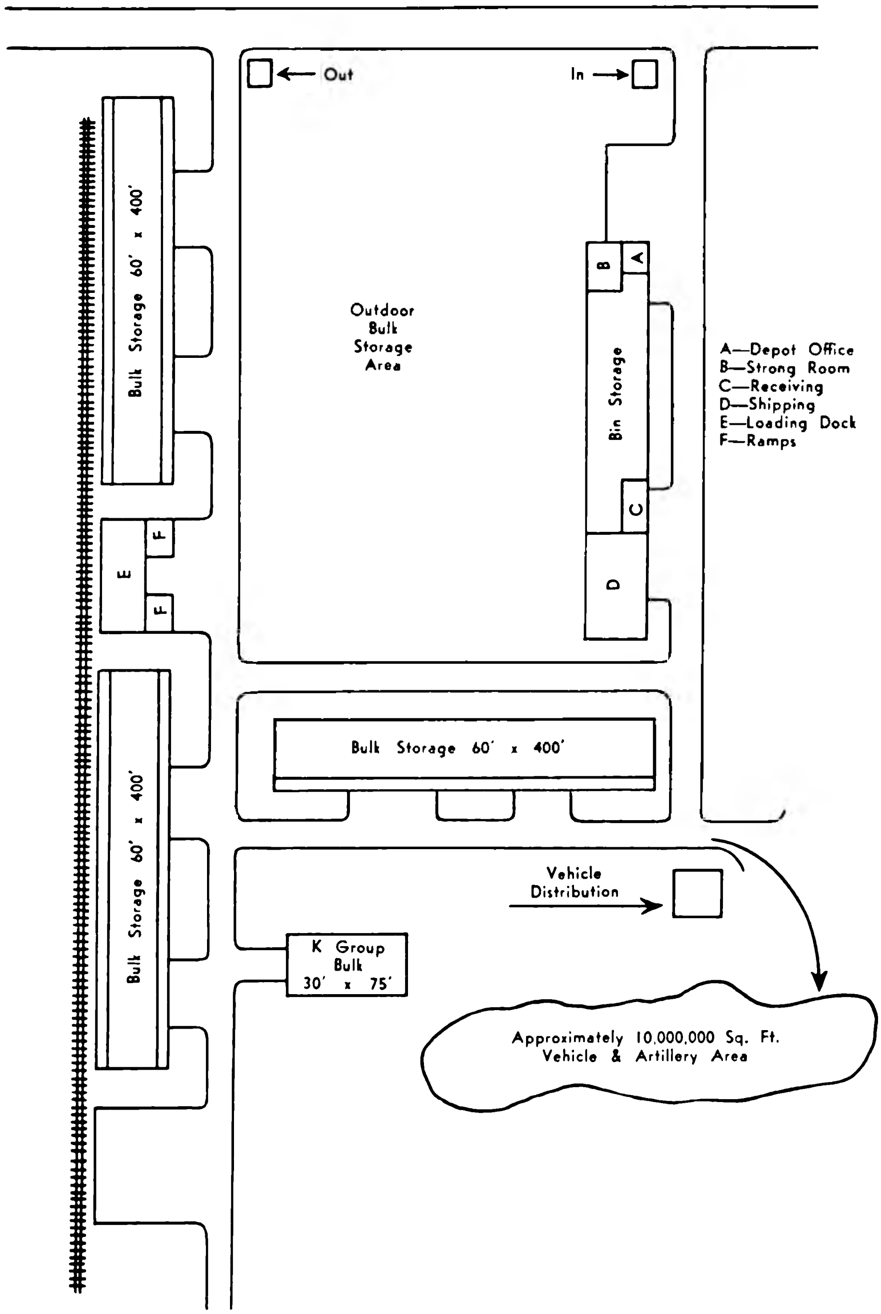


Figure 30. Sample Layout of a Typical Communications Zone Depot.

Organization of the Depot. Officers and noncommissioned officers of the depot companies constitute the key personnel in the various sections of the depot; whereas the depot command is assigned by the base ordnance officer, or by the base commander, as recommended by the base ordnance officer. The depot commander assigns duties to subordinates and will place the responsibility for the performance of each duty squarely upon the shoulders of the individual concerned.

Functions of the Depot Commander. The depot commander is responsible for·

Administration of the depot.

Efficient technical operation of the depot.

Proper storage, care, maintenance, and issue of stores.

Proper packing and marking of shipments.

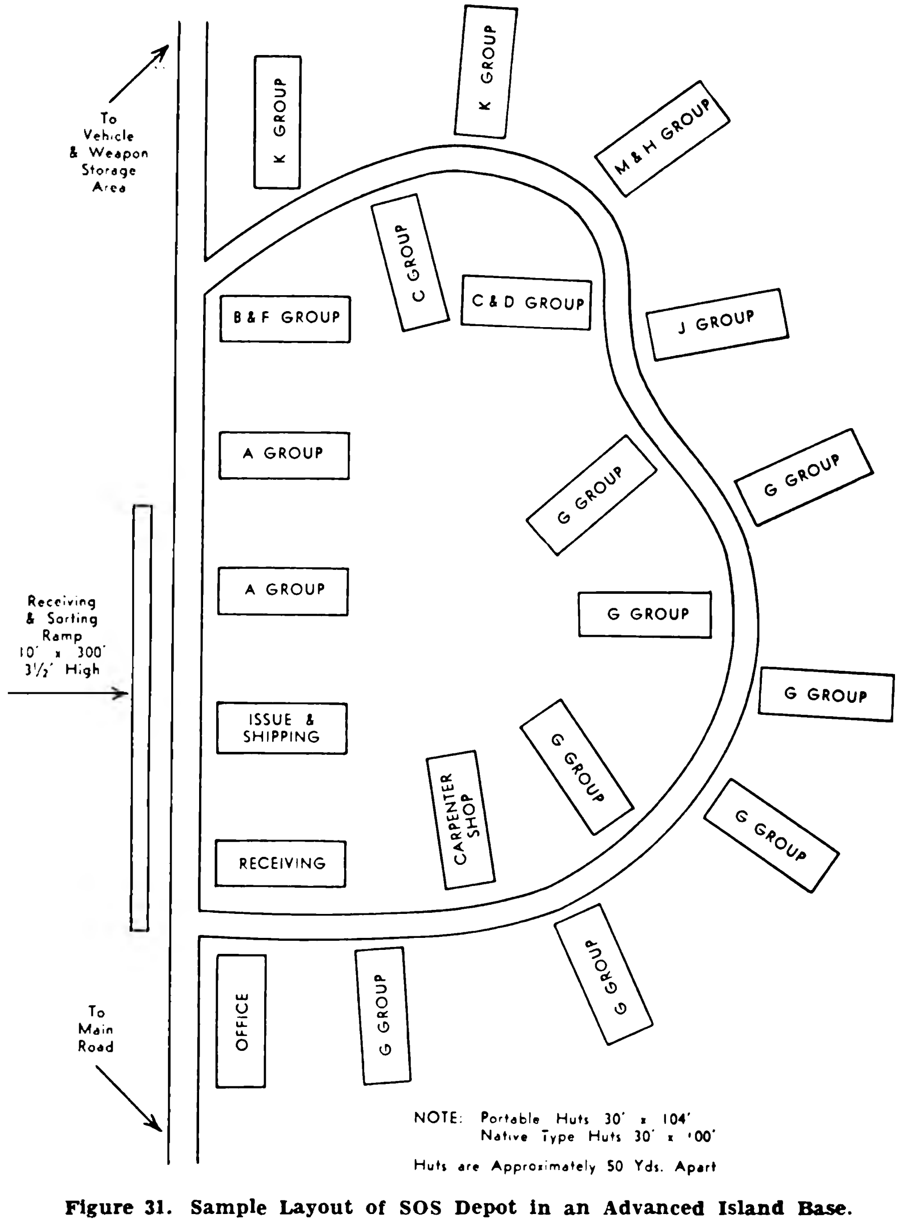


Figure 31. Sample Layout of SOS Depot in an Advanced Island Base.

Necessary arrangements with transportation agencies for incoming and outgoing shipments.

Supervision of loading and unloading of supplies.

Formulation and timely submission of reports required by higher authority.

Maintenance of records.

Establishing, maintaining, and adjusting stock levels.

Security of Stores.

Training of Personnel.

The depot commander will personally formulate the general plan of the depot and will exercise close supervision over all depot operation. Planning present and contemplated operation requirements and customer demands will be accomplished by subordinates under his supervision. He will personally make frequent inspections of operations to determine the manner of performance of duties of personnel and will conduct staff meetings for the dissemination of policies and solution of general problems of the installation.

THE ORDNANCE BASE DEPOT COMPANY

Mission. The mission of the ordnance base depot company, T/O & E 9-377, is to operate ordnance general supply base depots as required by the theater commander.

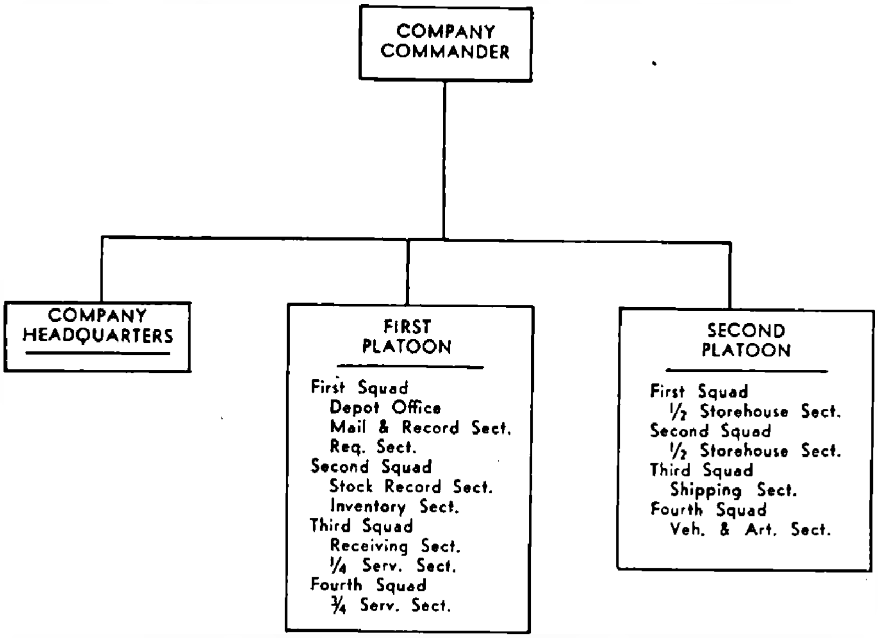
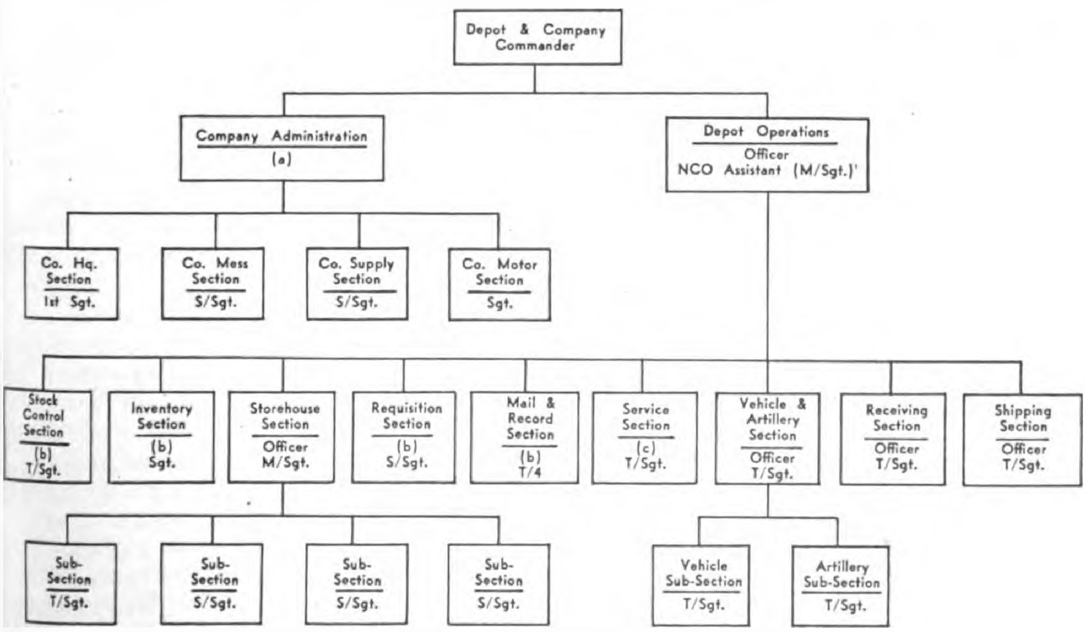


Figure 32. Suggested Military Organization, Ordnance Base Depot Company.



(a) All officers have company administration duties in addition to primary duties in depot.
(b) Under supervision of depot officer and chief clerk.
(c) Under supervision of officer in charge of Receiving Section.

Figure 33. Sample Technical Organization of an Ordnance Base Depot Company.

T/O & E 9–377

ORDNANCE BASE DEPOT COMPANY

SECTION I

ORGANIZATION

Designation †______ Ordnance Base Depot Company

	1	2	3	4	5	6	7	8	9
1	Unit	Technician grade	Company headquarters	Depot office	Receiving section	Shipping section	Storehouse platoon	Total company	Enlisted cabre
2	Captain		1					1	
3	First lieutenant			1			1	2	
4	Second lieutenant				1	1	1	3	
5	Total commissioned		1	1	1	1	2	6	
6	Master sergeant, including			1			1	2	2
7	Chief clerk (502)			(1)				(1)	(1)
8	Chief storekeeper (769)						(1)	(1)	(1)
9	First sergeant (585)		1					1	1
10	Technical sergeant, including			1	1	1	4	7	4
11	Assistant chief storekeeper (769)						(4)	(4)	(1)
12	Clerk, stock control (374)			(1)				(1)	(1)
13	Section chief (186, 195)[a]				(1)	(1)		(2)	(2)
14	Staff sergeant, including		2	2	1	1		6	2
15	Assistant section chief (186, 195)[a]				(1)	(1)		(2)	
16	Clerk, requisition (055)			(1)				(1)	
17	Clerk, shipping and receiving (186)			(1)				(1)	
18	Mess (824)		(1)					(1)	(1)
19	Unit supply (821)		(1)					1	1
20	Sergeant, including				2	2	4	8	
21	Clerk, receiving (186)				(2)			(2)	
22	Clerk, shipping (195)					(2)		(2)	
23	Storekeeper (769)						(4)	(4)	
24	Corporal, including		i					1	1
25	Clerk, company (405)		(1)					(1)	(1)
26	Technician, grade 4 (including)							18	7
27	Technician, grade 5 (including)		7	11	13	22	33	19	1
28	Private, first class (including)							21	
29	Private (including)							28	
30	Carpenter, general (050)	4				(1)		(1)	(1)
31	Carpenter, general (050)	5			(1)	(1)		(2)	
32	Carpenter, general (050)				(1)	(2)	(2)	(5)	
33	Clerk, checking (186)	4			(1)	(2)	(3)	(6)	(1)
34	Clerk, checking (186)	5			(1)	(2)	(3)	(6)	
35	Clerk, checking (186)				(2)	(4)	(6)	(12)	
36	Clerk, general (055)	4	(b1)	(1)			(1)	(3)	(1)
37	Clerk, general (055)	5		(1)	(1)	(1)		(3)	
38	Clerk, general (055)			((b1)2)	(1)	(3)		(6)	
39	Clerk, parts (348)	4			(1)	(1)	(2)	(4)	(1)
40	Clerk, parts (348)	5			(1)	(1)	(b2)	(4)	
41	Clerk, parts (348)				(2)	(2)	(4)	(8)	
42	Clerk, stock control (374)	4		(1)				(1)	(1)
43	Clerk, stock control (374)	5		(1)				(1)	
44	Clerk, stock control (374)			(2)				(2)	
45	Clerk, stock record (323)	4					(2)	(2)	(1)
46	Clerk, stock record (323)	5					(2)	(2)	
47	Clerk, stock record (323)						(4)	(4)	
48	Clerk, typist (405)			(2)				(2)	
49	Cook (060)	4	(1)					(1)	(1)
50	Cook (060)	5	(1)					(1)	(1)
51	Cook's helper (521)		(2)					(2)	
52	Basic (521)		(2)	(1)	(1)	(2)	(2)	(8)	
53	Total enlisted		11	15	17	26	42	111	18
54	Aggregate		12	16	18	27	44	117	18
55	O Carbine, cal. .30		10	13	14	21	35	93	
56	O Gun, machine, cal. .60, HB, flexible		1					1	
57	O Rifle, US, cal. .30, M1903		2	3	4	6	9	24	
58	O Truck, ¼-ton			1				1	
59	O Truck, ¾-ton, weapons carrier		1					1	
60	O Truck, 2½-ton, cargo						1	1	
61	O Truck, wrecking, heavy						1	1	

10 — Remarks

†Insert number of company.

Assignment.—One or more to an ordnance base depot as required.

Function.—To operate the general supply branch of an ordnance base depot.

Capacity.—Handles general ordnance supplies for a balanced force of about 30,000 troops operating under average conditions. Additional labor as required may be assigned from general pool or by use of local civilian labor.

[a] The serial number symbols apply respectively with the columns.

[b] Also drives truck.

For specification serial numbers shown in parentheses, see AR 615-26.

AGO 177

Figure 34. Table of Organization, Ordnance Base Depot Company (From T/O & E 9-377).

Assignment. Ordnance base depot companies are assigned to the theater as required. Normally, the ordnance base depot company is assigned to an ordnance battalion within an ordnance base group or to general depots.

Organization. The organization of the ordnance base depot company as set forth in T/O & E 9-377 is not a rigid requirement which must be strictly adhered to under all circumstances. Flexibility of organization is essential and is similar to that discussed for the depot company.

The company must be prepared to operate on a 24-hour basis. Reliefs must be organized and personnel assigned to the reliefs in a manner providing properly balanced teams.

The company headquarters may be organized as shown in Figure 32.

The military organization of the ordnance base depot company, like that of the ordnance depot company, is similar to that of an infantry company.

The technical organization of the company must conform to the supply installation being operated. This organization normally will provide greater centralization of control and operations than that of the field depot. The technical organization of this company may be as shown in Figure 33.

In a rear base, the base depot company may be augmented by civilian personnel, when available.

Equipment. A complete list of organizational equipment is found in T/O & E 9-377 and SNL N-377. Additional organizational equipment may be authorized by the theater commander, and special materials handling equipment, such as fork lift trucks and pallets, may be assigned to the depot being operated by the company.

OPERATION OF THE SECTIONS

The depot organization includes: receiving section; storehouse section; vehicle and artillery sections; mail and record section; requisition section; stock control section; inventory; shipping section and service sections.

Receiving Section. A central receiving section is responsible for all receipts, including:

Arranging for the correct spotting of railroad cars.

Arranging for and supervising the unloading of railroad cars and trucks.

Checking all incoming receipts by package.

Processing acknowledgments of receipt, if required.

Preparing intra-depot tallies for each stores unit to which items in the incoming shipment are assigned.

Arranging with the service section for delivery of packages to the proper stores unit.

Maintaining records pertaining to all receipts.

Storehouse Section. The storehouse section is responsible for the storage of all parts, assemblies, and subassemblies, and for the storage of major items other than vehicles and towed or self-propelled artillery.

Organization. The storehouse section is normally divided into subsections and into stores units. The number of subsections and stores units will depend upon the number of items and the quantities of each to be stored, the number and kind of buildings available, and the layout of the depot. In general, items should be assigned to subsections and stores units by SNL groups (i.e., A, B, C, etc.) and subgroups (i.e., A-5, etc.).

Functions of stores units. Establishment, execution, and continuance of an up-to-date location system, in accordance with the storage plan.

Preparation and up-to-date maintenance of locator cards in accordance with the location system.

Checking contents of packages received from the receiving section, except packages which are to be placed in bulk storage, if their contents are identified by packing lists or by sufficient markings.

Preparation of tally-ins which are forwarded to the stock control section for posting to stock records.

Placing items in proper bins, drawers, and spaces and bulk packages in correct storage bays in accordance with location system.

Protection of stores from misappropriation and damage by fire or rusting.

Picking from stock those items to be issued or shipped and delivering them to the shipping section.

Strong room. The depot strong room for the storage of small, valuable items requiring extraordinary safekeeping, such as pistols and instruments, is the direct responsibility of the chief of storehouse section. The strong room should be locked except when items are being placed in storage or are being withdrawn for issue. Keys should be in the custody of the depot commander, the section chief, and one or two assistants.

Vehicle and Artillery Section. The vehicle and artillery section operates the vehicle and artillery major items pool of the depot. Its functions include:

Storage of all vehicles and artillery.

Checking each vehicle or artillery piece to determine that it is completely equipped with all authorized accessories, spare parts, and tools.

Obtaining any shortage from or through other sections of the depot.

Issuing completely equipped vehicles and artillery.

Maintaining records pertaining to vehicles and artillery, including locator records, inspection records, and maintenance records.

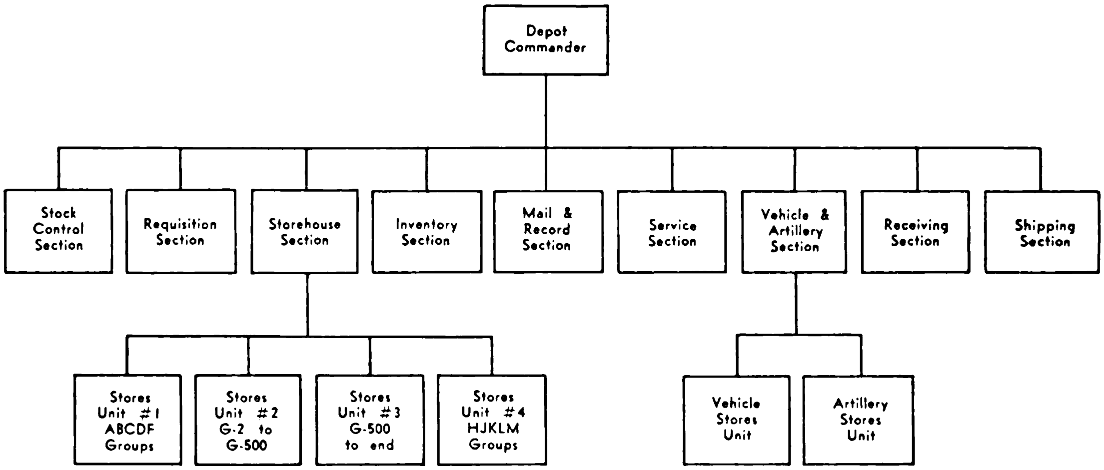


Figure 35. Sample Organization of Communications Zone Depot.

Organization. The vehicle and artillery section may be divided into subsections and stores units, depending upon the number of vehicles and artillery weapons being stored and issued. It may include special surveillance and inspection units, or those functions may be included in the duties of the stores unit personnel. It will include a special record section directly under the section chief.

Mail and Record Section. The mail and record section receives, records, and distributes all depot mail. Its operations include:

Opening and time-stamping all incoming mail, except personal mail.

Routing and distributing all incoming mail.

Dispatching outgoing mail.

Providing an intra-depot messenger service.

Indexing, recording, and filing correspondence.

Requisition Section. The requisition section performs the following operations:

Receives and registers all incoming requisitions, shipping and transfer orders.

Edits incoming requisitions for basis of issue and authority for issue, when required.

Prepares tally-outs, according to stores units, when the requisition or shipping order includes items stored by more than one stores unit and there are not sufficient copies for each stores unit.

Prepares and registers all outgoing requisitions.

Conducts systematic follow-up of the depot's requisitions.

Prepares shipping tickets or shipping documents from tally-outs returned by the shipping section.

Maintains all requisition and shipping order files.

Stock Control Section. The stock control section:

Maintains a stock control card for each item stored and issued by the depot. This function includes the following operations:

Checking tally-ins against incoming shipping documents and posting verified receipts to stock control cards. Further, back-order tally-out's are prepared concurrently with tally-in posting.

Posting issues to stock control cards.

Posting dues-in to stock control cards from outgoing requisitions or information copies of shipping orders.

Posting dues-out to stock control cards from outgoing requisitions or information copies of shipping orders.

Enters the quantities to be issued on all tally-outs and copies of requisitions or shipping orders used as tally-outs.

Inventory Section. The inventory section operates directly under the depot officer. Its function is to conduct spot inventories, to check stock control records, to determine causes of any discrepancies between balances shown on stock control cards and stock actually on hand in stores units, and to recommend action to be taken to prevent recurrences. This section also reviews computations of stock levels, depot control levels, and emergency order points, and studies stock control records with a view to detecting need for revision of stock levels, depot control levels, and emergency order points.

Shipping Section. The shipping section handles all outgoing shipments and issues. Items picked by the stores unit and forwarded to the shipping section for shipment or issue are checked against the accompanying tally-outs or copies of shipping orders or requisitions. The section then packs the items and marks all boxes, crates, and other packages. The number of the box or package in which each item has been packed is indicated on the tally-out or on the copy of the shipping order, requisition, or other document being used as a tally-out. This section makes necessary arrangements for shipping, and clecks the loading of each shipment or issue.

Service Section. The service section is a labor pool composed of riggers, carpenters, mechanics, painters, drivers, and general laborers, not specifically assigned to other sections. It furnishes any service or labor required by other sections of the depot. It assists the receiving and shipping sections in unloading and loading trucks and railroad cars. It makes and installs signs and road markers, furnishes extra drivers and checkers to the vehicle and artillery section, assists the stores units in making large issues and stowing large receipts, and generally assists other sections of the depot whenever needed.

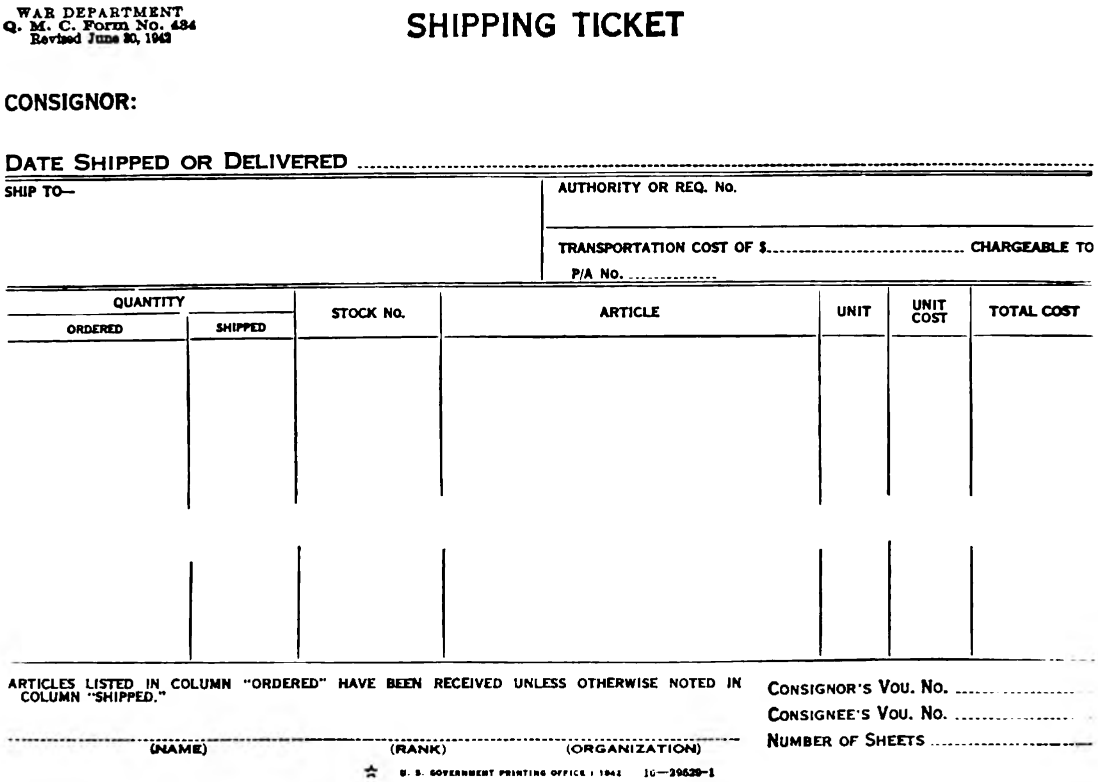
RECEIPTS

Proper receiving of materiel is required in order to insure that supplies will be issued when needed. The depot cannot make issues unless receiving operations correctly identify materiel received, accurately determine the quantity received, place each item in its proper location, and quickly transmit this information to pertinent depot records. Failure to issue items or the issue of incorrect items may result from mistakes in identification or improper location.

Advance Shipping Information. Advance notices of incoming shipments are immediately forwarded to the chief of the receiving section in order that he may determine the type and quantities of materiel to be received, arrange for the personnel and equipment required to handle the unloading and checking, and inform the chief of each stores unit as to the quantity of each item to be received and transferred to his stores unit for storing. The stores unit chief in turn determines the labor and equipment required to check and inspect contents and to place the materiel in storage. He also makes advance plans for the location of each item.

Types of advance notices. Shipping tickets. Advance information copies of shipping tickets identify the shipment and the method of shipment. This information enables the receiving section to make inquiries of transportation officers in order to obtain advance notice of time of arrival. The advance information copy of the shipping ticket also gives a detailed description of the materiel, including nomenclature, stock numbers, and quantities, and listing the types of packages and the number, weight, cubage, and contents of each, enabling the chief of the receiving section to determine the exact nature of the shipment, the labor and equipment required to unload and receive it, and the items and quantities to be distributed to each stores unit. It also refers to all related documents.

Shipping document. Advance copies of War Department shipping documents contain the same information as information copies of shipping tickets. In the case of shipments originating in the zone of the interior, the shipping document will give the shipping designator code of the shipment. This code may be used in requesting advance notice of arrival dates from transportation officers and port authorities. (See W.D. Pamphlet No. 38-5.)



WAR DEPARTMENT
Q. M. C. Form No. 434
Revised June 30, 1942

SHIPPING TICKET

CONSIGNOR:

DATE SHIPPED OR DELIVERED ....

SHIP TO—

AUTHORITY OR REQ. NO.

TRANSPORTATION COST OF $.............................. CHARGEABLE TO

P/A NO. ....

QUANTITY		STOCK NO.	ARTICLE	UNIT	UNIT COST	TOTAL COST
ORDERED	SHIPPED					

ARTICLES LISTED IN COLUMN "ORDERED" HAVE BEEN RECEIVED UNLESS OTHERWISE NOTED IN COLUMN "SHIPPED."

....
(NAME) (RANK) (ORGANIZATION)

CONSIGNOR'S VOU. NO. ....

CONSIGNEE'S VOU. NO. ....

NUMBER OF SHEETS ....

☆ U. S. GOVERNMENT PRINTING OFFICE : 1942 16—29520-1

Figure 36. Shipping Ticket (W.D., QMC Form No. 434).

Shipping orders. Information copies of shipping orders are of less value than shipping tickets and shipping documents for purposes of advance preparation for receiving. They show the items and quantities ordered to be shipped, but do not show the packaging. Moreover, the installation directed to make the shipment may be unable to fill the order in full and may send one or more partial shipments.

Miscellaneous. Various advance notices of shipments such as cables, radiograms and letters may refer to the depot's requisition. In these instances, the requisition must be consulted in order to determine the approximate nature of the shipment.

Unloading and Checking. Railroad cars are spotted at the depot's siding as arranged by the chief of the receiving section with the rail transportation office, and trucks bringing incoming shipments are routed to appropriate docks by the receiving section.

The receiving section assigns checkers and labor crews to each railroad car or truck. Receiving section personnel are augmented by laborers obtained from the service section, whenever the additional labor is required. A bulk tally-in is prepared for each car or truck. These bulk tally-ins are assigned a depot number in series and cross reference to the shipper and the shipper's number. All information identifying the shipment is entered on each bulk tally-in. This information includes:

Designation of the consignor.

The number assigned to the shipping ticket or shipping document by the consignor.

The bills of lading or similar documents, if any, covering the shipment.

The depot's requisition, or the shipping order issued by higher authority, which initiated the shipment.

Any code marking designating the shipment.

As the car or truck is unloaded, the checker enters the number and type of each package on the bulk tally-in. Unpackaged items, such as tank track sections, are recorded by description and quantity. The checker also indicates the stores unit to which each package or unpackaged item is to be delivered. If the contents of the car or truck are to be assigned to various stores units, they are segregated according to stores units on the unloading dock and later delivered to the stores units with intradepot tallies.

An intradepot tally is prepared by the receiving section for each stores unit to which materiel in the shipment is assigned. All intradepot tallies pertaining to a particular bulk tally-in are given the depot serial number of that bulk tally-in and the designation of the stores unit is prefixed or suffixed to the serial number. All intradepot tallies are noted on the corresponding bulk tally-in. Intradepot tallies list the number and type of each package sent to the stores unit, and give all information identifying the shipment. Unpackaged items are listed by description and quantity. When a single stores unit will handle all contents of a car or truck, a copy of the bulk tally-in is used as an intradepot tally.

At Stores Unit. The stores unit prepares a tally-in listing the items and quantities received. When a packing list (Example: copy of W.D. shipping document) accompanies the shipment, it is used as a tally-in, and any discrepancies are indicated on the packing list. Each tally-in is given the same number as the intradepot tally covering the same materiel, and all information on the intra-depot tally identifying the shipment is placed on the tally-in. If the contents of a package are identified by markings or by packing lists as to nomenclature and quantity, and, if the package is to be placed in bulk storage, its contents are tallied in at the quantity listed by the packing list or outside markings. Other packages are opened and their contents inspected and quantities checked by physical count.

As items are tallied in, they are placed in the proper bins, drawers, and spaces. If any item is placed in a bin, drawer, or space, which has not been previously assigned to it, the new location is immediately entered on the locator card for that item. Care must be exercised to preserve identification. Nomenclature and stock number should be placed on envelopes containing small items. Other items should be tagged. In no event should an item be left outside of marked bins and spaces unless some tag or note with its proper identification is secured to the item.

The stores unit also indicates on the intradepot tally all packages and unpacked items received by the stores unit. The tally-in and the intradepot tally are clipped together and sent to the receiving section which checks them against the bulk tally-in to determine that all packages or unpacked items received by the depot have reached the proper stores unit. The tally-in is then sent to the stock control section for posting to the stock control cards.

At the Stock Control Section. Each tally-in is posted to the stock control card for every item listed on the tally-in. If the tally-in is a packing list, and if there is a discrepancy between the quantity called for by the packing list and the quantity received by the stores unit, the quantity called for by the packing list is dropped from the dues-in. If the tally-in was completely prepared by the stores unit on W.D. Q.M.C. Form No. 489, (Figure 23 or an improvised form, the quantity received is dropped from dues-in, necessary adjustments for discrepancies between quantities received and those supposedly shipped will be made upon notification from the requisition section. In all cases, the quantity actually received is posted as received and added to balances on hand. As each item is posted, that fact is indicated by an "×" or a check mark (✓), and, when all items have been posted, the stock control clerk marks the tally-in "Posted" and initials the remarks. These precautions reduce the likelihood of double posting. The tally-in is then forwarded to the requisition section.

At the Requisition Section. The requisition section checks the tally-in against the shipping ticket or shipping document and it is posted to the depot's requisition. The tally-ins are then filed with the requisition. If there are any discrepancies between the quantities received and those listed by the shipping document or shipping ticket, or if acknowledgment of receipt is necessary, the tally-ins and the shipping ticket or shipping document are forwarded to the depot officer for necessary action before being filed.

STORAGE

Storage is not a separate operation. It is a continuation of the receiving operation and a preparation for the issuing operation. Efficient storage insures that supplies may be issued and shipped in a serviceable condition with safety and with speed.

Storage Plan. Each stores unit chief is responsible for developing and executing a plan for the storage of items assigned to his stores unit, in accordance with the policies established by the depot commander and the space assigned to the stores unit. The details of stock arrangement are dependent upon the types of materiel, the quantity of materiel, and the size and physical characteristics of the storage area available. Reference to stock control cards and SNL's assists in determining the storage space required for each item.

Open and covered storage. The shortage of storage space is chiefly a shortage of buildings. A depot rarely has sufficient covered space for all of its stocks. The first step in making a storage plan is to determine which items can be placed in open storage and which items require indoor storage. Preference must be given to items in direct relationship to adverse effect of climatic conditions upon the items, and the chief of the stores unit must bear in mind that when warehouse space is exhausted, new receipts must be stored in the open regardless of their nature, unless time, labor, and equipment are wasted in rehandling items which could have been originally stored outside.

Bulk storage and bin storage. The stores unit chief must determine the extent to which each item will be affected by the retail and wholesale operations of the depot. Certain items are always placed in bins because of their size and nature, the type of packaging, or the small quantities carried in stock. Others are always placed in bulk storage because of their large size. However, many items will be placed both in bulk storage and in bin storage. Issues of large quantities are made from bulk storage and issues of small quantities are made from binned stock.

Location by Group and by Size. *Binned Stock.* Location of all items by SNL subgroup and by alphabetical sequence or stock number within SNL subgroups is impracticable, because it is extremely wasteful of storage space. Items are placed in bin storage by cubic size within SNL subgroups, combinations of SNL subgroups, or entire stores units, depending upon the degree to which storage space is critical.

Bulk storage. The location of items placed in bulk storage is determined by many factors including:

The cubic space required.
The area or floor space required.
The activity of the item.
Difficulty or ease of handling.
Nature of the item.

Items of same SNL subgroup. To the extent consistent with other considerations, items of the same SNL subgroup should be stored together. This facilitates stock picking, since requisitions and shipping orders list items in each SNL subgroup together.

Layout of Stores Unit Area. The storage layout must conform to the structural features of the warehouse, such as the locations of doors, platforms, posts, and windows, the allowable load in pounds per square foot for each floor space, and the ceiling height at each point.

Light bulky items should be stored in central sections where ceilings permit materiel to be piled high. Space near platforms and doors should be assigned to big, heavy items. Small easily handled containers and inactive supplies should be located in remote parts of the storage area.

Aisles must be well planned. Transportation aisles should run the full length and breadth of the warehouse and must be wide enough to permit passing of mechanical equipment proceeding in opposite directions, and to provide maneuvering space for available fork lift trucks and personnel.

In order to reduce aisle space to a minimum, materiel requiring the same width aisle for handling should be located along the same aisle. Materiel requiring the greatest aisle width for its handling should be located along main aisles running to and from clearing spaces, doors, and platforms.

No stack may contain more than one item and adjacent stacks must be separated. The space between stacks should be sufficient to permit taking of inventories.

Clearing spaces should be located near outside doorways.

Clearing spaces and aisles should be clearly marked by painting or other suitable marking on the floor. No form of floor marking should present a hazard to personnel or an obstacle to equipment by projecting above the floor surface.

Allowable floor load in pounds per square foot should be determined for each area, and each area should be marked with this information so that the marking is visible before and after the area is filled.

Open Storage. The layout of open storage areas is similar to that of bulk storage within warehouses. Hauling distances from unloading points to storage points should be kept short. Roadways and aisles should provide a straight line between carrier and storage. Heavy items requiring crane handling should be near unloading points.

Supplies subject to damage by the weather should be protected by tents, tarpaulins, or building paper. All stacks should be placed on adequate dunnage.

Locator System. Each stores unit maintains a locator system. All storage space, covered and open, assigned to the stores unit, is divided into areas according to a logical sequence. Each indoor bulk storage area and open storage area is divided into blocks. Each area and block is designated by number or letter. Bins are designated by storage area, row, tier, and bin number.

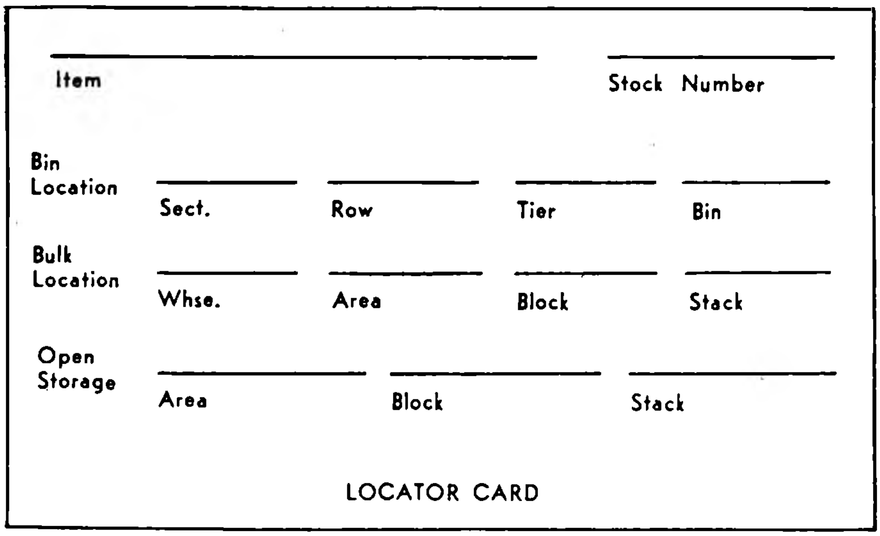

Item
Stock Number
Bin Location: Sect. Row Tier Bin
Bulk Location: Whse. Area Block Stack
Open Storage: Area Block Stack
LOCATOR CARD

Figure 37. Sample Locator Card.

Each item is assigned one or more definite locations and a locator card is prepared for each item (See Figure 37). Each location is recorded on the card. If the location of any item is changed, the locator card is immediately corrected to show the new location, and when a new receipt of any item is placed in a location not previously assigned to that item, the new location is promptly entered on the locator card.

Stowing. Always store from the wall toward the aisle. If a storage space is bounded on all four sides by aisles, establish a line through the center and store from it outward to the aisles. In any space to be filled, stowing is commenced at the back left-hand corner and is carried vertically in a single or double row of columns until the columns are brought to the front and completed. The second row of columns will commence in the back left-hand corner of the remaining space, and will be built up and forward in the same manner. This process continues until the space is filled or the total stock of that item has been stowed. If the storage area is bounded at the rear by an aisle, and it is desired to store a different item facing each aisle, the center of the space may be considered to be an imaginary wall, marking the rear of each half of the area.

Floor area is not space. Space begins at the floor and extends upward. Height of stacks should be limited only by the quantity of supplies, the allowable floor load, the physical characteristics of supplies, the strength of containers, the stacking ability of the personnel and equipment available, and the requirements of handling space between the top of the stack and the ceiling of the warehouse. An exception must be made to this rule for items of such a nature that they may be adversely affected by heat which may prevail near the roof of the building.

Packages with defective wrappings should be stowed last, in order that they may be issued first. Materiel must be rewrapped where necessary for its protection and issue.

Containers are normally placed with the ends toward the aisle into which the containers will be withdrawn. However, if space will be conserved by different placement, or if it is necessary to have both ends available for handling, the containers are placed in the most advantageous manner. Accessibility and flexibility are aided by avoiding cross-piling, except where necessary for stability.

Stacks may be cubical or pyramidal. Cubical stacks are preferable because less space is required, uniformity and regularity are attained, and inventory is made easy. Pyramidal stacks are advantageous for stacking cylindrical articles without bracing, and are better protection from weather when covered.

Items affected by water are put on dunnage. Stacks requiring free circulation of air for their preservation are built up with dunnage between layers. Where stock is adversely affected by sunlight and moisture, consideration is given to the location of this stock with reference to windows, doorways, and other openings.

In general, only one item should be placed in a single bin. If more than one item is placed in a bin, each item should be separated from the others by dividers or partitions.

Handling. Full use should be made of all available handling aids and mechanical equipment. (See ASF Manual M-402 for a discussion of pallets, roller conveyors, fork lift trucks, cranes, tractors, other mechanical equipment, and their uses.)

ISSUES AND SHIPMENTS

All operations of the depot are directed toward the timely, efficient issue and shipment of materiel as called for in requisitions, shipping and transfer orders. The depot's efficiency is determined by its ability to fill requests promptly.

From the supply standpoint, issue implies pick-up of supplies at the depot by the requisitioner, whereas, shipment is the action of transferring supplies (usually in bulk quantities) from one storage point to another. Shipments may be prepared in advance but normally will not leave the depot control until written authority therefor has been received by the depot commander. Issues are normally initiated by unit requisitions and shipments by direction of higher authority, contained in shipping orders, transfer orders, and special directives.

Registration. All requisitions are immediately stamped with the time and date of receipt and forwarded to the requisition section where they are entered in the requisition register and each is assigned a register number for reference and filing purposes. The registration clerk also checks the requisition for any approval which may be required. He then forwards it to the tally-out clerk.

The tally-out clerk prepares a tally-out for each stores unit handling items listed on the requisition. Each tally-out is prepared in duplicate and is given the same number as the requisition. Copies of requisitions are used as tally-outs whenever practicable. Copies of requisitions are prepared as tally-outs for each stores unit by redlining all items stored and issued by other stores units. Tally-out forms are prepared when there are insufficient copies of requisitions or when the preparation of tally-out forms involves less work than converting copies of requisitions into tally-outs.

The original requisition is placed in the requisition file. A separate file is maintained for each requesting organization, and requisitions are filed in each according to the registration number assigned by the depot. Tally-outs are forwarded to the stock control section for editing and posting.

Oral requisitions are reduced to writing by prepared tally-outs in quadruplicate. The original and one copy are placed in the requisition file. The extra copy is later mailed to the supply officer of the requesting unit. This practice enables organizational supply officers to detect and investigate any unauthorized oral requests.

Shipping and transfer orders are stamped, registered, and processed in the same manner as requisitions. The original is filed in the requisition file maintained for the organization or depot designated as the consignee by the shipping order.

Editing Nomenclature and Posting. Tally-outs are distributed among stock control clerks according to the SNL groups and subgroups. The clerk consults the stock control card for each item listed on the tally-out to determine that the nomenclature is accurate and sufficiently complete for correct identification of the item by the stores unit. If an item on the tally-out cannot be identified, the matter is placed in the hands of the parts interchangeability clerk, who traces the item through interchangeability records and cross references and furnishes the official stock number under which the item is stored by the depot.

As each item is checked for nomenclature, the stock control clerk also determines whether or not the quantity requested is in stock. The quantity to be issued is entered with red pencil on the tally-out, requisition, or shipping order, and that quantity is posted to the stock control card as an issue. If an item is not available, a zero is placed after the item and the quantity requested is posted to the stock control card as a dues-out. If part of the requested quantity can be supplied, that amount is placed on the tally-out after the item, and posted as an issue, the unfilled balance being posted as a dues-out.

If standard tally-out and requisition forms are used, the red pencil entries are placed in the column headed "Issued" or "Approved". If these columns are not available on improvised forms, the red pencil entries are placed beside the requested quantity entries.

Stock control cards should contain data concerning standard packages of issue, in order that the quantity to be issued may be in even multiples of the number of items packed in cartons, boxes, and other packages placed in bulk storage. For example, the unit of measure for Compound, anti-freeze, is a gallon, and it is normally packed as 6 one-gallon cans per box or carton. If a requisition from another depot lists 45, the stock control clerk should raise the quantity to be issued to 48, so that the stores unit can pick up 8 cartons from the bulk storage rather than 7 cartons from bulk storage and 3 cans from binned stock, and so that the entire quantity can be shipped in existing packages rather than having to send 3 loose cans to the packaging department.

The tally-out is sent to the stores unit handling the items listed in it.

Picking Stock. When the tally-out is received at the stores unit, the chief of the stores unit consults the locator cards and indicates the location from which each item is to be picked.

In the event that the stores unit is unable to issue the quantity indicated in red pencil, the matter is referred to the inventory section for checking. If additional quantities are not found and the stock control card is in error, the tally-out is returned to the stock control section which corrects its records and changes the red pencil quantity on the tally-out. The stores unit chief should check all items which have been zeroed or which the stock control section indicated could not be filled in full. If it is found that any of these items are in stock and can be issued in excess of the red pencil quantity, the matter is referred to the inventory section, which immediately checks the status of that item and all pertinent records. As soon as the check is completed, the stock control card and the tally-out are corrected by the stock control section. In no event will the quantities entered in red pencil be altered by anyone other than the stock control section, and no issue will be made which does not coincide with the red pencil quantities.

The items and the tally-out are forwarded by the stores unit to the shipping section.

Issues. The shipping section checks all items delivered to it by the stores unit against the tally-out, and sets them aside for the requesting organization to pick up. One copy of the tally-out is receipted by the representative of the receiving organization and returned to the requisition section for filing. The other copy is given to the organization.

Shipments. Items received from the stores unit are checked against the tally-out and loose items are packaged. Each package is numbered and the number of the package or packages containing each item is entered on the tally-out after each item.

The tally-out is sent to the requisition section for preparation of shipping tickets or shipping documents and packing lists. A packing list is prepared for each package. Copies of the shipping ticket or shipping document may be used as packing lists. Single pages of multiple page shipping tickets may be used as packing lists if all items in the packages are listed on that page.

A copy of the shipping ticket or shipping document and a packing list for each package are sent to the shipping section. A packing list is placed in or attached to each package. All packages are marked, and loose items are tagged. Shipping arrangements are completed and bills of lading or similar documents are prepared. When railroad cars or trucks arrive, they are loaded by the shipping section with additional help from the service section.

Emergency Extract Requisitions. When tally-outs are returned to the requisition section by the shipping section, they are attached to and filed with the original requisition or shipping order. If the requisition or shipping order is for materiel required to remove vehicles or other major items from deadline, and the depot was unable to fill the request, the requisition section immediately prepares an emergency extract requisition for the items and quantities required to meet the request in full. Extract requisitions are sent to the stock control section where they are posted in the same manner as other requisitions.

STOCK CONTROL AND REPLENISHMENT

Computation of Stock Levels. The depot commander directs the stock control section to establish stock levels for each item in accordance with the supply levels and replacement factors prescribed by higher authority. He issues full instructions concerning methods of computation and gives all information required for the computation. Actual computation is done by stock control clerks under the supervision of the chief of the section. When stock levels are being initially established, or when there is a general revision of all stock levels, competent personnel from the inventory section and other sections of the depot may assist in this work.

Depot control levels and emergency order point are also computed and established in the same manner.

Replenishment. Each time that a tally-out is posted to a stock control card, the stock control clerk checks the new stock on hand balance and the dues-in balance against the depot control level. If the stock on hand plus dues-in is less than the depot control level, the stock control clerk indicates this fact. When W.D., A.G.O. Form No. 421 (fig. 18) is used for stock control records, this is done by inverting the card so that the corner will protrude from the upper right corners of the other cards. If W.D., A.G.O. Form 9-72, formely W.D., O.O. Form No. 7356A (fig. 17.) is used, the card may be indicated by attaching colored signals. At a specified time each day, a clerk from the requisition section goes through the stock control cards assigned to him and prepares a requisition for the items which have dropped below the depot control level. As each item is placed on the requisition, the stock control card is placed with the notched corner up or the signal is removed.

Copies of requisitions are sent to the stock control section where the quantities ordered are posted to stock control cards as dues-in.

Inventories. The inventory section continually takes spot inventories and checks stock control cards against the results of these inventories. It also reviews the stock control cards with a view to detecting the need for revision of stock levels and depot control levels.

DUES-OUT

Origin. Whenever tally-outs are posted to stock control cards and the stock on hand balance is less than the quantity requested, the difference between the quantity requested and the quantity issued is posted as a dues-out, and is to be earmarked for the requesting organization upon receipt of that item.

Backorder Tally-Outs. Each time a tally-in is posted to a stock control card, the clerk checks the card for existing dues-out. If there is a dues-out, he immediately prepares a backorder tally-out in duplicate, listing the item and the quantity due-out. Backorder tally-outs are given the register number of the requisition which created the due-out. If another item on the tally-in being posted is due-out to the same organization, it is listed on the same backorder tally-out. Backorder tally-outs are posted to stock control cards as they are prepared and forwarded to the stores unit.

Issue of Dues-Out. The stores unit picks the due-out items and forwards them with both copies of the backorder tally-out to the shipping section. If the items are to be shipped, they are handled in the same manner as other shipments. If they are due-out to maintenance organizations or other troops located near the depot, the shipping section sets the items aside and notifies the organization to call for them. The issue is handled in all respects in the same manner as other issues.

Due-Out Items Obtained on Emergency Extract Requisitions. Shipments made in response to emergency extract requisitions will normally be marked reissue to the organization whose request occasioned the emergency extract requisition. In this event, the receiving section will prepare a tally-in-tally-out using a copy of the shipping ticket or shipping document. This tally-in-tally-out is sent to the stock control section where it is posted to the stock control card, cancelling the dues-in and the dues-out and posting the quantities as received and as issued. This dual posting, as received and as issued, is necessary in order to maintain correct expenditure data. The tally-in-tally-out is then returned to the receiving section which forwards it and the items to the shipping section. The shipping section ships the materiel or issues it in the same manner as other dues-out. Tally-in-tally-outs are posted to the depot's emergency requisition and filed with the customer's requisition.

VEHICLES AND ARTILLERY

Vehicle and artillery major items present different depot problems than parts and smaller major items, such as rifles or watches. Special operating procedures are required for the receipt, storage, issue, and control of vehicles and artillery.

Receiving. When vehicles are received by rail, checkers from the receiving section prepare bulk tally-ins, and where practicable will list each vehicle by serial, *i.e.*, "W" number. As each vehicle is unloaded from a rail car, it is driven or hauled to the vehicle and artillery section where checkers of that section take a physical count of all tools, equipment, other accessories, spare parts sets, and supplies attached to, installed in, or stored in each vehicle. Special tally-ins for each type and model, prepared in advance, are used for this purpose. These tally-ins are given the number assigned by the receiving section to the bulk tally-in, and each is identified by the serial number and engine number of the vehicle being checked. The body of the tally-in lists every item of equipment for the complete vehicle and the quantity of each item. The checker indicates equipment received by a check mark. An item which is not received with the vehicle is indicated by a zero, and one which is received in a different quantity than that listed is indicated by placing the quantity received after the item. Checkers prepare these tally-ins in duplicate. One copy is retained by the vehicle and artillery section and the other is sent to the receiving section. The copy sent to the receiving section is processed in the same manner as tally-ins prepared by other stores units.

Vehicles delivered to the depot under their own power are received in the same manner, except that a checker from the receiving section prepares the bulk tally-in as they pass the receiving section.

Artillery weapons are received in the same manner as vehicles, except that accessories and spare parts packed in one or more boxes will be tallied in according to items and quantities listed on shipping tickets, shipping documents, or packing lists, and the boxes will not be opened and checked.

Storing. Normally vehicles and artillery are stored in the open.

Issues. Vehicles and artillery weapons are issued and shipped complete with all equipment, tools, accessories, and organizational spare parts sets. In active theaters half-track and full track vehicles and armored cars are frequently issued 'combat-loaded' that is, complete and ready to enter combat.

Tally-outs should list vehicles by type, model, serial number, and engine number, and should contain an itemized list of all equipment, tools, accessories, and organizational spare parts sets, constituting the complete vehicle as issued. Special tally-outs may be prepared in advance for each type and model.

Artillery is issued on similar tally-outs and is listed by serial number of both the cannon and the carriage or mount.

Shipping tickets or shipping documents should list the same information as the tally-outs and in addition will show weight (tons), cubage, and marking data of shipment.

Stock Control. Stock control cards should be made for each type and model of vehicle and artillery weapon. If vehicles and artillery weapons are also carried as bare major items without accessories and spare parts sets, other stock control cards are maintained for these bare major items.

When the vehicle and artillery section draws equipment, accessories, or spare parts sets from other stores units to make a basic major item a complete vehicle or artillery weapon, the basic major item and the equipment, accessories, or parts sets are dropped from their respective stock control cards and the complete vehicle or artillery weapon is picked up on the stock control card for the complete item.

REGISTERS, FILES, RECORDS, AND REPORTS

Registers. *Receiving Section.* The receiving section maintains an incoming shipment register.

REGISTER NUMBER	DATE RECEIVED	SHIP TO	REQUISITION NUMBER	REMARKS
771	10 Aug.	I Army depot #1	194-761-44	Stock replenishment, Filled
772	10 Aug.	I Army depot #2	861-902-44	" " Part on B.O.
773	10 Aug.	23rd Ord Base Arm. Bn	23-861-44	" " Filled
774	10 Aug.	I Army depot #1	194-762-44	Deadline 4 scout cars. Granted #301
775	10 Aug.	37th Ord. Base Auto Bn	37-502-44	Stock replenishment Filled

Figure 38. Incoming Requisition Register, Communications Zone Depot.

Requisition section. The requisition section maintains the following registers:

Incoming requisition register.

Outgoing requisition register.

Shipping section. The shipping section keeps an outgoing shipment register.

Files. *Receiving Section.* The receiving section maintains the following files:
Bulk tally-in file.
Pending receipt file.
Requisition section. The requisition section keeps the following files:
Incoming requisition file.
Outgoing requisition file.
Stock control section. The stock control section keeps the following files:
Status of stock report file.
Dues-out report file.

NUMBER	DATE	UPON	REMARKS	FOLLOW-UP – RECEIPTS
194-101-44	4 Mar.	Rouen Ord. Depot	Stock Replenishment	1st part. 9 Mar. S/I 1797 Follow-up 14 Mar Back order notice 18 Mar. Final shipment 11 April S/I 2107
194-102-44	5 Mar.	Rouen Ord. Depot	Extract from 502-97-44 5 half-tracks deadlined	Final shipment 8 Mar. S/I 1789
194-298-44	11 April	Rouen Ord. Depot	Extract from 86-116-44 2 tanks deadlined	Follow-up 14 April Back order notice 15 April
194-299-44	11 April	Rouen Ord. Depot	Stock Replenishment	Final shipment 17 April

Figure 39. Outgoing Requisition Register.

Records. *Stock Control Section.* The stock control section maintains a stock ontrol record for each item stored and issued by the depot.
Stores units. Each stores unit maintains a locator record for each item it handles.
Reports. The stock control section prepares the following reports:
Status reports.
Dues-out reports.

FIELD DEPOTS

The Army ordnance officer, or the commander of the army ordnance group, letermines through command channels, the assignment of each field depot, estabishing its command relationship with higher authorities and specifying the actical and service units to be supported. Normally an advance mobile field lepot, assigned to furnish support through ordnance maintenance units to one r more tactical units, supplies from 15,000 to 45,000 troops, depending upon the uantity and kind of weapons, vehicles, and other ordnance equipment in the ands of those troops. Advance field depots are normally located to the rear, bout a one hour drive distance from ordnance divisional units, and to the ront about a one hour drive from the army depot. In island warfare this depot ocation may be considerably nearer the actual combat and much farther from he rear supply base. Operating personnel usually consist of an Ordnance Depot ompany organized under T.O.&E. 9-57. Frequently the company commander is lso the depot commander, and as such, his duties approximate those of the ommander of a communication zone depot with the added factors related to actical operations.

The basic supply principles previously enumerated apply equally to field and base depot operation. Supply officers experienced in either of the two types of operation should have little difficulty in becoming adapted to the other type. Two systems of stock control, namely, centralized operation with records operated and maintained in the stock control section, and de-centralized operation with the function executed by the storehouse sections have each proved advantageous as shown by experiences of officers in overseas supply operations. The former plan is found more generally used in communications zone depots while the latter has been used in field depots. Both systems are presented here in the relation named in anticipation that supply officers will adopt the plan deemed most judicious for their particular situation.

As presently equipped the field depot is not mobile since its supplies and men cannot be moved simultaneously. Actually, in overseas operations, special authorizations for additional tractor trucks, storage vans, and cargo trucks has in many cases enabled highly mobile depot companies to keep pace with fast-moving maintenance units. The discussion below envisions movement effected in T/O transportation, augmented as required by additional trucks, shuttling, marching, or some combination of these methods.

Site. Rail facilities and buildings are not normally used in field depot operations since these are frequently targets for enemy bombing and artillery fire. The factors considered in selecting a communications zone depot site are mainly applicable with additional considerations as follows:

Site should be sufficiently far back from the front as to be accessible by lateral roads, as well as adjoining a main road.

The site must be accessible in all kinds of weather.

Location should provide well knit natural cover, defilade, and other terrain features offering concealment and protection against enemy action.

Movement. The depot commander must keep informed of the tactical situation and be always ready to recommend new depot sites both to the front and rear according to requirements. Both map and personal reconnaissance should precede any movement and the final plan of movement will include:

Notification to using units of date and time of move.

Notice to supporting depots for proper time for re-directing replenishment shipments to new depot site.

Arrangements for additional transportation, labor, and equipment required to move stores and men.

Coordination of shuttling so that high priority supplies are moved first, and down-time of the various units is minimized.

Security. Security is a command responsibility and is of two phases: internal security and protection against enemy action.

Internal Security. Each stores unit leader is delegated the responsibility for protection of depot supplies of his section against damage by fire, pilferage, weather damage, and accidental injuries to personnel. The depot SOP will include employment and location of fire equipment such as extinguishers, pails, and sand buckets, inspection and precautions to be observed in averting injuries of personnel.

Defense against enemy action. The chief protection of the field depot against enemy action consists of passive measures designed to avoid detection. The selection of the depot and bivouac sites is the most important factor. It should be located so that the combat units being supported by the depot afford protection against ground attack. The site should be selected to take full advantage of available natural cover and, if within the range of enemy artillery, the site selected should be a defiladed area, whenever practicable. Measures must be undertaken to provide camouflage and enforce camouflage discipline. In addition to these measures designed to avoid detection, the commander must provide plans for defense against possible direct attacks. Slit trenches and foxholes should be prepared for all personnel Barricades and antitank obstacles may be advisable. Outpost positions should be established. Plans should be prepared and rehearsed for the disposition of personnel and weapons. Weapons contained in depot stack may be used to augment organizational weapons, if ammunition is available and the situation warrants.

Destruction of a depot. Orders for the destruction of the depot normally will come from the army ordnance officer although the depot commander may have to make this decision himself in an emergency. In making this decision, the depot commander should consider whether or not the enemy will be able to exploit the depot stocks. For example, an enemy force might appear in the vicinity of the depot on a raid, or during a partial break-through which our reserves can overcome. In either of these cases, the enemy himself would seek to destroy our stores before withdrawing. On the other hand, when circumstances indicate that the enemy will retain possession of the vicinity indefinitely, the depot commander must destroy stocks. Important materiel is smashed or rendered useless with explosives and grenades. The depot is then fired with gasoline.

General Operation Control. Certain operations of the field depot should be centralized. These operations include receiving, preparation of and follow-up on requisitions for the depot, maintaining records of requisitions upon the depot, traffic control, certain phases of security, and all matters pertaining to company administration and welfare of personnel.

Certain other operations of the field depot will be de-centralized. De-centralization is accomplished by assigning definite items or groups of items to each stores unit, and providing that the stores unit performs most of the operations pertaining to those items. The stores unit is the basic operating unit. It is responsible for mantaining stock control records and initiating replenishment of the items assigned to it, as well as the storage and issue of those items. This method of organization provides for specialization by SNL, groups rather than by functions.

THE ORDNANCE DEPOT COMPANY

Mission. The mission of the ordnance depot company, T/O & E 9-57, is to establish and operate ordnance general supply depots as required by higher authorities.

Assignment. In the combat zone, ordnance depot companies are normally assigned to an army, independent corps, or task force, as separate companies or as units within an ordnance battalion. The following table shows the *approximate* ratio for the proper balance in the field assignments of ordnance depot companies. In specific cases, it is subject to the necessary modification as dictated by conditions.

per Infantry Division	.40
per Light Division and Airborne Division	.20
per Cavalry Division	.40
per Armored Division	1.00
per Tank Battalion	.10
per Tank Destroyer Battalion (S.P.)	.10
per Tank Destroyer Battalion (Towed)	.05
per Antiaircraft Artillery Battalion (Gun & AW)	.04
per Cavalry Regiment (Mechanized)	.15
per Coast Artillery Battalion (Mob.)	.05
per Field Artillery Battalion (Light and Medium)	.03
per Field Artillery Battalion (Heavy)	.05
per Other Unit	As required on a comparative basis

The ordnance depot company may also be assigned to the communications zone as required.

The normal assignment of ordnance depot companies in the air forces is one company per air force general depot.

Organization. The personnel and equipment prescribed by T/O & E 9-57 is sufficient for the operation of a field depot company supporting tactical units in approximately the number and of the kind set forth above. However, the organization of the depot company set forth in T/O & E 9-57 is not a rigid requirement which must be strictly adhered to under all circumstances. Flexibility of organization is essential in order that the company may be adapted to varied assignments and the requirements of each situation. Changes in the strength of sections, the assignment of duties, and the disposition of grades and ratings should be made by the company commander in accordance with the job to be done, the personnel available to do the job, and the skill of that personnel.

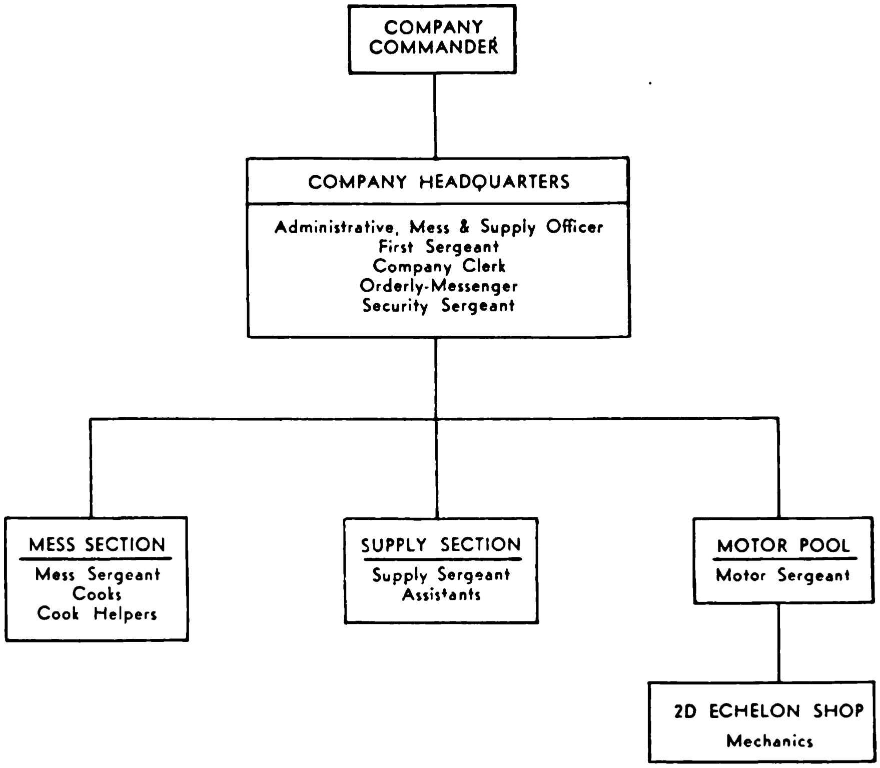


Figure 40. Organization Chart, Depot Company Headquarters.

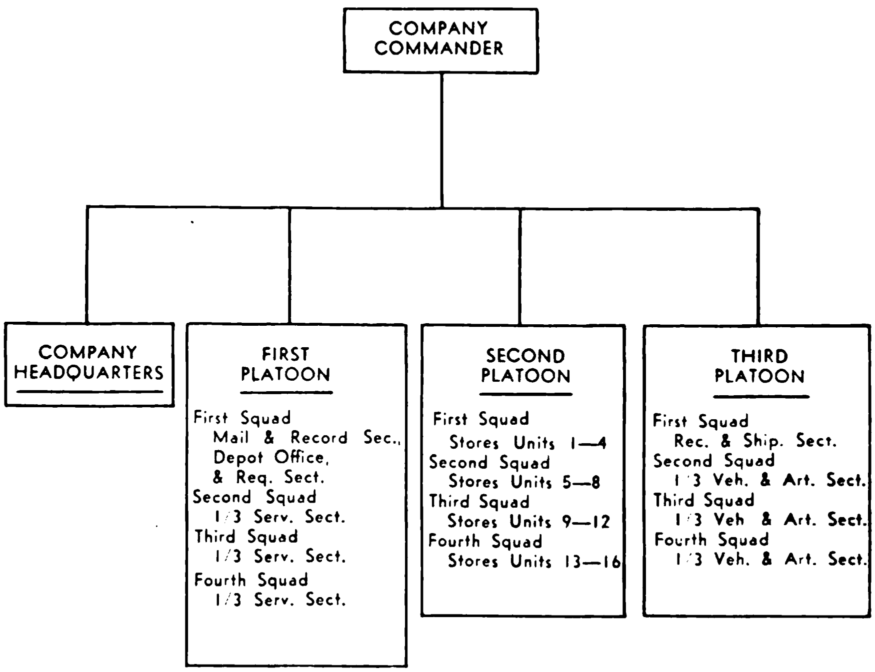


Figure 41. Suggested Military Organization, Ordnance Depot Company.

The company must be prepared to operate on a 24-hour basis. Reliefs must be organized and personnel assigned to reliefs in accordance with fluctuations in volume of work and to provide properly balanced teams. Moreover, the company must be prepared to meet sudden and unexpected demands without confusion. In addition, organizational duties must be performed and security measures maintained at all times.

An organization of the company headquarters is shown in Figure 40.

The military organization of an ordnance depot company is similar to that of an infantry company. However, the personnel engaged in military administration should be the minimum required to accomplish the job.

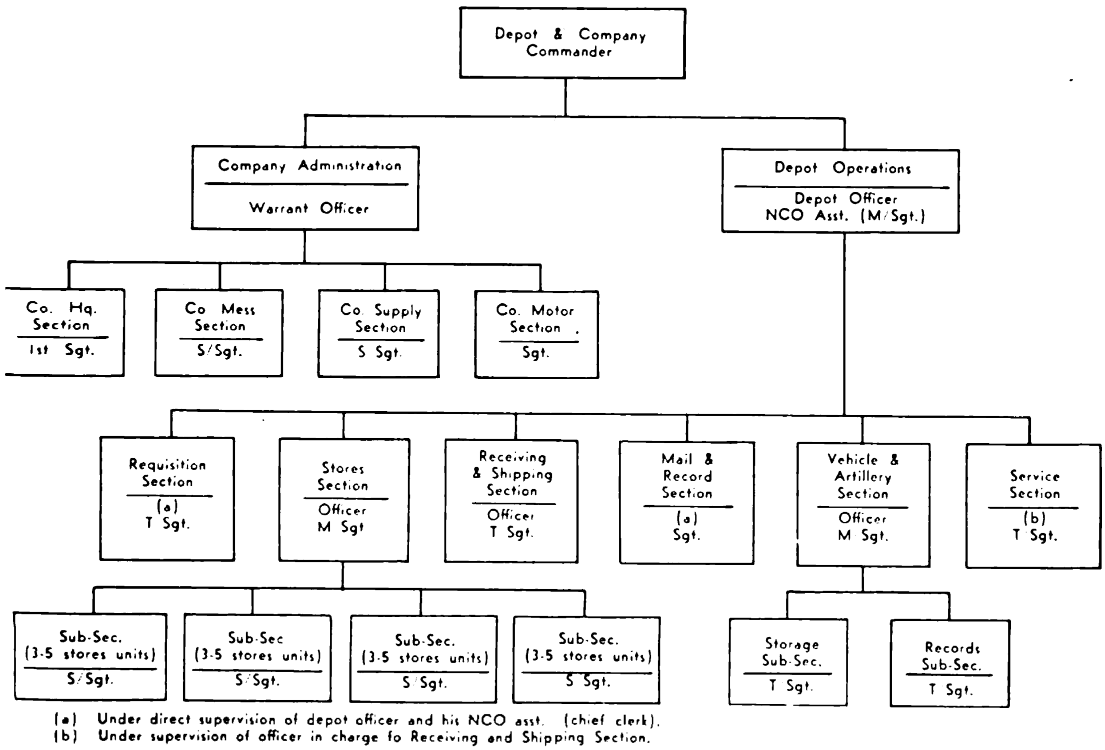


Figure 42. Sample Technical Organization of an Ordnance Depot Company.

The technical organization of the company must meet the requirements of the supply installation being operated, and will vary with the particular situation and conditions encountered. The technical organization should provide for the most efficient performance of the functions of obtaining, receiving, classifying, storing, preserving, and issuing ordnance general supplies. The company may be organized as shown in Figure 42.

Equipment. A complete lists of organizational equipment is found in T/O & E 9-57 and SNL N-57. Individual equipment is listed in T/E 21. Additional equipment may be authorized by theater commanders.

Operations. The operations of the ordnance depot company vary with the assignment given to the company. These are discussed in sections dealing with the various ordnance general supply installations.

ORGANIZATION

The details of field depot organization will be derived from a consideration of numerous factors of which the following will be found basic:

Type of items handled and quantities of each. For example, depots handling large numbers of artillery pieces and vehicles will separate the artillery park and vehicle pool into separate sections. Further, when supporting mechanized units the depot commander will allocate a larger than normal proportion of the vans for storage of armored vehicle parts. Vans should be combined so that each

	1	2	3	4	5	6	7	8	9	10	11	12
			Headquarters platoon				2 supply platoons (each)					
1	Unit	Technician grade	Company headquarters	Depot headquarters section	Service section	Total headquarters platoon	Platoon headquarters section	Receiving and shipping section	Storehouse section	Total supply platoon	Total company	Enlisted cadre
2	Captain		1			1					1	
3	First lieutenant			1		1	1			1	2	
4	Second lieutenant			1		1					2	
5	Total commissioned		1	2		3	1			1	5	
6	Warrant officer		[a] 1			1					1	
7	Master sergeant, including			1		1			1	1	3	3
8	Chief clerk (502)			(1)		(1)					(1)	(1)
9	Chief storekeeper (769)								(1)	(1)	(2)	(2)
10	First sergeant (585)		1			1					1	1
11	Technical sergeant, including			2	1	3		1		1	5	5
12	Chief parts clerk (348)			(1)		(1)					(1)	(1)
13	Receiving and shipping (186)							(1)		(1)	(2)	(2)
14	Section chief (813)				(1)	(1)					(1)	(1)
15	Truckmaster (668)			([b] 1)		(1)					(1)	(1)
16	Staff sergeant, including		2	1		3	1	1	1	3	9	4
17	Assistant chief parts clerk (348)			(1)		(1)					(1)	
18	Assistant storekeeper (769)								(1)	(1)	(2)	
19	Mess (824)		(1)			(1)					(1)	(1)
20	Receiving and shipping (186)							(1)		(1)	(2)	
21	Rigger (189)						(1)			(1)	(2)	(2)
22	Supply (821)		(1)			(1)					(1)	(1)
23	Sergeant, including		1	2		3			1	1	5	1
24	Clerk, parts (348)								(1)	(1)	(2)	
25	Clerk, stock record (323)			(1)		(1)					(1)	
26	Inspector, motor parts (413)			(1)		(1)					(1)	
27	Motor (812)		(1)			(1)					(1)	(1)
28	Corporal, including		1	2		3					3	2
29	Clerk, company (405)		(1)			(1)					(1)	(1)
30	Motor (813)			(2)		(2)					(2)	(1)
31	Technician, grade 4 } including										25	5
32	Technician, grade 5 } including		24	11	7	42	1	15	40	56	50	1
33	Private, first class } including										32	
34	Private } including										47	
35	Carpenter (050)	5						(2)		(2)	(1)	
36	Carpenter (050)										(3)	
37	Clerk, parts (348)	4						(1)	(4)	(5)	(10)	(1)
38	Clerk, parts (348)	5						(1)	(4)	(5)	(10)	
39	Clerk, parts (348)							(2)	(8)	(10)	(20)	
40	Clerk, file (355)	5		([e] 1)		(1)					(1)	
41	Clerk, file (355)			([e] 1)		(1)					(1)	
42	Clerk, general (055)	4		(1)		(1)					(1)	
43	Clerk, general (055)	5						(1)		(1)	(2)	
44	Clerk, general (055)							(1)	(1)	(2)	(4)	
45	Clerk, receiving and shipping (186)	4						(1)		(1)	(2)	(1)
46	Clerk, receiving and shipping (186)	5						(1)		(1)	(2)	
47	Clerk, receiving and shipping (186)							([e] 2)		(2)	(4)	
48	Clerk, stock, control (374)	4		([e] 1)		(1)					(1)	(1)
49	Clerk, stock control (374)	5		(1)		(1)					(1)	
50	Clerk, stock control (374)			(1)		(1)					(1)	
51	Clerk, stock record (323)	4							(1)	(1)	(2)	
52	Clerk, stock record (323)	5							(1)	(1)	(2)	
53	Clerk, stock record (323)								(3)	(3)	(6)	
54	Clerk, requisition (186)	4		(1)		(1)					(1)	
55	Clerk, typist (405)	4					([d] 1)			(1)	(2)	
56	Clerk, typist (405)	5		([e] 1)		(1)					(1)	
57	Clerk, typist (405)			(1)		(1)					(1)	
58	Cook (060)	4	(2)			(2)					(2)	(1)
59	Cook (060)	5	(2)			(2)					(2)	(1)
60	Cook's helper (521)		(2)			(2)					(2)	
61	Cutter, glass, (358)	5			(1)	(1)					(1)	
62	Driver, truck, heavy (245)	5							([e] 2)	(2)	(4)	
63	Driver, truck, light (345)	5	(1)	(([f] 1)2)		(3)					(1)	
64	Driver, truck, light (345)										(2)	
65	Driver, wrecker (529)	5	(1)			(1)					(1)	
66	Mechanic, automobile (014)	4	(1)		(2)	(3)					(3)	(1)
67	Mechanic, automobile (014)	5			(2)	(2)					(2)	
68	Rigger (189)	5						(1)		(1)	(2)	
69	Rigger (189)							([e] 2)		(2)	(4)	
70	Warehouseman (252)	5							([b] 8)	(8)	(16)	
71	Warehouseman (252)								([b e] 8)	(8)	(16)	
72	Welder (256)	4			(1)	(1)					(1)	
73	Welder (256)	5			(1)	(1)					(1)	
74	Basic (521)		(15)			(15)					(15)	
75	Total enlisted		29	19	8	56	2	17	43	62	180	22
76	Aggregate		31	21	8	60	3	17	43	63	186	22
77	O Carbine, cal. .30		26	16	6	48	2	13	33	48	144	
78	O Gun, machine, cal. .50, HB, flexible		2			2					2	
79	O Gun, submachine, cal. .45			1		1	1			1	3	
80	O Launcher, rocket, AT				1	1	1	1		2	5	
81	O Rifle, cal. .30, M1903		5	4	2	11		4	10	14	39	
82	O Semi-trailer, 6-ton								8	8	16	
83	O Trailer, 1-ton, 2 wheel, cargo		1	1		2					2	
84	O Truck, ¼-ton			1		1					1	
85	O Truck, ¾-ton, weapons carrier, w/winch						1			1	2	
86	O Truck, 2½-ton, cargo		1	1		2					2	
87	O Truck, tractor, 4–5 ton								2	2	4	
88	O Truck, 10-ton, heavy wrecker		1			1					1	

13 Remarks

[1] Insert number of company.

[a] Administrative, motor, mess, and supply officer.

[b] Also assists in operation of vehicle replacement pool.

[c] Armed with carbine, cal. .30, unless otherwise indicated.

[d] Drives truck, ¾-ton.

[e] Armed with rifle, cal. .30, M1903.

[f] Armed with gun, submachine, cal. .45.

Normal Assignment: Component of Ordnance Service, Army (or independent corps) or Air Force.

Function: Supply of all items of Ordnance including vehicles and excepting ammunition.

Capacity: One company can perform army supply for an average of 30,000 men. This is subject to variations depending on the type of units in the force.

The serial number symbol shown in parentheses is an inseparable part of the specialist designation. See AR 615–26.

Figure 43. Table of Organization, Ordnance Depot Company (From T/O & E 9–57).

subsection handles approximately the same number of items, and so that the items handled within a subsection are related as closely as possible

Depot Equipment. Where the volume of stock exceeds van capacity the various stores units will operate an outside storage area for the items within the SNL groups assigned to that unit.

Assignment. Missions requiring great mobility increase the need of decentralization and team-operation of stores units. Further, situations requiring multi-location supply point operations will necessitate setting up dual van storage and sub-dividing stores unit personnel into two teams each capable of independent operation.

Sections. The depot organization will normally provide the following sections:

- Receiving and shipping section
- Stores section
- Vehicle and artillery section
- Service section
- Requisition section
- Mail and record section

Receiving and Shipping Section. The receiving and shipping section handles all receiving, outgoing shipments, and issuing of due-out items. Its functions include:

Arranging for transportation necessary to obtain replenishment stock from rear depots or to return excess stock.

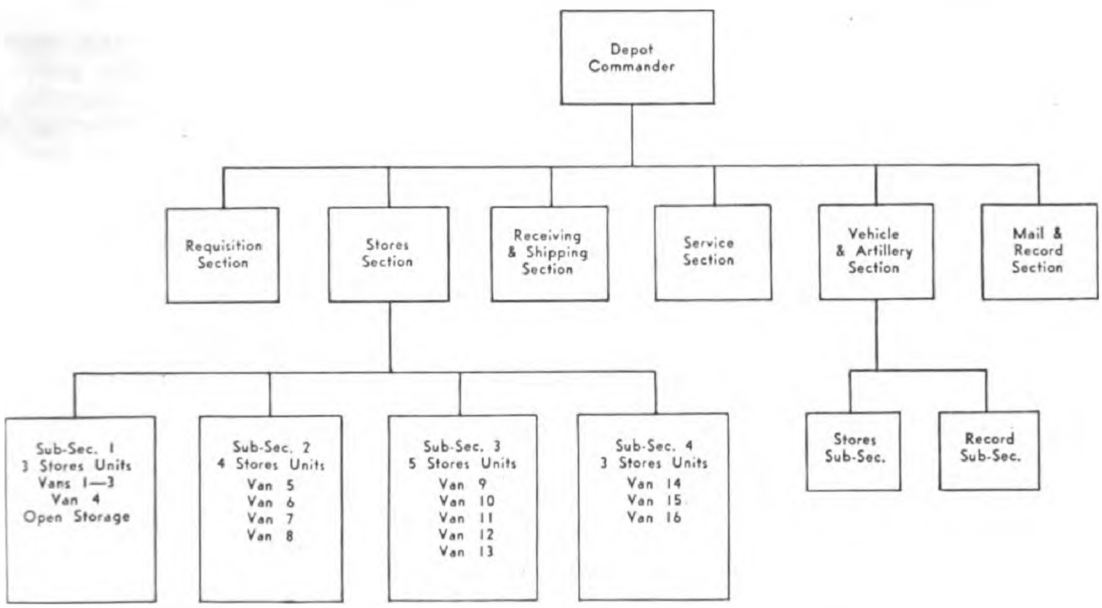


Figure 44. Sample Organization of a Field Depot.

Arranging for and supervising the unloading of railroad cars and trucks, including the transportation of supplies from railhead to the depot site.

Checking all incoming receipts by package.

Processing acknowledgments of receipts, if required.

Arranging with service section for delivery of packages to proper vans and open storage areas.

Making all shipments by truck or rail, including packing, marking, and loading.

Earmarking and issue of due-out items.

Stores Section. *Stores Units. Vans.* Each van is ordinarily a stores unit. However, a stores unit may be composed of two or more vans. When a main alphabetical SNL group is assigned to two vans, those vans may be operated as a single stores unit; or when two or more vans are assigned large units and assemblies, they may be combined as a single stores unit.

Open storage areas. Each open storage area may be a stores unit or it may be subdivided into one or more stores units, depending upon the number of items placed in open storage. In certain stable situations, a stores unit may be composed of a van and an open storage area adjacent to the van, and limited to items within the SNL groups or subgroups assigned to the van. In mobile situations, each open storage area should be a separate stores unit, so that the stock control cards remain with the corresponding items during a move.

Assignment to stores units. Each stores unit, whether van or open storage area, should be assigned definite SNL subgroups or specified items. The subgroups assigned to any one stores unit should belong to the same alphabetical SNL group, or should combine all subgroups within a logical combination of alphabetical groups, such as A and B, or H and J.

Heavy units. Heavy units are an exception. All items which are too large and bulky for convenient storage with other items belonging to the same SNL group may be assigned to a special heavy unit stores unit, which may consist of more than one van or which may be an open storage area.

Interchangeable parts. Each interchangeable part which is common to two or more major items may be stocked in the stores unit handling the SNL subgroup to which the item is assigned, and a reference stock control card should be established in other stores units handling subgroups in which the interchangeable item is listed. If the interchangeable part is an item of frequent issue in more than one stores unit, this part may be stocked in more than one van. For items stored in this manner, the stock control must be centralized in the depot office or in the stores unit which makes the most frequent issues.

Centralized supervision. Stores units are combined into subsections. Each subsection chief is responsible for coordinating the work of the stores units under him, for supervising their operations, and enforcing conformity with the general policies and uniform operating procedures established by the depot commander. Stores units handling related groups should be placed in the same subsection in order to facilitate interchange of personnel from one stores unit to another and to obtain other advantages of specialization by SNL groups.

Subsections are combined into sections. Each section chief, normally a commissioned officer when the depot is operated by a full ordnance company (T/O & E 9-57), is directly responsible to the depot officer for the operation of his entire section, as well as each subsection and each stores unit within his section. His functions are supervising operations, checking manner of performance, coordinating the subsections and stores units, and enforcing the general policies and uniform operating methods established by the depot commander and the depot officer.

Functions Each stores unit is responsible for the following operations with respect to the items assigned to it:

Establishing, maintaining, and revising a locator system.
Checking contents of package received.
Preparing tally-ins.
Placing items in proper bins, drawers, or spaces.
Application of correct storage methods, including proper preservation.
Surveillance of stored materiel.
Picking stock and making issues.
Computation of stock levels, depot control levels, and emergency order points.
Maintaining stock control cards.
Preparing backorder tally-outs and forwarding due-out items to receiving and shipping section.
Maintaining interchangeability data.
Preparing replenishment lists.
Preparing status reports and dues-out reports.

Vehicle and Artillery Section. The vehicle and artillery section performs all functions of the same section in a communications zone depot. It also performs most stock control operations pertaining to the items it handles. Normally the stock level of all major items including artillery and vehicles is established by theater policy thus obviating procurement initiation by this section.

Requisition Section. The requisition section performs the same operations in the field depot as it does in a communications zone depot.

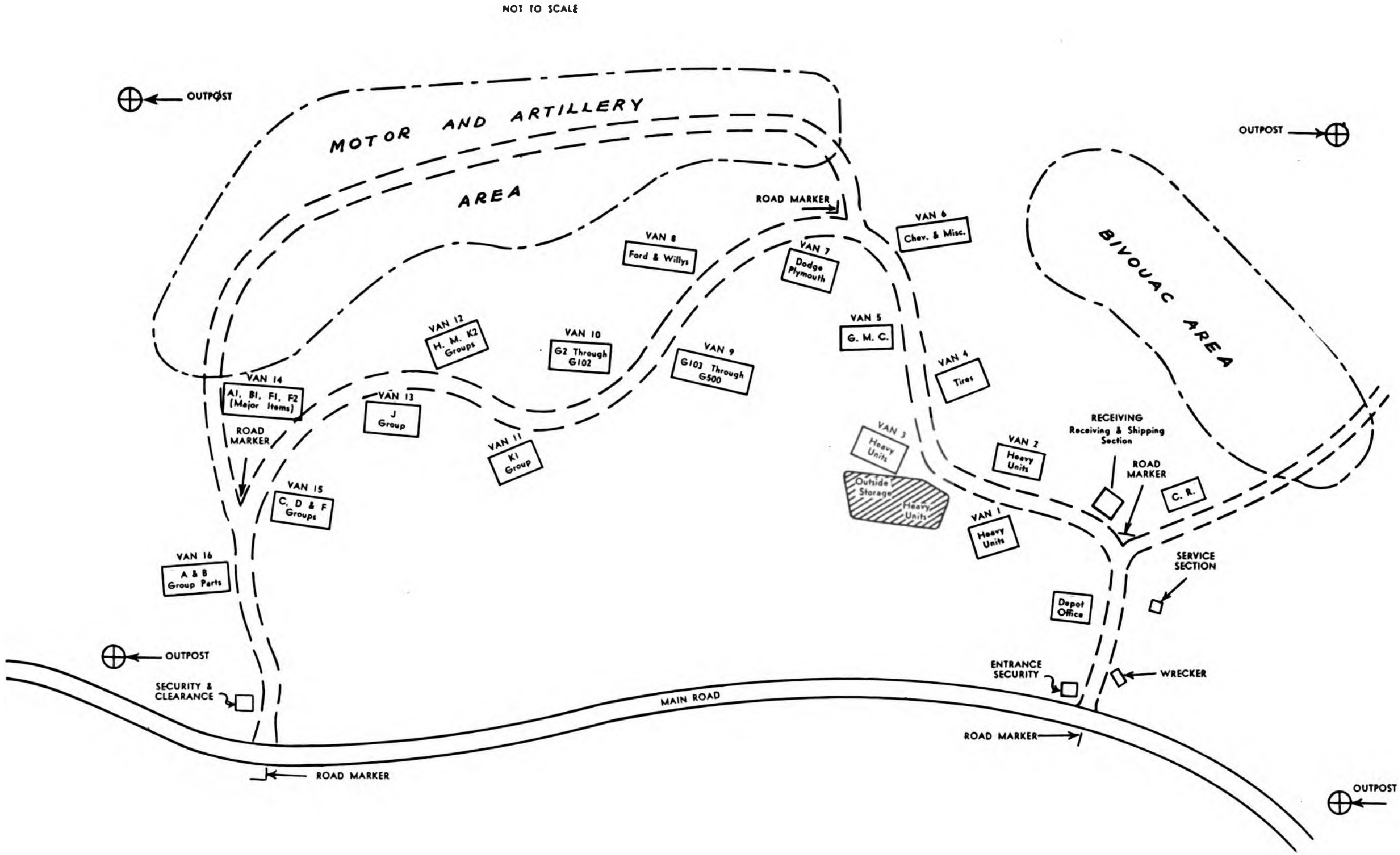


Figure 45. Schematic Layout, Ordnance Field Depot.

Service Section. The service section performs the same functions in the field depot as it does in a communications zone depot.

Mail and Record Section. This section operates in the same manner as it does in a communications zone depot. In some cases all supply papers will be registered in and out of the depot in the mail and record section.

LAYOUT

The layout of a field depot differs materially from that of a base depot. The layout is largely governed by the site selected. Vans must be located on the roadnet within the site and full advantage should be taken of the natural cover available. The depot office should be near the entrance. The service section and the receiving and shipping section should be near the office. In general, heavy unit vans and open storage areas should be the stores units nearest to the entrance. This permits the customer's detail to load heavy items before drawing small items. The parts common vans should be centrally located, and vans storing related materiel should be adjacent to each other.

RECEIPTS

Advance Planning. The field depot will receive fewer advance notices and less complete information than communications zone depots. However, the receiving and shipping section should take full advantage of any advance notice and make preparations to handle the incoming shipment. If the depot receives shipments at a railhead and brings the materiel to the depot by truck, careful planning insures that the trucks are loaded so that they will be unloaded at the proper van.

Central Receiving Operations. *Arriving by Truck.* Supply trucks arriving at the depot are directed to the receiving and shipping section, which determines the nature of the items carried by each truck, and routes the truck to the proper stores unit. A checker accompanies each truck. He checks the packages received and prepares a bulk tally-in. Trucks containing items assigned to several stores units are unloaded at the receiving and shipping section, and the packages are segregated by SNL groups and subgroups for distribution to the proper stores units. Intradepot tallies are prepared for each stores unit, giving all data identifying the shipment and listing the packages by type and number and unpackaged items by nomenclature and quantity.

Arriving by rail. Notice of a shipment arriving at a railhead is received at the depot office and is transmitted to the receiving and shipping section. The chief of the receiving and shipping section determines the personnel, trucks, and other equipment needed and arranges with the motor sergeant and the service section for the necessary trucks, drivers, laborers, roller conveyors, wreckers, and other equipment. If the depot's trucks, equipment, and personnel are insufficient, the depot commander arranges with higher authorities for additional trucks, drivers, laborers, and equipment. Checkers from the receiving and shipping section accompany the detail to check the shipment, to direct the unloading, to supervise the loading and dispatching of trucks, and to secure all information required by stores units for posting stock control cards and by the requisition section for posting its records. Checkers prepare intradepot tallies for each truck as it is loaded, a tally being prepared for each stores unit handling items on the truck. If a truck contains items stored by several stores units, a single tally is prepared and the truck is unloaded at the receiving and shipping section which segregates the items, prepares an intradepot tally for each stores unit, and distributes the packages to the proper stores units.

At the Stores Unit. The stores unit checks all receipts. All items are identified, counted, and inspected. When required, items are cleaned, preserved, and wrapped before being placed in bins and storage spaces.

The stores unit prepares a tally-in, listing each item and the quantity received. Packing lists are used as tally-ins when available. If there is no packing list, tally-ins are prepared on W.D., Q.M.C. Form No. 489. (Fig. 23.)

Tally-ins are posted to the stock control cards by the stores unit in the same manner as they are posted by the stock control section in a base depot.

At the Requisition Section. Posted tally-ins are forwarded to the requisition section. If no acknowledgement of receipt is required and there are no discrepancies, the shipping ticket and the tally-ins are filed. If acknowledgement of receipt is required or the quantity received differs from the quantity listed on the shipping ticket or other shipping document, the requisition section refers the papers to the depot officer, who takes the action necessary to acknowledge receipt, notifies the shipper of overages or shortages, if required, and determines what action, if any, will be taken to obtain items which were not received. The shipping ticket is then returned to the requisition section for filing.

STORAGE

Storage Plan in Vans. Each stores unit chief determines the location of items within his van or storage area according to policies established by the depot commander. In general, items within an SNL group should be stored together in the same section of the van and by size within the SNL group. Economical use of storage space may compel limited departures from locating items of the same SNL group together. The van must be laid out and items located according to a definite scheme. Each bin, drawer, shelf, cabinet, and space must be designated according to a clearly-defined system. As each item is assigned a location, that location must be posted to the stock control card maintained in the van for that item. If an item is stored in more than one bin, drawer, or space, the designation of each location will be entered on the stock control card. In determining the location of each item, the van chief should consider the size of the item, the quantity to be stored, the rate of turnover, and the space required by protective packing.

The location plan must be such that the bins, drawers, cabinet doors, and bulk articles can be quickly secured and fastened, and the van put in readiness for movement to another site. Stock should be located so that the weight is evenly distributed and will not shift when the van is in motion. Each item must be stored so that it will not be damaged, displaced, or mixed with other parts when the van is moved over rough terrain. Very small items should be kept in envelopes. If space is critical and more than one item is placed in a bin or drawer, fragile items must not be put in the same bin with items which are heavier and may crush them.

The storage plan of the van should provide space for new items and for additional quantities of items already stocked. Approximately 30% of each bin size should be ample for this purpose, and about half of this 30% should be allocated so that it may be used for parts of major items or models which are not currently supported by the depot.

Open Storage. Open storage areas should be laid out in blocks with sufficient room between blocks for loading and unloading trucks. No stack should contain more than one item. All blocks and stacks should be designated by numbers or letters according to a logical system and the block and stack entered on the stock control card for each item.

Supplies subject to damage by the weather should be protected by tents, tarpaulins, or building paper. All stacks should be placed on adequate dunnage and good drainage provided for the area.

If natural cover is not available, stacks should be well dispersed and camouflaged. Irregular stacks and pyramidal stacks are preferable to regular cubical stacks.

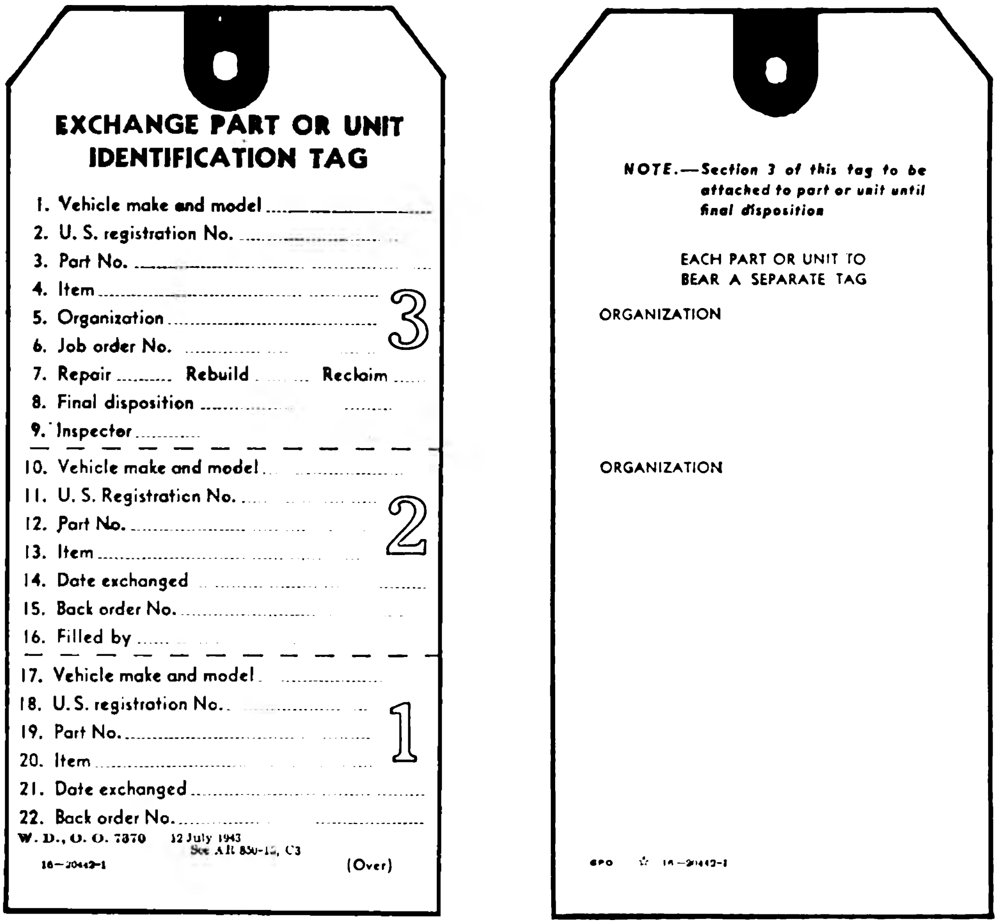
ISSUES

Registration. The detail sent to the depot by the maintenance company or other unit obtains clearance from the entrance guard and proceeds to the depot office where it presents its requisition to the requisition section. The requisition is recorded on the register sheet in the front of the requisition file maintained for the particular maintenance company or unit. The date and time, the requisition number, and pertinent remarks are recorded. The requisition is then briefly checked for apparent errors in quantities requested and manifest errors in nomenclature.

If all but a few items are handled by one stores unit, the requisition clerk prepares, in duplicate, an extract tally-out for those few items and deletes them from the requisition by redlining them and indicating that an extract tally-out has been prepared for them. The extract tally-out is given the number assigned to the requisition by the requesting organization and is clearly marked as being an extract from that requisition.

In an emergency, if a customer arrives at the depot without a written requisition, the request is reduced to writing by preparing a tally-out in triplicate. All tally-outs of this type are given numbers in a single consecutive series and each tally-out is recorded on the register sheet of the requisition file for the particular customer in the same manner as a requisition. The triplicate copy is sent to the supply officer of the requesting unit for the purpose of informing him that an oral request has been made for the items listed.

The requisitions, extract tally-outs, and tally-outs, with routing slips showing the stores unit or stores units which will fill each, are given to the officer or soldier in charge of the customer's detail, who distributes them among his drivers and directs them to the proper stores units.



EXCHANGE PART OR UNIT IDENTIFICATION TAG

1. Vehicle make and model
2. U. S. registration No.
3. Part No.
4. Item
5. Organization
6. Job order No.
7. Repair .... Rebuild .... Reclaim
8. Final disposition
9. Inspector

3

10. Vehicle make and model
11. U. S. Registration No.
12. Part No.
13. Item
14. Date exchanged
15. Back order No.
16. Filled by

2

17. Vehicle make and model
18. U. S. registration No.
19. Part No.
20. Item
21. Date exchanged
22. Back order No.

1

W. D., O. O. 7370 12 July 1943 See AR 850-15, C3

16—20442-1 (Over)

NOTE.—Section 3 of this tag to be attached to part or unit until final disposition

EACH PART OR UNIT TO BEAR A SEPARATE TAG

ORGANIZATION

ORGANIZATION

GPO ☆ 16—20442-1

Figure 46. Exchange Part or Unit Identification Tag (W.D., A.G.O. Form 9-81).

Issuing Procedure at the Stores Unit. The stores unit clerk lays out each item, referring to stock control cards to determine locations when necessary. As each item is laid out, the quantity issued is written in the "Approved" or "Issued" column. When improvised forms do not provide this column, the quantity issued is placed immediately after the quantity requested. If an item is not available and none is issued, a zero is placed after that item. The customer's driver receipts the completed requisition or tally-out, loads the issued items, and proceeds to the exit or to another stores unit. The duplicate copy of the requisition or tally-out is given to the driver to return to his organization.

The original is immediately posted to the stock control cards by the stores unit clerk. The quantities issued are dropped from the stock on hand balances, and, if any item was not issued in the quantity requested, the difference between the quantity requested and the quantity issued is posted as a dues-out. The stores unit clerk then marks the requisition or tally-out "Posted to Stock Control Record", initials the entry, and forwards it to the requisition section.

Direct Exchange Procedure. Issues upon direct exchange are infrequent at a field depot. If, however, an unserviceable item is brought to the depot for exchange, the customer is directed to the requisition section which prepares an exchange tally in duplicate, unless the customer has brought one. The customer is then directed to the receiving and shipping section which accepts the unserviceable item and receipts the exchange tally, after determining that the item is properly tagged or preparing a tag, W.D., A.G.O. Form No. 9-81, formerly O.O. Form No. 7370 (Figure 46.) The customer then takes the exhange tally to the proper stores unit where the issue is made. The stores unit posts the exchange tally to the stock control cards and returns it to the requisition section for filing in the customer's file. The receiving and shipping section turns the unserviceable item over to a maintenance company for repair, reclamation, or other disposition, using a tally-out which is cross referenced to the exchange tally. If the item is clearly beyond repair and no parts can be reclaimed, the receiving and shipping section turns the item over to a salvage unit. The tally-out to the maintenance company or salvage unit is sent to the requisition section and filed with the exchange tally.

Shipping Procedure. Shipments initiated by shipping orders are handled in the same manner as issues, except as follows. Copies of the shipping order are used as tally-outs or tally-outs are prepared. These are registered and filed according to the consignee. Items picked by the stores units are sent to the receiving section. The receiving and shipping section packs the items, numbers and marks each package, and indicates on the tally-out the type and number of the package containing each item. The tally-out is sent to the requisition section which prepares shipping tickets or shipping documents for the shipment. Actual shipping is done in the same manner as in the communications zone depot.

Shipments of excess stock initiated by the depot itself are handled in the same manner as those initiated by higher authority, except that tally-outs must be prepared.

Extracting and Filing. After the requisition, tally-out, or copy of shipping order has been posted to the stock control cards, it is returned to the requisition section and placed in the customer file. The customer file consists of a series of folders, one for each maintenance company or other unit making direct requests upon the depot. All requisitions or tally-outs pertaining to each unit are filed in sequence in the folder for that unit.

If a requisition or tally-out returned from a stores unit contains items needed at once for the repair of deadlined major items, and one or more items were not issued, the requisition section immediately prepares an emergency extract requisition on the next higher echelon of supply for the items which the field depot was unable to issue. The extract emergency requisition and the customer's requisition are cross referenced. Duplicate copies of all emergency extract requisitions are placed in a special file and all follow-up efforts, notice of shipment, or further extraction and receipts are noted upon the requisition or attached to it.

STOCK CONTROL AND REPLENISHMENT

Procedures. The stock control and replenishment procedures of a field depot are the same as those of a communications zone depot, except that all functions and operations of the stock control section in the communications zone depot are performed by the respective stores units in the field depot.

DUES-OUT

Procedures. Dues-out are handled in the same manner as in the communications zone depot, except that the stores unit performs the operations handled by the stock control section, and that the receiving and shipping section performs the operations done by the receiving section and the shipping section.

REGISTERS, FILES, RECORDS, AND REPORTS

Registers. *Receiving and Shipping Section.* The receiving and shipping section maintains the following registers:
Incoming shipment registers
Outgoing shipment register
Requisition section. The requisition section maintains the following registers:
Register sheet in each customer's requisition file.
Outgoing requisition register.

Files. *Receiving and Shipping Section.* The receiving and shipping section keeps the following files.
Bulk tally-in file.
Pending receipt file.

INCOMING REQUISITION REGISTER

UNIT 502nd Ord. HM Co. TK

DATE	TIME	NUMBER	REMARKS
11 Sept.	0900	502-67-44	Replenishment. Filled + B.O.
11 Sept.	0900	502-68-44	Deadline 6 half tracks. Extracted Req. # 1769
11 Sept.	0900	502-69-44	Deadline 2 med. tanks Filled
12 Sept.	0950	502-73-44	Replenishment. Filled
12 Sept.	0950	502-74-44	Deadline 3 armd cars. Filled

Figure 47. Register Sheet, Incoming Requisition File, Field Depot.

Requisition section. The requisition section maintains the following files:
Customer's requisition file.
Outgoing requisition file.
Records. Each stores unit keeps a stock control record.
Reports. The requisition section prepares the following reports:
Status reports.
Dues-out reports.
Information for these reports is supplied by each stores unit.

BASIC LOAD PLANNING

Definition. A basic load is the quantity of spare parts and major items that an ordnance depot or maintenance unit carries for stockage, in order to maintain materiel in the hands of using units which that ordnance unit is serving. The basic load bears no relation to the T/O & E equipment of an ordnance company, and the records used to keep their balances are entirely separate.

Data Required to Compute Basic Load. The following minimum specifications will be furnished commanders to enable computation of the unit's basic load.

The level of supply and period of maintaining major items.

Quantity and type of major items to be supported

Special information. Pertinent information affecting supply such as expected activity of general purpose vehicles, tanks, small arms and artillery, use of armor, probable consumption of cleaning and preserving material required by mobility of the unit, etc.

ASF Catalogue and SNL Addendum Lists.

Addenda. In order that commanding officers of ordnance maintenance or depot companies will have some basis on which to start computing basic load, the Ordnance Department publishes an addendum to each SNL from A to G inclusive, which lists the correct nomenclature and amounts of every item that maintenance or depot companies should stock. Generally, the amounts listed are based upon 100 weapons being in the hands of the using units for which parts are stocked, and it is assumed that stocking is for a 12-month period. These figures remain the same from addendum to addendum; that is, 100 major items in the hands of the using units for 12 months of maintenance or storage.

MAJOR ITEMS AUTHORIZED FOR UNIT REPLACEMENT

Note Symbol Col. 1		Stock No. Col. 2	Piece Mark or Drawing No. Col. 3	Nomenclature Col. 4	12 Mos. Field Maintenance Col. 5	Major Overhaul (5th Echelon) Col. 6	Unit Weight (Lb.) Col. 7
A-1			51-10	GUN, machine, cal. .30, Browning, M1917A1	0	0	31.50
A-1		A001-03-05803	D7371	MOUNT, tripod, machine gun, cal. .30, M1917A1	0	0	51.00
				MAINTENANCE PARTS FOR 100 GUNS, MACHINE, CAL. .30, BROWNING, M1917A1			
	%	A005-01-00010	C64142	ACCELERATOR (straight lugs)	32	28	0.15
	%	A005-01-00040	D35388	BARREL	200	100	2.76
		A005-01-00080	C8342	BASE, movable, rear sight	4	0	0.25
		A005-01-00110	B17463	BLADE, front sight	12	8	+
	%	A005-01-00180	B147299	BOLT, assembly	8	2	2.36
	%	A005-01-00185	B8824	BOLT, cover	4	4	0.06
	%	A005-01-00210	A157374	BUSHING, belt feed lever pivot	8	6	0.01
		A005-01-00220	B17494	CAM, cover extractor	0	4	0.06
		A005-01-00230	C8452	CAM, extractor	4	4	0.02
		A005-01-00240	B17469	CAM, feed, extractor	0	4	0.04
		A005-01-00250	C64133	CAM, lock, breech (55° cam)	8	4	0.26
A-37	%	A037-01-00357	C9823	CAP, combination rear sight slide	4	4	0.02
		A005-01-00340	A9777	CHAIN, cork stem	4	0	+
		A005-01-00350	B147210	CHAIN, cork stem, w/S-hook, assembly	4	4	0.01
	%	A005-01-00360	A20636	COLLAR, rear sight windage screw	4	0	0.02
	%	A005-01-00380	A9262	CORK	52	48	+
	%	A005-01-00390	B147211	CORK, assembly	32	24	0.02
	%	A005-01-00400	B131316	CORK, w/CHAIN, assembly	12	12	0.04
		A005-01-00420	C64138	COVER, assembly	4	4	1.65
	%	A005-01-00445	A9374	DISK, buffer	16	8	+
	%	A005-01-00450	B17497	EJECTOR	32	28	+
		A005-01-00460	A20550	ESCUTCHEON, stock, left	4	4	+
		A005-01-00470	A20551	ESCUTCHEON, stock, right	4	4	+

+ Indicates weight less than 0.01 pound.

Figure 48.

A glance at figure 39 will show that the amounts that the addenda advise are divided into two sections: Column 5, details the amounts that ordnance units going into the combat zone should take. Column 6, on the other hand, lists amounts that Ordnance units should use as a basis for computations, if they are going to be at base shops or other 5th echelon installations in the communication zone.

While the addendum is based upon 100 major items for a 12-month period, it seldom happens that an Ordnance company would be fortunate enough to service exactly 100 major items for exactly 12 months. You might be told, for example, to provide service for 240 weapons for a period of 10 months, or any similar combination of figures. It is your job then to figure out for each of the major items to be serviced, just exactly how many spare parts you should carry in your stock to perform this maintenance. At first glance through an addendum this appears to be an all day job, but with a few short cuts, you will be able to figure the whole addendum in a much shorter time.

Computing Basic Load from the Addendum. Going back to our hypothetical example of having to service 240 major items for 10 months, let us see how to compute the maintenance parts we would require for the Gun, machine, cal .30, Browning, M1917A1.

First let us figure the number of accelerators we would take for field maintenance. If there were only 100 guns to be serviced the page from SNL A-5 tells us we should take along 32. But there are 240 guns to be serviced. It should be apparent then, since this addendum is based on 100 guns, that we would have to take along 2.4 times as many accelerators, or $\frac{240}{100} \times 32$. However the maintenance is to be for only 10 months, while the addendum is based on 12 months. From the time point of view only, we would have to take $\frac{10}{12} \times 32$ accelerators. Putting the time element and the number of guns together we finally arrive at one equation which would read:

$$\frac{240}{100} \times \frac{10}{12} \times 32 = 64 \text{ accelerators.}$$

Let's next figure the numbers of barrels to be taken in our basic load. We proceed in exactly the same fashion as before, since the number of machine guns to be maintained remains 240, and the time for which we are to do maintenance is still 10 months. The only difference is that we substitute the figure 200 for 32, taken from the addendum. The resulting equation would be:

$$\frac{240}{100} \times \frac{10}{12} \times 200 = 400$$

For one more example, figure the number of base, movable, rear sight that should be stocked. To find the answer we now substitute the amount 4 for the previous 200.

$$\frac{240}{100} \times \frac{10}{12} \times 4 = 8$$

By this time it has become apparent that the first two fractions have remained constant throughout all our computations. And the $\frac{240}{100} \times \frac{10}{12}$ would remain exactly the same no matter how many other spare parts we figured. This fact now enables us to take a great short cut in figuring basic loads; that is to reduce the two fractions to one constant figure. When this is done the result is 2.

When the constant has been determined it is simply necessary to multiply the figures listed in column 5 by the constant. This should be a relatively easy matter. In arriving at the constant, it may sometimes turn out to be a decimal, such as .46. In such a case it will be advisable to round the figure off to .50, for the addendum is actually an estimate as to what maintenance parts are actually required. Any minor variations in quantities from the SNL figures are relatively unimportant.

In order to assist in arriving at the constant, the method used may be put into words in an equation as follows:

$$\frac{\text{No. of major items to be maintained}}{\text{The figure on which the addendum is based (Normally 100)}} \times \frac{\text{Time in months Of maintenance}}{\text{The time on which the addendum is based (Normally 12)}} = \text{Constant}$$

You are now able to complete computations for the basic load. Bear in mind, however, that in addition to stocking spare parts for the gun, you must also take maintenance equipment as well as spare parts for this maintenance equipment. The addenda also list the equipment items you should take, however, so that nothing is left to chance.

One factor of substantial assistance in speeding computations of the basic load is that the figures listed in each column frequently will repeat themselves, such as 4, 8, 12, 16, etc. Therefore, when the figure has been calculated one time, the end product applies equally to repeaters.

As a practical safeguard it is wise always to take at least one of every item in the addendum, even though your figuring tells you, for example, that only .15 of a part is required.

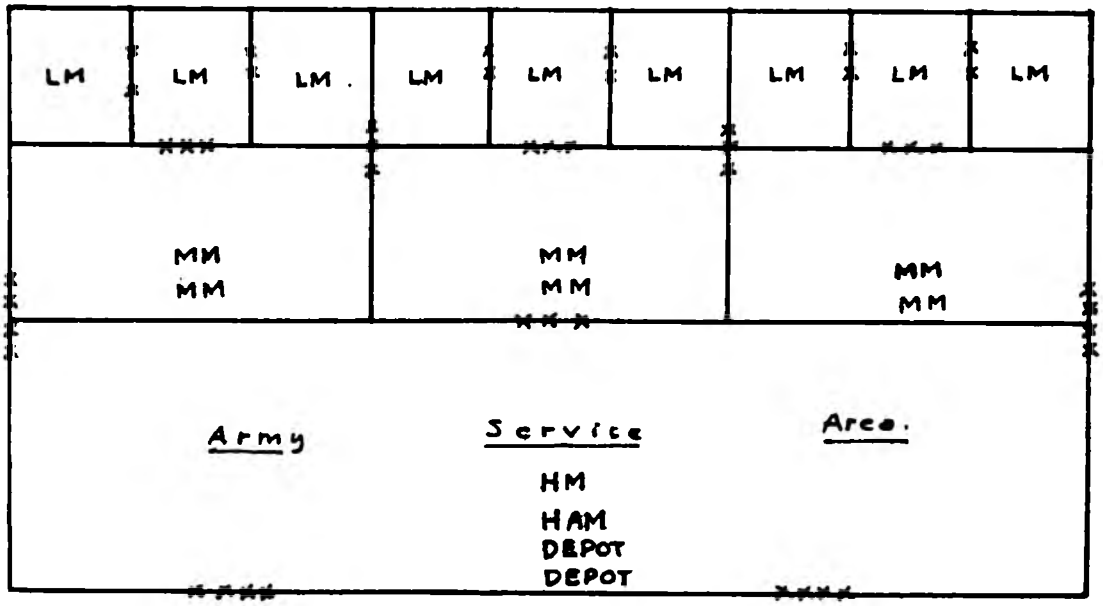


Figure 49. Example of Ordnance Units in Army.

Experience vs. Addendum. Supply officers will give broad recognition to experience when computing basic loads. Such is partly recognized by SNL's in the statement, "no ordnance field organization will ever normally require all the parts listed in column 5." The addendum figures are not limiting factors nor an indication of necessary requisite supplies, but rather guides for planning purposes based upon the best available field experience, considering all overseas theaters as a whole, and operations under average conditions.

For the purposes of assuring a well balanced supply load, and fitting the basic load to available storage capacity, supply officers will give consideration to volume of the stores as well as weight.

Some of the factors that might enter into the alteration of an addendum amount by an officer are:

Mobility and mission of the combat troops.

Makes or models of the major items to be serviced.

Time element necessary for re-supply.

Previous experience with the troops served.

Non-Duplication of Major Items. It is the responsibility of the chief ordnance officer of task force, or the theater ordnance officer, or the army ordnance officer to see that ordnance units do not duplicate major items used as a basis for figuring their basic load. Take the case of an army organized with the ordnance units shown in figure 49 included below:

Each division has 6,300 M1 rifles, or a total of 56,700 in the divisional areas alone. Assume that each corps has an additional 5,000 M1's and that there are 10,000 in the army service area. This gives a total for the army of 81,700 M1 rifles. The army ordnance officer will assign each ordnance unit a proportionate share of these major items for the purpose of computing basic loads of spare parts. A sample of how he might do the job is:

Ea Lt Mn Co.	2,000 x 9 = 18,000
Ea MM Co.	5,000 x 6 = 30,000
The HM Co.	8,000 x 1 = 8,000
The HAM Co.	4,000 x 1 = 4,000
Ea Depot Co.	10,850 x 2 = 21,700
Total	81,700 M1 rifles

By the method adopted for allocating major items, the army ordnance officers will include every rifle in the area for a definite ordnance company to use in computing basic load. This does not mean that a light maintenance company, for example, would only carry out maintenance for 2,000 items; it means they would only stock parts for the maintenance of 2,000 rifles. When they or any other ordnance company needed replenishment of their stock they will requisition on their supply base.

Major Items. Some addenda, in addition to listing spare parts and equipment that should be carried, also list the number of major items that should be carried in stock. Where major items are authorized, they should not be confused with the major items in the hands of the troops. The major items referred to here are the ones ordnance units will have on hand to replace those lost in combat or those which will be issused in direct exchange for unserviceable ones. If major items are listed, the amount to be carried in the basic load should be determined exactly the same as for all the spare parts, making use of the constant. It is not necessary to compute additional spare parts for these extra major items, since that is taken care of automatically by the figures in columns 5 and 6.

Weight Limitations. Figuring the individual quantities of spare parts to be carried for each major item does not complete the job of figuring basic load. In addition, it will be necessary to compute the weight of the load, for obviously you can't carry more weight than the capacity of your vehicles. In column 7, of the figure there is indicated the weight of each item, with a plus sign indicating that the part weighs less than 0.01 of a pound. It would be a tedious task to multiply each item in your basic load by the item weight, but here again, a shortcut is provided.

TOTAL WEIGHTS

	Total Wt. (Lbs.) For Quantities Shown in Col. 5	Col. 6
Gun, Machine, Cal .30, Browning, M1917A1		
Mount, Tripod, Machine Gun, Cal .30, M1917A1		
MAINTENANCE PARTS FOR:		
Gun, Machine, Cal .30, Browning, M1917A1	666.40	352.04
Mount, Tripod, Machine Gun, Cal .30, M1917A1		
MAINTENANCE EQUIPMENT:		
ACCESSORIES:		
For Gun	216.72	172.19
For Mount		
For Pack Transport		
ARTICLES FOR INSTRUCTIONAL PURPOSES		
MAINTENANCE PARTS FOR ACCESSORIES; FOR:		
CHEST, water, cal .30, M1		
CHEST, water, cal .30, M1A1		
CHEST, water, machine gun, cal .30, M5		
ELEVATOR, gun, cal .30		
HANGER, ammunition, machine gun, M1		
HANGER, ammunition, machine gun, M2 (4 box)		
HANGER, ammunition, pack, cal .30, M17 (T7)		
HANGER, machine gun, cal .30, M5		
HANGER, tripod, cal .30, M3		
MACHINE, belt filling, Browning, M1918		
ROD, cleaning, jointed, cal .30, M1		
SIGHT, A.A., front area		

Figure 50.

Figure 50, under the heading of Total Weights, has this computation providing you are maintaining 100 weapons, again for 12 months. In order to find the weight of every maintenance part for 240 major items for 10 months, we again revert to the constant of 2 which was used previously. It is now necessary to multiply that constant by the weight indicated in column 5 and it is found the spare parts required for field maintenance weigh 666.40 x 2 or 1,332.80 pounds.

Similarly it is determined the maintenance accessories for the 240 guns for the 10 months will weigh 2 times 216.72 or 433.44 lb.

Where the weights are not given in this section of the addendum, as they sometimes are not, it is then necessary to calculate the weight of each item individually and then add them all together. If this is done, be sure to include an estimated weight for the items marked with a "+", for in bulk these items will add up to a considerable total weight.

Summary of Addenda. So far we have merely discussed the formation of the basic load for one major item. Actually the ordnance units would have to figure a basic load for every major item in the hands of the using units. However, by using the method outlined for arriving at the constant this task would not be too onerous. The number of different major items for which you may anticipate having to figure basic loads are:

Infantry division—for approx. 35 major items.
Corps —for approx. 200 major items.
Army --for approx. 300 major items.

N Series SNL'S. By consulting the latest ASF Cat ORD 2 OPSI, it can be ascertained what SNL's have been published in the N series. Herein the ordnance department has supplied a printed list of every item that an ordnance company should have in its stock. These SNL's are published with the same N number as the sub-number of the T/O & E. For example a Light Maintenance Company is organized under T/O & E 9-8, so its N SNL is SNL N-8.

Where such an SNL is published for your type of company, your basic load problem is simplified tremendously, for all you need to do is copy on requisitions the spare parts listed in the N SNL and submit them, in order to receive your basic load. A second section of these SNL's also gives the expendable supplies that the company is authorized to draw from the other supply branches.

One caution about the quantities specified in the N SNL's, is necessary. They are based upon a specific number of major items being in the hands of the using units. In using the N SNL's it is probable you will find yourself in an unusual situation with either more or less major items than the number upon which the N SNL was based. This will call for re-figuring of the basic load in a manner similar to that described previously under Addenda for the unusual items only. The rest of the basic load should work out satisfactorily.

Basic Load of Cleaning and Preserving Materials. None of the sources of information so far discussed under basic loads gives the amounts of cleaning and preserving materials that an ordnance unit should carry. T/A Cleaning, Preserving and Lubricating Materials has been rescinded, therefore the source of information used is Section II ASF Cat ORD 5 SNL K-1. This information is also contained in WD Cir 78/44. This section of SNL K-1 is not intended to be used as a basis for computation of ordnance company basic loads, but rather as an authority for the issuance of cleaning and preserving materials to using units; however, it will serve the purpose ideally in lieu of more formal data.

SNL K-1 includes 3 separate charts, which cover small arms, artillery, and automotive. Each of these charts lists the necessary amount of various cleaning and preserving materials for a specified number of major items. See figure 51 for the chart pertaining to small arms items. By referring to this figure it is determined that 100 carbines will require 3 ea Brush, artist, bristle, flat, ¾", etc. right on down the list for the carbine or any other weapon. It should be noted further that the chart is prepared to cover a 30-day period.

Reverting to our original example of 240 cal .30 MG which we were to maintain for 10 months we may now estimate our needs of cleaning and preserving materials. Again we could make use of a constant, computed as follows;

$$\frac{240}{6} \times \frac{10}{1} = 200 \text{ for the constant.}$$

(The figure on which the column for .30 cal. MG is based) (The number of months on which the chart is based)

In order to arrive at the amounts of cleaning and preserving materials required, we now must multiply each figure in the .30 cal MG column by 200. The answers derived must then be adjusted for climatic conditions in the area of operations based upon information contained in the technical manuals covering the particular weapon. (Reference chapter 1, Small Arms)

Mortality Tables. An unofficial source of valuable information may sometimes be procured from mortality tables prepared locally by certain depot companies or ordnance battalions. These are not to be construed as having official sanction but they do contain actual experience data in regard to parts mortality in a particular theater and may prove of value in a similar situation.

These tables actually are a form of addendum and it is likely the information they contain will actually be incorporated in future official publications. However, when using local mortality tables, officers should proceed with caution and compare the apparent background of such data with anticipated conditions for which basic loads will be used.

SMALL ARMS / SUPPLIES	Note Symbol	Unit of Measure	Adjustment Factors: Summer	Adjustment Factors: Winter	Company or Battery	Carbine, Cal. .30	Rifle, Cal. .30, M1903-17	Rifle, Cal. .30, M1	Rifle, B.A.R., Cal. .30	Pistol, Cal. .45	Gun, Submachine, Cal. .45	Gun, Machine, Cal. .30, Air-Cooled	Gun, Machine, Cal. .30, Water-Cooled	Gun, Machine, Cal. .50, Heavy Barrel	Gun, Machine, Cal. .50, Water-Cooled	Launcher, Rocket, A.T., 2.36 inch
BASIS—NUMBER OF WEAPONS						100	100	100	100	10	10	10	10	10	10	10
BRUSH, artist, bristle, flat, ¾ in.	1	Ea				3	3	3	3	1	1	3	3	3	3	1
BRUSH, paint, metal-bound, flat, No. 1, 3 in.	1	Ea										2	2	2	2	
CLEANER, rifle bore	2	2oz				100	100	100	100	10	10					
	2	6oz										10	10	10	10	10
	2	Qt				5	5	5	5	1	1	2	2	2	2	1
CLOTH, crocus		Sht				10	10	10	10	1	1	4	4	4	4	1
CLOTH, wiping, cotton	3	Lb				40	50	50	50	3	4	25	25	25	25	[illegible]
COMPOUND, anti-freeze	4	Gal											40		60	
ENAMEL, synthetic, olive-drab	5	Gal										1	1	1	1	1
GREASE, O.D., No. 0/00	6	Lb														
GREASE, rifle		C						100								
OIL, linseed, raw, type A	7	Gal				0.3	0.3	0.3	0.3		0.1					0.1
OIL, lubricating, preservative, light	8	2oz				100	100	100	100	10						
	8	4oz									10					[illegible]
	8	Qt				6	6	6	6		9.5	20	20	30	30	1
OIL, neat's-foot	9	Qt			1											
OIL, recoil, light	10	Qt													0.5	
PATCHES, cut (canton, flannel)		M				12	18	18	30	2	3	4	4	4	4	
SOLVENT, dry cleaning		Gal				5	5	5	5	1	2	3	3	5	5	1
THINNER, enamel, synthetic		Gal								0.2	0.2	0.2	0.2	0.2		

Figure 51. SHL K1 Small Arms Table.

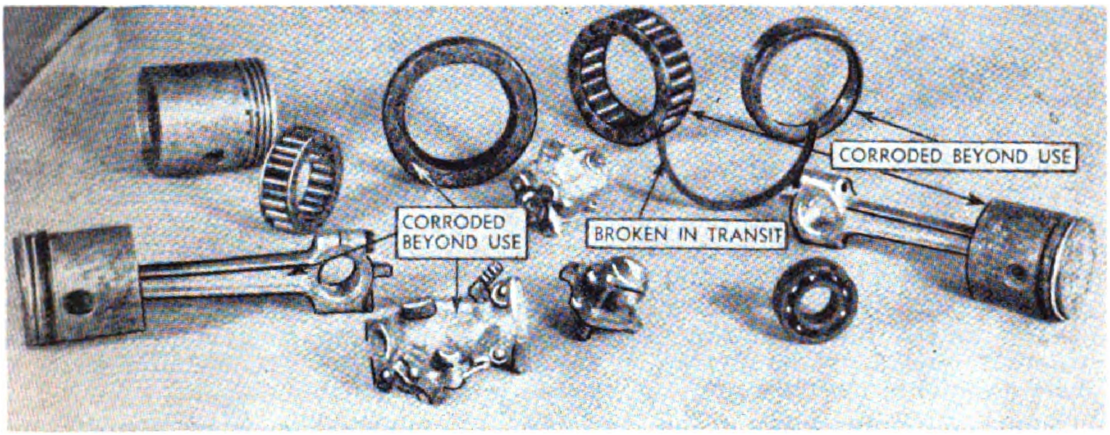
PREPARATION OF SUPPLIES FOR SHIPMENT

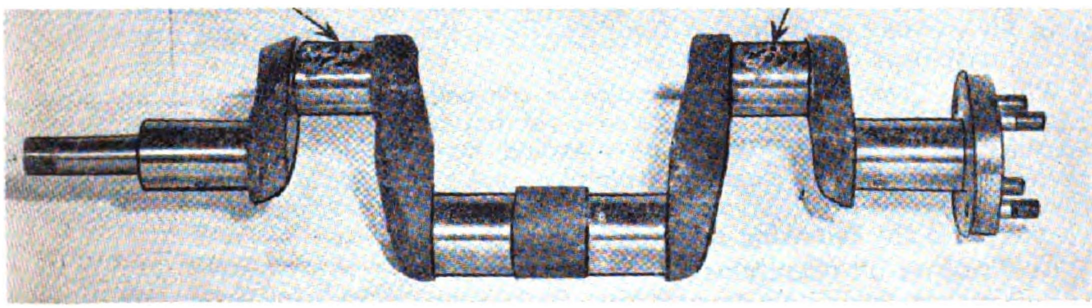
Cleaning, Preserving and Packaging for Export

The material herein is derived from processes and procedures currently used and which have been developed by Ordnance General Depots and allied agencies in the Zone of Interior following extensive test and experience in packaging and shipment problems of overseas depots as shown in field visits. The methods and production outlay indicated below are necessarily more elaborate and more advanced than those normally obtainable in field installations; however, the objective in this section, is to furnish packing and shipping sections of large communications zone depots useful data and a few of the more basic principles involved.

Corrosion Prevention. In a discussion of export packaging we are primarily concerned with one objective; namely, corrosion prevention. Specifically we want to make certain valuable ordnance materiel does not deteriorate and hence be rendered unserviceable while en route to the using unit. The problem then, becomes one of preventative maintenance in export packaging ordnance supplies. Two groups share this responsibility in the Zone of Interior; first, the manufacturing facility, and second, the depot. In the following discussion reference will be made only to the depot.

In order to attain our objective of corrosion prevention, we must observe a series of 'steps' in export processing. The various steps are both inter-related and inter-dependent and will therefore be strictly adhered to. Eliminating one step will render the entire process unsuccessful. These steps are: cleaning, drying, preserving, and wrapping or packaging. As each step is separately discussed the reader will consider the dual importance for a complete chain-like continuity of the various operations, and as a measure of preventing re-contamination of materiel in process, the need for allotting a minimum time for progressing through from beginning to end of the process.





Damage resulting from insufficient protection and packaging. Damage resulting from insufficient protection. Arrows point to places where corrosion was caused by wood coming in contact with machined surfaces.

Figure 52. This is What We Want to Avoid!

Cleaning. The best preservative is practically worthless when applied over a dirty surface. To obtain maximum results from various preservative coatings, there should be no 'dirt residues' under the coating which could cause corrosion. These 'residues' may be defined as any deposit foreign to the composition of the part, such as perspiration from handling, residual soldering, or brazing fluxes, cutting, cooling, buffing and grinding compounds, metallic residues, heat treat salts, and chemical deposits, residues from marking solutions, smoke residues, etc. Even if parts appear clean, traces of corrosive residues will eventually combine with moisture from humid atmospheres, or from surrounding packing material and cause corrosion. It is impossible to overemphasize the necessity for thorough cleaning. You would not paint your automobile without first removing the dirt, greases, etc. How much more necessary, then, it is to properly clean ordnance materiel prior to preserving, so that there will be no corrosion underneath when that materiel reaches the soldier on some faraway island some 10,000 miles from the depot.

Before we can select a cleaner we must recognize a few pertinent factors which may influence our choice. These factors are most important and must be carefully considered in planning the cleaning job.

Composition of the Part. The material used must be non-corrosive and must not chemically attack the part. Moreover, it should leave no residue that will subsequently cause corrosion after it has been preserved. For instance, aluminum, magnesium, and their alloys and zinc-base die castings cannot be cleaned in the normal type alkaline cleaner. Non-metallic parts, such as rubber, fibre, fabrics, leather, and other organic materials which are already in place on metallic parts cannot be haphazardly cleaned in either organic solvents or in water. Thus, in the combination of metallic and nonmetallic materials in an assembly, the method of cleaning should be considered very carefully. In general, there is more danger of inducing corrosion by using a water-soluble cleaner than by using a solvent cleaner.

Nature of Parts Surface. The degree of finish, and polish of the surface must be considered. In the case of extremely close tolerances or highly finished surfaces, such as fine ball bearings, alkaline cleaning is not applicable. Solvent cleaning is recommended in all cases for highly critical surfaces.

Complexity of Construction. Whenever, and wherever possible, only unit parts of very simple assemblies should receive cleaning of any type employing the use of water. Complex assemblies should not be cleaned with this type cleaner for fear of trapping the cleaning material which could not be removed easily in subsequent operations. A careful hand cleaning procedure in liquid solvent is recommended. Certain complex assemblies, such as generators, motors, starters, gauges, meters, timing devices, etc., which are made up from many dissimilar materials, should not be cleaned in the assembled state. The metallic parts of these assemblies must therefore be cleaned prior to assmbly.

Nature of Contaminants to be Removed. If contamination is merely dirt, oil or grease, or other organic residues, usually cleaning solvent will do the job. However, if a highly critical surface is contaminated with dirts, oil and greases, plus, for instance, perspiration from handling, then double solvent cleaning, plus a methanol rinse must be employed.

When to Clean. The item should be cleaned in as simple unit as possible. Handling of parts should be kept to a minimum after cleaning. After carefully considering these prerequisites to cleaning, we are now ready to discuss the preferred methods of cleaning Ordnance materiel. Recognizing as we do that there are many excellent commercial cleaners, we nevertheless must choose a cleaner with the following qualifications:

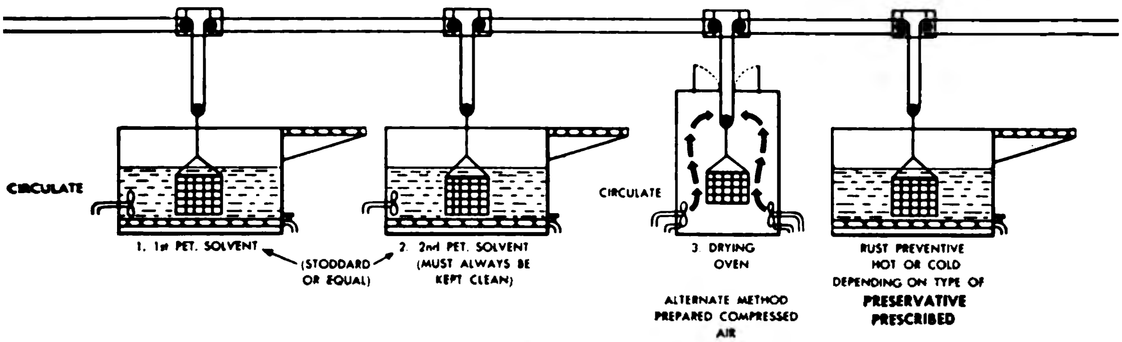
1. Fairly easily procurable.
2. Comparatively safe to use from the standpoint of both personnel and materiel.
3. One which requires the least amount of technical knowledge to use.

It is to be remembered, moreover, that our depots possess only a limited amount of skilled technicians. For this reason and the ones set forth above, the *Solvent Cleaning Method* is generally specified for depot use.

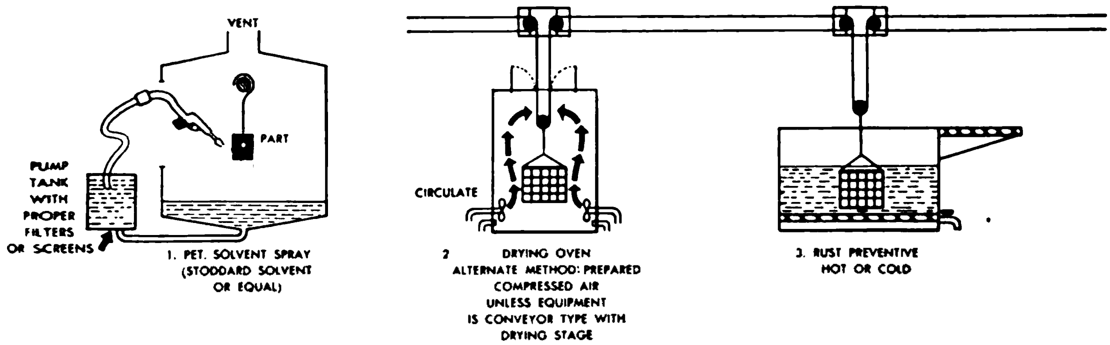
In application, we divide the solvent cleaning into two categories; namely, the one solvent, and two solvent, immersion methods. The former is used when only organic contamination is present, and the procedure in actual performance is quite simple. The parts are immersed in the petroleum solvent (with agitation if possible), and they should remain long enough to insure complete removal of contaminants. In no case, however, should this period be less than one minute. The parts should be brushed or scrubbed wherever possible to aid removal of contaminants. If the surfaces are critical, immersion in a second tank of solvent should be accomplished to give a higher degree of cleanliness.

In the event inorganic contaminants are present on the parts, such as perspiration salts, then it becomes necessary to utilize the two solvent cleaning method, as these residues are not removed by ordinary petroleum, or even chlorinated solvents. In this process we merely follow the solvent immersion cleaning step, which is the first of the two solvents, with a special perspiration residue removing solvent rinse. The use of these special solvents should always follow, and never precede, the petroleum solvent immersion step. The material most widely used in depots is methanol (methyl alcohol), and to use it, we immerse the part (previously cleaned of organic residue), and rinse in the solution. In this manner, then, we have removed both organic contaminants and perspiration salts.

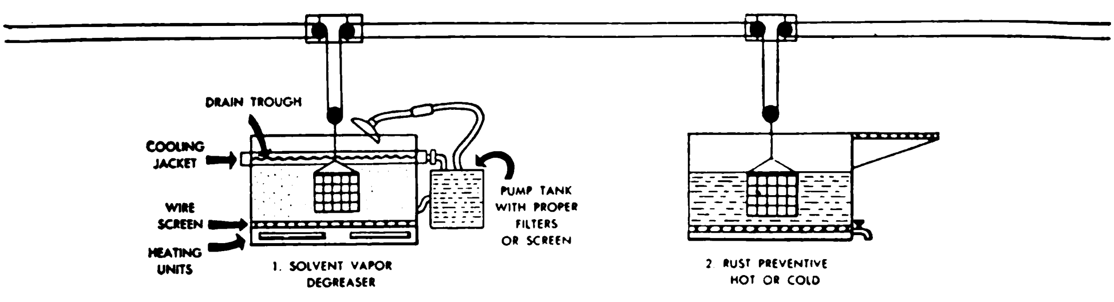
Now, let use suppose we have a quantity of automobile pistons to clean. First, we immerse the parts in a tank of petroleum solvent, agitate the solution, and scrub the parts with a light brush, because the surfaces are critical, until all visible contaminants are removed. Then immerse in a second tank of the same



Petroleum Solvent Immersion Method (Two Steps).



Petroleum Solvent Spray Method.



Solvent Vapor Degreasing Method.
Figure 53. Cleaning Methods.

solvent to give a higher degree of cleanliness. Now we allow all the excess solvent to drain off the pistons, and rinse in a tank of methanol to remove perspiration stains. If this procedure has been carried out correctly, you can rest assured that the pistons are free of all contaminating residues, and ready for further processing.

Perhaps a word of caution should be added here. Don't hesitate to use the two solvent method. If you are cleaning highly critical surfaces, and there is any doubt in your mind about the nature of the contaminants present, always add the methanol rinse to assure complete removal of both organic and perspiration or other inorganic residues. Finally never handle parts with bare hands after extracting from the methanol.

In any cleaning operation these important points should be kept in mind: gloves (preferably neoprene, synthetic rubber) should be worn at all times to protect the parts from recontamination, and personnel from possible skin irritations; handle parts on hooks, racks, and baskets to protect, and to provide suitable measures for drainage; do not use solvent on nonmetallic materials which might provoke deterioration, use solvent and methanol only at room temperature, and when either becomes contaminated, replace with fresh solvent. Keep solvents in metal containers and fully covered when not in use.

Petroleum solvent should be a neutral, water white, petroleum distillate having a minimum flash point of 105° F. This material is produced by nearly all of our leading oil companies. It is advisable to become familiar with these in the event that it becomes necessary to procure the solvent locally. A few of the more popular nomenclatures are: solvent, dry cleaning; varsol; dry cleaning naphtha; stoddards solvent; amosol, etc. Specifications for methanol provide that it shall be neutral, water white, and 95% anhydrous methyl alcohol.

Remember, every metal surface must be thoroughly cleaned before we can apply a preservative. This is vitally important.

Drying. Drying parts after cleaning and before applying corrosion preventives is essential, regardless of the method of cleaning used. Failure to dry parts will lead to poor adhesion of the preservative to the parts surface. Compressed air and drying ovens are the two most desired methods used in drying materials. Manufacturing facilities seem to prefer the compressed air process, while depots usually use the drying ovens. An alternate method, wiping with cloths, should only be utilized when both of the other two are impractical.

When compressed air is used to 'blow' the part dry it should be 'prepared air.' That is, it should be free of moisture. This may readily be detected by exerting the air stream on a base metal surface, at room temperature, and observing for condensation. If condensation appears, moisture traps must be provided and these traps emptied daily; further, each outlet must be provided with an oil and dirt filter. These may be improvised with fabric, screen, or ceramics, provided they are the equivalent of 200 mesh or finer. Filters must be replaced or cleaned whenever air flow is restricted. In using compressed air we must be extremely cautious so as not to induce 'wet' or humid atmosphere on the parts surface. This condition is fairly prevalent in areas of high humidity, and instructions regarding inclusion of moisture traps must be adhered to in such areas.

In using the oven for drying, it is essential that it be thermostically controlled, and temperature should be between 250°-350° F. for best results. Higher temperatures are not practical because low melting solders or organic materials are present on many parts. Fans or air jets should be provided so as to circulate and replace the air within the oven. This accelerates the drying operations and prevents air in the oven from becoming saturated with moisture or solvents. In fact, safety regulations insist that this be done in most establishments.

Preserving. After the parts have been thoroughly dried, we should lose no time in applying the correct preservative or corrosion preventive. Bare metal surfaces that are allowed to stand in the open for any length of time after cleaning and drying are subject to recontamination from any corrosive agents which might be present in the area—*i. e.* factory smoke acids, humid atmospheres, etc.

Selection of Preservatives. Selection of a correct preservative should be done systematically and with ample forethought. These two questions should remain paramount: (1) Will this material adequately protect the parts surface until it reaches the ultimate consignee, without injuring or complicating that surface? (2) Will the user be able to remove the preservative without disassembly of the unit? With regard to these two questions, it might be well to remind the reader that an enormous amount of research has been done in the corrosion prevention field, and as a result we now have an adequate variety of preservatives for different types of materiel. It is no longer necessary to apply, for instance, a heavy, grease type preservative on a delicate, complicated assembly, as our technicians have developed lighter weight preservative oils to do this job, and the results are equally successful. It must be remembered that ordinary lubricating materials are not to be used as preservatives in export processing, for they normally do not contain corrosion inhibitors in sufficient quantities to provide maximum protection against the many shipping hazards which are so prevalent under wartime conditions.

Perhaps the best approach to the problem of preservation is to name each preservative, explaining its characteristics, uses, limitations, etc. If we always refer to these qualifications, then, when choosing a preservative for a specific job, our task will be much simpler and the results will be better for all concerned. Remember, each has been developed because a need for it existed. We have a wide variety to select from so there is absolutely no excuse for using the wrong type of preservative.

Classification of Preservatives. For the sake of classification, we divide our preservatives into groups according to their characteristics. The first of these is the petrolatum or 'grease type' preservatives which must be applied in a heated state. Results will be poor if an attempt is made to apply without heating, as the viscosity is too great to provide an adequate coating while the materials are in a 'grease-like' state. The following are classified in this category:

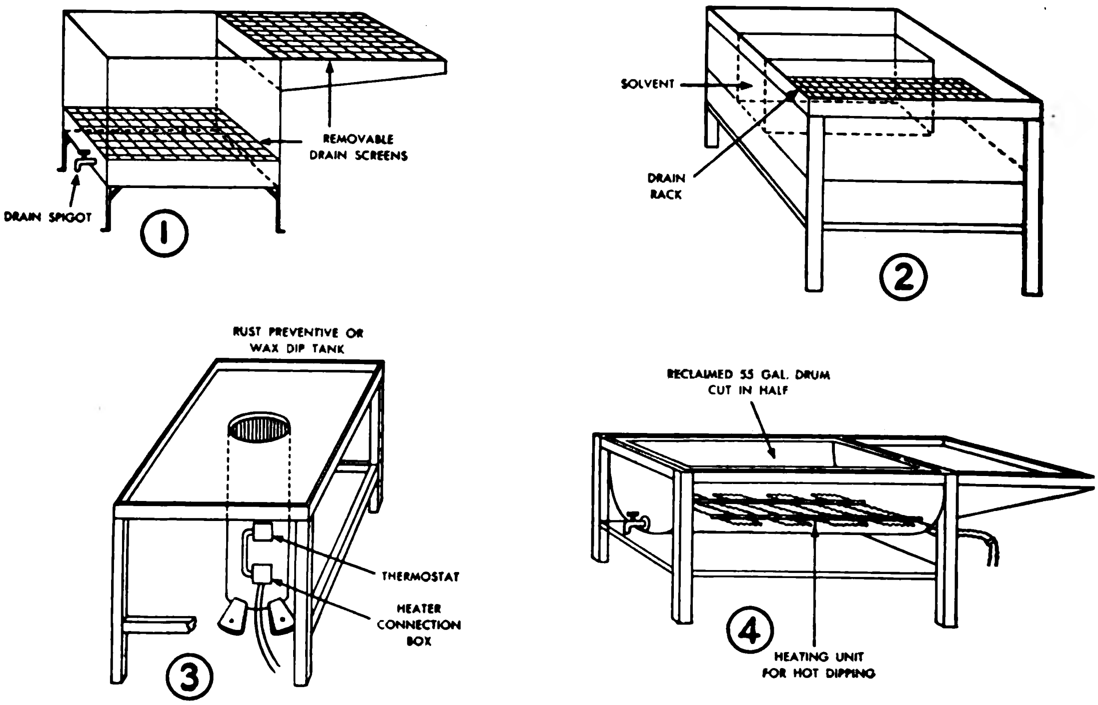
Compound, Rust Preventive, Heavy, (U.S.A. 2-82c). This is an almost hard, thick firm type of material, used on any part, or assembly, which can be properly coated, and satisfactorily cleaned by the using arm prior to use. It is especially useful on highly finished, critical, operating surfaces, where corrosion prevention periods of several years may be necessary. It offers resistance to impact and abrasion, and will withstand temperatures up to 150°F. It should not be diluted with solvents or applied from a cold dip. This is most important. Examples of parts suitable for preservation with this material are; Bolts, nuts, washers, braces, brackets, hose clamps, unassembled gears, gun tubes, pulleys, rivets, rods and shafts (solid), shims, supports, valves, yokes (tie rod). Compound rust preventive, heavy, may be applied by dipping, spraying, or brushing.

Compound Rust Preventive, Medium, (AXS 1001). This preservative conforms to Ordnance Department tentative specification AXS 1001, and is a medium-hard, thick film-like type. It is an intermediate compound between heavy and light compound rust preventives. It may be used on any part or assembly which permits proper coating and subsequent removal of the preservative. It may be used on the same kinds of materiel as its predecessor, U.S.A. 2-82c, but offers greater ease of removal because it is less viscous. AXS 1001 will withstand temperatures up to 135°F., and offers a good resistance to abrasion and impact. It, too, must be applied in a heated state by dipping, spraying, or brushing. It should never be diluted with solvent or applied from a cold dip. Typical examples of parts suitable for preservation with this material are: Breech mechanisms, bushings, sleeves, connecting rods, cylinder blocks and heads, castings, forgings and stampings, differential assemblies, gun mount parts, pistons and rings, shims, springs, steering and braking control assemblies.

Compound Rust Preventive, Light, (U. S. A. 2-84B). This is a soft, thick-film type preservative. Recommended use is on highly finished, critical or operating surfaces when corrosion preventive periods of approximately one year may be necessary at temperatures under 120°F. U. S. A. 2-84 B is an extremely popular preservative, often referred to as the 'Workhorse' of all the preservatives, because of its wide usage. It is soft and less viscous than the aforementioned compound rust preventives. Moreover, it is much more desired for use on assemblies, as removal is simplified. However, due to this characteristic, wrapping must be sufficient to protect the preservative from abrasion and pressure damage. Like other petrolatum type preservatives, it too, must be heated, and may be applied by dipping spraying, or brushing. It should never be diluted with solvents or applied from a cold dip. These items are representative of those suitable for treatment with compound, rust-preventive, light: Clamps (hose), bolts, nuts and washers, fittings, tees and elbows, gears (unassembled), gun parts, pistons, rivets, shims, spare parts, (small arms), springs, supports, thermostats (bimetal), tubes or barrels (small guns).

The second group of preservatives are the lubricating, preservative oils. They are non-hardening liquids and are applied at room temperature. Their development resulted from a need for a material which could be used on complicated assemblies, and which would offer subsequent ease of removal. In many instances, it is not necessary to completely remove the preservative prior to placing the item in service. This is particularly true in the case of rifles and other small arms. These are the preservatives in the second group:

Oil, Lubricating, Preservative, Medium, (AXS 674, latest revision). This is a nonhardening, thin film lubricating material to which has been added rust inhabitive substances. It should be used on highly finished, critical or operating surfaces of assemblies when these surfaces are complicated with grooves, cavities, recesses, etc., and which would prevent proper removal should a heavier, grease-type preservative be used. It must be remembered that AXS 674 is a non-hardening oil, and therefore demands a sufficient outer wrapping to give the necessary protection for prolonged storage or shipment. This material is an excellent, temporary, preservative against salt water and salt atmospheres. Consequently in many of our recent amphibious operations, troops have been issued various quantities as individual equipment, and have used it in lieu of ordinary lubricating oils which have proved ineffective against salt conditions. The following are examples of those suitable for this type of preservation: Connecting rods (with drilled lubricating holes), filters (oil and fuel), gear assemblies (enclosed), ignition parts, oil seals, piston rings, pump assemblies, shafts (hollow or drilled), springs (small precision), thermostats (bimetal), and major items of small arms. It may be applied by dipping, spraying, fogging, or brushing, at room temperature.



(1) and (2) Solvent Emersion Tanks. (3) Wax Dip Tank. (4) Hot Dip Preservative Tanks.

Figure 54. Suggested Simple Tank Designs.

Oil, Lubricating, Preservative, Special (AXS 777). This is a very light non-hardening, thin film lubricating material. It is primarily designed as a lubricant and temporary preservative for small arms and extremely complicated assemblies. Because it is so very thin it should only be used for temporary protection, except in specific cases where its use is prescribed by the procuring agency. One of its more important recent uses is for protection of aircraft armaments when a light preservative oil is necessary, because of colder temperatures in higher altitudes. A heavier material is subject to freezing under such conditions. AXS 777 may be applied in the same manner as AXS 674, at room temperature.

The last preservative which we have available is, *Compound, rust-preventive, thin film* (AXS 673). It should be placed in a category of its own because its uses and characteristics are absolutely unrelated to any of those previously discussed.

It is a solvent containing thin film-type of material which gradually hardens after application, and the subsequent evaporation of the solvent. Due to its hardening characteristics, it should be used only on parts or assemblies which do not have highly critical, finished, or operating surfaces. It was developed primarily as a paint substitute, and is not unlike a light lacquer in appearance. It has the advantage of flexibility over most paints, and upon subsequent expansion and contraction of metals it is less likely to crack than paint.

The preservative develops abrasive resistance upon aging, and thus is very useful when external wrapping, or packing does not offer sufficient protection against damage to the film by high temperature, shock, or abrasion. It should be applied by dipping, spraying, brushing, or float coating without heating. Remember, although the material is liquid in its original state, it hardens with age, and must not be used on critical surfaces with close tolerances. It is a good rule never to use it on surfaces which ultimately will require removal. We have other preservatives for this type of corrosion prevention, which are easily removed and equally effective.

Typical examples of parts suitable for preservation with compound, rust-preventive, thin-film are: Bolts, nuts, washers, tail pipes, mufflers, all metal tank tracks, drain pans, steering knuckles, exterior of gun tubes, housings (transmission, transfer case, axle and other gear). Ports of embarkation, in processing vehicles for export, use tremendous amounts of this preservative for protection of outside surfaces of vehicles. The spray method is most expedient for this operation.

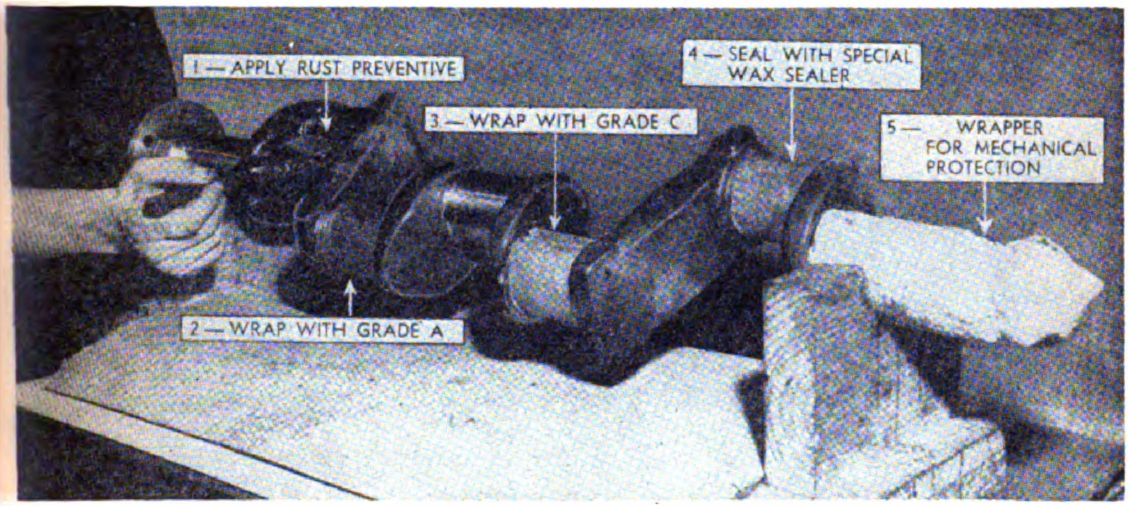
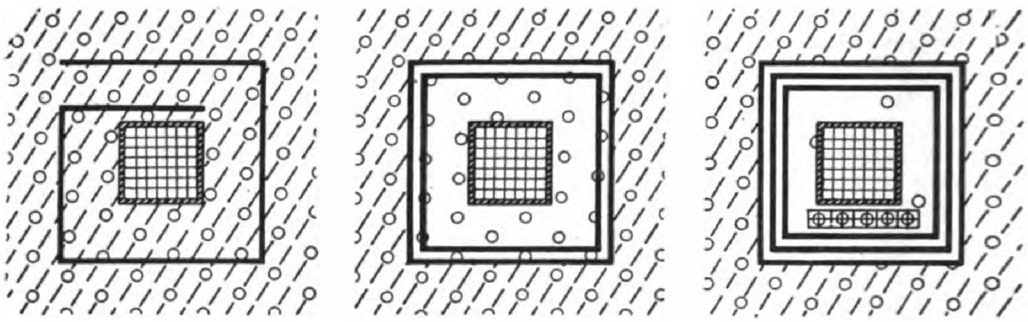


Figure 55. Application of Corrosion Preventive and Protective Wrappers for Crankshaft.

In summarizing the discussion on preservation, it is well to reiterate a few important considerations. Few are the individuals, if any, who can do a good job of applying preservatives without a certain amount of technical training. However, there is no substitute for experience. For instance, the ideal coating of the petrolatum type preservatives should be approximately 1/16 inch. This can be accomplished only by heating to a proper consistency and controlling the length of time the parts remain in the preservative. Failure to consider this will result in a poor coating which might mean subsequent breakage and entrance of corrosive residues. Another pertinent point is that the use of the improper preservative often will do more harm to the part than if none were used. Be extremely diligent in choosing your preservatives.

Wrapping (Packaging). The proper choice and proper application of a wrapper or inner package is fully as important, and in many cases even more important, than proper cleaning and preservation. If the inner wrap or package is improperly applied, all previous efforts are wasted. When packaging materiel, it will be necessary to choose one of three general methods. The choice of the method will depend on the following factors: (1) Composition or kind and type of part or assembly. (2) Preservative coatings possible or already present under the wrapping. (3) Protection required, and (4) Difficulties of application. There is no sharp line of distinction between these factors. All blend into, and are modified by, one another so that no one or two of these factors alone can be the determining points. All must be considered before a choice is made.



Method I

Part preserved. Wrapper not sealed. Water as liquid or vapor and corrosive atmospheres having relatively free contact with the preserved part.

Method I–A

Part preserved. Waterproof wrapper sealed. Only moisture-vapor penetration possible to the preserved part.

Method II

Part preserved where possible Waterproof and moisture - vaporproof barrier. Sealed. Only traces of moisture-vapor penetration and this is absorbed by dehydrating agent.

Legend

	Part or assembly		*Waterproof, sealed wrapper*
	Preservative		*Waterproof, moisture - vaporproof sealed wrapper*
	Desiccant, absorbing moisture		*Moisture vapor*
	Unsealed wrapper		*Rain, salt spray, wave slushing, and the like*

Method I. Part preserved. Wrapper not sealed. Water as liquid or vapor and corrosive atmospheres having relatively free contact with the preserved part.
Method I-A. Part preserved. Waterproof wrapper sealed. Only moisture-vapor penetration possible to the preserved part.
Method II. Part preserved where possible. Waterproof and moisture-vapor-proof barrier. Sealed. Only traces of moisture-vapor penetration and this is absorbed by dehydrating agent.

Figure 56. Graphic Illustrations of the Three Packing Methods.

Method I. Method I wrap is unsealed, and grease proof, accomplished with grade A wrapper (paper). This material must be greaseproof and non-corrosive. It functions primarily to prevent flow-off of the preservative, and to prevent parts surfaces from coming in contact with blocking and dunnage, and to provide some protection against mechanical damage from impact, abrasion, etc. Corrosive resistance in a Method I package is provided entirely by the applied preservative. This preventive must be adequate to resist the corrosive action of atmospheres, moisture vapors, and possibly liquid water, for it must be remembered that this package is not sealed. Therefore, from a corrosion standpoint, the wrapper itself will contribute little or no protection. On the other hand, the lack of sealing

Scene of interior depot packaging line, showing Method IA packaging. Preserved parts have been wrapped in grade C material, and are awaiting immersion in wax sealing compound.

Scene of interior depot packaging line, showing Method IA packaging. Wrapped packages are being dipped into a hot tank of wax sealing compound.

Figure 57. Method IA Packaging.

permits easy exit of any condensed vapor or water which might prove corrosive. In general, Method I wrapping may be applied to any part or assembly when it is definitely known that the preservative coating alone is sufficient corrosion protection for the part or assembly, provided it is kept in place. Handling of preservative-coated parts prior to wrapping must be kept to a minimum both to prevent recontamination and rupture of the film. If the preservation is a soft or liquid type, the wrapper must completely enclose the part, preferably in two or more layers. The wrapper should also conform to the contours of the part without squeezing or scraping the preservative from any localized areas. The closing edge or lap of the wrapper should be secured in place by folding, taping, tying, or stapling. If the preservative is a hard type, the wrapping need be applied only as a means of separating the preserved surfaces from blocking and dunnage. Materiel may be placed in bags or cartons in lieu of a wrap, and still conform to Method I. The interior surfaces of these bags, or cartons must be greaseproof and non-corrosive, however.

Grade A materials used in a method I wrap are of three types, *i.e.*, types I, II, and III. These types designate strength of the materials, with type I the strongest, etc. Due consideration should be given this in choosing the wrapper, as it must be strong enough to resist tearing, or puncturing.

Method IA. The second method of packaging is called method IA, or sealed wrapping. To meet fundamental requirements for this type of packaging, parts or assemblies must: (1) Have preservatives which will offer adequate protection against moisture and condensation from included air volumes, and against moisture transmitted through the wrap. (2) Be inclosed in waterproof packaging material. (Either wrapper alone, or wrapper plus dip coating sealing compound, will be waterproof, but not necessarily moisture-vapor proof). (3) Be sealed within package so that no liquid water can enter. Included air volume should be kept to a minimum.

As in method I packaging, the wrapper immediately next to the part should be greaseproof and non-corrosive, and all wraps should be sufficiently strong to offer protection against mechanical impact or abrasion. The wrapping and folding of the package should be designed so that continuous contact at all seams, folds, and corners, is obtained.

Method IA packaging may be accomplished in the following ways:

1. Conforming wraps—The part or assembly is wrapped in a grade C material. This material must have the qualifications of grade A materials, plus pliability and adherence. This enables us to seal more effectively. Sharp or irregular shaped parts should be underwrapped with a grade A material to cushion against puncture. Also the strength of grade C material used should be in direct relationship to the weight and shape of the part being packaged. These materials, as in the case of previously mentioned grade A materials, also are produced in three types. Wherever possible, the joints should be of the lock seam types to provide strength. If joints of the overlap type are made, the overlap also should be substantial for strength.

Immediately after wrapping, the entire package should be sealed by dipping in compound, sealing, dip coating (AXS 1015). This is a wax-like material which gives the final liquid waterproof protection to the package. The most practical range of temperature for this melted sealer bath is between 180° and 210° F. Temperature below this range will result in too thick a coating, and cause subsequent cracking. Temperatures above this range will yield too thin a coating, and will not offer maximum protection. Packages should be dipped in two stages, with an overlap at the center. The first half of the package will be dipped for not longer than 10 seconds, and must be allowed to attain the proper set before the second dip. Do not allow packages to stand for prolonged periods between dips as the enclosed air will cool down and re-expand on the second dip, causing a discontinuous coating. The second dip will be not longer than five seconds. After setting, and before final packaging, the package must be overwrapped with kraft paper to prevent cohesion of the wax surfaces, should two or more such packages be placed in the same exterior container.

2. Individual Cartons.—Within size and weight limitations, any type of material requiring method IA packaging may be packaged in cartons. They are, however,

particularly adapted for sharp-cornered or sharp edged articles. Prior to placing preserved material into the cartons, it must be wrapped in grade A paper to prevent absorption of the coating by the carton. Exception to this is when the interiors of the cartons are lined with greaseproof and non-corrosive materials conforming with specifications. The part must be sufficiently cushioned and braced within the carton to prevent shifting. After properly enclosing the part, the exterior of the carton will either be wrapper or bagged in waterproof material and all joints sealed watertight. If grade C wrapper is used, the package must be dip coated with AXS 1015 sealing compound as previously discussed.

3. Greaseproof-waterproof bags. Materiel to be placed in bags must be small or moderate size parts, regular in shape. The bags may be of any material which is waterproof. In addition, the interior surface of the bag must be lined with a greaseproof, non-corrosive material, such as is required of grade A materials, or the part must be wrapped in grade A paper. The bags, moreover, should be sufficiently strong to resist tearing and puncturing. Materials meeting these requirements may be treated papers in single ply, laminated or duplex form, plastic films, or a combination of cloth or paper with metal foil, coated with plastic heat-sealing compounds.

Bags should be designed for a close fit over parts and to exclude the maximum amount of air, which would induce condensation of moisture. Before closure, bags should be deflated with the hand or with some other system so as to exclude all possible air. Method of sealing the bag will depend upon the type of material used. Some may be heat-sealed, others mechanically sealed, and still others sealed with compound, sealing, dip-coating.

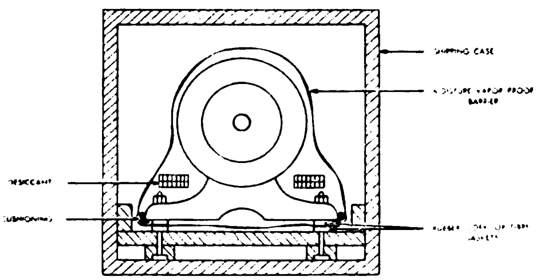


Illustration of one type of "floating bag" method II packaging procedure.
Figure 58. Method II Packaging.

Method II. The third method of packaging is generally known as Method II, or sealed wrap with dessicant (dehydrating material). This is the most technical and most difficult of all packaging. The field is extensive in scope so we will not attempt to cover all phases in this discussion. However, some of the more important procedures are as follows:

1. Use moisture, vapor-proof bags directly over cushioned parts or assemblies. (Usually 5 lbs. or less).
2. Use moisture vapor-proof bags or sealed wraps over cartons containing materiel, and then place the carton in a tight-fitting outer unit container (5-25 lbs.).
3. Use the floating bag type of packaging when the moisture-vaporproof bag is placed around the part or assembly, mounted on platforms or cradles within the outer shipping box, in a manner which will place no stress on the bag (For all sizes and weights).

To meet fundamental requirements for method II a package must have: (1) A wrap or barrier which is moisture-vaporproof as well as liquid waterproof, and (2) A sufficient quantity of dessicant (dehydrating agent) within the package to absorb (at least one year) the moisture of the included air and dunnage, and moisture transmitted through the barrier.

Protection against corrosion in this method of packaging is obtained by maintaining the moisture content within the package at low levels. This is accomplished as the dehydrating agent absorbs the moisture within the package. This absorption however, does not go on indefinitely. Eventually, the dehydrating agent becomes water-saturated and must be replaced or the packaging will become ineffective. For this reason, and for reasons of proper handling, method II packages will be marked as such, and the date of packaging will also be indicated. The wrapping will be performed to present a continuous moisture vapor-proof surface of minimum area. Any small holes or cracks in this barrier will soon permit the transmission of sufficient moisture to saturate the included dessicant, and once this occurs the packaging is ineffective. Hygroscopic cushioning or bracing material included within the barrier must be kept at a minimum. Fiberboard is preferred, but when wood is essential, it should be dry and well seasoned. If it is necessary for included woods to contact base metal surfaces, those surfaces will be insulated from the hygroscopic materials by sufficient greaseproof and non-corrosive materials.

The barriers used in method II packaging must be waterproof and moisture-proof. Ordnance specifications provide that the materials are moisture vapor-proof if they have a moisture-vapor transmission rate of 0.25 grams of water per 100 sq. inches in 24 hours. This is equivalent to about 1/100 ounce, and though apparently insignificant, it is enough to promote corrosion. Thus, the necessity of the dehydrating agent within the package. At the present, we are using impregnated single ply or laminated papers, plastic films, and metal foil materials for barriers. All however, must be approved by the procuring agency.

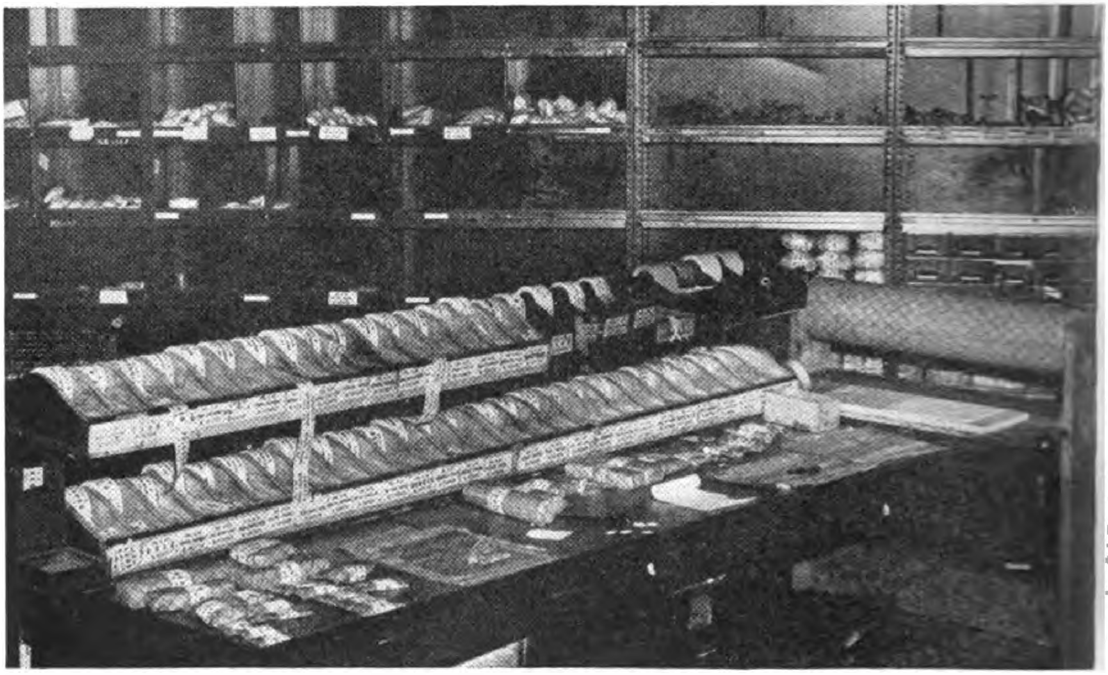


Figure 59. Scene of Interior Depot Packaging Line Showing Materials and Imprinted Pressure-Sensitive Tape for Identification of Packages.

The dessicant (dehydrating agent) used within the package conforms with Ordnance Dept. Tentative Specifications AXS 778. The minimum amount to be included in a package is calculated from the formula:

Pounds of dessicant$=0.2A+\frac{1}{2}D$

A=area in square ft. of the barrier

D=weight in lbs. of any included hygroscopic material inclosed within the barrier.

This formula is based on the requirements for one years protection under average conditions of handling and storage.

A sealed container should be used to hold the dessicant, and it should be opened only long enough to remove the required amount. Only a small quantity should be removed at any one time, and it should not be exposed to the atmosphere any longer than is absolutely necessary; in no case for more than fifteen minutes. The dessicant will usually come from the manufacturer in bags of different weights.

rom 1 ounce up to several pounds. These units should be securely anchored in lace within the package to prevent possible movement and puncture of the ontainer, and as close to the critical surface of the parts as possible.

In summarizing the previous discussion concerning our methods of packaging, t is well to pause and consider a few generalities. Primarily, according to our ection on preservation, the type or kind of materiel being packed determines argely the kind of preservative we will use, and the packaging (or wrap) is lanned to supplement the preservative. However, in the majority of cases an ideal nethod of application would be to apply preservatives which are more easily renoved prior to use of the protected part, and to apply method I-A wrappers. Hence, even with parts on which it is permissable to use thick, heavy preservatives ased on normal considerations, it would be much easier to handle the parts in he field if they were coated with a light, oily type of preservative and then were ackaged according to method IA, or in special cases, method II. From the standpoint of the differences of protection afforded by the various packaging methods, he following generalizations can be made: method I will be effective as long as he underlying preservative coating is heavy and continuous. However, the nsealed wrapper permits easy contact of corrosive agents with the preservative ilm, and whenever this film is thinned or injured, corrosion may result. If only mall volumes of air are inclosed in a method I-A package, and if similar materials are used for wrapping and sealing, either according to method I-A, or method II, then these methods will be equivalent in their protective qualities. The difference between the two is that method I-A packages will not require inspection, or rewrapping, whereas method II packages will slowly deteriorate with the absorption of moisture by the dessicant. This will eventually require replacement of the dessicant in order to function effectively.

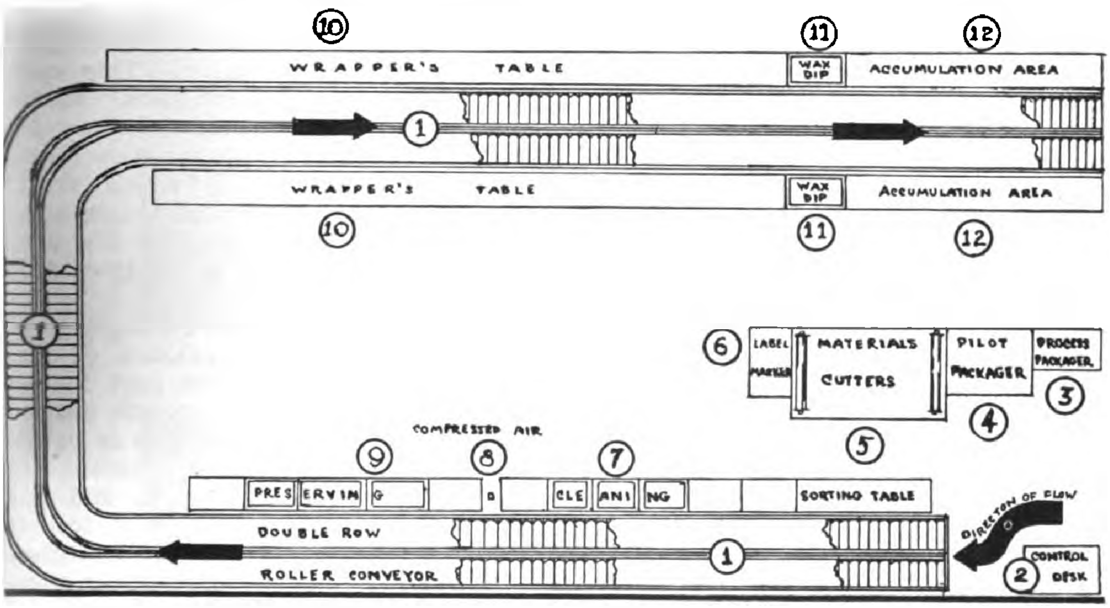


Figure 60. A Practical Layout for Preserving and Packaging as Observed in a Depot.

The layout and procedure sequence for preserving and packaging ordnance general supplies at interior depots is shown in the accompanying cuts. Similar layouts, on a somewhat less elaborate scale, are frequently set-up in large communication zone depots.

Identification. It is significant to note that we have left this discussion of identification until now. Previous mention of this has been avoided, because it is sufficiently important to warrant a separate section. No package, regardless of methods used, is complete without complete identification of contents. This should consist of (1) The official ordnance part numbers, (2) Exact nomenclature, and (3) Quantity. In case of method 1A packages, both inside and outside wrappers shall be plainly marked. This is most important, for after the package is removed from the outer container somewhere overseas, the kraft wrapper is most likely to be destroyed, leaving only the method I A package, hence the necessity of identifying both wrappers.

It is impossible to overemphasize the necessity for proper identification. Unidentified parts are dead stock and dead stock doesn't do anyone concerned any good. Let us make certain that we do not counteract all our efforts in export packaging by failing to include proper identification.

PACKING, CRATING AND MARKING FOR EXPORT

We have discussed export packaging which is a necessary prerequisite to packing and crating. Regardless of how carefully ordnance materiel is cleaned, preserved and packaged, it must be further protected by adequate and effective packing. In other words, exterior containers must be constructed to withstand the many hazards of war-time shipping, and the packages must be packed in these containers so as to prevent shifting and subsequent damage to the contents and container. These are the considerations we take up now.

Our packing and crating problems are extremely complicated because of the many different factors that make war-time shipping difficult. Some of the more important factors include:

1. The fact that the consignor has little or no idea of the ultimate destination of the shipment. Most of our shipments to ports of embarkation are marked with a code address (with the exception of some air shipments), and therefore there is no way for the shipper to determine the destination, how many times the packages will be handled, etc. Our packaging experts calculate that the average package moving through a port is handled in the neighborhood of 100 times before it finally reaches the using unit. Is there any wonder, then, that our packing specifications must be rigid, and strictly adhered to?

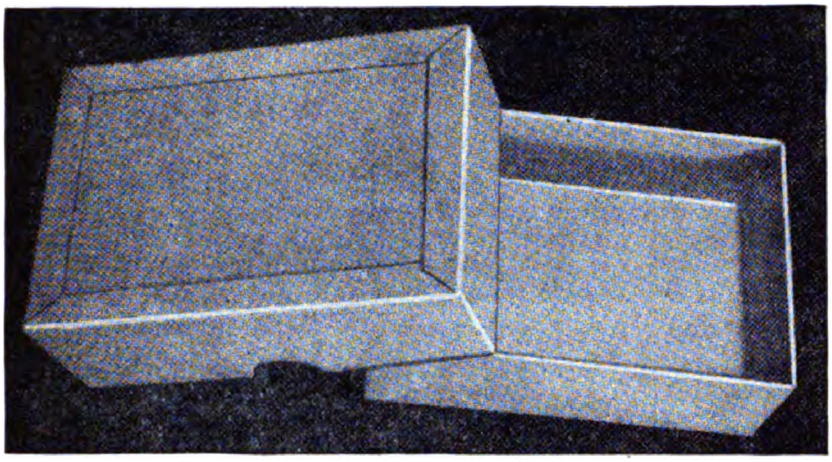
2. Due to wartime drain on manpower, we're having to utilize inexperienced labor both in our depot packing lines, and at ports of embarkation. This condition promotes inefficient handling and maltreatment of the containers. Moreover, the conditions at ports of debarkation are even worse where in many instances we have little or no unloading equipment, and are forced to use native labor.

3. There are many hazards encountered in wartime shipping which aren't present in ordinary peacetime shipping. Materiel may move by rail, truck, ship, barge, pack animal, and in the hands of the troops before it reaches it's final destination. As each item is handled and changed from one form of transportation facility to another, the attendant hazards are increased.

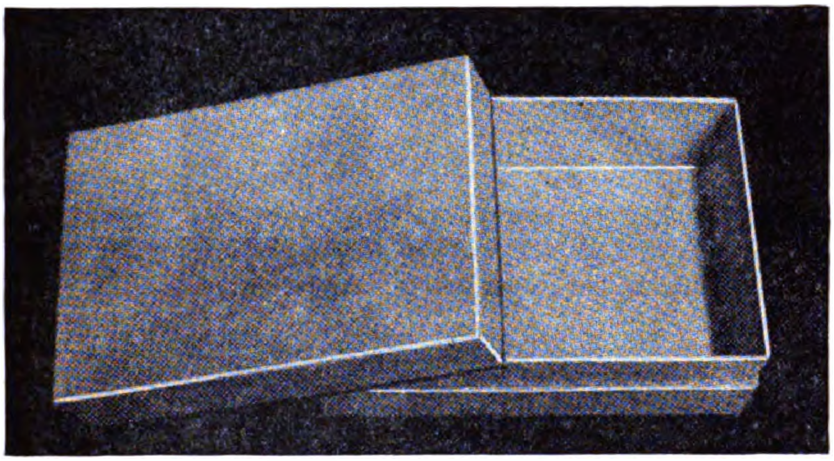
4. Size and weight restrictions are more rigid in wartime. The inadequacy of materiel handling equipment in some theaters, the various capacities of our different cargo vessels, and other limiting factors play an important part in our packing program. Too, sometimes different forms of transportation require entirely different types of packages for the same items. An example of this is in air transportation which we are utilizing to a greater degree than ever before. In these shipments, the weight limit is the most important consideration, and our containers must be constructed from light weight materials. Consequently, for air shipments the fibreboard container is preferred wherever practical. On the other hand, should the same shipment move by water, in most instances a wooden container would be specified.

5. The nature of contents of containers. There are over 300,000 different items of ordnance materiel, and many are of extremely critical nature. The packing of these items presents problems greater than anything that we had to overcome in peacetime, and requires close cooperation amongst our packaging engineers and industry in order to draw up specifications which will insure maximum protection to the items while in transit.

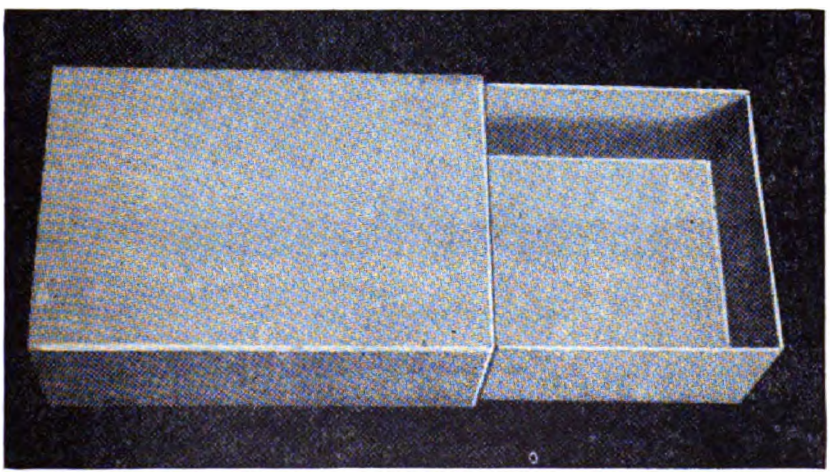
Due to these numerous unpredictable hazards connected with wartime shipping we can not ascertain accurately how rigid or how strong to construct any individual container. Our job is to pack all materiel using the specifications which have been carefully drawn up by persons who are familiar with all the attendant shipping hazards, and who are equally familiar with the statistics which have been compiled on the performances of the various types of shipping containers used thus far in our export shipping. We have had to learn many of these things the hard



Full telescopic set-up box.

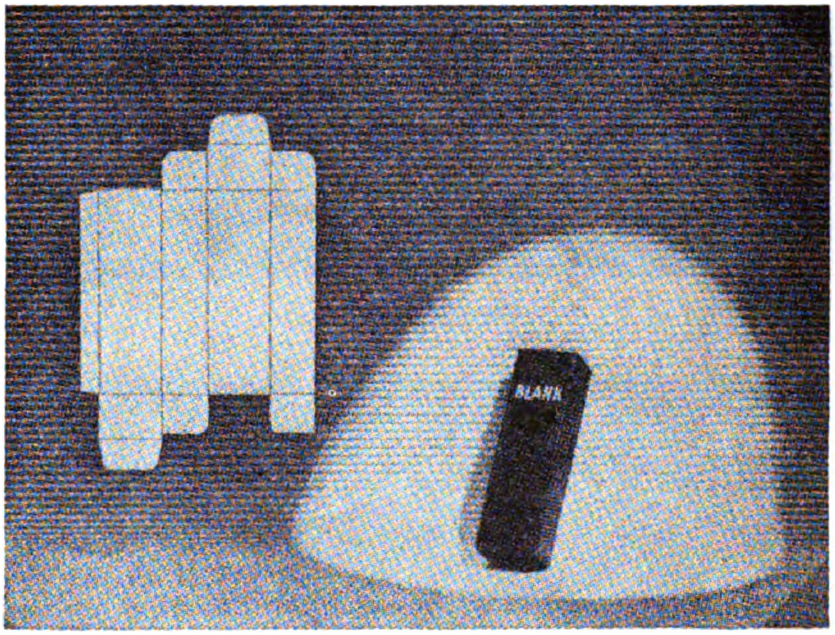


Shouldered set-up box.

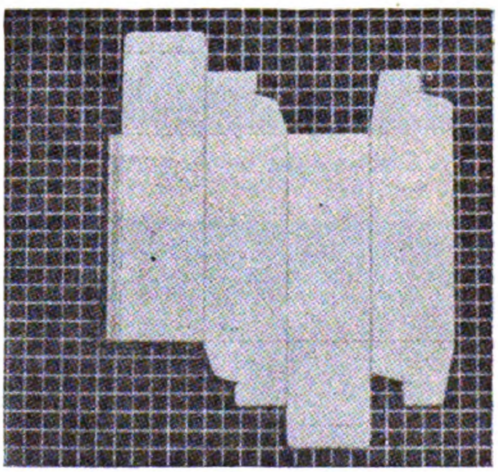


Slide set-up box.
Figure 61. Set-Up Boxes.

way, and in numerous instances in our earlier shipments through ports of embarkation our packing proved entirely inadequate. This in turn, worked a terrific hardship on our troops overseas whose misfortune it was to receive the damaged materiel. However, we have gone a long way since the early days after Pearl Harbor, and if we adhere to packing specifications to the letter, there is no reason for a repetition of these occurrences. Materiel is too valuable, and time is too short to permit poor packing, and subsequent damages to this materiel when it may be so urgently needed in some particular theater of operation. Our packing failures



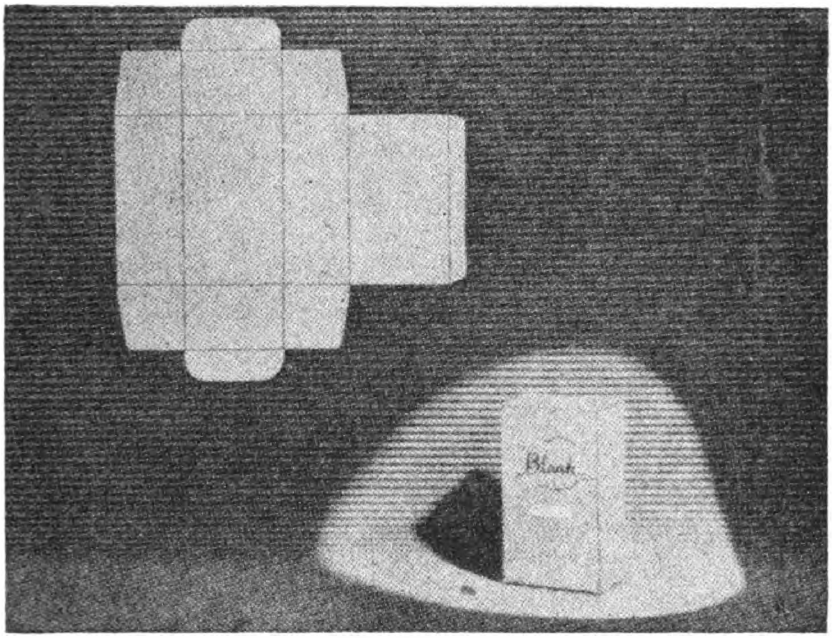
Reverse tuck box.



Reverse tuck with arthur lock, top and bottom.
Figure 62. Folding Boxes.

in the beginning of the war might be in some measure excusable, as most of them are attributable to our inexperience. However, to pack a container poorly now, where there is an available specification, would be a crime for which some soldier could pay with his life.

Interior Packing. In addition to the instructions on packaging in the preceding chapter, it is felt that additional emphasis might well be placed on the subject as concerns more specifically cartonizing materiel prior to placing it in the exterior container. In fact, we are turning more and more towards the use of



Straight tuck box.
Figure 63. Folding Boxes (Continued).

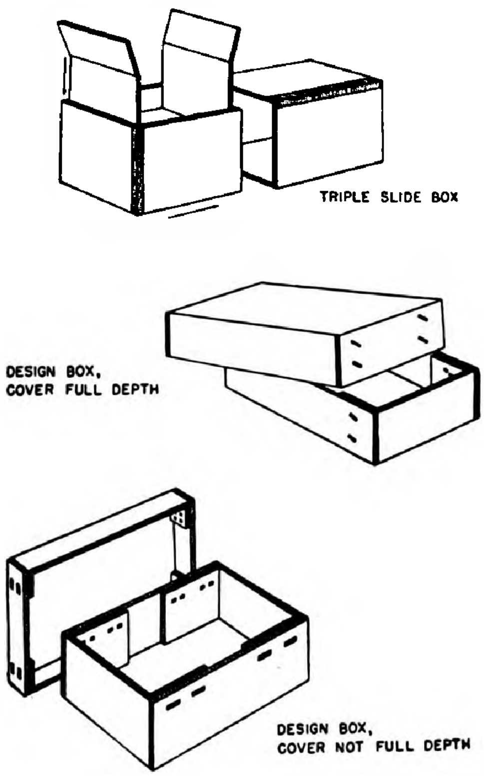


Figure 64. Styles of Corrugated and Solid Fibreboard Boxes.

cartons in interior packing because it not only makes for better packing in the outer container, but also is easier for the units overseas to handle and store. Particularly is this true in the case of field depots where materiel must be stacked into improvised bins in practically open storage.

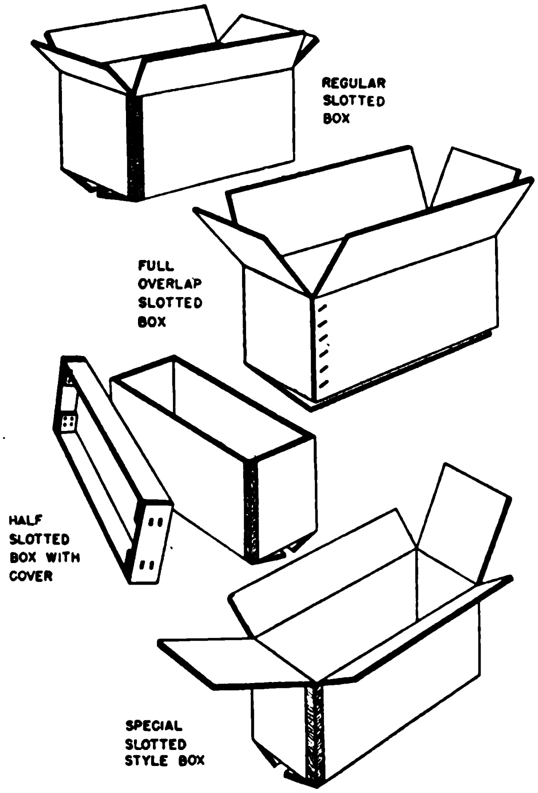


Figure 65. Styles of Corrugated and Solid Fibreboard Boxes.

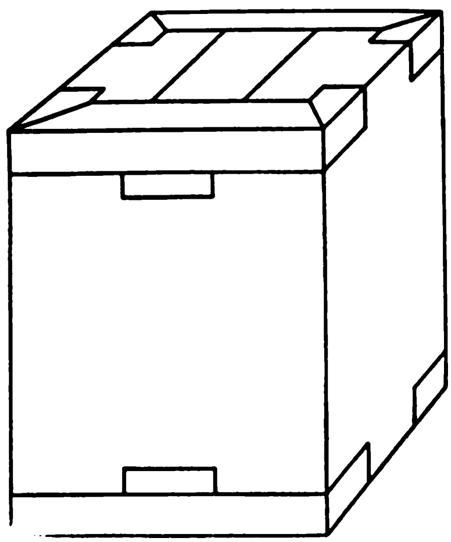
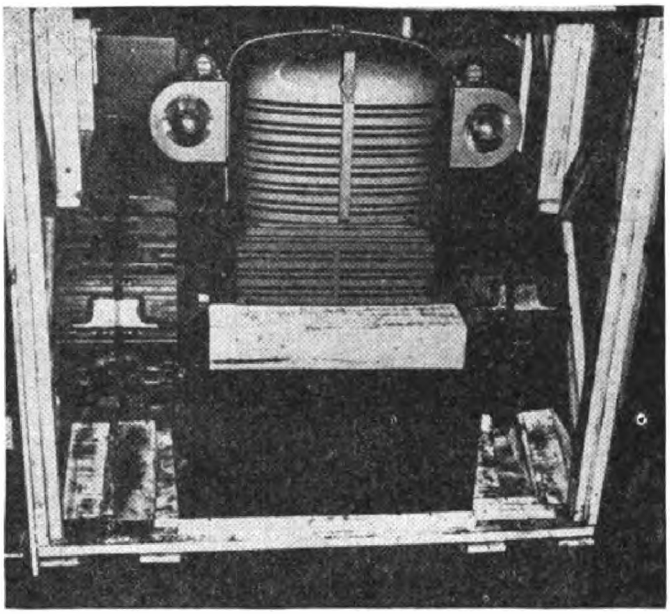
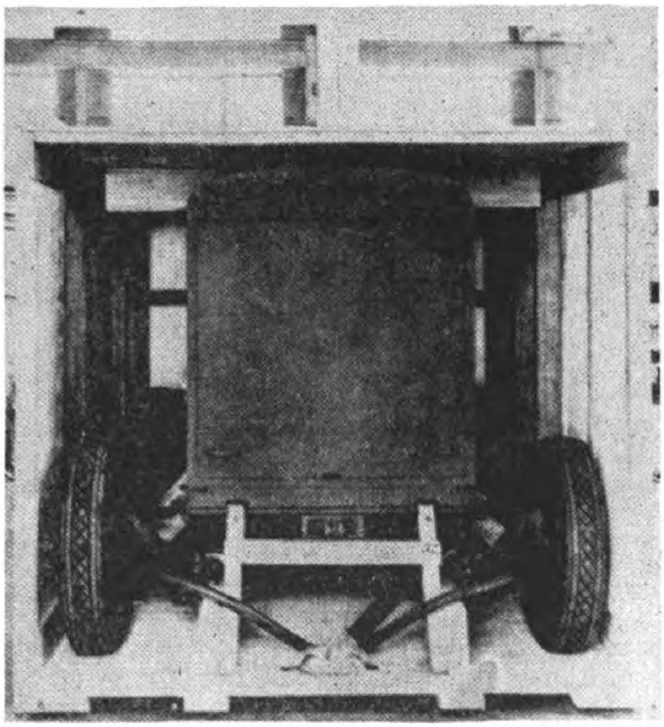


Figure 66. Method of Applying Sealing Tape to Fibreboard Containers.

Types. There are two general types of boxes which may be used as interior containers, and both have been accepted because they provide sufficient protection to the contents, making for convenience in handling when the exterior container is unpacked. The first of these containers are folding and set-up boxes. Their use should be limited to contents weighing not more than 5 pounds. The more



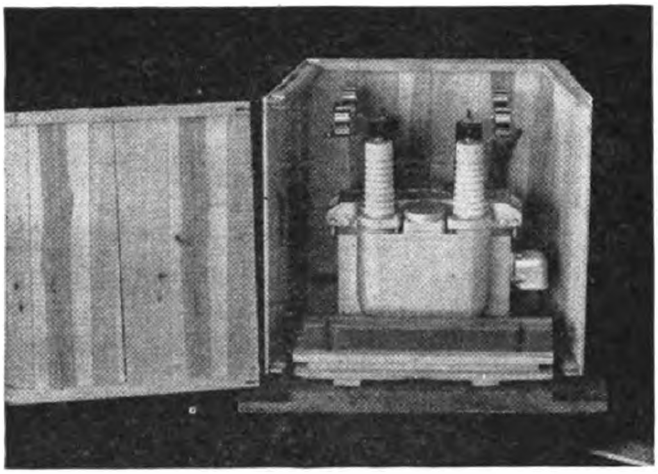
Method of blocking a tractor in a crate.



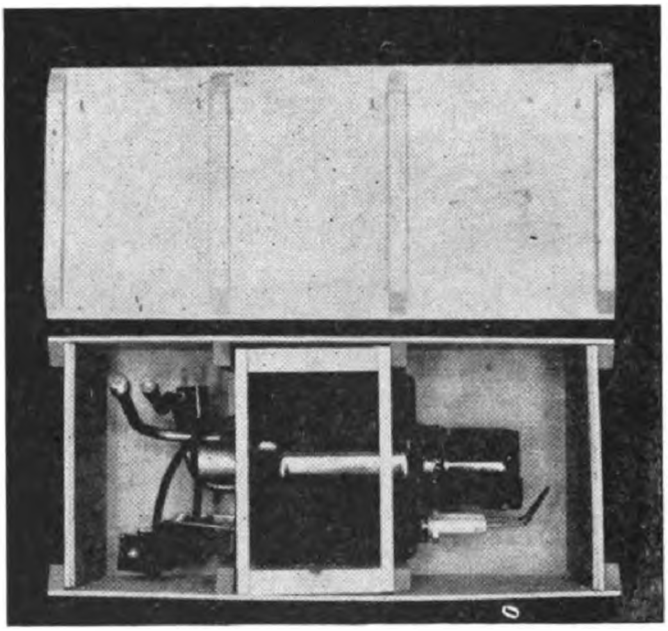
Power unit in plywood crate.

Figure 67. Method A, Blocking and Bracing—Interior Packing, Type III Loads.

popular types of these are shown in Fig. 61 and 62. Gum tape is used in closing all folding and set-up boxes. This procedure, in addition to sealing the boxes, gives strength to the creases which would ordinarily be broken from within by the force of the article. The amount of tape used and where it is used depends on the nature of the contents.

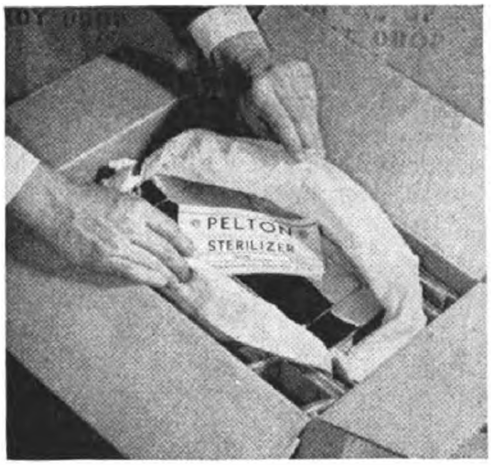


Transformer bolted to skid which becomes base of box.
Figure 68. Method B, Bolting—Interior Packing, Type III Load.

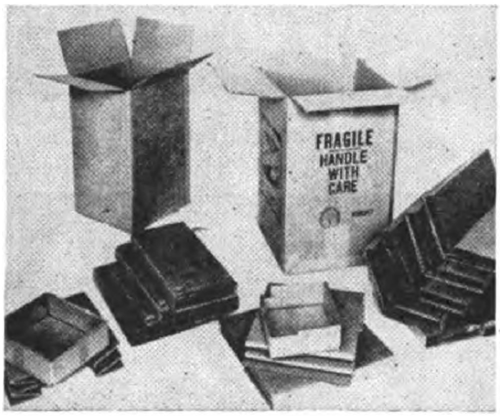


Heavy article floated in wirebound box.
Figure 69. Method C, Flotation of Heavy Items—Interior Packing, Type III Load.

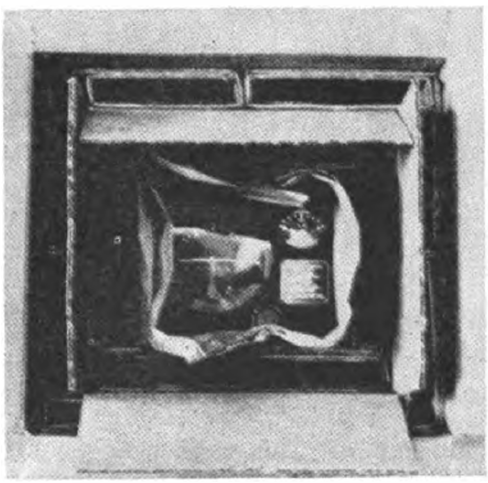
The second type of interior packing boxes includes corrugated and solid fibreboard types. Specifications state that this type of container must have a certain amount of water resistance, and may be used for weights up to 15 pounds. Only the following styles of corrugated and fibreboard boxes may be used as interior containers (See Figures 64 and 65.): regular slotted, center special slotted, full overlap slotted, half slotted with cover, telescope design cover not full depth, full telescope design (cover full depth), and triple slide. All of these boxes must be sealed in such fashion that they will not be opened during transportation. The easiest and most preferred method for accomplishing this is through the use of gum tape. The tape must be at least 2½ inches wide, and it must withstand a



Sterilizer cabinet wrapped in creped cellulose wadding to prevent damage to the polished surfaces. Corrugated board cells are used to float the cabinet in the container.



Interior packing required to pack a delicate instrument for aircraft.

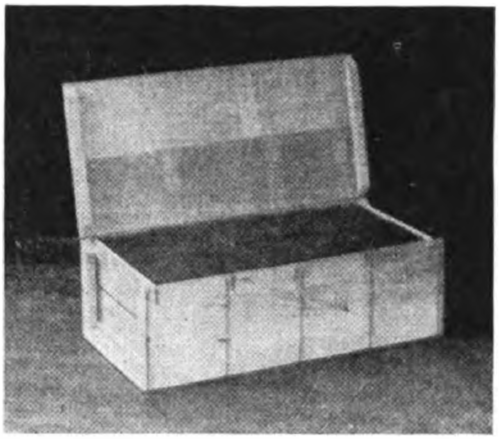


Instrument for aircraft and interior packing shown in Figure 65 in place. Container ready for closing.

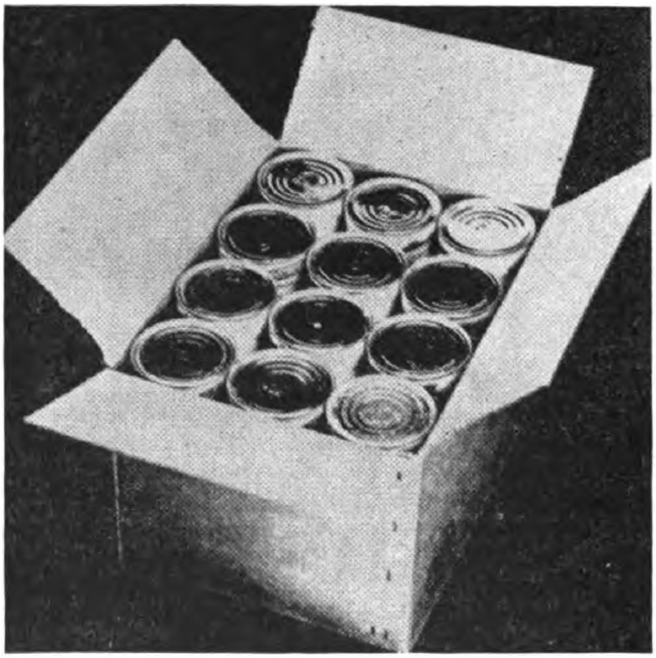
Figure 70. Method D, Flotation of Relatively Light and Fragile Articles—Interior Packing.

Mullen bursting test of 60 pounds. The method of applying the tape is shown in figure 66.

Many items lend themselves readily to a regular packing arrangement, and may be packed into interior containers as discussed above. This cartonizing procedure lends itself to a regular packing arrangement that completely fills an exterior container. Other items, because of odd shape or irregular concentration of weight, are packed loose in the container, and careful study is required if satisfactory and efficient packing is to be accomplished. Several general methods are available for accomplishing this type of interior packing. For easy reference we label them in the following manner:



Hardware in cartons.



Canned goods in waterproof solid fiberboard shipping box.

Figure 71. Method E, Items Packed in Cartons and Cans—Interior Packing, Type II Load.

Method A—blocking and bracing: This method is generally employed with heavy articles to prevent shifting of contents, and subsequent damage to the article itself. This bracing makes the article virtually a part of the box itself. (See Fig. 69.)

Method B—bolting: This method differs from method A in that the article is rigidly attached to one face of the box. The article is often bolted to a base or skid which is fastened to the box, or acts as one side or face of the box. (See Fig. 68.)

Method C—flotation of heavy articles: This is achieved by floating the article in guides attached to the box or by holding the article tightly in a frame which in turn floats in guides. (See Fig. 63.)

Method D—flotation of light and fragile articles: Shock is absorbed by interior packing so that it will not be transmitted to the contents. This may be achieved in the following ways:

1. Article is adequately cushioned in an interior container.
2. Article is packed in a container (a folding, set-up, or fibreboard box) which is floated in cushioning material.
3. Article is packed in corrugated cell-partitions with liners and pads. (See Fig. 64.)

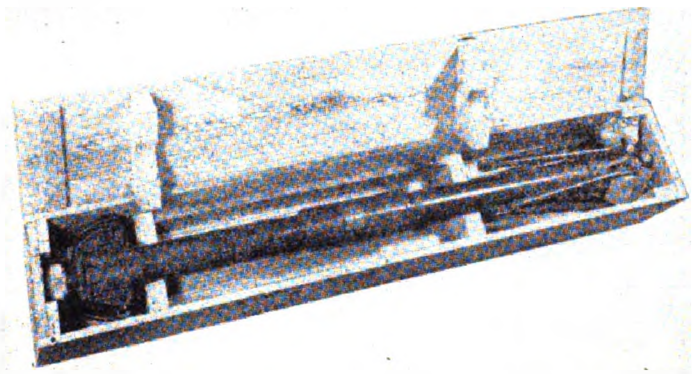


Figure 72. Method F, Items of Heavy Density Packed Loose—Interior Packing, Type III Load.

Method E—items packed in cartons and cans: This method is used for convenience in handling contents which are often of relatively small nature. The contents add support to the shipping box.

Method F—Items of heavy density, packed loose: This refers to relatively small items such as bolts, rivets, etc., which are not damaged by abrasion. If these items are packed by a definite pattern, the force applied from within will act only on two faces of the container. (See Fig. 72.)

Method G—Cushioning to protect surfaces: This packing is to protect surfaces from being dented or scratched. Thus the cushioning may range from light paper or creped cellulose wadding to corrugated board, or other protective materials. (See Fig. 73.)

Method H—Reinforcing or overpacking for extra protection: It is often necessary to reinforce a box used for domestic shipment in order to make it suitable for export. For instance, plywood boxes may require extra battens for reinforcement. This should not be done, however, unless necessary, as it adds extra weight and cubage. (See Fig. 74.)

Method I—Corrosion prevention: This topic is covered fully in the preceding chapter.

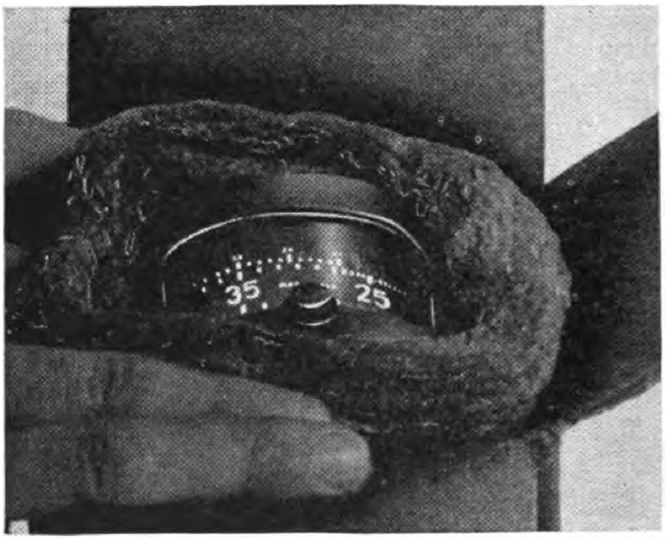
Palletizing. In order to facilitate movement of property by mechanical means wherever possible, items which move in large quantities and which can not be economically packed, are palletized. Palletization should take place wherever there are facilities, for the simple reason that both depots and ports will receive benefit from man-hours saved. In all cases, where materiel is palletized, receiving depots and ports should be notified in order that arrangements can be made for unloading facilities. Results of palletizing one carload of 360 bogie wheels at a facility showed a saving of 506 man-hours in packaging, packing, and loading.

Factors Pertaining to Palletizing. In considering pallet-loading, several factors are important:

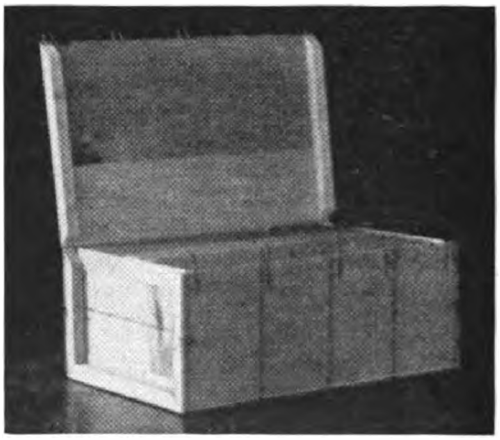
1. All items in a pallet load should be identical.
2. Items for palletization should be selected on the following basis:

a. They need no mechanical protection against handling.
b. They move in large quantities.
c. They do not lend themselves to economical handling.
d. Though boxed, they require protection afforded by pallets (For example, storage batteries).

e. They may be high volume items shipped in uniform boxes; in which case palletizing speeds handling. (For example, lubricating oils).



Delicate instrument cushioned in creped cellulose wadding.
Figure 73. Method G, Cushioning to Protect Surfaces—Interior Packing, Type III Load.



Fiberboard container, enclosed in wire-bound box.
Figure 74. Method H, Reinforcing or Overpacking for Extra Protection—Interior Packing, Type I Load.

Pallet Construction. The maximum length of a pallet should be 48 inches to permit handling of two pallets in the width of a freight car. (The Navy is using 48 inch x 48 inch pallets wherever possible).

Width of a pallet will depend upon size, shape and weight of commodity and the availability of fork lift trucks to handle it. Is usually does not exceed 36 inches, although it may be as wide as 48 inches. If the load is under a ton, the 36 inch width will prevail. Maximum weight of palletized items should not exceed three thousand pounds.

The pallet should not be less than 3 inches deep, and the maximum height of the load should not be over 53 inches. (This will permit a 108 inches fork lift truck to handle a third layer.) If the pallet is required to carry a load greater than 2,000 lbs., provision should be made to have surface boards overhang (they should be not less than 4 inches) the end stringers, to provide for hoisting by ship's tackle. All pallets should be double faced. Skids are not suitable for storing on other freight and for moving in ships. Load should cover the pallet completely. That is, it should conform to the outside dimensions, or overlap.

Shipping Palletized Supplies. When loads are strapped, straps should be stapled to the pallet bracing. Straps would be 1¼ inches wide by .035 inches thick or the equivalent in wire. On shipping palletized goods from depot to port, the overseas address is placed on the load in at least four places, including on the pallet, the bracings, and the commodity itself.

Common sense plus good blocking and bracing principles should apply in loading palletized goods. It is well to remember that we are blocking the load, not the pallet. (If the load is smaller than the pallet, this becomes a difficult task, hence the warning to have loads the size of, or larger than, the pallet.) Bulkheads should be used for heavy pallets, or when the ends of the cars are uneven. End gates, should, as a rule, be used, and they should always cover the height of the load.

Packing and Crating. Before we can enter upon any discussion of packing and crating we must make a choice of an exterior container. Herewith are listed a few of the considerations which might govern this choice:

Type of load to be packed. For the sake of classification, we divide our loads in the following manner:

Type I. This is called the 'easy' load. Contents are packed so that the exterior container is completely filled. Contents, through the medium of one interior container, or due to the nature of the contents themselves, are fully in contact with and thereby fully support all faces of the exterior container. This makes for more rigidity, and in the event the container is dropped, the shock is partially absorbed by the contents, rather than the container having to bear all the burden of shock.

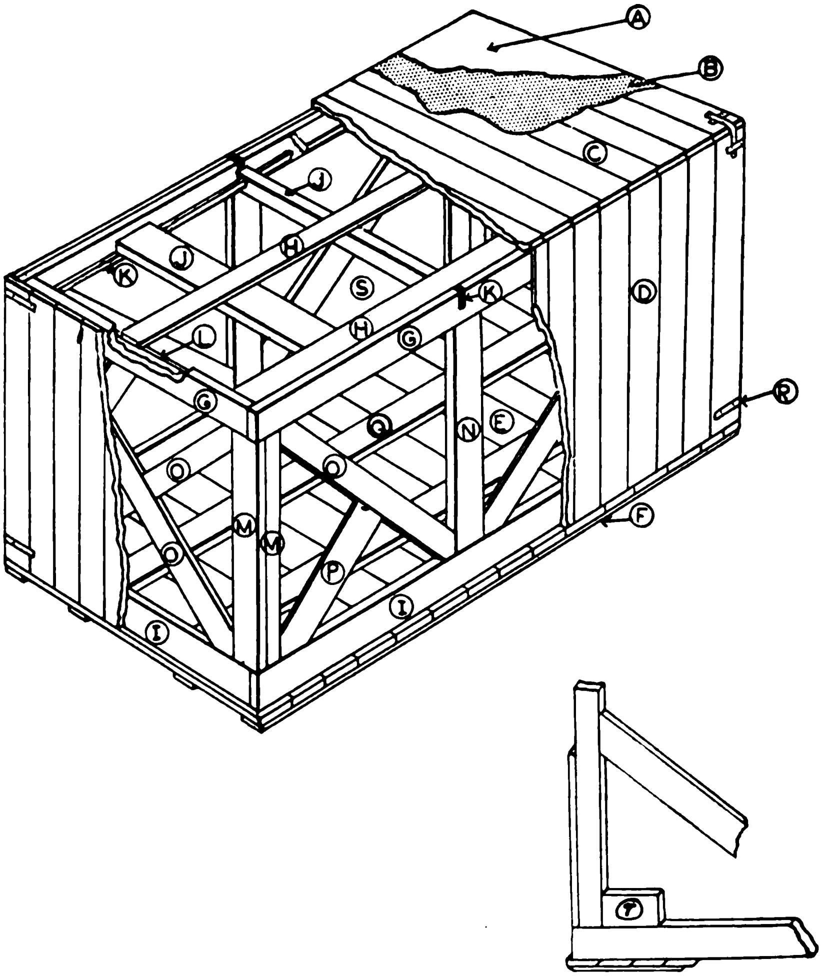
Type II. This is the 'average' load. Contents are packed directly into the outer shipping container, or are subjected to an intermediate stage of packing in interior containers. As in Type I, the contents are in full contact, and support all faces of the exterior container. The principal difference is that in a Type II load, the contents are usually broken up into several interior containers, rather than one container.

Type III. This is the 'difficult' load. Contents are highly concentrated articles which require maximum protection, or do not support faces of exterior container. Usually these articles exert pressure on certain faces of the container, and the load is consequently unequally distributed in the container. In order to protect the faces of the container which are called upon to support more than their proportionate shares of the weight, the articles must be blocked and braced within the container to give the necessary rigidity, and to prevent the load from shifting during shipment. Examples of these articles are axles, shafts, rods, mounts, gun tubes, etc. Unfortunately, this type of load is very prevalent in ordnance packing, and we must concentrate on packing them so that the container will withstand the many attendant shipping hazards.

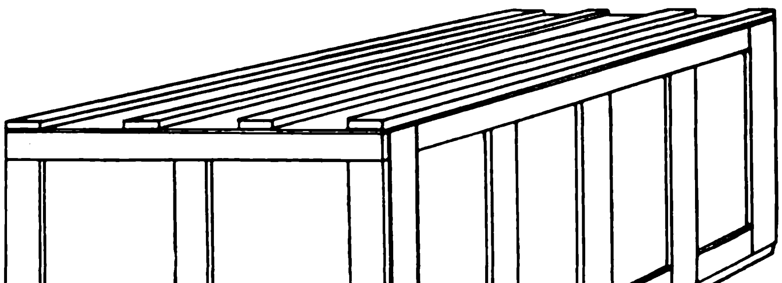
Weight of the materiel to be packed: War time shipping difficulties make it imperative that we not exceed weight limits of the various containers which will be discussed later in this chapter. Moreover, we must always consider in packing materiel in a container, that it will have to be handled by our troops overseas many, many times, and oftentimes proper handling equipment will not be available at the destination. The cardinal rule in this instance, then, is not to overpack a container. The trend is more and more towards lighter weight exterior containers so that they may be more easily handled when they arrive overseas.

Cubic displacement: The same considerations apply here as in weight restrictions. Bulky containers slow down loading and unloading procedures, particularly at ports. Consequently, it has been necessary to establish restrictions on cubage wherever possible. Conversely, minimum cubic size containers have been established in order to eliminate shipping complications from numerous small mail and express packages.

Ease in handling and storing: In chosing containers we often have to consider



Modified box type of sheathed crate with sill type base.



Plywood sheathed crate.

Figure 75. The Crate.

ease of handling before and after loading. For instance, this consideration in many instances dictates the use of the skid type crate instead of the sill type, because the former is much easier handled in loading and unloading at the ports and while in transit.

Cost of materials: Because our many ordnance depots are scattered throughout the length and breadth of the United States, some of the materials used in packing are more prevalent, and consequently may be procured at a cheaper cost, in certain areas than in others. This is particularly true with various kinds of lumber, veneer, plywood, etc. True, at the beginning of the war cost was of little consequence. We were more concerned with getting materiel out in the quickest way, regardless of cost. This, however, is no longer the case, and we should choose our packing materials with an eye toward economy, consistent, of course, with good packing.

Types and Selection of Containers. With the aforementioned factors in mind, we will be better able to choose the correct kind of exterior container for each type of shipment. A general discription of each of the different containers follows:

Nailed Wood Shipping Crate: A complete text on the construction of this container may be found in Army and Navy General Specification No. 100-14a, Section 4, pp. 13-50. The crate should be capable of supporting a superimposed load of 175 lbs. per sq. ft. over the entire area of the top. Sides are constructed so as to support 400 lbs. per sq. ft. It is most suitable for heavy, sizeable items, and is the largest and sturdiest container that we use in shipping. However, whereever practical, weights should be limited to approximately 11,200 lbs. (5 long tons), and length limited to 30 ft. These limitations are necessary because many of our small ships are not equipped to handle larger weights and lengths. Moreover, it often becomes necessary in some foreign ports for ships to unload their cargo with only the ships gear to do the job. We must remember, then, not to exceed these limits unless the size and weight of the item itself so dictates.

Crates are very rigid and sturdy when built according to current specifications and have a high resistance to shock. They should be used in lieu of boxes when the length is over 6 ft., width and depth over 3 ft. and/or weight more than 1000 lbs.

In packing a crate one of the most important considerations is the base. In order to offer maximum protection, the materiel must be securely fastened to the base. There are available specifications on two types of bases:

Skid Type—This type base is used for heavy loads when the supporting area bears on a large flat surface, or when loads are concentrated at a few points at the floor line.

Sill Type—This type is used in preference to the skid type whenever the supporting points of an item are above the floor line, and proper bearing can be made so that cubage is conserved.

Unless individual specifications indicate otherwise, all export crates must be properly weatherproofed in order to protect the contents during shipment. This procedure is as follows:

On all sheathed crates, the inner face of the top and the end and side section shall be lined with waterproof paper. A list of the different types of papers and the characteristics of each may be found on page 157, table 60 Army and Navy Gen. Spec. 100-14a. For ordnance weatherproofing measures only types H-1, H-2, J-1, J-2, L-2, and M may be used. Paper is placed between the sheathing and frame members of the sides, ends, and tops. In addition, the top surface is coated with a 1/16-inch layer of asphaltic adhesive, and then covered with another layer of reinforced waterproof paper. This layer of paper must overlap edges of top at least 3 inches. The overlaps are then glued down with waterproof adhesive, and tacked down with galvanized roofing nails, 6 to 8 inches apart. If these nails should tear the paper in any way, more adhesive must be applied around the nail holes to give maximum protection. Clusters of ½-inch holes must be cut in each divided section of the bottom, near the outer edges, to permit drainage of water. This latter provision is most important, for if water should seep through the top, sides, or end members, there would be no way for it to drain out without the clusters of holes in the bottom. This would most surely induce corrosion of any critical surfaces.

To give reinforcement to the crate we must strap, with metal strapping material, the points of stress, and the 4 corners at the top. Strapping is fastened to the crate by nails before the application of asphalt adhesive, so that nail holes may be adequately sealed by the adhesive. Strapping must be sufficiently long to tie-in adjacent frame members of the crate, and to permit the driving of at least two nails into each frame member.

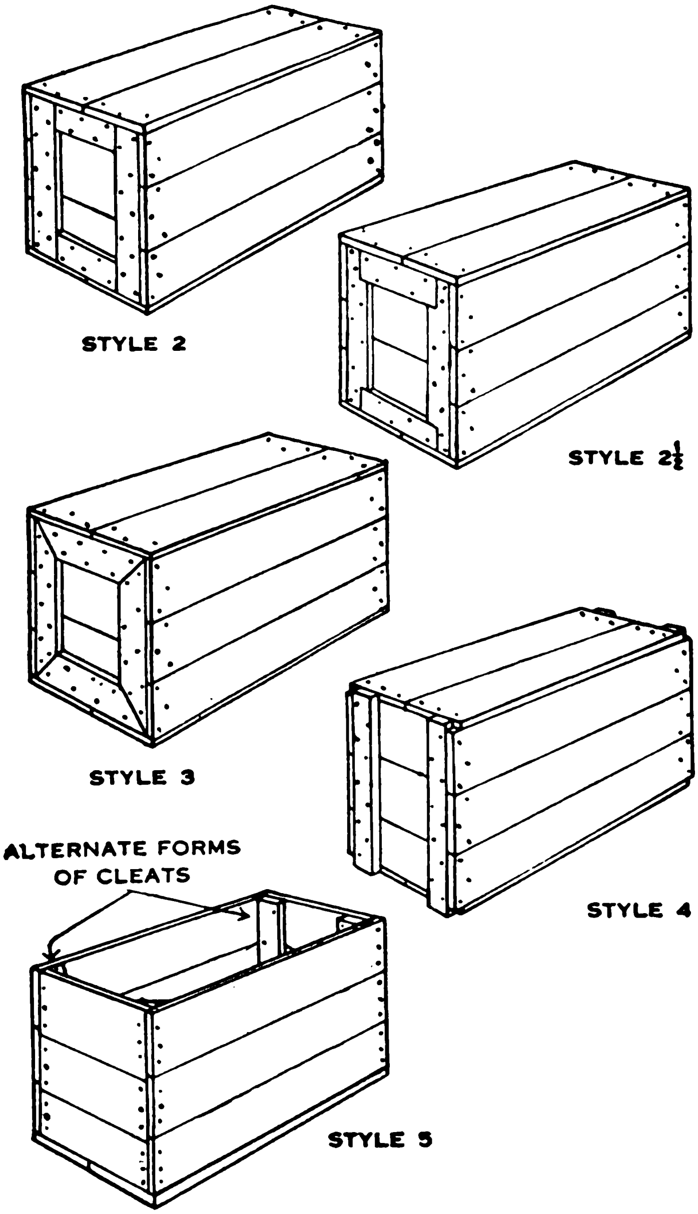


Figure 76. Styles of Nailed Wood Boxes.

In packing a crate it is well to remember to spread the contents over as large an area as possible so that all surfaces will bear equal support. Contents must be securely fastened to the base either by strapping, blocking and bracing, bolting, etc., so that the load will not shift and damage the container during shipment.

Nailed wood shipping boxes: A complete text on the construction of these containers may be found in Army and Navy General Specifications, No. 100-14a, pp. 59-70, Section VI. The following are the only styles of nailed wood boxes which the ordnance department uses in overseas shipments:

Style II—There are two vertical cleats at each end, and two filler (horizontal) cleats between them. The maximum weight limit is 1,000 lbs.

Style II½—This box is the same as style II, except that the filler cleats are mortised into the vertical cleats. The main advantage is protection from nails being driven into filler cleats. Maximum weight limit is 1,000 lbs. This container is not very popular in ordnance shipping because it is more difficult to construct, and offers very little more protection than the style II.

Style III. This container, too, is similar to the regular style II, except that cleats are mitered together at corners. Maximum weight limit is 1,000 lbs. It is not widely used for the same reasons that a style II½ box is not widely used.

Style IV. This box is constructed with only two vertical cleats at each end. Cleats should extend to within 1/8 inch of the top to prevent splitting of the top boards. Maximum weight limit is 400 lbs. Due to the current regulations limiting weights of boxes wherever possible to 70 lbs. (the one man load), this box is specified for use in such instances, rather than a stronger box with more cleats, and one which consequently is more expensive to manufacture.

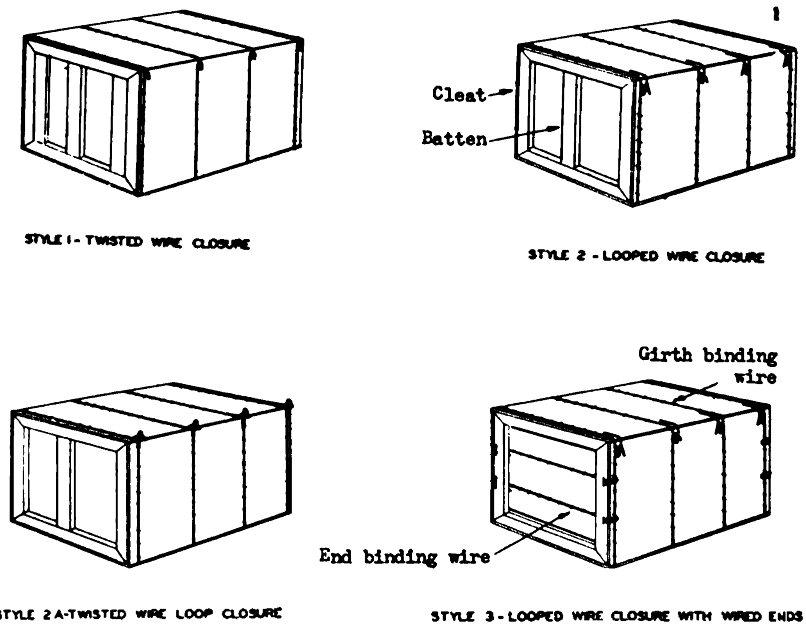


Figure 77. Styles and Closures of Wirebound Wood Boxes.

Style V. This box has the same characteristics as the style IV, except that the two end cleats are on the inside of the box. Because of this cleat construction it is sometimes preferred over all others for type III loads, as the internal blocks and braces may be more easily anchored to the cleats. Conversely, it is not practical for other types of loads, as it tends to increase necessary cubage.

Box Fabrication and Loading. In constructing nailed wood boxes, we must first determine the thickness of lumber to be used. The type of load to be packed has a direct bearing on this, and the information may be found in tables 13 and 14 of 100-14a. Additional strength is given to the box by staggering nails wherever possible. No container is stronger than its fastenings so it is advantageous not only to use the right kind of nails, but also to use the correct amounts and to place them where they will provide the maximum amount of protection. Cement coated nails should always be used for export containers, as the 'jagged' effect of the nails gives greater holding ability. Moreover, there should be at least two nails per board, spaced from 6 inches to 8 inches. Nails joining cleats to the end of boxes must be clenched on the inside to prevent rupture of box liners and damage to contents.

In packing the contents into a box we must be certain that the load is rigid and sturdy, so that subsequent handling of the container won't damage the contents. Specifications must be carefully studied for each kind of packing job. These speci-

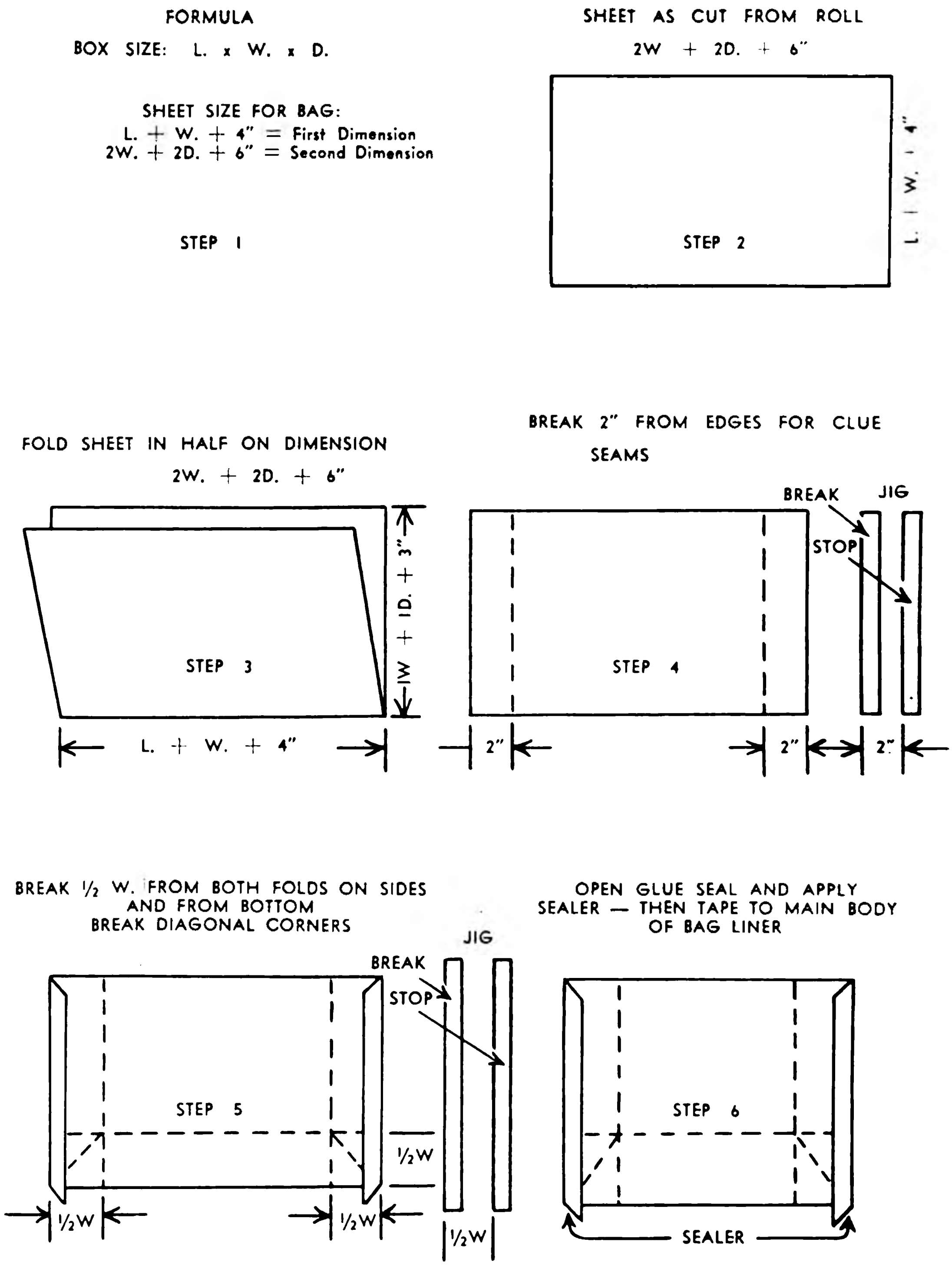


Figure 78. Steps in Making a Box Liner.

fications are available now for almost all types of Ordnance materiel, and are the results of months of technical effort. Therefore. they should be strictly adhered to, and never deviated from without proper authority.

Use of strapping. All boxes regardless of style must be strapped after tops have been nailed on with either round wire or flat metal band as an added protection to the boxes. It has been estimated that this strapping adds over 50% additional protection to the container. Tables 20 and 21, 100-14a show the sizes of flat metal bands, and gages of round wire for various weights of boxes, and they should be used whenever there is doubt as to the size of band or gage of wire to be used on a particular box. Strapping should always be applied as the last operation, and should bite into the sides of the box, because of possible shrinkage of the lumber. We are having to utilize green lumber in our box construction, moreover, to give more protection to the straps in the event of subsequent shrinkage of the lumber. Straps should be stapled to the boards if all faces of the box are in excess of 12 inches, and the boards are 7/16 inch thick or greater. Staples are located at intervals of about 6 inches. Care should be exercised not to overdrive staples and weaken the strap. To aid in this operation, there have been made available to all ordnance depots staple machines to speed up the process, and to protect the straps against overdriving. The number of straps for any particular box is governed by the gross weight of the box and the length. Boxes under 125 lbs. and under 18 inches in length require only one strap. Those over 125 lbs., and under 250 lbs., or over 18 inches in length, and under 48 inches require 2 straps, while boxes exceeding these specifications must have three straps. An additional strap is added for each 24 inches of increased length. If two or more straps are used, the distance of the two straps from each end of the box shall be 1/6 of the length of the box. Additional straps, as required, are placed equidistant between these two straps.

Use of paper liners. Nailed wood boxes packed for export must be lined with waterproof paper as an additional protection against corrosion or other damage to the contents. Exceptions to this rule must be granted by the proper procurement authorities. This waterproof paper is made into bag liners either by the shipping agency, or may be ordered prefabricated from the approved paper manufacturer. In either case the joints and seams of the liner must be sealed with an approved waterproof adhesive, and should fit into the box loosely. In no event shall it be glued, or fastened to the sides of the box, as it must be loose to prevent tearing. The height of the bag must be at least 6 inches above the top of the box to permit a watertight overlap inclosure.

Wirebound shipping boxes: A complete text on the uses and assembly of this type container will be found in Section VII, pages 70-80, 100-14a. The wirebound boxes are procured from the manufacturer, and come to the user in knockdown form, ready for assembly and use. To facilitate the assembly of these containers the manufacturer furnishes tools with which to make the closures. The fundamental principle of the wirebound box is to use steel wire, cleats, and relatively thin boards in order to obtain strength equivalent to the same size nailed wood box constructed with thicker lumber. The wire is stapled to the cleats and boards, extending around the girth of the box.

The cleats on the ends of the boxes are joined together by miter, or mortise and tenon joints, and the styles (of which there are 4 used) are determined by the way the ends are held together. (Refer to Fig. 77.) Boards used may be either sawed lumber, veneer, or plywood. When the distance between the end cleats is over 5 inches, a batten is added between the cleats or if the weight of the box exceeds 125 lbs., 2 battens are added, except in the case of a style three box which has end binding wire instead of cleats.

The rules for waterproofing this container are the same as described for the nailed wood box, except that the prefabricated bag liner is preferred. Strapping is applied as follows: If the gross weight is under 150 lbs., no strapping is necessary. If the weight is over 150 lbs., place one strap lengthwise around middle of box. If it exceeds 250 lbs., add two more girthwise straps approximately 3 inches from ends of the box. If straps are necessary, they should be placed before the box is closed so that the wire closures may be tight.

This box is most practical for type I and II loads, as it is subject to puncture and is not suitable for the ordinary type III load; also, due to the thin boards used in its construction, it is pliable and won't absorb shock as well as a more rigid container. Its main advantages are its ease of assembly, saving of lumber, ability to reuse, and conservation of storage space while it is in knockdown state.

The maximum weight limit of the wirebound box is 500 lbs.

Cleated plywood boxes: A complete text on the manufacture and characteristics of this type container may be found in section V, pages 51-59, 100-14a. This type of box is similar to a crate, except that no skids are used. The cleats on the plywood box are like the frame members of the crate. However, in comparison to a nailed wood box, relatively thin plywood is used instead of thick boards. Plywood is obtained usually in larger pieces than ordinary wood. This may be advantageous, as the box will completely cover the contents. Plywood boxes are extremely rigid, and shock resistant. They are also lighter in weight in comparison to the nailed wood box. The minimum thickness of plywood used in export boxes is 1/4 inch. This provision reduces the chances of puncturing the container, a possibility against which we must guard in any plywood container. Styles A and B (Fig. 79) are the only two permitted for export use. The maximum weight limit of each is 1,000 lbs.

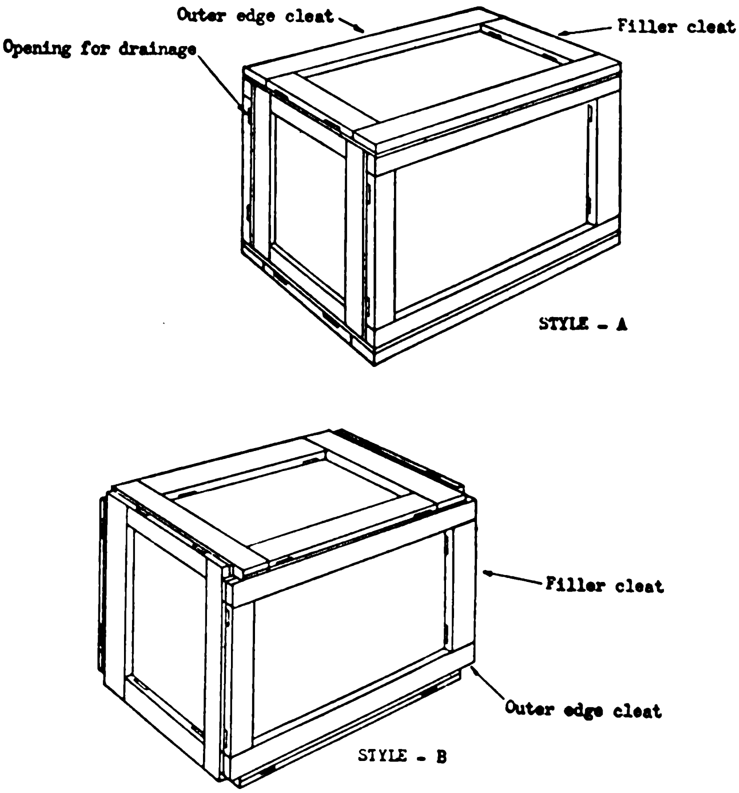


Figure 79. Styles of Cleated Plywood Boxes.

When concentrated loads bear on one face of the box, additional cleats are used and strapped over, with either round wire, or flat metal bands. If the gross weight of the box is less than 175 lbs., one strap is placed over the center cleats. If weight is over 175 lbs., additional straps are placed over the edge cleats. For boxes with distributed loading, not less than two straps are placed over the end cleats for weights under 250 lbs. Over 250 lbs., additional straps are placed over each intermediate cleat. Waterproofing measures for the plywood box are the same as outlined for the nailed wood box.

It must be remembered that in the plywood box we have substituted thin plywood boards for thick lumber as used in the nailed wood box. Consequently, it cannot be expected to take all the punishment that a nailed wood box will. However, if constructed according to specifications, it will prove to be extremely sturdy and rigid but must be protected from puncture, and concentrated loads bearing directly on one or two surfaces. The maximum weight limit is 1,000 lbs.

Fibreboard shipping boxes: A complete text on the characteristics and manufacture of this type container may be found in section VIII, pages 81-89, 100-14a. Corrugated and solid fibre, treated to be highly water resistant, is the only material that may be used in making exterior fibreboard boxes for export. We call these containers 'V Board'. Ordinary fibreboard, untreated, shall under no conditions be used as an exterior export container. Moreover, articles which are fragile or susceptible to damage shall not be packed in fibreboard.

Fibreboard 'V Board' cartons may be used only with permission of the Packaging Section, and like all other exterior containers previously discussed, must contain a waterproof bag liner. All seams, including the manufacturers joint must be sealed with a waterproof tape. Additional protection is provided by sleeves over the containers, plus strapping as explained on p. 88, 100-14a.

Miscellaneous Containers: Tight barrels, metal drums, fibre drums, plywood drums, shipping bags and sacks, and bales and bundles, and other miscellaneous containers may be used only with special permission of the Packaging Section, and if used must conform with the requirements laid down in 100-14a.

Experiences in handling containers by our troops overseas have proved that in the past many of our ordnance containers were too heavy for the troops to handle without the aid of material handling equipment. Consequently, for spare parts loads, a weight limit of 70 lbs. has been established for all export containers. This has been termed the 'One man load,' and simply means that a fully equipped soldier can handle a container of this size effectively. Exceptions to this rule are permissible only if the weight of the item itself dictates a heavier container. Also, export boxes will contain only spare parts common to the same unit assembly, or sub-assembly. Whenever this is impossible, because the number of different parts requisitioned will not fill the smallest size authorized box (one cubic foot), whenever possible multiple packing is authorized, subject to the following rules:

1. The cubic size of a multiple packed export box shall be approximately 1 cu. ft., and never in excess of 2 cu. ft.
2. Only items common to the same assembly or sub-assembly shall be packed in any one interior container.
3. Like items or multiple packed items shall be wrapped or cartonized together and clearly identified on each wrap, or interior carton.

Marking (Export). Equally important as packing a container is the overseas marking which must be applied completely and accurately to each container. This should be the last procedure before the container leaves the depot, and should be checked very thoroughly at least once after all the marking has been applied, by a person familiar with this phase of shipping.

In marking containers, we should remember that the marking we apply will determine whether or not a container will ultimately reach the using unit overseas. Because most overseas addresses are written in code form, (always unless specified by proper authorities) it is even more important that we apply these with great care and accuracy. During the early part of this war many of our supplies were not reaching the requisitioning unit because there was apparently little standardization in marking. However, our latest reference on marking. 'Identification of Separate Shipments Made to Overseas Destinations,' sets forth a well coordinated marking procedure not only for the Ordnance Department, but for all the Army Service Forces. Its purpose it to provide a universal system of numbering requisitions by all units overseas, and to use this requisition number in marking containers so that each shipment may be positively identified with the originating requisition, as well as with the papers actually covering the particular shipment. It also prescribes a chronological flow of advance information from the zone of the interior to overseas commanders which will enable the latter to have available as soon as possible, information concerning the status of all shipments to his command. If the correct procedure as outlined in this reference is followed by all requisitioning and shipping agencies, there will be a complete correlation of markings on the requisition, shipping document, and on the container. This will assure, the arrival at the proper overseas destination of the materiel in the minimum amount of time necessary, and will eliminate great stores of materiel piling up in warehouses and open storage at ports of debarkation, undelivered to the using units because of improper or incomplete identifying markings.

The following is a typical example of a complete overseas address marking (shipping designator) which might be found on a container:

"BOBO-ORD II-A300RA1"

This shipping designator, as it is termed, gives the complete address and all the information necessary to assure delivery of the container to the requisitioning unit. 'BOBO' indicates the theater of operations, 'ORD II,' the class of supplies contained in the container, 'A300,' the requisition number which has been assigned by the overseas commander, and 'RA1,' the depot symbol and transportation unit number. In other words, we know that a package marked in the above manner will procede to the 'BOBO' theater; the package contains class II Ordnance supplies, it is the first requisition of series 'A' emanating from that theater, the shipping agency is Raritan Arsenal, and it is the first separate shipment made on requisition A300. It might be well to pause here and explain that each service has been assigned a block of numbers for use in identifying each requisition orig-

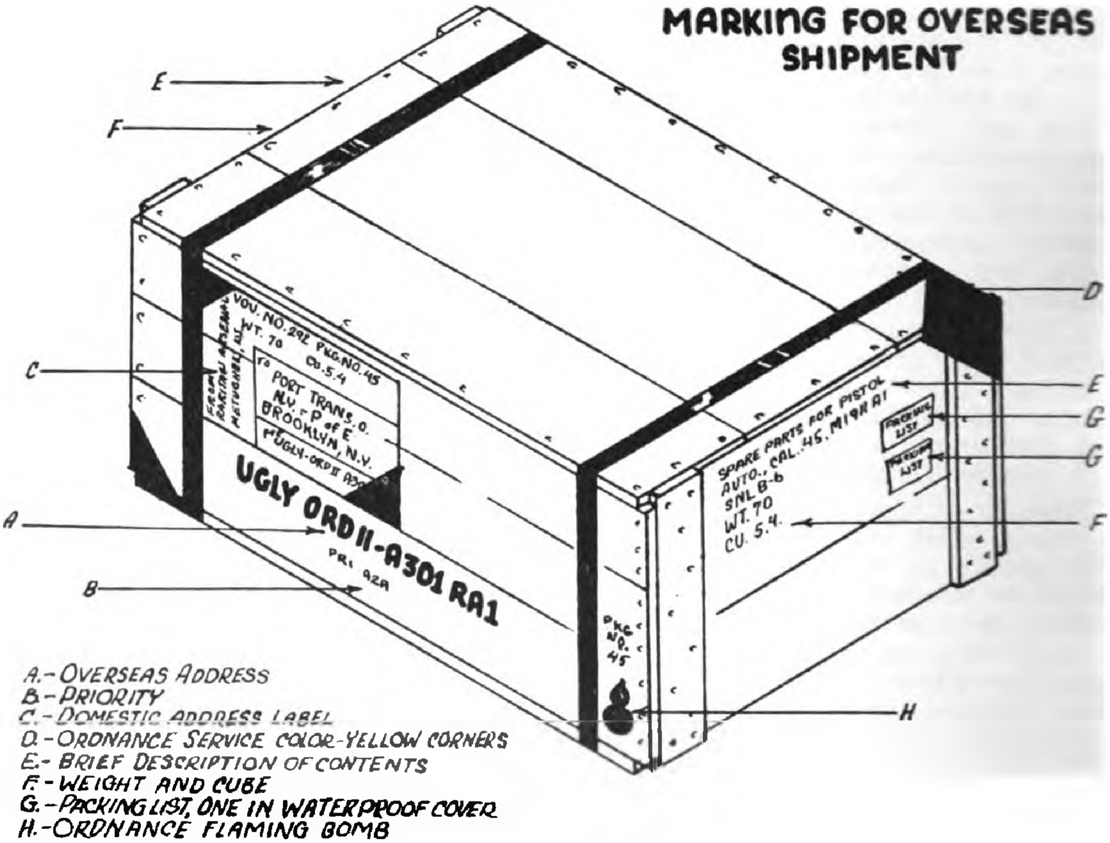


Figure 80. Marking for Overseas Shipment.

inated overseas. The Ordnance Department is assigned numbers 300-399 inclusive, and these numbers (as assigned by the overseas commander) are prefaced with a serial letter, as 'A' above. Any letter may be used with the exception of 'P' and 'S,' as these letters have been reserved for use of U. S. ports of embarkation, and U. S. technical services. For further information on this subject, it is suggested that the reader refer to the aforementioned reference. In no event will these markings be less than ¾" in height.

In addition to the shipping designator explained above, the following markings will appear on each export container:

Description of contents, weight and cubage: This information will be stenciled on both ends of the container if the size permits, in ¾" letters and numbers, and the space should be limited to the upper ⅔rds of each surface. When the container contains *one item*, or *like items*, the quantity, exact nomenclature, SNL group, weight and cube, will be stenciled on both ends and an exterior packing list is not necessary. However, if the container contains an assortment of items, a brief description of the contents will suffice (Ex. spare parts for M1 Rifle). The SNL group, weight and cubage, of course, will also be shown.

Package number: The package number of the container will be stenciled in ¾" numbers on the same face as the overseas address.

Service color marking: The Ordnance service color marking (yellow) is painted on two diagonally opposite corners of each container. This will result in a triangle appearing on each surface of the container. In addition the Ordnance flaming bomb is painted on one face to further facilitate identification of the shipping service.

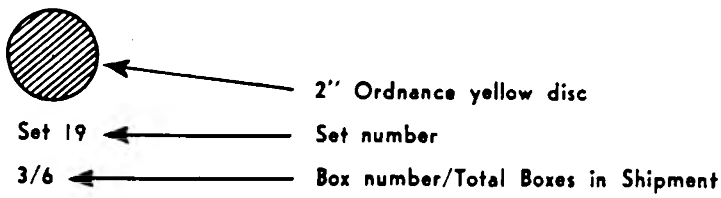


Figure 81. Set Markings.

Domestic address: A label not exceeding 28 sq. in. is used for the domestic address. It will show the consignor, consignee, overseas address, requistion number, and voucher number. It must be securely attached to the face of the container, and covered with a transparent, waterproof coating. This label should be placed in the upper left portion of the same face that carries the overseas address. If the size of the container prohibits the use of a label, waterproof tags should be attached containing the same information.

Shipments should be addressed directly to the Port Transportation Officer, and abbreviations are encouraged, except for cities. Example:

TO: PORT TRANS O
NY P of E
Brooklyn, N. Y.

Priority: When prescribed, the priority will be shown beneath the overseas address, as: PRI-A1A.

Special markings: Shipments of shortages to a P of E are marked as follows: containers will have a yellow 'S' marked in corners normally allocated to yellow triangles. Proper shipping designator will be used followed by any specific instructions contained in movement orders.

Set markings: Component parts of an item disassembled and placed in separate containers must be shipped *together*. Each container will bear, in addition to its own package number, the total number of containers making up the set, and the number of the sets within each shipment. A two inch Ordnance yellow disc will be placed above numbers on each container showing that all items of a set must be shipped together. This set marking will appear on the same face of the container as the overseas address. See Figure 81.

Shipping designators, requisition numbers, and consignee combinations are classified only as 'Restricted', so as to facilitate the processing of shipping papers, etc. However, all agencies concerned must exercise precaution in the circulation of papers which will disclose the meanings of all codes, so that the knowledge concerning them will be limited to those individuals who require the information in connection with their official duties.

STORAGE AND PRESERVATION

Storage Precautions

General. One of the objectives of the supply mission is that material issued must be in serviceable condition. To accomplish this, material in storage must be adequately maintained. Maintenance in storage includes the maneuvering, exercising, operating, testing, and special inspections required for the proper preservation of the material. The effectiveness of the procedure followed must be checked by percentage inspections. Rearrangements in storage and the application of paints, oil, grease, and rust preventives will be made where necessary to maintain ordnance material in proper condition. Each situation constitutes a separate problem and must be worked out locally in detail, using the fundamentals outlined in this chapter as a guide. For detailed information on storage, consult TM 10-250.

Material Requiring Special Considerations. In warehouse activities, many articles placed in storage, because of their nature, require special considerations. The effect of light, heat, cold, moisture, or other conditions on supplies to be stored must always be taken into account. These conditions may be intensified by storage in extreme climates, such as the tropics. The following special considerations are useful in storing the articles listed:

Batteries, storage. Batteries removed from vehicles should be cleaned, if dirty, by brushing the external parts and terminals with a soda or ammonia solution, being careful to prevent this solution from entering the cells. A light coat of vaseline or Compound, rust preventive, light, should be applied to the terminals. Batteries should be recharged at least every 60 days, or whenever the specific gravity reading is below 1.250 in winter or below 1.225 in summer. Hydrometer readings should be taken every two weeks, and proper water levels should be maintained. When water is added, the battery should be immediately recharged or agitated to mix the water with the electrolyte. A record will be kept showing the date the battery is placed in storage and its maintenance data while in storage.

Electrolyte. Electrolyte for Dry Charged and Moist Uncharged Batteries will be packed and shipped with Dry Charged and Moist Uncharged Batteries. It will be shipped only in U. S. standard one gallon bottles. The specific gravity of electrolyte and type number of battery for which it is intended will be marked on each inner and outer package of electrolyte. The specific gravity of the electrolyte in the bottles will be as follows:

For Dry Charged Batteries 1.275
For Moist Uncharged Batteries 1.345

For complete information concerning storage of batteries, see WDTB ORD 67.

Canvas. This material, oiled or waterproofed, should be stowed in a cool, dry place, allowing a good circulation of air. It should be located within easy reach in case of fire.

Cordage. All twines, cord, rope, and cable made of textile material must be kept in a dry place to avoid rotting.

Drills. These are wrapped in oiled paper and kept in a dry place.

Electrical equipment. All exposed finished metal parts, and all parts liable to rust should be coated with slushing oil. No oil should come in contact with rubber or other insulating material. Parts or assemblies containing insulating materials or wiring of any kind should be wrapped in waxed paper, if available, and should be placed in paper bags, envelopes, or small boxes, properly labelled or tagged, and kept closed.

Gas cylinders. Cylinders of oxygen combustible gases should be protected against excessive rise of temperature and should not be exposed to continuous dampness. Cylinders may be stored in the open but should be protected in such cases against extremes of weather. During winter, cylinders stored in the open should be protected against accumulation of ice and snow. In summer, cylinders stored in the open should be protected from the continuous direct rays of the sun. Cylinders should be segregated according to their contents and separated from highly inflammable substances, such as oil, gasoline, and waste. The cylinder should be painted frequently to prevent corrosion. Regulators, torches, and any parts of welding or cutting apparatus must *never* be oiled or greased, and oil and grease must *never* be allowed to come in contact with or be near oxygen cylinders. Oil or grease coming in contact with oxygen under pressure will ignite violently or explode. For additional information, see AR 850-60.

Gaskets, paper. Paper gaskets and paper gasket material are kept impregnated with light oil to prevent shrinkage and drying.

Gun slings. The following method of reconditioning and storing leather gun slings will preserve them and retard the formation of verdigris:

Eliminate all defective parts, including leather which is dead.

Remove verdigris from metal parts and from the junction of the metal part with the strap. This is best accomplished by the use of a wire brush of convenient size. Protect leather adjacent to the metal parts from the scratching effect of the wire brush by the use of a sheet metal guard.

Wash leather with water and castile soap, using a bristle brush to remove dirt.

Roll and recrease leather. These are important operations and aid materially in the preservation of the leather.

Apply a light coat of neat's-foot oil to the leather with a soft cloth, taking care not to allow the oil to come in contact with the metal parts.

Dip ends of sling to which metal parts are attached in melted paraffin, so that the paraffin will extend to a distance of about ¼ inch beyond the junction of the metal parts with the strap. Tie gun slings in bundles and pack in paper-lined wooden cases.

Hardware, light. Shelves, racks, or pegs are utilized for storing such loose articles as saws, hammers, and other hand tools. Securely locked cabinets are used for the storing of smaller and more valuable articles. Such small loose articles as bolts, nuts, or parts are stored in bins. Racks are provided for pipes, rods, and other articles of similar character. The use of racks conserves storage space and tends to prevent the warping or bending of the articles so stored.

Hose, fire. All water is drained from the hose before it is stored. The hose is stretched once every three months and water run through it. If it is cotton-covered, the covering is dried before stowing. The hose is kept in a cool, dry place to prevent kinks; it is coiled rather than folded. It is kept free from oil.

Leather. This should be stowed in a cool, dry place and inspected periodically, since it will be subject to mold and dryness. (See gun slings, above.)

Oils. Where possible, these are stored in an oil house or in special storerooms which are set aside for this purpose. Oils will be protected from sparks and open flames. Care must be exercised to prevent leakage. All oils are isolated from rags, paper, or other inflammable materiel, as spontaneous combustion may result.

Optical instruments. Optical instruments are stored in a locked storeroom, and precautions taken to keep all optical parts dry and free from dust, oil, and grease.

Paints and varnish. Where possible, these are stored in a separate building or storeroom provided for that purpose, usually together with oils. Care must be exercised to prevent leakage. All paints in drums are stored under cover and water should not be allowed to stand on the drums.

Rubber. This should be stored away from light and heat and kept from contact with water, oil, or grease. For a complete discussion on care of tires and tubes, see TM 31-200.

Tools. These are kept covered with a film of oil or wrapped in oiled paper and are inspected frequently to see that they are free from rust. Tools that have been used are thoroughly cleaned with a wire brush or abrasive paper to remove rust, and all parts not covered with paint are slushed with a heavy oil before storing. Tools made of chromium alloy steels or chrome-plated tools should not be cleaned with wire brushes or abrasives, as the surface is rust-resistant in its normal state, but scratching may destroy this property.

Unserviceable items. Unserviceable items should never be placed in storage unless it is impracticable to get them repaired.

Watches. These are handled with special care and stored in the strong room. Watches should be protected from extremes of heat, cold, and moisture.

Webbing. Webbing is sprinkled with flake naphthalene and stored in a dry place provided with good circulation. It should be inspected periodically for signs of moth activity.

STORAGE OF MOTOR VEHICLES

Technical Inspections. All motor vehicle equipment will be inspected at the time it is placed in storage and at frequent intervals thereafter. A tag or tags, tied to the vehicle, will be kept up to date by the inspector, indicating the condition of the vehicle and the type of work to be done before it may again be placed in service. Minor work of surface preservation will be accomplished at the time of inspection. Work involving disassembling and the use of shop facilities will be accomplished at the earliest practicable date.

Repairs. It is highly desirable that vehicles and their components, and equipment removed from vehicles, be overhauled before being placed in storage. Items such as batteries, seat cushions, and lamps, which may be removed for separate, protected storage, should be placed in serviceable condition before being stored, and tagged to show the vehicle to which they belong. If for any reason it is impossible to overhaul these vehicles, a careful inspection of them is made, and each vehicle is carefully marked with a tag showing all spare parts and repairs needed to place it in a serviceable condition. These tags are attached to the vehicle, in the cab if possible, and are shellacked to protect them against oil and moisture.

STORAGE OF WEAPONS

Storage of Small Arms. All small arms should be stored in suitable packing chests in secured covered storage. The utmost care must be taken to protect these weapons from dirt and rust, in order to insure perfect functioning of the mechanism and continued accuracy of the barrels. All small arms must be protected against theft.

Prevention of deterioration. Preservatives. Sperm oil or Oil, lubricating, for aircraft instruments and machine guns, is the most suitable oil for preserving the mechanism of small arms weapons. This oil is efficient for preserving the polished surfaces, the bore, and the chamber for a period of from two to six weeks, depending on the climatic and storage conditions. Oil, lubricating, preservative, special, or Oil, lubricating, preservative, light, may be used when sperm oil is not available.

Compound, rust-preventive, light, is a semisolid material, and Compound, rust-preventive, heavy, is a solid material at normal temperatures. This compound is efficient for preserving the polished surfaces, the bore, and the chamber for a period up to one year, depending on climatic and storage conditions. (See TM 9-850.)

Preparation for storage. The weapons should be cleaned and prepared with special care. The bore, all parts of the mechanism, and the exterior surfaces should be thoroughly cleaned and then dried completely with rags. In damp climates, particular care must be taken to see that the rags are dry. After a metal part is dried, the bare hands should not touch that part. All metal parts should then be coated with sperm oil or with rust-preventive compound, depending on the length of storage (see above). Application of the rust-preventive compound to the bore of the piece is best done by dipping the end of the bore in a vat of warmed rust-preventive compound and pumping the compound into the bore with ramrod. Small parts should be dipped into the rust-preventive compound. Paint the wooden supports with rust-preventive compound. Before placing rifles in the packing chests, see that the bolts are in the forward position and that the firing pins have been released. Place the weapon in the packing chest, handling it only by its wooden parts. Under no circumstances should a weapon be placed in storage wrapped in a cloth or other cover, or with a plug in the bore. Such articles collect moisture which causes the weapon to rust.

Storage of chests. Chests of arms should be stored with two or three-inch dunnage on the floor and with packing strips about 1/2 inch thick between layers of chests. If possible, a space of about 1 inch should be left between chests and between rows in order that air may circulate on all sides of the packing chests.

Prevention of theft. Small arms which are not in chests should be stored in a strong room in racks that are bolted to the floor. If it is impossible for them to be bolted to the floor, they should be chained together in such a large mass that it is impossible to move them.

Storage of Field Artillery. *Gun and Carriage.* Field artillery, especially light field artillery, should be stored in covered storage whenever possible. When open storage must be resorted to, all guns and carriages should be completely covered with tarpaulins and placed in such a manner that they are protected from the weather and from hostile observation. General precautions that should be observed in preparation of all field artillery for storage are:

The bore of the gun, breech mechanism, and all bright and unpainted surfaces should be thoroughly washed with soda ash solution, dried, and cleaned with solvent, dry-cleaning. A thick coating of compound, rust-preventive, light, is then applied to the metal surfaces.

The gun should be placed in serviceable condition before being placed in storage, and all necessary repairs made to insure perfect functioning of the mechanism. Repairs that have not been made should be noted on a tag securely attached to the gun and should be effected at the earliest possible time.

Gun slides and all exposed parts of the axle and traversing and elevating gears should be protected by a coating of Compound, rust-presentive, heavy, or light, depending on storage conditions.

The surfaces of the quadrant seat and the leveling plates should be coated with a rust-preventive compound, and protected from injury.

Covers for the breech, muzzle, and miscellaneous parts should be securely attached in their proper places.

Recoil mechanisms may be stored either separately or mounted on carriages. They must be kept filled with the specified recoil oil (TM 9-850), and the nitrogen maintained at the pressure specified for service. When mounted, the recoil mechanism and gun will be securely fastened so that the gun cannot slide.

All field artillery in storage should be inspected at periodic intervals, and the mechanism disassembled sufficiently to disclose any rust that may be forming. Special information pertaining to each weapon will be found in the applicable technical manual.

Sighting and fire-control equipment. Storage. Fire-control and sighting equipment should be repaired, cleaned, and placed in packing boxes in a strong room. Care should be taken to prevent grease from getting on the optical parts. Dunnage should be placed on the floor to insure adequate air circulation.

Preparation for storage. After the equipment has been overhauled and thoroughly cleaned, the following steps should be taken to prepare it for storage:

Instruments should be dried completely and metal parts covered with a film of oil, care being taken that the oil does not come in contact with any glass or rubber parts, or find its way into the interior of the instruments.

After being oiled, the instruments should be wrapped. Large instruments should be stored in the packing cases provided for them, care being taken not to rub off the rust-preventive compound. The padding in the cases should be absolutely free from moisture, and the bearing surfaces should have a thin film of oil over them.

All rubber attachments or component parts that can be removed without removing an integral part of the instrument or dismantling the instrument should be removed, cleaned with a mild soap solution, and thoroughly dried. Oil or grease should not come in contact with rubber parts.

STORAGE METHODS FOR OPEN STORAGE

In planning a storage area for open storage, the following precautions should be observed:

Area should be properly protected against aerial observation.

Supplies and equipment should have adequate protection against the effects of the sun and the weather.

Piles of supplies should be so arranged as to provide stability, speed in handling, and ease in making inspections or inventory count.

Preparation of particular items of material for storage is covered in the field manuals of the 23-series, and the technical manuals pertaining to particular items of equipment.

Protection Against Weather. *Foundation.* In order to keep the bases of the piles of equipment dry at all times, a foundation is laid of sufficient height to protect the supplies against surface water. Any available material, such as logs, stones, or cordwood, may be used, or a regular platform may be constructed.

Ventilation. As the piling proceeds, necessary passages for ventilation purposes are made by the insertion of dunnage between the layers of the pile. Sufficient ventilation should be provided to prevent the accumulation of enough moisture to deteriorate the supplies. This will depend largely on the type of material being piled.

Paulins. The tops and sides of the piles are protected against the direct rays of the sun and against rainfall by canvas paulins. These should be securely lashed in place, care being taken that the ropes do not touch the ground at any point. Ordinary untreated canvas will shed water if properly suspended so that pockets are not formed.

Methods of Piling Supplies. *Arrangement.* The arrangement of containers within a pile must be such as to facilitate inventory and inspection. In building a pile, only containers of uniform dimensions should be used. Each pile should bear a marker giving the number of containers and contents of each container.

Piles are placed throughout the storage area in irregular fashion whenever there is danger of aerial observation.

With the sides of the pile vertical, stability in piling may be achieved by the use of strip dunnage between layers or by alternate rows of headers and stretchers. The ratio between the length and width of the containers determines the minimum width of pile that may be used, since it is necessary that the width of the layers of stretchers and headers be the same. Ventilation and stability in such an arrangement can be achieved at the same time by leaving a small space between adjacent containers in each row.

A sloping roof is usually added to the pile to aid in shedding water from the canvas covers. Such a roof is formed by reducing the width of the layers alternately by one stretcher or two headers until a layer only one header wide is reached.

A pile triangular in cross section may be made by placing all packages as headers. The number of containers in each layer is uniformly reduced by one Such a pile will throw no sharp shadows from the sides, making aerial detection difficult.

Height. The most suitable height from the standpoint of the labor involved and convenience in the issue and receipt of stock is from 7 to 10 feet. At depots where large quantities must be kept in open storage, or where issues are infrequent, the height may be increased if necessary, provided adequate handling equipment is available.

References

Accounting for Government Property	AR 35-6520
Allowances	AR 310-60; T/O & E's T/A's and SNL's
Basic Load Planning	SNL Addendum's
Cleaning and Preserving Materiel	TM 9-850; SNL K-1
Equipment, Depot	ASF M-402
Equipment, Organizational	AR 35-6540; AR 45-80 T/O & E's and SNL's
Flow of Ordnance Supplies	Transportation Handbook Schedule SS650, C&GS School; OFSB 2-15
Inventories	AR 35-6520
Lubrication of Ordnance Materiel	OFSB 6 Series
Loss or Damage Changeable to Officers of Enlisted Men	AR 35-6640; AR 45-80
Marking	1OSSC (13)
Memorandum Receipt	AR 35-6520
Nomenclature	SNL's
Obsolete Equipment, Serviceable	AR 45-75
Original Packages, Receipt of	AR 35-6560
Over, Short and Damage Reports	AR 35-6640
Packing	OSSC's; 1OSSC; USA Spec. 100-14a; Ord Dept. Order No. 70 & C1
Procurement:	
Interbranch	AR 35-860
Interdepartmental	AR 35-880
Property:	
By Purchase	AR 5-100
By Requisition	AR 35-6540; AR 45-80
Relief from Responsibility	AR 35-6640
Report of Survey	AR 35-6640
Reports on Status and Condition of Ordnance Materiel	TM 38-250; OFSB 4-5; WD SUP Bulletin 9-23; WD Memo. 5850-8-43; WD Cir. 231, 43; WD Cir. 4, 44; ASF Circ. 4, 44; ASF Circ. 15, 44
Requisitions	AR 35-6640
Shipping Document	ASF M401
Shipping Ticket	AR 30-955; AR 35-6560
Small Arms, Safekeeping of	AR 45-80
Sources of Information	OFSB's 1-1 and 1-8; ORD 2 OPSI
Statement of Charges	AR 345-300; AR 35-6620; AR 35-6640
Station Supply	ASF M406
Field Supply	FM 9-5; FM 9-25
Stock Control	TM 38-205; TM 36-220
Stock Record Account	AR 35-6520
Storage of Automotive Equipment	AR 850-15
Surveying Officers	AR 35-6640
Warehouse, Equipment and Layout	ASF M402; 1OSSC (h) & (g)

References for Subjects Related to Ordnance General Supply

Staff Officer's Field Manual	FM 101-10
Company Officer's Manual	OS 9-29
Camouflage	FM 5-20 W/Supp. A Thru E Incl.
Rigging	TM 5-225, OS 9-59

CHAPTER 6

RECOVERY, EVACUATION AND FIELD RIGGING

RECOVERY AND EVACUATION

Relation to Tactical Operations. Battles are usually won by the commander who can maintain maximum strength against his adversary at all times. 'Maximum strength' refers not only to personnel but also to items of ordnance equipment. G-1 will take care of personnel replacements, while the ordnance problem will be the replacement of vehicles, tanks, guns, etc.

The ideal situation would be to have a new item, ready for immediate reissue, to replace every item abandoned on the battlefield. However, we all know that this is most impractical. All ordance equipment (pertaining to both enemy and friendly troops) which is disabled, partially worn out, or abandoned on the battlefield, in camp, or in bivouac must be placed in supply and maintenance channels so that it can be used immediately or repaired and reissued. This is a prodigious task but the benefits obtained are numerous. This system:

1. Gives us rebuilt items that we can reissue to using units;
2. Enables us to obtain maximum service out of each piece of equipment;
3. Relieves motor, rail, and water transportation;
4. Conserves equipment and raw materials;
5. Saves millions of dollars.

For the above reasons it is absolutely essential that all troops be thoroughly indoctrinated with the responsibilities attached to disabled and abandoned equipment.

If planning, full cooperation from all concerned, and hard work are present, your recovery and evacuation program will be successful. We have men to do the work and everyone will cooperate if plans are made efficiently and well in advance. Therefore, all commanders and staff officers must lay down procedures that will govern this important function; concerned are all echelons from the theater ordnance officer down to and including the division ordnance officer. Using unit commanders must also establish in their standing operating procedures certain basic rules that should be adhered to in regard to recovery. (For complete coverage of staff duties see Chapter 6, Vol. I.)

Naturally, all disabled and abandoned equipment cannot be removed from the battlefield by ordnance personnel. Assistance must be secured from combat troops. We call their part of the job 'battlefield recovery,' while ordnance personnel perform 'evacuation.'

Recovery Operations. Battlefield recovery is the removal (by combat personnel supplemented as necessary by service personnel) of disabled or abandoned allied and enemy materiel from the battlefield, and its movement to a defiladed area, collecting point, axis of evacuation, or maintenance and supply establishment. Combat troops are responsible for battlefield recovery because they are the men who are on the spot when trouble occurs, and the equipment should be removed from the battlefield immediately to prevent further damage or subsequent use by the enemy. In addition, combat troops have maintenance personnel who operate in the front lines. In an infantry division for example, there are 477 men trained in 2d echelon repair. These men have wrecking equipment to work with and can recover all but the heaviest equipment to the collecting point without too much trouble.

When combat troops are not able to recover the equipment for any reason, they must notify their supporting ordnance company so that the item may be brought in. Upon notifying the ordnance company, certain information must be given so that the recovery party sent out by the ordnance company will be able to locate and recover the equipment. It must be borne in mind that recovery parties, under normal conditions, will only go out when notified. Normally, they will not prowl around without a definite objective. The first and most important fact that must be reported is the location of the item to be recovered. Merely giving the location with reference to a nearby town or a prominent land feature is not sufficient. Operations are being carried out in foreign countries and very few people will be familiar enough with the terrain to locate anything by the above method. It would be far better to give the grid coordinates of the materiel to be recovered. Secondly, to aid the recovery party in finding the piece of equipment, the type should be disclosed to the ordnance company. This will give an excellent basis upon which to dispatch the necessary recovery equipment and the correct number of men to perform the work. It will also help if the serial number can be given. This will definitely locate the desired materiel and eliminate a large amount of hunting and inspection. It is also not impossible that

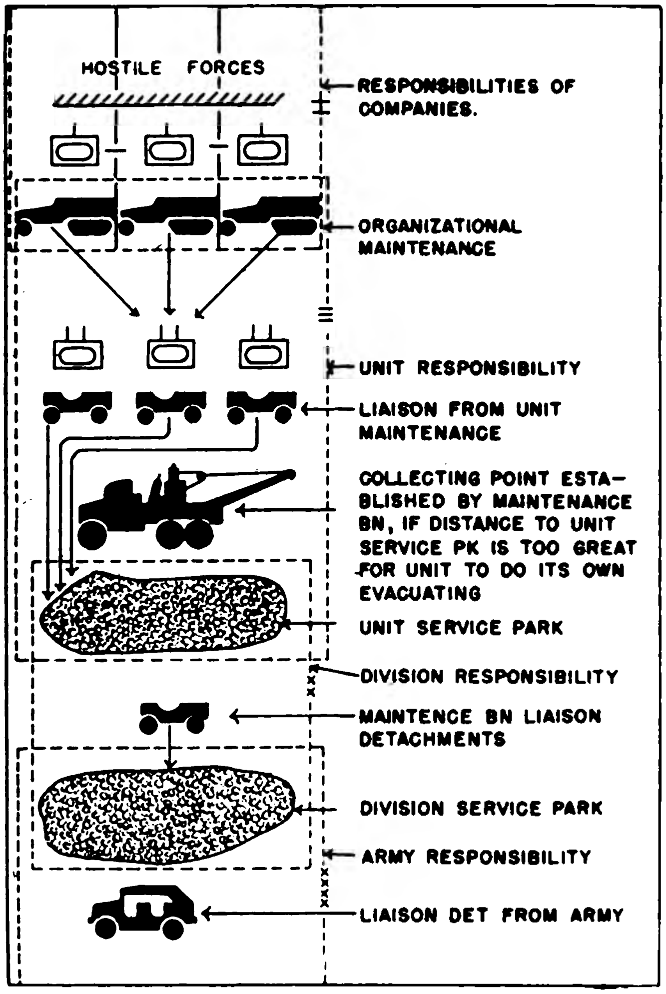


Figure 1. Schematic Diagram—Flow of Recovery and Evacuation.

another party may have recovered the equipment your party is after; the serial number will again save time. One way to insure prompt location of disabled materiel is to have the combat unit furnish a guide to lead the ordnance recovery party to the abandoned item. This system works very well and may be used to advantage when the materiel is in a controlled classification. The tactical situation, location of minefields, if any, and any protection furnished should also be given. At one time it was so important to recover and repair tanks in the African campaign that an order was published to the effect that tank crews were to remain with their vehicles until they were repaired.

The combat troops are expected to provide protection for the ordnance recovery parties operating in the front lines as ordnance companies are not authorized sufficient weapons and personnel to provide for their own protection. This protection will be given in several ways. Recovery by ordnance parties will normally be done at night but if daylight recovery is necessary smoke will give excellent results. Smoke serves the dual role of blinding the enemy and keeping him from placing direct fire on you. Naturally to be effective the smoke should cover a much larger area than the one that you are operating in. A platoon (this could be increased or decreased depending on the situation) of infantry for protection from enemy patrols is an excellent thing to have. These men will be able to fight off a large body of enemy troops and allow you to proceed with your work relatively free from enemy activity. In certain situations artillery protection might be necessary. An artillery barrage around your recovery operation will be very effective protection. Naturally, the importance of the operation will enter into the amount and type of protection you will be able to obtain. Normally you will be very fortunate to secure one of the above-named methods to assist you in your work.

In addition to combat protection you will occasionally need assistance from other branches of the Army. All personnel taking possession of abandoned materiel will first be sure that it does not contain booby traps and is not chemically contaminated. You will have to be especially careful of booby traps on enemy materiel. If booby traps *are* found, they will be disarmed and removed by personnel trained in this function as ordnance maintenance personnel are normally not qualified for this type of work. This is an Engineer function and they should be called in to do the job. In certain cases ordnance bomb disposal troops may render valuable assistance.

Chemically contaminated materiel will be decontaminated by recovery troops before use. When decontamination is beyond their means or unfeasible, they will plainly mark or tag the materiel and report its location to the unit chemical officer. Upon completion of the task, the chemical troops concerned will notify the appropriate unit so that recovery may continue.

Liaison in Recovery. Battlefield recovery of our own or enemy materiel requires cooperation between combat troop commanders and the commanders of the ordnance units involved. This can only be accomplished by constant liaison. It is rather superfluous to point out that while recovery of materiel may at the time be the prime consideration of the ordnance officer, it is not the main objective of the tactical commander, and the liaison and greater amount of cooperation must come from the ordnance personnel concerned. It behooves all ordnance officers dealing with recovery and evacuation to establish liaison between their ordnance installations and the combat units. This will promote a mutual understanding of each other's problems and will greatly increase cooperation. Liaison must be established to:

1. Keep abreast of the local tactical situation;
2. Make sure that using units know where the various collecting points are located;
3. Impress upon using units the necessity for giving the exact location of disabled materiel and, if necessary, furnishing guides;
4. Make the using units realize that you must have their protection (patrols, smoke screens, armored support) when you have to recover equipment under fire;
5. Help you solicit the help of the Engineers (for removing land mines and booby traps) and Chemical Warfare Service (for chemical decontamination) from time to time.

Liaison, efficiently handled, will ease your recovery problem considerably.

Collecting Point. The collecting point has been mentioned several times in preceding paragraphs. A collecting point is an area that is used to concentrate abandoned or disabled ordnance materiel. It is established in division, corps, and army areas, and will be operated by ordnance personnel. Each collecting point should have one or more inspectors on duty who are qualified to classify items for (1) evacuation to higher echelon (2) immediate repair, or (3) salvage. Items should be tagged and the proper records maintained.

Locations of collection points will be given in the administrative order. In corps and army areas they should be centrally located near the main supply road (MSR) or the axes of evacuation. However, in the division area conditions are different. The very nature of the mission demands that division collecting points be located close to the front lines. In order to have the combat troops recover the materiel, the collecting point will have to be convenient to the troops. Combat troops have a battle mission to perform and are prone to forget others in carrying it out. Therefore, to make their job easier and to help achieve our objective, our collecting points should be pushed up as close to the front lines as is operationally and tactically possible. Experience has taught that it is wise to send the recovery and evacuation section ahead of the company to establish its own collecting point somewhere in the vicinity of the regimental command posts. In order to operate this close to combat units, maximum advantage must be taken of the terrain. Natural camouflage should be used to the utmost and dispersion used when camouflage fails. The collecting point should certainly be in a defiladed area. Masking hills between the area selected and the enemy will greatly assist in keeping artillery fire away. Due to the amount of equipment and the bulkiness and size of recovery and evacuation impedimenta, it is necessary to locate this point on good roads. The main supply road (MSR) or the axes of evacuation would be ideal if practicable. Due to the vulnerability of collecting points, it will be necessary to find a location that is surrounded by combat troops so that they may protect the installation from enemy patrols or attacks.

Large amounts of disabled and abandoned equipment will funnel through our collecting points; they must be stratigically located and efficiently operated.

Theoretically recovery is completed when we have removed our piece of abandoned equipment to the collecting point or a defiladed area; it is off the battlefield.

Evacuation Operations. Now evacuation begins. Evacuation is the transportation by service units (Ordnance) of recovered materiel which has been severely damaged from collecting points, points on the axes of evacuation, or maintenance establishments to insure the eventual return of this material for further service or its use as scrap.

It is convenient to divide materiel to be transported to the rear into three classes as follows:

1. Light ordnance materiel: Small arms and other light equipment which can be loaded into trucks for transportation.
2. Heavy ordnance materiel: Artillery, vehicles, and other equipment which cannot be loaded into trucks, but which can be towed on its own wheels.
3. Immobile ordnance materiel: Tanks and other equipment which cannot be loaded into trucks and which are so disabled that they cannot be towed.

Light Ordnance Materiel. Contact parties sent out by ordnance maintenance units will normally utilize their transportation facilities to the maximum in the return of disabled materiel to the rear by trucks going for ammunition or other supplies. The responsible maintenance unit will maintain a collecting point in the vicinity of the supply point at which this materiel will be taken over by ordnance personnel. This collecting point will be visited as required by a contact party which will move the materiel to the maintenance shop or make arrangements for further evacuation.

Heavy Ordnance Materiel. The decision to evacuate heavy ordnance materiel to a maintenance shop for repair will normally be made by personnel of a contact party or the ordnance representative at the collecting point. The commander of the contact party will make arrangements for the transportation. If the contact party is unable to retrieve the item, the recovery party from the ordnance company will be called upon to perform the operation. If the distance of evacuation is great and the materiel is of such a nature that excessive wear and tear or damage will be caused by towing, an ordnance evacuation company will be requested to move the materiel. For complete details on the operation of the ordnance evacuation company see Troop Units, Chapter 7, Volume I.

Immobile Ordnance Materiel. All cases of immobile ordnance materiel requiring repairs which cannot be accomplished 'on-the-spot' and which come to the attention of a contact party will be reported by the party to its unit headquarters. If the supporting maintenance company cannot send out a special repair crew or evacuate the item, additional help will have to come from higher headquarters—usually Army. Normally this assistance will be an evacuation squad from the evacuation company. If the retreiving is to be performed near the front lines, combat units will provide covering protection. Ordnance units will retrieve or evacuate materiel forward of the front lines only when directed by appropriate commanders.

Training Recovery and Evacuation Personnel. The successful completion of recovery and evacuation operations is largely dependent on the type, amount, and quality of the training of all the officers and men in the organization. Complete and thorough coverage of the following subjects is necessary for proper training. It should include:

1. Scouting and patrolling and small-scale infantry tactics.
2. Use of maps, aerial photographs, and compasses (quickly, accurately, and at night).
3. Driving of heavily loaded vehicles over extremely difficult terrain and roads in all sorts of weather at night.
4. Proficiency in the use of block and tackle, slings, rigging, etc., under blackout conditions.
5. Operation of all types of motorized and armored vehicles.
6. Aircraft recognition and antiaircraft fire with machine guns.
7. Marksmanship with all small arms including rocket and grenade launchers.
8. All types of mines, booby traps, and mine fields to include markings of friendly fields, defuzing, removal of mines, and actual operation of the engineer mine detectors. The knowledge gained along these lines should be used only in an emergency. (See Engineers and bomb disposal squads if possible.)
9. Demolition and destruction of ordnance materiel.

From the above it is obvious that all ordnance personnel must be thoroughly trained in many strictly military subjects prior to reaching the combat zone. Ordnance men must be technically proficient in order to recover, supply, and maintain all ordnance materiel; and, at the same time, they must be trained and prepared to fight as combat troops in the protection of their own materiel and comrades. They must have initiative, resourcefulness, and plenty of stamina.

Adequate and reliable signal communications are extremely vital to any successful recovery and evacuation program. Messenger and field telephone communication should be supplemented whenever possible by radio communication between ordnance battalion and company headquarters, collecting points, and recovery parties. Ordnance battalions should have their own organic radio operators and radios, but if this is not feasible, it may be possible to secure them on a loan basis from a signal battalion through the signal officer. Evacuation companies should endeavor to keep one liaison agent equipped with a radio set at collecting points that will probably receive large amounts of ordnance materiel. This will make for efficient operation. Messengers (trucks, jeeps) for transmission of technical and other ordnance information (to include location of disabled equipment, etc.) must be maintained between the ordnance headquarters coordinating the recovery efforts and the different collection points and recovery teams. Coordination is absolutely essential and only by establishing efficient signal communication can it be accomplished.

Captured Enemy Ordnance. During combat you will be confronted with the disposition of captured enemy ordnance. Sometimes the quantities will be great and on other occasions only small amounts will be encountered. In addition, some equipment will be of very recent design while other types will not be. Your program must meet all these contingencies.

During combat, captured material may be placed to immediate use by combat units to the extent required by the situation. Due to the inherent difficulties of supply and maintenance, however, it should not be the policy that such materiel be retained in use except for the immediate emergency.

Recently designed enemy ordnance must be thoroughly studied. Engineering studies of enemy ordnance are essential in order to obtain a knowledge of the capabilities and weaknesses of enemy weapons. These studies serve as a guide for the development of new materiel and also are an indication of the enemy's resources. Therefore, all units in the field must constantly be on the lookout for enemy ordnance of new design.

Ordnance Intelligence Personnel. Enemy ordnance captured on the battlefield should be turned over to specially trained crews of ordnance intelligence per sonnel who are operating in each theater. These trained crews prepare th captured material for shipment to the research center established in the theate for the purpose of studying new types of enemy ordnance. In addition, they ma

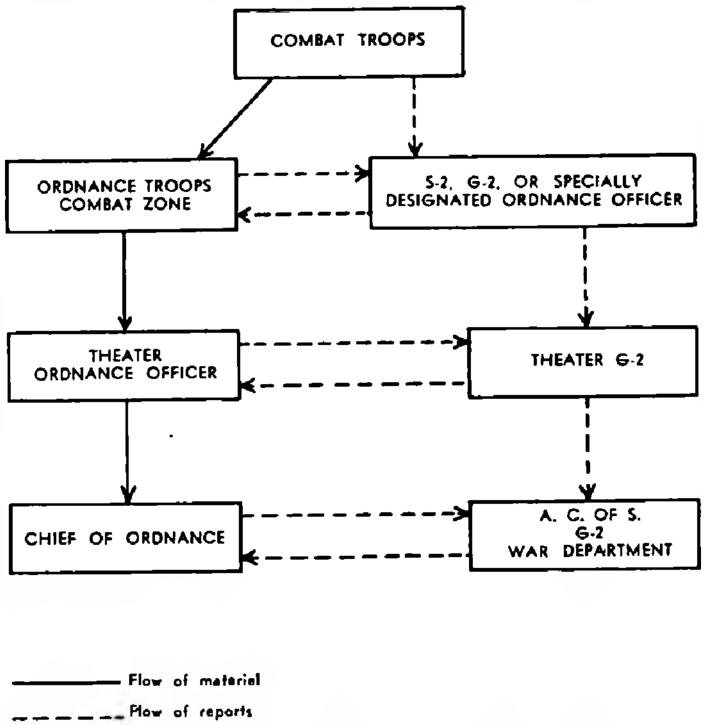


Figure 2. Flow chart for captured enemy ordnance.

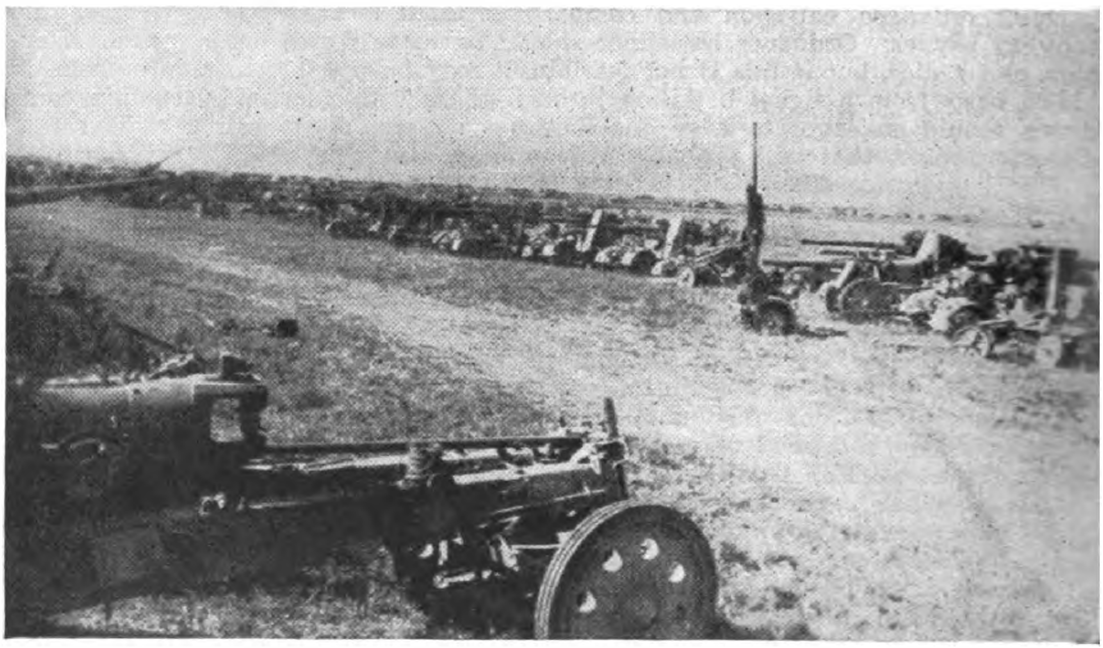


Figure 3. Typical collecting point for enemy ordnance.

prepare 'on-the-spot' descriptions for immediate use by the troops in the theater. The research center forwards reports and specimens of captured materiel to the zone of the interior so that a complete and accurate study, including highly technical tests, can be made. In the event that a research center has not been established in the theater, the equipment and reports are shipped directly to the research center in the zone of the interior. The accompanying flow chart shows the channels for the return of captured enemy ordnance.

It is important that name plates, serial numbers, and other pertinent data accompany the captured materiel when it is turned over to the ordnance intelligence crews by combat personnel. Care must be exercised at all times to prevent deterioration or damage through mishandling. Particular attention should be given to the evacuation of sighting equipment and optical instruments and the preservation of all accessories vital to the performance of the item. It is especially important that sighting and fire control equipment be plainly marked with the name of the weapon to which it applies.

Ordnance intelligence crews are small in number and have no organic equipment. As they work in conjunction with G-2, all units connected with recovery and evacuation must give them full cooperation. They are primarily interested in enemy ordnance of recent design and new enemy modifications. They supervise the disposition of enemy ordnance.

Therefore, when a large quantity of enemy ordnance is captured, it will have to be recovered by the regular methods prescribed in earlier paragraphs. In addition, combat units in fast moving situations cannot be counted on to recover too much enemy ordnance as they are interested in recovering their own equipment first. One can readily see that ordnance companies will have to recover the majority of the captured or abandoned enemy ordnance. Generally speaking, captured ordnance will be evacuated in the same manner and through the same channels as our ordnance and will in all cases be collected from the collecting points as rapidly as possible.

PRINCIPAL UNITS AND MAIN TYPES OF EQUIPMENT USED FOR RECOVERY AND EVACUATION

TABLE I

The equipment used and the units employed to accomplish recovery and evacuation are very numerous and varied. All types of combat and service units perform limited amounts of recovery. Infantry and Armored Service Companies perform large amounts of recovery while all Ordnance Maintenance Companies, including the Evacuation Company, perform recovery and evacuation. The list below gives the principal units employed and the main types of equipment used for recovery and evacuation.

UNIT	Truck: 2½ ton, with winch	Truck: Light Wrecker, 4 ton See fig. 5	Truck: Heavy Wrecker, 10 ton See fig. 8	Vehicle: Tank Recovery M 32 See fig. 12	Truck-Trailer, 40 ton, Tank Transporter. M-25 See fig. 14
Inf Div-Service Companies—Total	6	..	..	..	..
Inf Div Arty—Total	..	1	..	..	..
LIGHT MAINT CO	..	2	1	..	..
Three Armd Div Tank Bn's—Total	..	..	6	15	..
Three Armd Div Inf Bn's—Total	..	..	3	3	..
Three Armd Div F.A. Bn's—Total	..	..	3	6	..
ORD ARMD MAINT BN	..	..	11	..	9
MEDIUM MAINT CO	..	1	1	..	..
HVY MAINT CO (A)	..	..	2	..	..
HVY MAINT CO (FA)	..	..	2	..	..
HVY MAINT CO (T)	..	..	2	..	2
EVACUATION CO	..	..	3	..	18

Description of Vehicles Used for Recovery. In the following paragraphs a general description of each vehicle used for recovery and evacuation will be given.

Truck, Wrecker, 4-Ton, 6 x 6 (Light Wrecker)

Description. *General.* The truck, wrecker, 4-ton, 6 x 6, is used primarily for light recovery operations of wheeled vehicles only. The integral equipment on this wrecker includes two side booms with winches; two supporting telescoping brace legs; and a front winch used as an anchor, and, if necessary, as a means of recovering the wrecker itself. Since each boom winch has a top capacity of only 10 tons, it is not practicable to attempt heavy tank recoveries or recoveries of wheeled vehicles that are bogged down or disabled in such a manner that the strain produced would exceed 10 tons.

Booms. This wrecker features two free-swinging manually operated booms mounted at the corners of the boom frame just behind the cab. Each boom can be drawn through a 90° arc and is raised and lowered by a crank winch mounted in the drum housing at the base of the boom. A ½" topping cable is strung on each boom to give it support. When in the traveling position, the booms are fastened together with a snap pin at the top of the booms and anchored by the cable hooks in the safety rings on the bolster body. See figures 4 and 5.

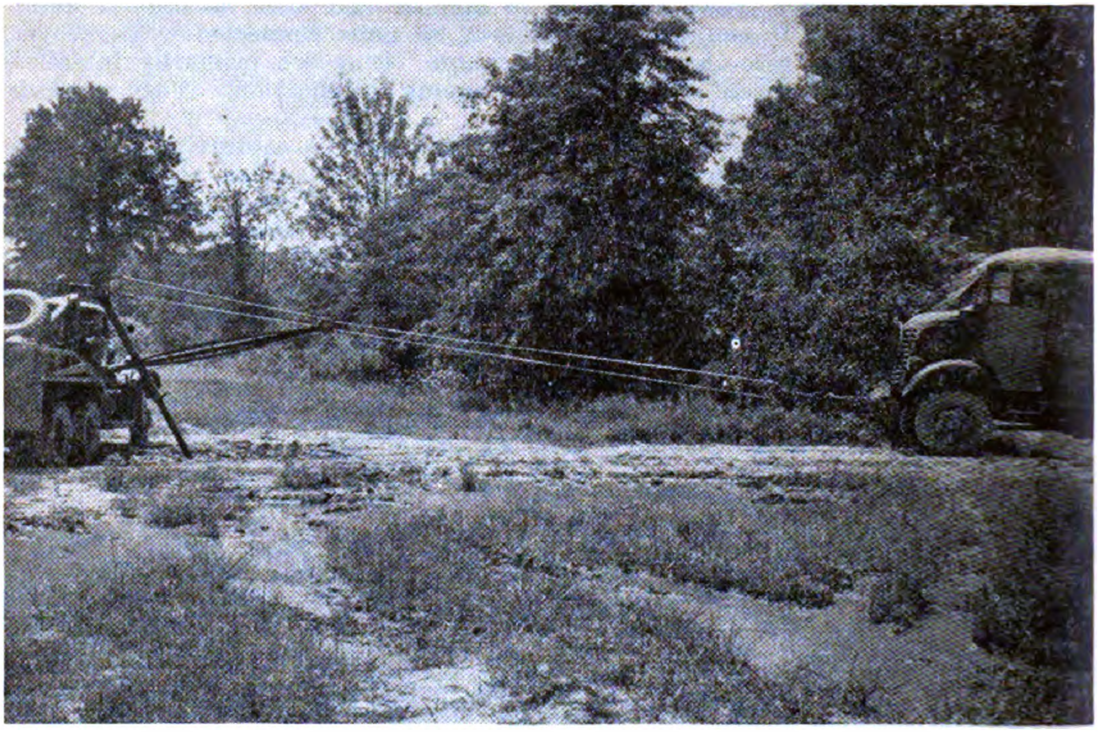


Figure 4. Recovering with right side winch, Truck, Wrecker, 4-ton, 6x6.

Brace Legs. To provide support for the booms in lifting operations, this wrecker is equipped with brace legs, one mounted on each side of the boom frame. The legs are the tubular telescoping type, the upper and outer portions being pinned to swivels mounted on the boom frame. The lower or sliding portion of each leg is equipped with a steel ground plate, to which a chain is secured. This chain, with a grab hook on the free end, limits the movement of the leg and prevents it from being kicked out under a load. In travel, each brace leg is held in its nesting position by a spring pin, located near the bottom of the outer tube, which passes through a corresponding hole in the inner tube.

Winches:

Front-winch capacity, direct pull ....15,000 lb.
Front-winch capacity, two lines ....30,000 lb.
Boom-winch capacity, direct pull, each ....10,000 lb.
Boom-winch capacity, two lines, each ....20,000 lb.

Recovery and Evacuation Equipment. The following is a list of the recovery and evacuation equipment carried on the 4-ton wrecker:

a. Left Rear Tool Box. The tool box mounted on the left rear side of the wrecker on top of the body contains the following welding equipment:

1 Box, tool, welder's	1 Hose, coil, welding, complete
5 Tips, welding	1 Hose, trailer, air brake
3 Tips, cutting	1 Hose, air, tire inflation

- 1 Regulator, acetylene
- 1 Regulator, oxygen
- 1 Wrench, torch
- 1 Hose (for air compressor)
- 1 Torch, cutting
- 1 Torch, welding

b. *Right Rear Tool Box.* This tool container, mounted opposite the left rear tool box, contains the equipment listed below:

- 1 Anchor, w/10 stakes (Holmes), 3 pieces
- 2 Blocks, snatch, single-sheave (1/2" cable cap.)
- 1 Block, snatch, single-sheave (5/8" cable cap.)
- 1 Block, rope, double-sheave
- 1 Block, rope, single-sheave
- 2 Chains, tow, 5/8"
- 1 Chain, tow, 7/16", utility
- 1 Bar, tow, universal
- 2 Clamps, steering-gear
- 1 Bar, tow, V-shaped
- 2 Cranks, operating
- 1 Sledge

c. *Rear Frame Tool Box.* This tool box, located at the rear of the wrecker between the side members of the frame, contains the following material:

- 1 Bag, tool
- 1 Crank, starting
- 1 Jack, hydraulic, 5-ton
- 1 Pliers, slip-joint, 6"
- 1 Wrench, wheel bearing nut (front)
- 1 Wrench, wheel bearing nut (rear)
- 1 Gun, lubr., lever-type, high pressure
- 1 Wrench, wheel, stud nut

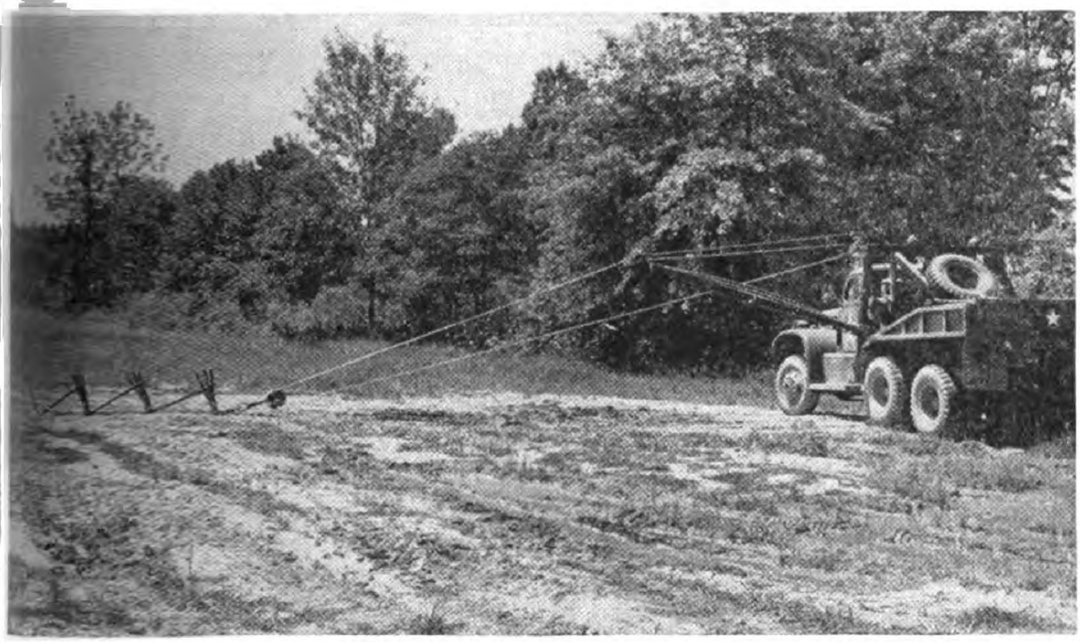


Figure 5. Anchoring with left side winch, Truck, Wrecker, 4-ton, 6x6.

d. *Mounted on the Wrecker.* (1) On each of the left and right rear tool boxes will be mounted one pick mattock, one ax, and one D-handle shovel.

(2) On the wrecker itself will be one acetylene cylinder, one oxygen cylinder, one crowbar (6'), and one rope (300').

(3) On the right outer side of the wrecker body is mounted a straight tow bar for use in recovering and towing wheeled vehicles.

(4) Located in the chassis cab are 9.00 x 20 tire chains for both the front and rear tires.

Truck, Wrecking, Heavy, 10-Ton

Types. This wrecker has been manufactured in several different series, but, on the whole, the differences between these series have been minor. The few major changes between the various series are: the lack of a rear winch on the series 1; a curved boom with double sheave or pulley positions on some of the series-4 models; double pulley positions and power-operated boom on the series 5.

Since the series 5 is the latest wrecker at the writing of this manual, the data, description, and operation discussed will be for this series. The wrecker which the reader may be operating may not compare in all respects with the one described here, but the operation of the integral recovery and evacuation equipment, the primary concern of this chapter, does not differ to any great extent, and the proper use of this equipment should be easily determined.

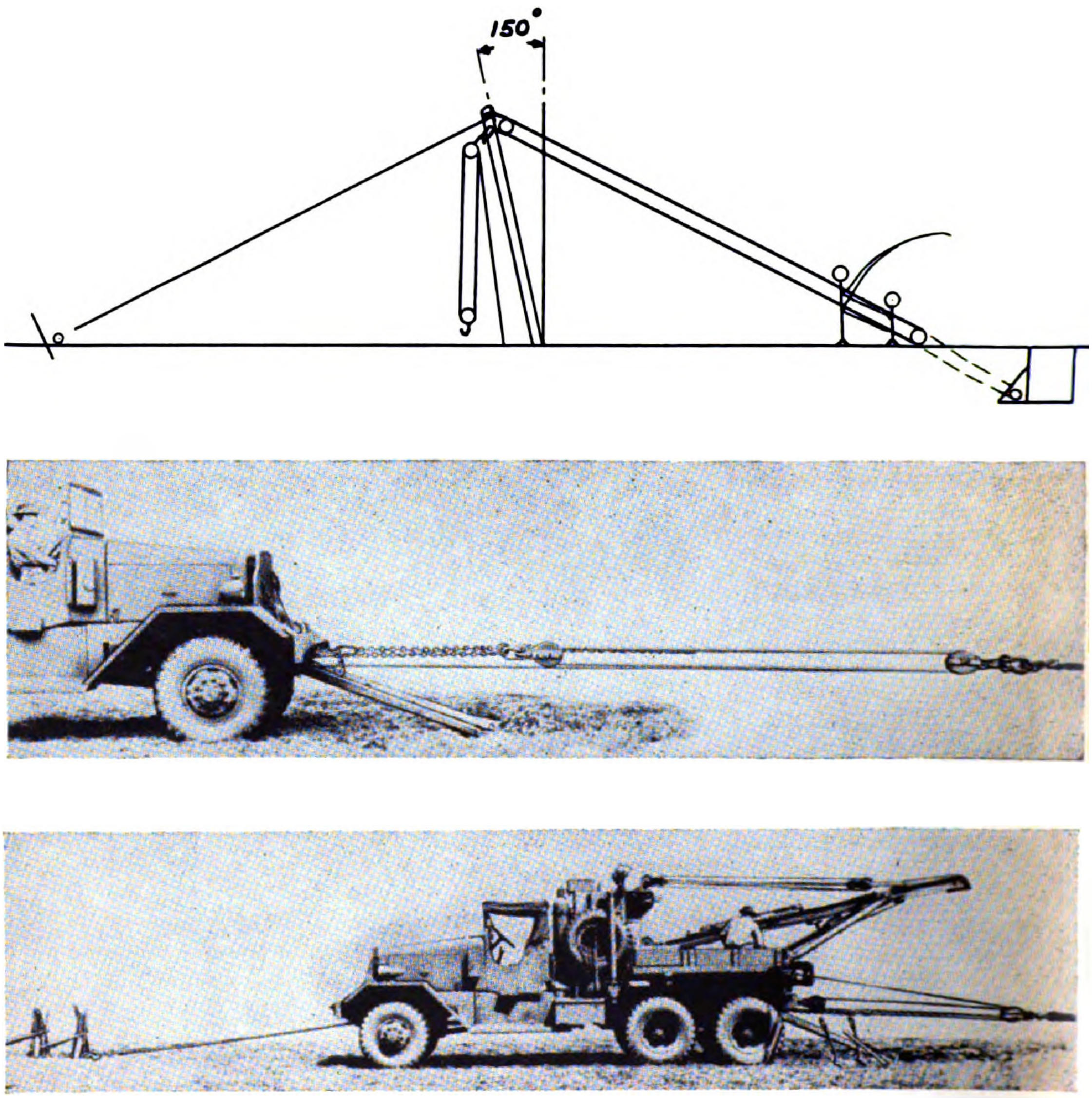


Figure 6. Use of Winches, Truck, Wrecking, Heavy, 10-ton 6x6.

Uses. This wrecker is an all-around recovery and evacuation vehicle. Its winch capacities are adequate for all but heavy tank recoveries, and its towing facilities are adaptable for hauling practically all vehicles into collecting points. The use of this wrecker in a field shop is not within the scope of this manual, but the vehicle is quite useful in lifting motors, turrets, etc., out of disabled vehicles.

Integral Equipment. *General.* The integral recovery equipment of this wrecker includes three winches—front, rear, and crane. Each winch has a separate set of controls, which are usually operated singly and not in conjunction with each other. Although the boom and body jacks, outriggers, and ground spades are not integral equipment, they are used in almost every recovery operation. Each of these mechanisms or pieces of equipment is described in this paragraph.

Front Winch. The front winch is power-driven from the transfer-case power

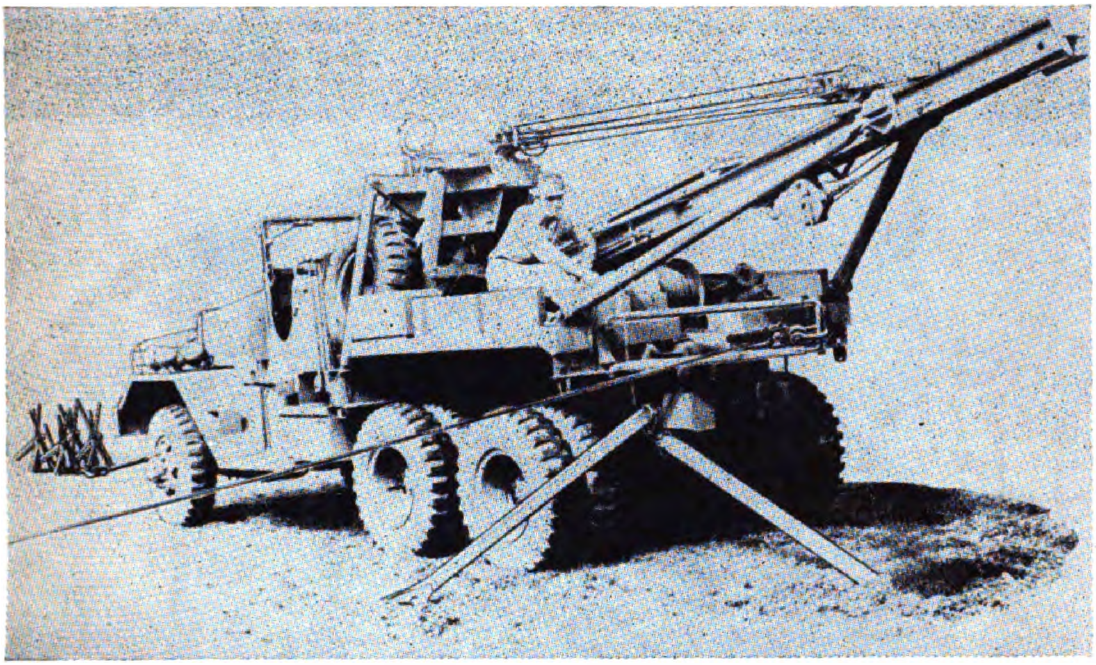


Figure 7. Rear-winch Angle of Recovery.

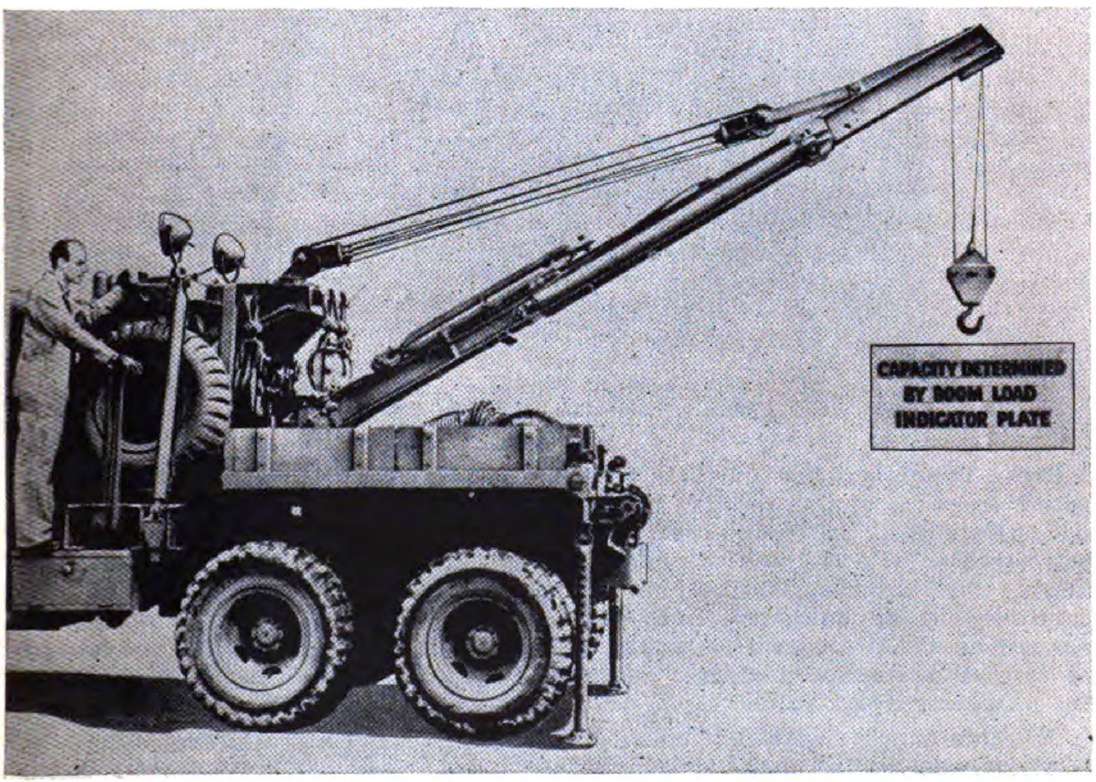


Figure 8. Rear Lift, 16,000-lb. Capacity.

take-off through a lay shaft and has a direct-pull capacity of 20,000 lb. with one cable. The 300′ x ⅝″ cable has a 4′ chain and hook attached to it.

Rear Winch. This power-driven winch receives its energy from the transfer-case power take-off through a gear box which has two speeds forward and one speed in reverse. Using only one cable, this winch has a maximum direct pull of 47,500 lb. The cable, made of preformed plow steel, is ¾″ in diameter and 350′ in length, having a 6′¾″ chain and hook attached.

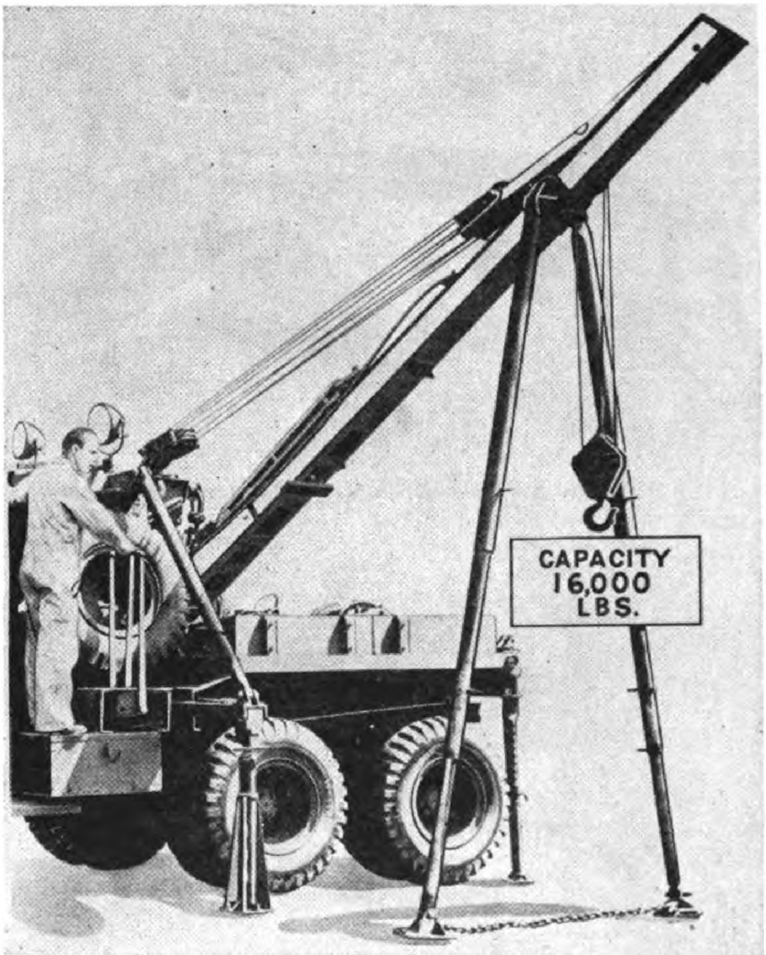


Figure 9. Side Lift, 16,000-lb. Capacity.

Crane Winch and Boom. (1) The crane on this wrecker is operated entirely by power from the engine through the power take-off mounted on the transfer case. All operations of the boom—raising, lowering, and swinging—are accomplished by worm-geared winches and a swinger. One clutching gear case is provided for driving the load hook and topping and swinging the boom, each operation being controlled by an individual hand lever located at the side of the crane frame. An engine throttle control is installed at the left of the levers for the purpose of regulating the speed of operation. Also installed at the left of the levers is the swinger cut-out valve.

(2) This wrecker's straight boom is equipped with two boom hook line sheave positions, one located at the end of the boom and the other approximately 3′ from the end. The movable double sheave may be fitted in either position. The capacity of this crane will vary with the boom's elevation and the position of the boom hook line sheave. The operator can determine the crane capacity by consulting the indicator plate at the base of the boom.

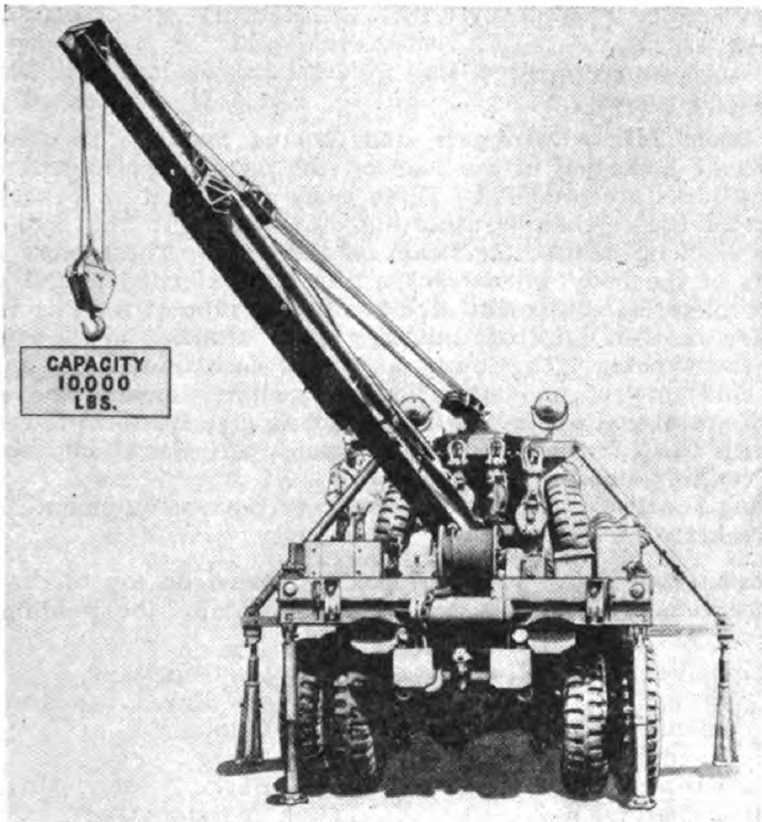


Figure 10. Lift and Swing, 10,000-lb. Capacity.

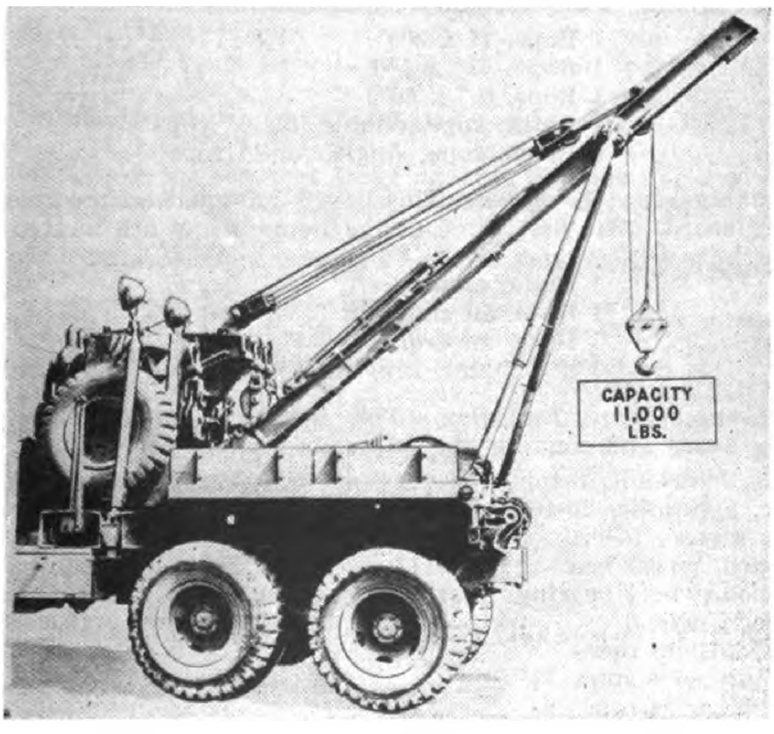


Figure 11. Lift and Transport, 11,000-lb. Capacity.

Crane:

Capacity	16,000 lb.
Swinging arc	180°
Front winch capacity, direct pull	20,000 lb.
Rear winch capacity	47,500 lb.

Body and Boom Jacks, Outriggers, and Ground Spades. To give the vehicle stability and take a portion of the load off the wrecker springs when making a recovery, body jacks are provided. These jacks are placed in sockets in the body corners when in use. When transporting or lifting with the boom, telescoping boom jacks are set up to take the strain off the boom. These jacks are anchored to the corners of the body when transporting and extended to the ground when lifting. Other pieces of equipment used to provide support for this wrecker when engaged in side recoveries include outriggers, one attached to the crane frame on each side of the wrecker. The lower portion of each telescoping outrigger (outrigger jack) folds inward under the body immediately behind the cab in travel. Ground plates are placed under this equipment to give it a firm foundation. When recovering with the front winch, ground spades are placed into sockets on the front bumper to help stabilize the wrecker.

The following is a list of the recovery and evacuation equipment carried on the M1 heavy wrecker.

a. Boom-frame Tool Box. This tool box is located on top of the boom frame behind the acetylene and oxygen cylinders. It contains the welding and cutting equipment.

4 Tips, welding, 2″, 4″, 6″, 8″
2 Tips, cutting
1 Hose, welding, 50′ coil
1 Torch, welding
1 Torch, cutting
1 Regulator, acetylene
1 Regulator, oxygen
1 Wrench, torch
1 pr. Goggles
1 pr. Gloves, asbestos
1 Lighter
1 Mixer
1 Bucket, water, canvas, M1
4 Reflectors, red
2 Reflectors, amber

b. Rear Body Tool Box. The rear body tool box is located immediately under the boom. It contains block-and-tackle equipment.

1 Rope, 1″ x 300′
1 Rope, ¾″ x 100′
1 Rope, ⅜″ x 50′
1 Block, rope, double, for 1″ rope
1 Block, rope, single, for 1″ rope

c. Left Running-board Tool Box. This box is mounted on the rear of the left-hand running board. The first three of the items below are located in a tray in the top of the box.

1 Light, trouble
1 Hose, air inflation
1 Hose, air trailer
3 pr. Chains, tire, 11.00 x 20

d. Right Running-board Tool Box. This box is mounted on the rear of the right running board and contains the following equipment:

2 Jacks, hydraulic, 8-ton
1 Jack, hydraulic, 30-ton
1 Gun, grease, 16-oz.
1 Wrench, wheel bearing (front)
1 Wrench, wheel bearing (rear)
1 Wrench, wheel
1 Kit, tools, 13 items
6 Clamps, wire rope, ¾″
6 Clamps, wire rope, ⅝″
6 Thimbles, ¾″
6 Thimbles, ⅝″
2 Shackles, anchor, round pin
1 Hook, for chain or cable
1 Vise, 5″
2 Clevises, #1000-383
2 Clevis pins, #1000-725
2 Chains, tow, 12′

e. Long Body Tool Box. This box is mounted on the right side of the body of the wrecker.

1 Saw, crosscut, 4'6"
1 Saw, crosscut, 26"
2 Crowbars, ⅞" x 42"
2 Bars, wrecking, ¾" x 30"
1 Frame, hacksaw, adjustable, 8" to 12"
12 Blades, hacksaw, 12"
1 Cutter, bolt, ⅝"
2 Chisels, 1" x 24"
1 Chisel, blacksmith, 1-¾"
1 Punch, blacksmith, ⅜"
1 Wrench, pipe, 18"
1 Wrench, monkey, 21"
1 Screwdriver, 6"
1 Screwdriver, 12"
1 Screwdriver, 18"
1 Pliers, heavy-duty, 10"
1 Cutter, diagonal
1 Hammer, straight claw
6 Pins, shear, front winch
6 Pins, shear, rear winch
2 Pins, shear, boom swinger
1 File, hand, smooth, 8"
1 File, 3 sq., smooth, 6"

f. Blackhawk Tool Kit. This box is mounted on the left side of wrecker body and contains a set of Blackhawk mechanic's tools.

1 Heavy-duty socket set (¾" square drive)
1 Normal-duty socket set (½" square drive)
1 Light-duty socket set (⅜" square drive)
1 Extra light duty socket set (¼" square drive)
3 ea. Wrench, box, long
3 ea. Wrench, box, short
6 ea. Wrench, engineer's, regular
4 ea. Wrench, engineer's, midget
1 ea. Wrench, tappet, size—½" x 9/16"
1 ea. Wrench, tappet, size—⅝" x 11/16"
1 ea. Wrench, tappet, size—¾" x ⅞"

g. Mounted on the Truck. (1) Pioneer equipment consisting of one ax, one pick mattock, two round-point shovels, and two sledges is mounted on either side of the wrecker below the cab doors.

(2) Five fire extinguishers are carried—two on the boom frame, two on the rear of the cab, and one inside the cab.

(3) A spare-parts kit is located under the cab seat.

(4) Also in the cab are two battery lanterns and the starting crank.

(5) Two boxes of flares are located on the right side of the wrecker, fore and aft of the cab door.

(6) The whiffletree assembly is mounted on the front bumper.

(7) The directional angle pull bracket is attached to the rear body bolster.

(8) Mounted on the boom assembly are the tow bar, the tow cable, and two single snatch blocks.

(9) The two double snatch blocks are in a rack on top of the right running-board tool box.

(10) In the bed of the wrecker body are the Holmes anchors (four pieces with 14 stakes), two crowbars (1-¼" x 5'), one crane snatch block, and the two body jacks.

(11) The spades and legs are mounted in brackets alongside the body frame.

Vehicle: Tank Recovery, M32 Series

Types. Tank recovery vehicles are designed exclusively for recovery work and must be capable of doing the heavy work of removing disabled tanks from rough terrain and towing them to the axis of evacuation. The tank recovery vehicles of the M32 series are built on the chassis of the M4 medium tanks and are of several types:

a. M32—welded hull, radial engine.
b. M32B1—cast hull, radial engine.
c. M32B2—welded hull, G.M. Diesel engine.
d. M32B3—welded hull, Ford engine.
e. M32B4—welded hull, Chrysler engine.

Description. The tank recovery vehicles of the M32 series are the standard M4 medium tanks with the following modifications:

a. The turret and basket, ammunition racks, and Homelite auxiliary generator have been removed.

b. An irregular-hexagon-shaped fixed turret has been added, with an antiaircraft

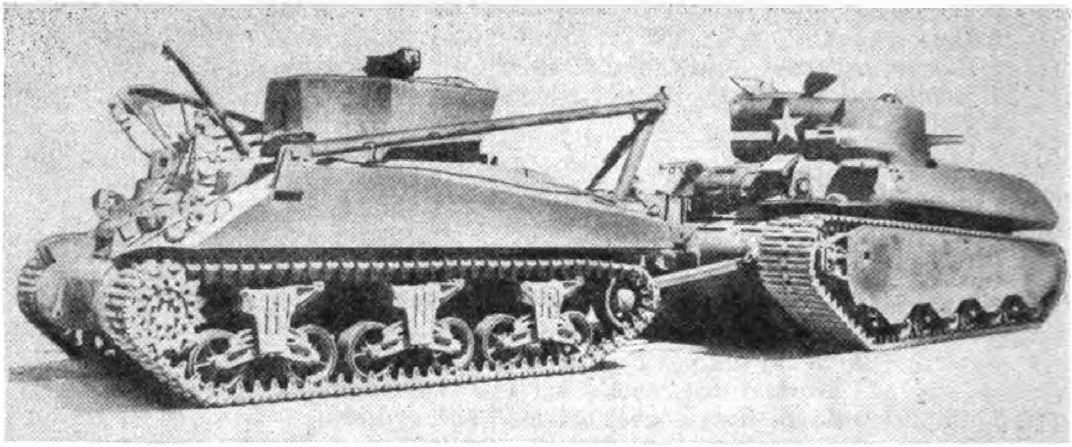


Figure 12. Tank Recovery Vehicle, M32, Towing Heavy Tank.

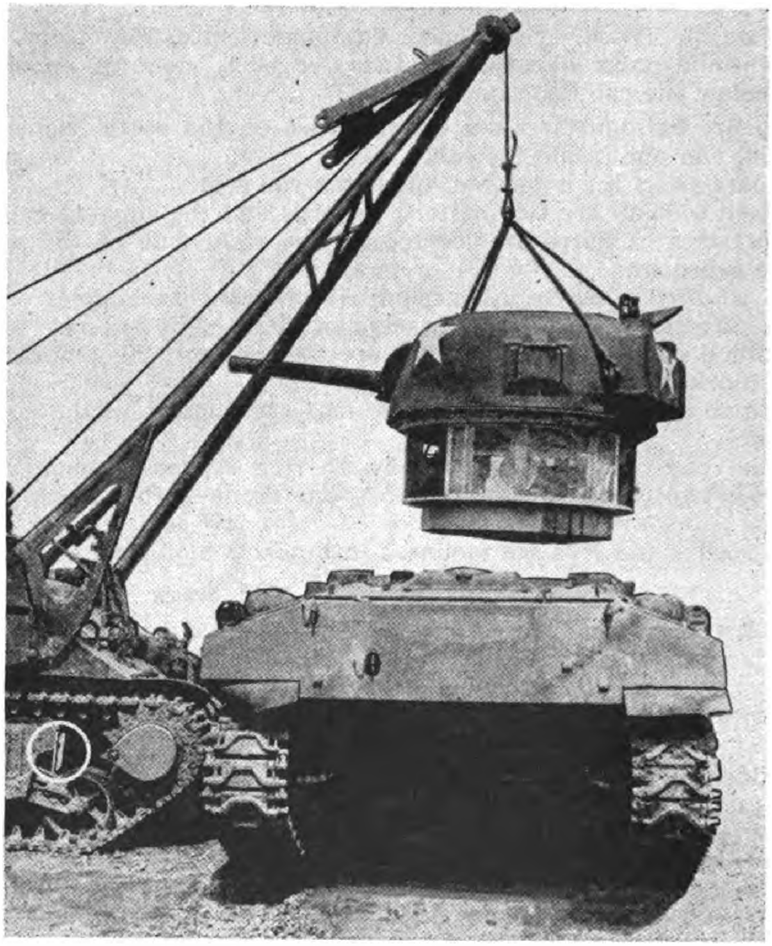


Figure 13. M32B3, Tank Recovery Vehicle Lifting Turret.

ring mount and a hatch in the top and a pulley front and rear for the winch cable. The turret does not rotate.

c. A winch has been installed on the floor slightly forward of the center of the turret.

d. An A-frame-type boom of 5″ seamless steel tubing has been mounted on the forward part of the sponsons, pivoted so that it may be used in either the carrying position (folded to the rear) or the raised position (erected on the front and secured by a cable).

e. The drive for the winch comes from a chain sprocket that is built on the front end of the propeller-shaft companion flange. The controls for the winch are mounted directly to the rear of the driver and are operated by the driver from the driver's seat.

f. The winch line can be threaded out through a plate in the front of the tank or through the turret over pulleys to the front or rear.

g. An 81-mm mortar is mounted on the front of the vehicle for the purpose of laying smoke screens during battlefield recovery operations.

Uses. *a.* The M32 tank recovery vehicles are full-track units intended for recovery of tanks from the battlefield. Operated by a six-man crew, they are capable of a number of operations. They are the only pieces of equipment specifically and solely designed for recovering tanks and other equipment from difficult terrain, and, if properly used, will tow anything up to and in some cases exceeding their own weight.

b. Some of the basic operations of which these vehicles are capable are listed below. This list can be expanded as the initiative and ingenuity of the operating personnel allow.

(1) Towing light, medium, and heavy tanks cross-country and on highways, either with tow chains or with a tow bar.

(2) Winching tanks out of mudholes, sand, and soft ground, and up slopes. On occasion the recovery vehicle may have to be deadmanned to another medium tank to pull out the object of recovery.

(3) Removal of turrets from medium tanks.

(4) Lifting either a side, the front, or the rear of a medium tank with the boom in the carrying position in order to replace a thrown track. In some cases, using the boom in the raised position, the side of a tank can be raised for work on the suspension system.

Data. Each type of vehicle in the M32 series varies in the same respects as the models of M4 medium tanks. The M32B3 recovery vehicle is representative of the various models in use. The characteristics of the M32B3 are as follows:

Chassis:

Weight, total	62,070 lb.
Length	23′3″
Width	9′1½″
Height	9′8″
Clearance	1′5⅜″
Height of rear pintle above ground	1′8″

Winch:

Type	Gar Wood, Model 6M
Capacity	60,000 lb.
Drive	Sprocket attached to front companion flange on propeller shaft
Clutch	Engine clutch
Clutch operation	Pedal operated by driver
Transmission	One speed forward, one reverse
Speed (1,400 r.p.m.):	
Out	43.5 ft./min.
In	17.1 ft./min.
Maximum engine speed on heavy pulls	1,000 r.p.m.
Drum dimensions:	
Width	14½″
Diameter (O.D.)	8″
Flanges (O.D.)	19¾″
Capacity	200′ of 1″ cable

Boom:

Type	A-frame
Material	5″ seamless steel tubing
Length	18′ 4¼″
Pulley on end of boom	8″
Pulley on inside of turret	6″
Capacity	30,000 lb.

The M32 series of tank recovery vehicles is equipped with apparatus for towing and lifting loads, for protecting the crew, and for laying down smoke screens when the occasion demands. The equipment carried in and on the M32 tank recovery vehicles, excluding tools and spare parts for the repair of the vehicles themselves, is as follows:

a. Armament and Accessories:

1 Gun, Thompson, submachine, cal .45, M1928A1
1 Gun, machine, cal .30, M1919A4 (Flex.)
1 Gun, machine, cal .50, M2, H.B. (Flex.)
1 Mortar, 81mm, M1
1 Mount, tripod, machine gun, cal .30, M2

b. Ammunition:

5 Grenades, hand, fragmentation, Mk. II
15 Grenades, hand, smoke, WP, M15
20 Pots, smoke, HC, M1
30 Shells, smoke, 81mm, M57
300 Cartridge, cal .50 (80% A.P., 20% tracer)
600 Cartridges, cal .45
2,000 Cartridges, cal .30 (80% AP., 20% tracer)

c. Radio:

Interphone system, RC-99

d. Recovery Accessories and Equipment:

2 Chains, roller, f/winch drive
2 Chains, winch
20 Clamps, 1″ cable (Crosby)
4 Clamps, ⅜″ cable (Crosby)
6 Cables, ⅝″ dia., 4′ long, w/eye in each end
1 Chain, 6′, ¾″ dia., high tensile steel, w/large clevis at each end
2 Chocks, steel, fabricated
6 Eyes, lifting (to fit tapped holes in M4 turret)
6 pr. Gloves, leather
2 pr. Mittens, asbestos
1 Net, camouflage, 45′ x 45′
1 Lamp, inspection
2 Lanterns, electric, portable, 6-volt
2 Poles, hold-off
6 Shackles, tank
1 Bar, tow
2 Blocks, snatch, single, w/clevis, f/1″ cable
1 Rope, manila, ½″ x 50′
1 Sling, 3-chain
1 Spotlight, demountable, w/reel
1 Tarpaulin, 12′ x 12′
1 Bucket, canvas, folding
1 Tube, flexible nozzle
1 Ax, chopping, single bit, 5-lb.
1 Crowbar, pinchpoint, 5′
1 Mattock, pick, M1, w/handle
1 Shovel, short handle
1 Sledge, blacksmith, double-face, 10 lb.
2 Plates for relieving pressure on volute springs under heavy loads

e. Sets of Maintenance Tools:

1 set, Company special tools for each of the following type vehicles (1 set for each 2 recovery vehicles):

Half-tracks, M2 and M3
¾-ton chassis (37mm gun motor carriage, M6)
Truck, 2½-ton
Truck, ¼-ton
Medium tank, M4

1 set, Company spare parts for each of the following type vehicles (1 set for each 2 recovery vehicles):

Half-tracks, M2 and M3
Medium tank, M3

5 sets each of the following tools (5 sets carried in 2 recovery vehicles):

Mechanic's hand tools Special mechanic's tools for medium tank, M4.

The recovery of disabled tanks under actual battle conditions is a complex problem which has received extensive attention in the Ordnance department. A suitable remote control recovery hook, incorporating the characteristics set forth by the Armored Board and designed for use in conjunction with the M32 Series Tank Recovery Vehicles, has been developed and tested. It is used in combination with wire rope bridles attached to the front and rear of the vehicle and permits recovery of disabled tanks under practically all conditions within the ability of the recovery unit without exposing the crew. Recent information indicates M32 Tank Recovery Vehicles will be supplied with the hook mechanism and mounting bridle.

Truck, Trailer, 40-Ton, Tank Recovery, M25

The Truck, Trailer, 40-ton, Tank Recovery, M25, is a major combination consisting of the Truck, Tractor, M26, and the Trailer, Semi, M15. It is designed for use in recovering and evacuating disabled materiel and is capable of handling one medium tank, or two light tanks. Also it is capable of handling gun motor carriages, trucks, and other pieces of ordnance equipment.

The M25 may be used either as a unit or with the two components disassembled. When the tractor-truck and the trailer are coupled, the unit is capable of a variety of winching operations and of transporting up to 40 tons. The tractor-truck alone may be used as a recovery vehicle, since it is equipped with one front winch, two rear winches, and a collapsible vertical lifting device of the A-frame type. The semi-trailer, when detached from its prime mover, may be loaded and made ready for travel in the absence of the tractor-truck, since its front end may be made to rest on skids supported by collapsible legs.

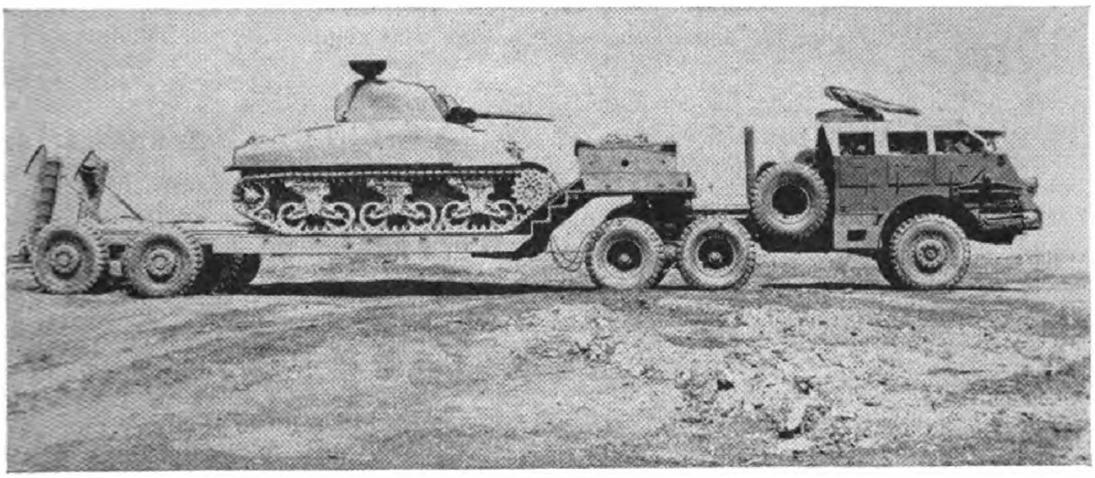


Figure 14. Truck, Trailer, 40-ton, Tank Recovery, M25

The combination is capable of a wide variety of operations because of its ability to maneuver in all types of terrain. The tractor-truck is powered by a water-cooled in-line gasoline engine rated at 240 hp. at 2,000 r.p.m. and has two front and four dual rear wheels, all of which may be engaged when soft ground or steep slopes are encountered. Both sets of rear wheels are chain-driven from a common differential. The semi-trailer has eight wheels. Walking beams, oscillating on trunnion shafts, are fastened to the main frame, thereby allowing any one wheel to pass over a 9" obstacle with all other wheels remaining in contact with the ground.

It is impossible to make a complete listing of the operations that the M25 unit can perform. The versatility of the vehicle depends on the training and inventive capacity of the crew. The transporter can be a self-sufficient recovery and evacuation vehicle by itself if properly handled. Despite its size, it can move through mud and sand with comparative ease. Because of its equipment, it can free badly mired materiel and tow it to firm ground or to a position suitable for loading onto the trailer. A few of the operations of which the M25 is capable are listed below:

It can recover and tow any vehicle the Army uses, including heavy tanks.

It can transport for any distance one medium tank or gun motor carriage built on a medium tank chassis, or two light tanks or comparable vehicles, and all other equipment (wheeled or tracked) up to a weight of 40 tons.

Vehicles with damaged tracks, bogies, or wheels can be recovered onto the semitrailer. Special skids and two winches are provided to speed this operation.

Foreign equipment similar to that used by the United States can be recovered and transported without trouble. The trailer wheels may be moved closer together or farther apart to accommodate vehicles of different widths.

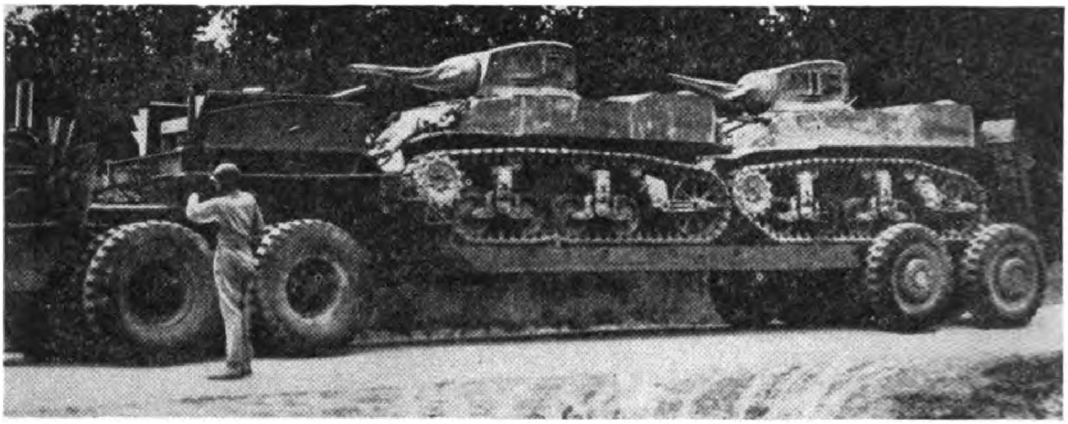


Figure 15. Semitrailer, M15, Carrying Two Light Tanks.

When the tractor-truck is separated from the trailer, it can perform most of the functions of a heavy wrecker. It can assist in putting on tracks and in transporting engines, tracks, gun tubes, and differentials; and it can pull disabled vehicles off the semitrailer itself. It can tow vehicles in the same manner as the heavy wrecker.

Data. The essential weights and measurements of the Truck, Trailer, 40-ton, Tank Recovery, M25, are as follows:

Truck, Trailer:

Weight	84,400 lb.
Length	57'4"

Tractor-Truck:

Weight	48,300 lb.
Length	25'4"
Height	11'5½"
Width	10'10¾"
Wheelbase	14'4"
Ground clearance	14½"
Fording depth (limited by ignition coils)	59"

Trailer:

Length (ramps up)	38'5⅛"
Length (ramps down)	44'2"
Height (highest point)	9'
Height of bedplates	40"
Width, wheels out (maximum)	12'6"
Width, wheels in (minimum)	10'4"
Rated capacity	40 tons

Capacities:

Front axle	13 qt.
Front axle universal drive	4 qt.
Rear axle	12 qt.
Engine oil (refill)	24 qt.

Fuel (two tanks), 72-octane gasoline	120 gal.
Radiator	15 gal.
Transfer case and auxiliary transmission	6 qt.
Transmission	9 qt.
Steering gear	1½ qt.
Hydraulic power steering system	3 qt.
Chain oiler, each side	8 qt.
Air cleaner	2 qt.
Worm-gear case	3 qt.
Jaw-clutch gear box	8 qt.

Tires:

Size	14.00 x 24
Number of ply	20
Air pressure	90 lb.
Tread	Nondirectional

Winch capacities (direct pull):

Front	47,500 lb.
Rear (each)	80,000 lb.

Recovery and Evacuation Equipment. The following list covers the recovery and wrecking equipment carried on the M25 truck, trailer, together with the approximate location of the equipment on the vehicle:

Tool Box. The tool box is located on the left side of the truck in front of the dual wheels and contains the vehicular tools. In addition, the following wrecking and recovery equipment is carried there:

1 Jack, hydraulic, 20-ton. w/handle
1 Tarpaulin, 12′ x 12′
1 roll Wire, soft iron, 14-gage, 10′
2 Tubes, flexible nozzle
1 Vise, 5″, on removable bracket
1 Wrench, adjustable screw, 18″
1 Wrench, pipe, 18″

Blackhawk Mechanic's Tools. A tool box mounted inside the cab and at the rear of the engine contains a complete set of Blackhawk mechanic's tools. For a list of these tools, see the tool list for the heavy wrecker, M1.

Tool Box Under Floor Plate to Rear of Engine. The tool box located inside the cab under the floor plate, directly behind the engine and to the rear of the Blackhawk kit, contains the following equipment:

1 Bar, wrecking, ¾″ x 30″
10 Blades, hand, hacksaw, 10″
1 Bucket, canvas, folding
1 Chisel, cold, blacksmith, w/handle (1½″ cut, 14-17″ handle)
2 Chisels, 1″ x 24″
7 pr. Gloves, leather
1 Hammer, claw, 20 oz.
1 Hacksaw, adjustable, 8″-12″
1 Hose, air-brake, 13½′
1 Kit, tire-repair (cold patch)
3 Lamps, electric, portable, 6-volt
1 File, hand, smooth, 8″
1 File, 3-square, smooth, 6″
1 Lamp, trouble, w/50′ cord
1 pr. Mittens, asbestos
1 pr. Pliers, combination, slip-joint, 8″
1 pr. Pliers, side-cutting, 8″
1 Screwdriver, 3″ blade
1 Screwdriver, 6″ blade
1 Screwdriver, 10″ blade

Tools on Tractor-truck. The following tools are mounted on the outside of the tractor-truck.

1 Cutter, bolt, capacity ⅝″—above engine on cab roof
6 Flares—at rear of cab by left door
1 Bar, tow, tank—at front of cab, below radiator
2 Sets pioneer tools—one set on each side of tractor-truck and each consisting of the following:
  1 Ax, chopping, single-bit, 5-lb.
  1 Handle, mattock
  1 Mattock, pick, M1
  1 Shovel, short handle
  1 Sledge, blacksmith, double-face, 10-lb.
  1 Kit, welding, containing cutting tips, hose, head, goggles, and instructions—located under rear seat next to left door

Recovery Equipment on Semitrailer. The following items of recovery equipment are carried on the semitrailer, M15:

1 Saw, crosscut, w/handle
2 Jacks, hydraulic, 20-ton, w/handles
1 Jack, hydraulic, 30-ton, w/handle
1 Saw, crosscut, hand
1 pr. Pliers, combination, 6"
1 Wrench, adjustable
1 Hammer, ball peen, 1½ lb.
1 Wrench, calk
1 Screwdriver, 5/16" x 6"
1 Crane, hoist, and accessories
2 Boards, jack, ground
4 Blocks, snatch, 16"
1 Tread, plank, curve
1 Sling, wire rope
1 Block, snatch, single, 6"
1 Block, snatch, double, 8"
2 Skids, channel
2 Skids, removable
4 Covers, wheel
1 Coil rope, hemp, ⅜"
1 Coil rope, hemp, ¾"
1 Coil rope, hemp, 1"
1 Cable, jumper, light
2 Hoses, air
2 Chains, tow
4 Chains, utility
2 Chains, anchor
1 Plank, loose tread (bottom)
2 Planks, loose tread (frame)
4 Planks, loose tread (front)
1 Plank, loose tread (skid)
20 Stakes, ground anchor
6 Anchors, ground
2 Bars, cant
2 Crowbars
4 Blocks, chock
4 Pins, clevis
6 Shackles, tank, w/pins
1 Shackle, ring
2 Hammers, sledge, 14-lb.
2 Jacks, pedestal
2 Chains, fall, hand-ratchet
1 Hoist, trolley

Use of Front Winch. The front winch of the Tractor-Truck, M26, is the same as that used on the rear of the Truck, Wrecking, Heavy, M1, and it accordingly has the same direct-pull capacity (47,500 lb.). The primary use of this winch is the recovery of the truck, trailer, itself when stuck in terrain which it cannot negotiate. However, it can also be used for the recovery of other loads if the terrain makes the use of the rear winches unfeasible.

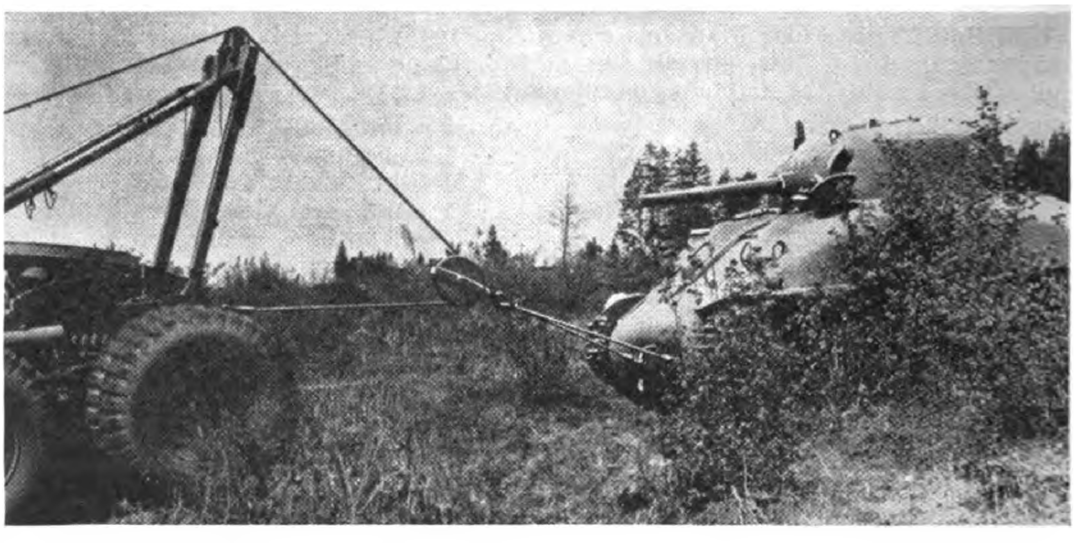


Figure 16. Tractor-Truck M26, Used as a Wrecker.

Uses of Rear Winches. The M25 unit is equipped with two rear winches of equal capacity. The diameter of the cables on these winches is 1⅛". These winches are generally used for loading and unloading the semitrailer and for doing the bulk of the recovery work which the M25 unit or the M26 tractor-truck may be called upon to do.

The two winches may be used in tandem on the same job or independently of each other. For instance, in unloading tanks from the semitrailer, one line may be used for pulling off the load while the other line may be used to snub the load and prevent slipping. In loading the trailer, both lines may be used simultaneously to insure a straight, even pull.

Either of the winch lines may be used for hoisting operations by passing it over the pulley on the top of the A-frame lifting device at the rear of the tractor.

Rear Winches Used Without Trailer. When the terrain is such that the trailer cannot be brought into position, it may be detached from the tractor-truck and the tractor-truck alone used for the recovery operation. A Collapsible A-frame is mounted on the rear of the truck for this purpose.

The tractor-truck alone may also be used for jobs generally assigned to a wrecker.

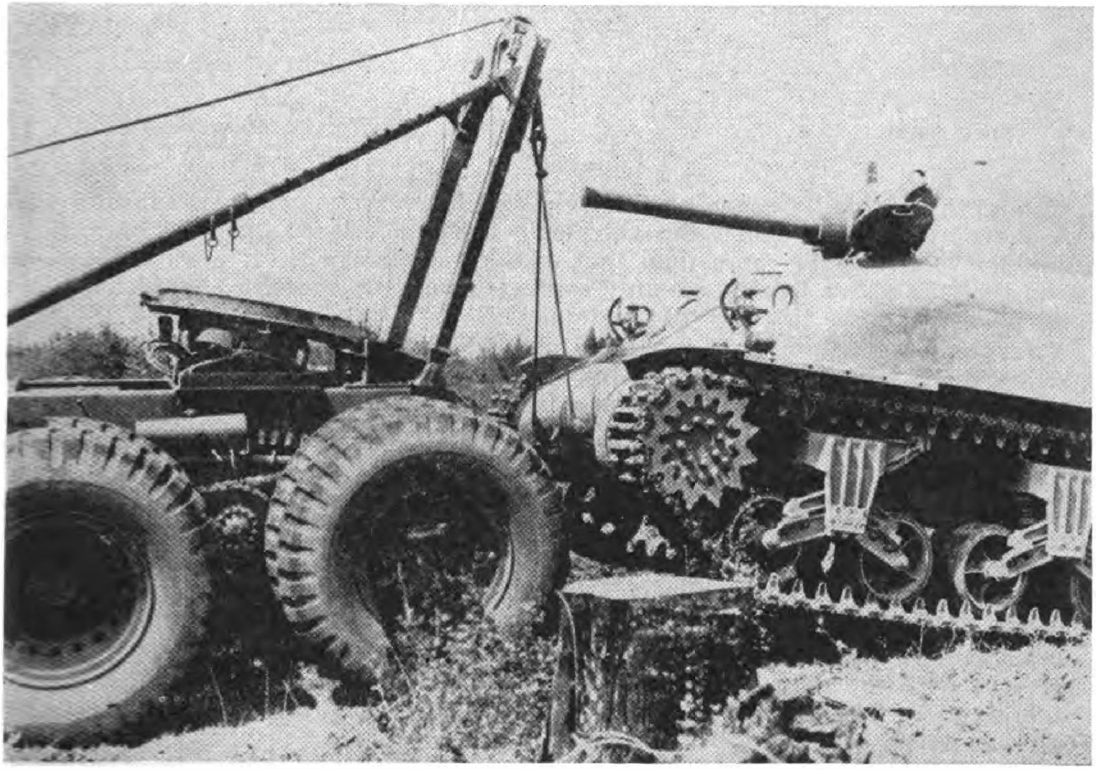


Figure 17. Collapsible A-Frame Used for Lifting.

The procedure for positioning the vehicle is the same as that described for the combination truck, trailer. The preparation for recovery is the same as that for the complete unit with the exceptions of lifting the A-frame and the operation of the trailer.

Practical Applications

Recovery is rarely 'Salvage.' Many wrecker operators feel that getting the recovered object back to the workshop is their only task. It is the primary mission and *duty* of recovery units to bring damaged equipment back to the workshops, dumps, or bases without inflicting further injury on the recovered object.

Certain phases of recovery are therefore covered in this article to aid wrecker operators in recovering equipment easily and speedily. It should always be remembered, however, that A FEW MINUTES' CONSIDERATION OF THE RECOVERY JOB BEFORE IT IS STARTED SAVES MANY FOOT-POUNDS OF WORK (human and mechanical).

Calculating Loads. There is a tendency among many wrecker operators to use improper hook-ups in recovery work. This is generally due to a faulty estimation of the load they are putting on the line or lines. Although the cable normally will have a safety factor capable of handling most loads, a permanent strain will be set up within the cable on overloading, which will reduce its maximum strength for future operations.

The three main resistances encountered in recovery work are rolling resistance, grade resistance, and overturning resistance.

Rolling Resistance. This is the pull required to move the vehicle on level ground. It is a function of ground resistance, wheel diameter, width of track or tire, friction in the bogies, etc. When estimating the resistance to be overcome on pulling a load, all these conditions must be borne in mind.

For rough estimating the following figures can be used for pulling vehicles.

Type of terrain	*Load on cable*
Smooth Road	$\frac{\text{Weight of vehicle}}{25}$
Grass	$\frac{\text{Weight of vehicle}}{7}$
Gravel	$\frac{\text{Weight of vehicle}}{5}$
Soft sand	$\frac{\text{Weight of vehicle}}{4}$

In mud the pull will depend on the weight of the vehicle and the depth and consistency of the mud. When the vehicle is pushing a large quantity of mud in front, the load may be more than that of the vehicle itself. It must be remembered that the above figures are only estimates, and the operator should use more lines whenever he is in doubt of the total pull.

Example. A medium tank is stalled on level ground with a graveled surface, and has to be pulled to a repair point. What is the strain on the line, assuming the weight of the tank to be 60,000 pounds? By substituting in the above table:

$$\text{Amount of load on the cable} = \frac{60{,}000}{5} \text{ or } 12{,}000 \text{ pounds}$$

Grade Resistance. Grade resistance is the resistance due to gravity when moving a vehicle up a slope. Again a rough figure can be obtained by taking the resistance as 1/60th the weight of the vehicle for each degree in angle of slope up to 45°. Do not lose sight of the fact, however, that degree of slope and per cent of grade are not one and the same. A 45° slope is equal to a 100% grade.

Example. A medium tank is stalled at the bottom of a 15° slope and has to be recovered over the slope. What is the strain on the lines assuming the weight of the tank to be 60,000 pounds? The necessary pull would be 15/60ths of 60,000 pounds or 15,000 pounds.

In computing resistance do not forget that the grade resistance is in addition to the rolling resistance and must be added to it when figuring the total load to be pulled. Thus, pulling the tank over a 15° gravel slope would be equal to the grade resistance (15,000 pounds) plus the rolling resistance (12,000 pounds), or a total of 27,000 pounds.

Overturning resistance. The maximum pull required to bring a vehicle back onto its wheels or tracks when overturned can be assumed, for all practical purposes, to be equal to one half the weight of the vehicle.

In all the above examples, if the end of the vehicle is buried toward the direction of pull, the ground should be dug away in front to reduce the pull required. Skidding, or planks, may be laid down to form a smooth surface for the vehicle. If the vehicle is to be dragged on its axle the planks should be heavily greased.

Towing. Before hooking up a towing device on a vehicle whose motive power has failed, it must first be determined why this motive power has ceased to function. If only the engine has failed, a simple rigid towbar may be attached and the vehicle towed to a repair point. However, if the failure is the result of damage to the transmission or transfer case, the drive shaft must be disconnected. If this is not possible or if the failure is in the differential, or wheels, it will be necessary to raise the wheels before a towing operation can be undertaken.

When the wheels have to be elevated from the ground by a wrecker for towing operations, it is best to remove the wheels from the vehicle. This prevents damage to the wheels, axle, springs and steering mechanism when passing over rough terrain.

A rigid bar should, whenever possible, be used for towing when the vehicle is capable of rolling. A loose cable, rope or chain should only be used for short distances and under exceptional circumstances. When the loose method of towing is used the following precautions should be taken:

1. An operator must be in the towed vehicle to guide its direction.
2. When starting with a loose tow extreme care should be observed in taking up the slack in the tow line. When moving, the cable, rope or chain should be kept taut at all times and no sudden jerks should be put on the line.
3. Hand signals used by the driver of the towing vehicle should be repeated by the driver of the towed vehicle
4. A horn "halt" signal must be arranged between the drivers of the two vehicles, and must be acted on immediately by the driver of the towing vehicle, should the towed vehicle be in any difficulty.

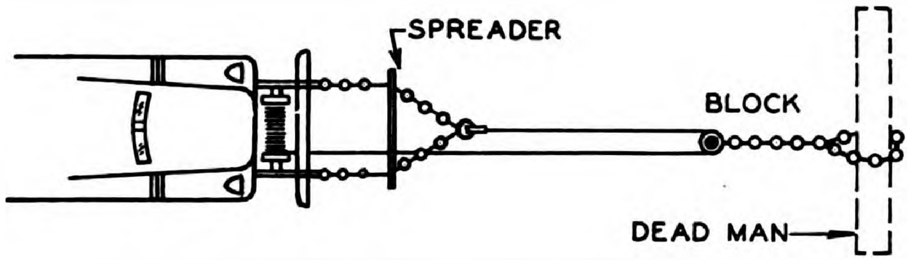


Figure 18. Use of Deadman For Anchorage.

Deadman. Arrangements for pulling vehicles over difficult terrain vary according to circumstances. Several typical situations are shown. Minor variations of these can be used in most cases. For exceptionally heavy going the arrangement shown below is ideal. The pulling power of the winch is doubled without exceeding its capacity.

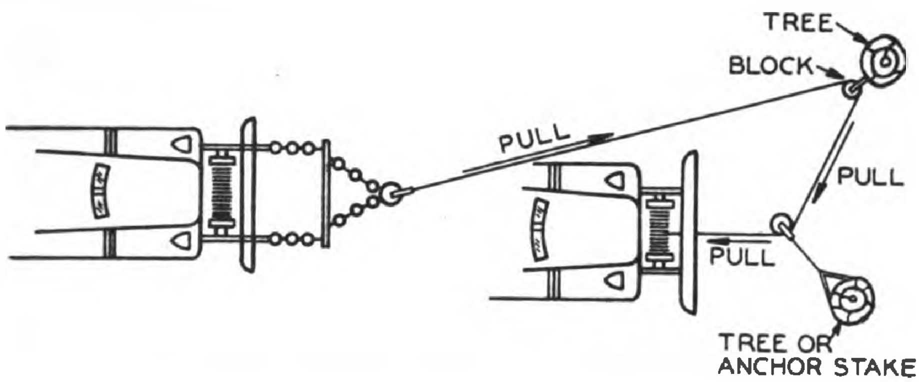


Figure 19. Use of Natural Anchorage Plus Stakes.

Natural Anchor Plus Stakes. In the arrangement below, notice the position of the anchored stakes. They are placed exactly opposite the direction of pull of the cables.

Using Anchorage to Gain angular Pull. An angular pull can be made with the arrangement shown below. Personnel should never stand in the area which is shaded. If the block happens to break, or come free from its anchorage, it would be hurled in that direction with a very great force.

A-Frame Aids Lifting. When a lifting and pulling force is required to remove vehicles from a shell hole or a narrow ditch, an A-frame should be used. A typical situation is shown below.

Chain Bridle. The chain bridle is often used as part of the rigging for wheeled-vehicle recovery. It is made by looping a chain around the frame of the vehicle to be recovered. The hook end of the chain is fastened to the first or second link of the loop end of the chain, leaving the loop free for attachment to a sheave block or cable.

Rigged for Towing in a typical arrangement for towing a vehicle over rough

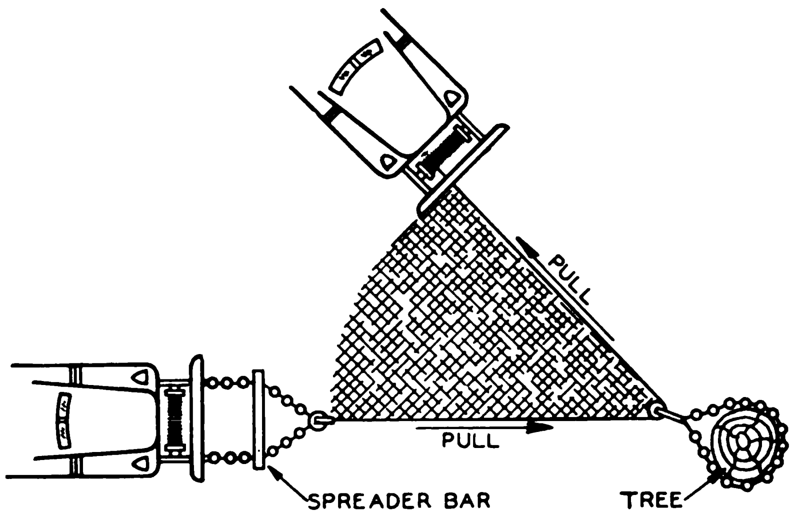


Figure 20. Use of Anchorage to Gain Angular Pull.

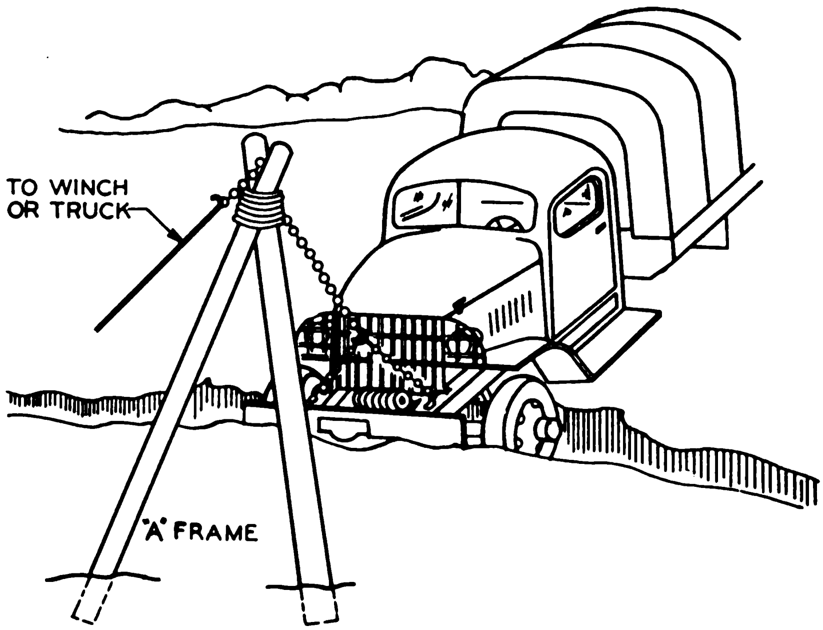


Figure 21. The A-Frame Aids in Lifting.

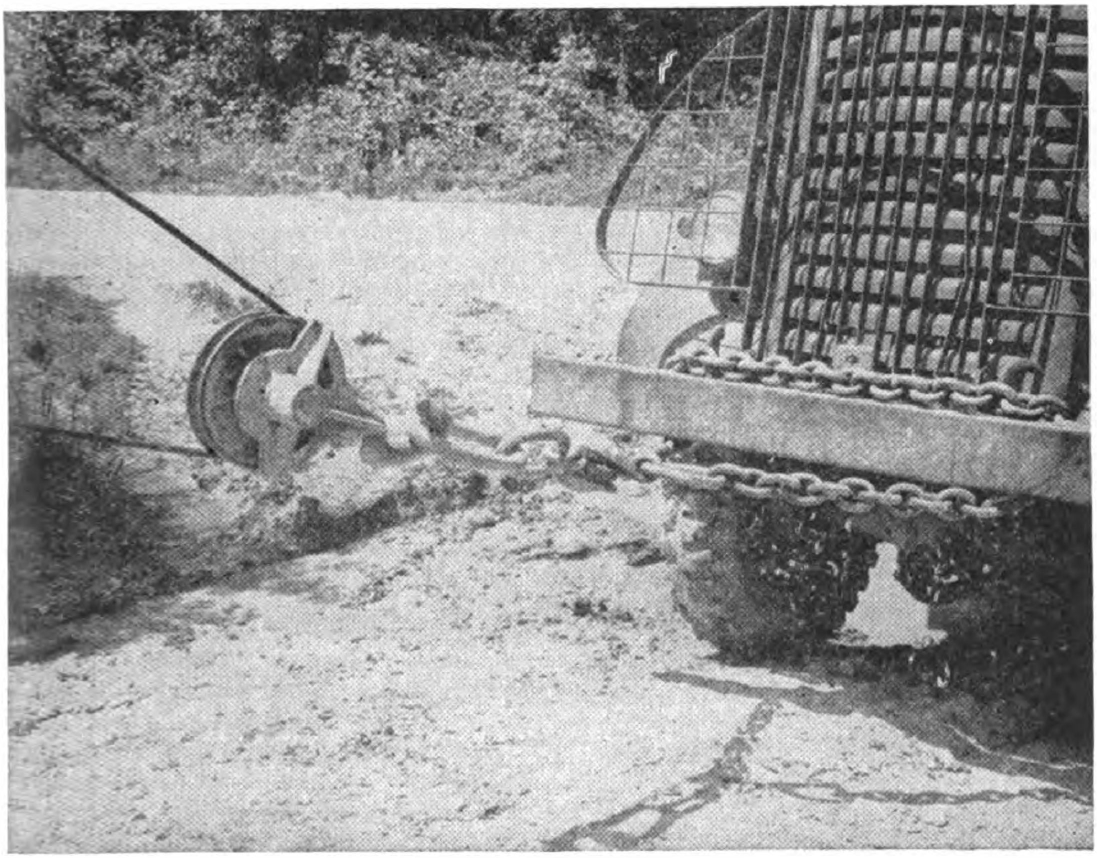


Figure 22. Chain Bridle.

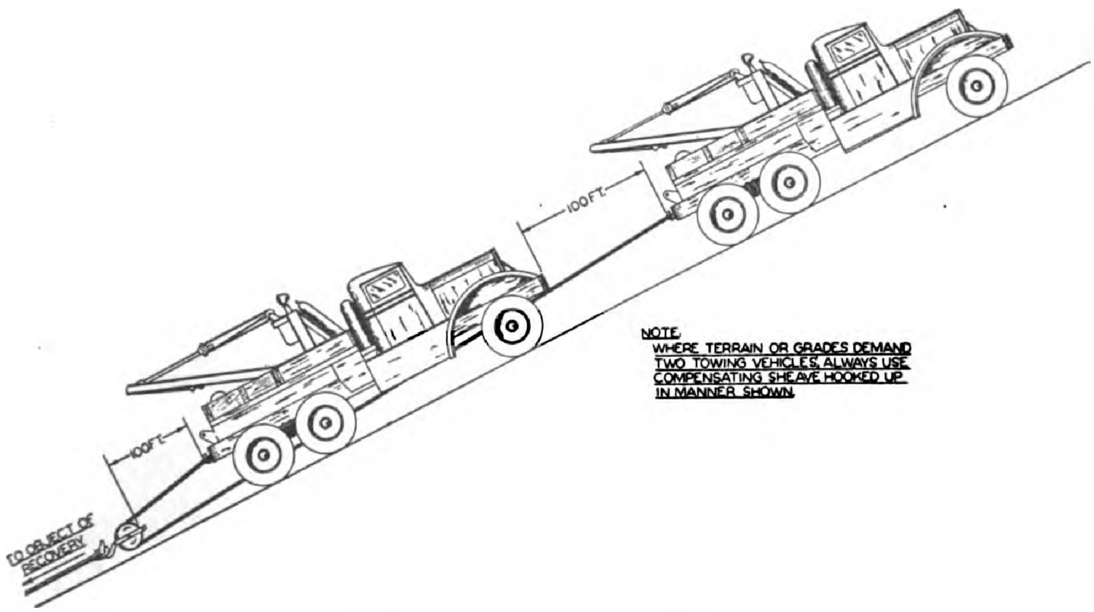


Figure 23. Dual-Truck Towing.

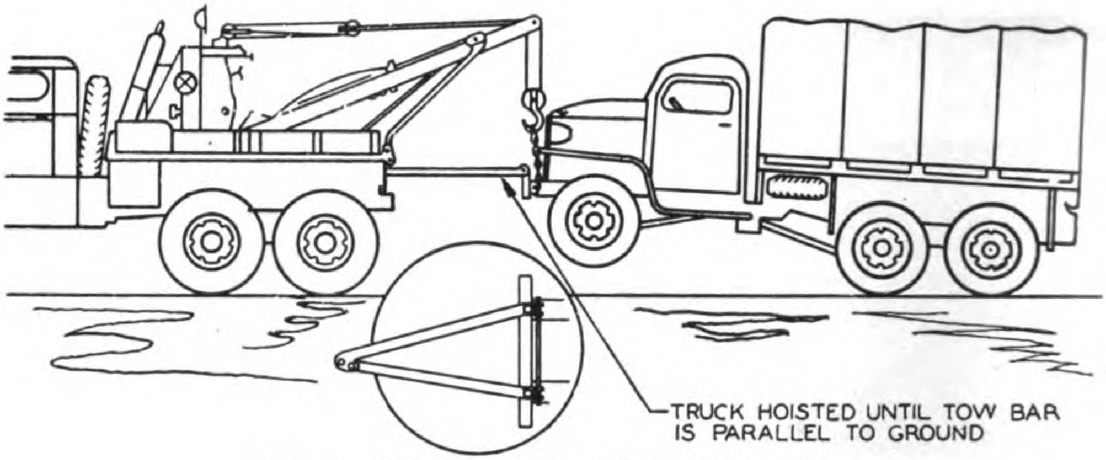


Figure 24. Rigged for Towing With the M1 Wrecker.

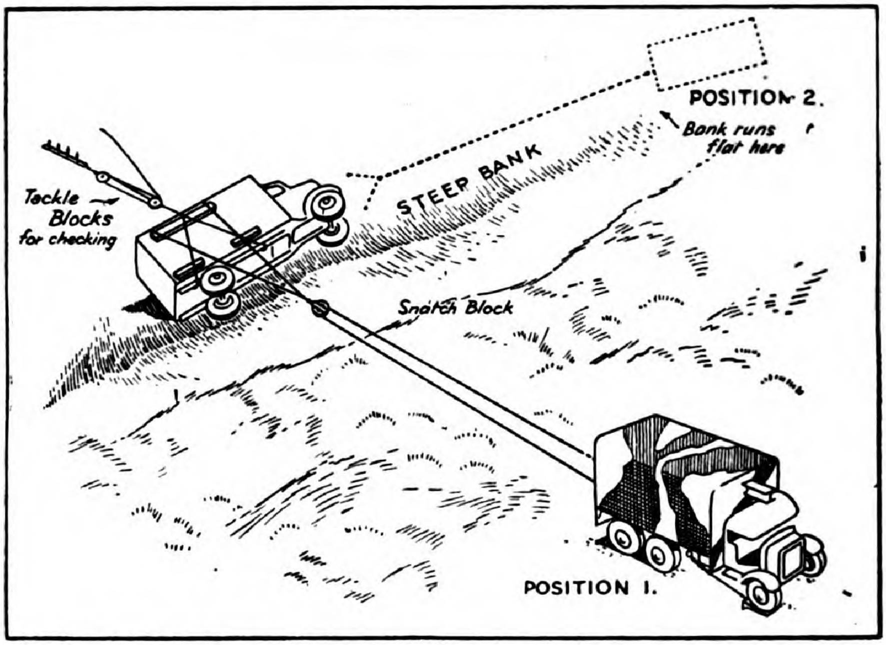


Figure 25. Righting an Overturned Vehicle.

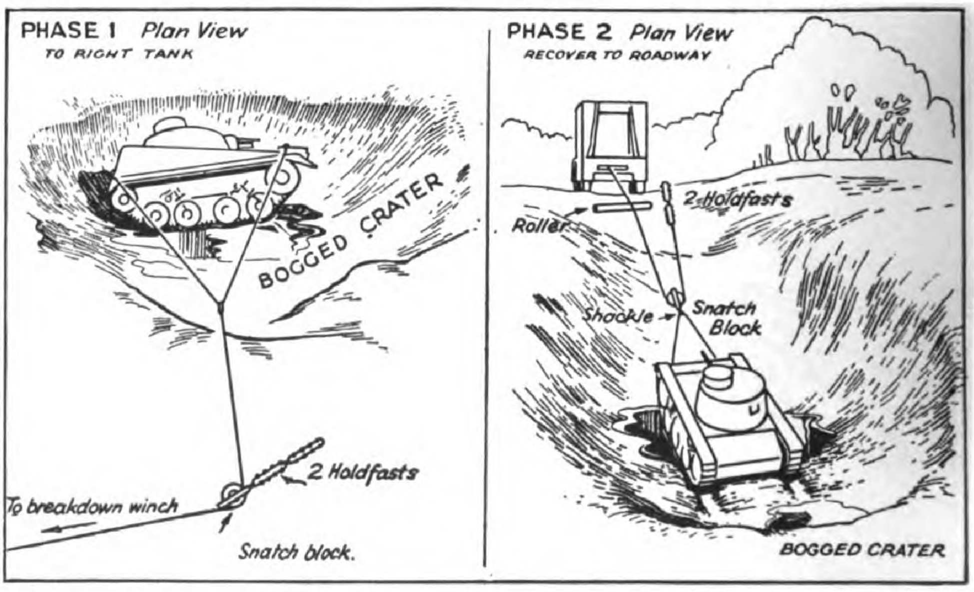


Figure 26. The Method Adopted in Righting the Light Tank and Recovering it to the Roadway.

Figure 27. Method Utilized to Recover M10 Gun Motor Carriage.

Figure 28. Recovery Party at Work With M25.

terrain. Here the crane is used to raise the front of the truck and the tow bar is placed between the wrecker and the towed vehicle to draw the load.

Righting an Overturned Vehicle. Overturned vehicles can often be righted by manpower alone. When this is impossible, a rigging similar to that shown in the figure may be used. Brakes should be applied before the vehicle is righted. Any of the towing means may be used to pull on the rope. Holding lines should be used to prevent the vehicle from being damaged by settling too rapidly. When the vehicle has been righted, a careful inspection must be made to determine the extent of damage caused by the accident. The axles may be bent, the frame twisted, the wheels bent or broken, or the steering mechanism damaged. Such damage should be repaired as soon as possible, since driving the vehicle invites other and perhaps more serious accidents. Before the vehicle is moved under its own power, necessary oil and gas, battery acid, and radiator water should be replaced.

Bridge Estimation

The problem of Ordnance recovery and maintenance service has frequently been complicated by bridges of uncertain strength. Although the Corps of Engineers reconnoiter and post load classifications on bridges on the main highways, they often do not have time to do so on secondary roads. These secondary roads are frequently used by Ordnance personnel in taking the most direct route to their destination.

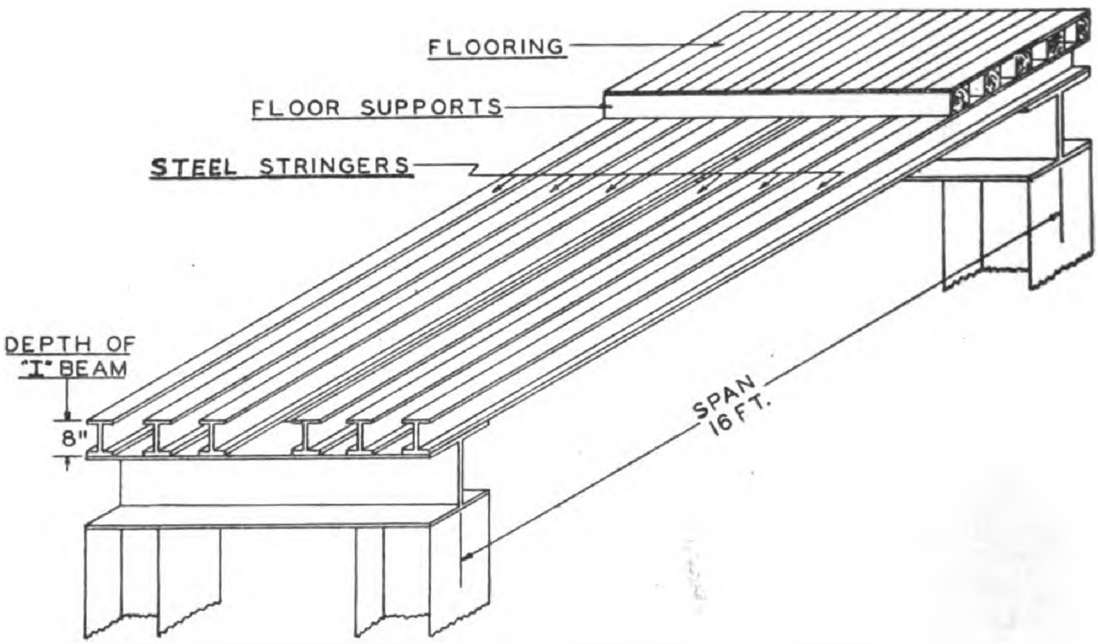


Figure 29. Sample Military Bridge, Showing Parts to be Checked in Capacity Estimation.

In the field it is seldom possible to determine the exact capacity of a bridge. In foreign countries even a trained engineer encounters unfamiliar materials and designs. Concrete made in Libya may not have the same strength as concrete made in Texas. A steel beam from India may be only three-fourths as strong as a similar beam made in Pittsburgh. Age, weather, methods of construction, and other factors serve to complicate the question of capacity. The best one can do is make an intelligent estimate based on certain assumptions and guided by common sense. It is obvious that an experienced engineer can make a better estimate than an untrained person, so, whenever possible, an engineer should reconnoiter each bridge over which vehicles are to pass and post it to prevent vehicles above the safe weight limit from passing over it.

Although training and experience are indispensable for capacity estimation of special types of bridges, the information presented in this section should enable personnel without technical training to make an intelligent estimate of capacities of many existing bridges. This information is presented generally in tabular form and is designed primarily for inexperienced personnel. In addition, this section deals only with those bridges that would normally be encountered on secondary roads. There is no easily applied formula for truss and suspention type bridges, for which the Engineer Officer should be consulted.

Before attempting to understand capacity estimation, it is necessary to know bridge nomenclature. The types of bridges we are going to discuss are shown in figures 29 and 30.

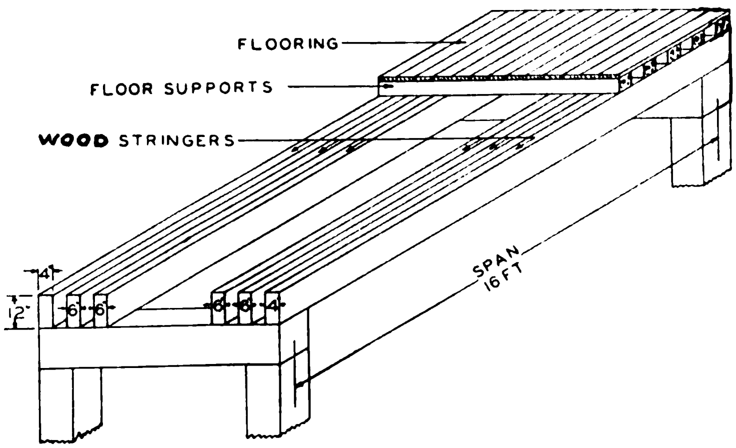


Figure 30. Wood Stringer Bridge.

Upon arriving at a bridge that has not been posted by the Engineers, you should inspect the bridge thoroughly before making an estimation of its strength. A brief outline of this inspection follows:

1. Where the bridge is in territory that has been evacuated by the enemy, abutments, piers and other members of the bridge should be carefully examined for mines, sabotage, or other evidences of enemy action.
2. Examine all steel members for corrosion, bending, twisting, etc.
3. Examine all wooden members for rotting, splitting, breakage, etc.
4. Check and see if any wooden or steel stringers are missing.
5. During your inspection you should make the following measurements and observations: Span of bridge, depth of stringers, width of stringers and number of stringers.
6. Naturally any broken stringers should not be counted as good ones.

Once your inspection has been completed you are ready to estimate the capacity.

Table II. Hasty estimation of bridge capacity, steel stringers, with timber flooring, safe gross load in pounds for one steel stringer

Span	Depth of stringer (inches) [1]										
	4	5	6	7	8	10	12	15	18	20	24
10	2,200	3,500	5,300	7,000	10,000	18,000	26,000	43,000	65,000	80,000	129,000
12	1,800	2,900	4,400	6,300	8,000	15,000	22,000	36,000	54,000	71,000	106,000
14	1,500	2,400	3,700	5,300	7,200	12,000	18,000	30,000	45,000	60,000	90,000
15	1,400	2,200	3,400	4,800	6,700	11,600	17,000	28,000	42,000	56,000	84,000
16	1,300	2,100	3,200	4,600	6,300	11,000	16,000	26,000	40,000	52,000	78,000
18	1,100	1,800	2,800	4,000	5,500	9,500	14,000	23,000	35,000	46,000	69,000
20		1,600	2,500	3,600	4,900	8,400	12,000	21,000	31,000	41,000	61,000
24		1,200	1,800	2,700	3,700	6,400	9,500	16,000	24,000	31,000	47,000
28			1,500	2,200	3,000	5,300	7,900	13,000	20,000	26,000	39,000
32			1,200	1,700	2,400	4,100	6,100	10,000	16,000	21,000	31,000
36				1,400	2,000	3,600	5,300	8,900	13,000	18,000	27,000
40				1,200	1,700	3,100	4,600	7,800	12,000	16,000	24,000

[1] Values below black lines should not be used for design purposes since ratio of span length to depth of beam should not exceed 30.

PROBLEM 1. To determine the capacity of a one-lane bridge that has steel stringers as shown in figure 29.

Span of bridge .... 16 feet
Depth of steel stringers .... 8 inches
Number of stringers 6

Solution: Refer to table II. Capacity of an 8-inch steel stringer, span 16 feet, is 6,300 pounds. Capacity of the span is 6 x 6,300 which equals 37,800 pounds or 19 tons.

PROBLEM 2. To determine the capacity of the wood stringer bridge shown in figure 30.

Span of Bridge .... 16 feet
Depth of stringers .... 12 inches
Number of stringers:

2 are 4 inches wide } total width 32 inches
4 are 6 inches wide }

Solution: Refer to table III. Capacity of 12-inch wood stringer, span 16 feet, is 940 pounds. Total width of stringers is 32 inches. Bridge capacity is 32 x 940 which equals 31,280 pounds or 15 tons.

Table III. Hasty estimation of bridge capacity, wooden stringers with timber flooring; safe gross load in pounds for rectangular wooden stringers 1 inch wide

Span	Depth of beam (inches)[2]										
	4	6	8	10	12	14	16	18	20	22	24
10	170	380	690	1,100	1,600	2,100	2,800	3,500	4,300	5,300	6,300
12	140	300	560	890	1,300	1,800	2,300	2,900	3,600	4,300	5,200
14	110	260	480	750	1,100	1,500	1,900	2,500	3,100	3,700	4,400
15	110	250	440	700	1,000	1,400	1,800	2,300	2,800	3,400	4,100
16	100	230	410	650	940	1,300	1,700	2,100	2,000	3,200	3,800
18		200	360	570	820	1,100	1,500	1,900	2,300	2,800	3,400
20		170	320	500	730	1,000	1,300	1,700	2,100	2,500	3,000
24		130	230	380	550	760	1,000	1,300	1,600	1,900	2,300
28		100	190	310	450	630	830	1,100	1,300	1,600	1,900
32			150	240	350	490	650	840	1,000	1,300	1.500
36			120	200	300	420	560	720	900	1,100	1,300
40			100	170	260	360	480	620	780	950	1,100

[2] Values below black lines should not be used for design purposes since ratio of span length to depth of beam should not exceed 30.

FIELD RIGGING

Almost every Ordnance officer or enlisted man will at some time have to handle an object that is too heavy for him and his men to lift. He will then use some kind of mechanical device to multiply human strength. There is ready-made equipment, such as chain falls and power cranes, that is especially designed to do this work but it is not always available. Therefore, the heavy work must be done with rigging, by using blocks, beams, spars, cribbing, and rollers.

Rigging requires a planned, systematic procedure in order to do a job efficiently and safely. The simplest installation that will do the job with the least expenditure of time and labor is the best. Safety precautions must be observed at all times.

Hemp Rope. Rope is one of the important items used in rigging. It is made up of many fibers of hemp or similar material which are twisted into yarns. The yarns have a right hand twist (or lay). A certain number of yarns are placed together and twisted to the left to form a strand. Several strands, usually three, are laid to the right to form a rope. The combined reversals of the 'twists' in the fibers, yarns, and strands, 'balance' the finished rope and prevent it from 'unlaying' when tension is applied; this also positions all the fibers parallel to the axis of the rope. The majority of ropes used by the Army are 3-strand, right laid.

Rope should be stored in a cool, dry place. When it becomes wet it should be thoroughly dried before being coiled and placed in storage. It should be dried in the shade away from artificial heat. If possible, it should be hung on a peg or beam in such a way as to allow air to circulate around it.

Rope should be washed regularly, especially if it has become covered with sand,

sap from green timbers, or dirt which might mold or cut the fibers. A strong spray of water played on the rope is a very effective method of washing it. It is necessary to inspect rope frequently to determine wear and damage. Be sure to test rope whenever there is any doubt as to its strength. The inner surfaces of the rope should be inspected by opening the 'jaws' (point at which the strands touch one another) with a hard twist against the lay.
Special note should be made of:

Broken inner fibers caused by sand or other sharp particles which cut the fibers when the rope is flexed.

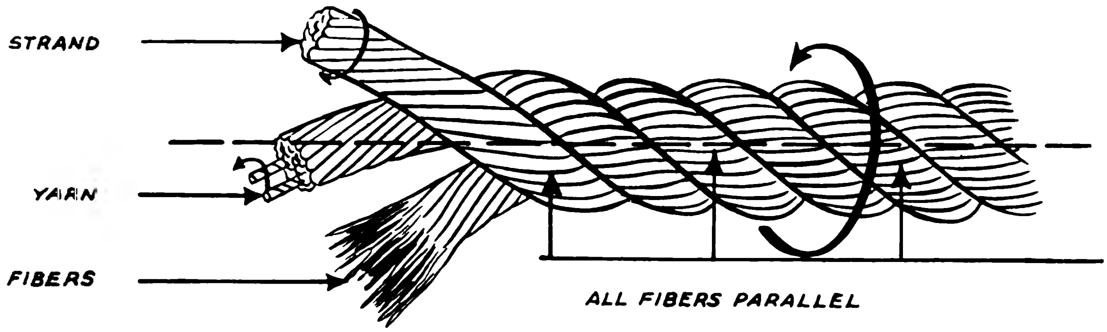


Figure 31. Hemp Rope Construction.

Discoloration caused by the action of acid or strong caustics. This will appear as a reddish-brown stain which is much darker than the natural color of the rope. If the discoloration is due to acid, the fibers will 'flake' when scratched. Cut out the damaged portions and resplice the rope.

Mold caused usually by damp storage. It can be recognized by its musty odor. It may appear as a green, white, or black dust in the jaws of the rope. If mold is found, rope must be tested before using.

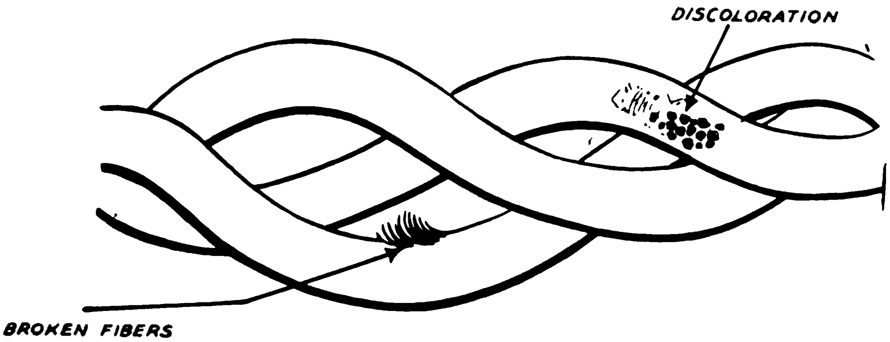


Figure 32. Jaws of Rope Opened for Inspection.

Dry rot caused by storing rope in a hot dry place. The natural oils of the hemp fibers are dried out, and the rope becomes stiff and brittle. Avoid storing rope in attics and furnace rooms. Test by 'flicking' with thumb nail.

When storing or handling rope, be sure to guard against acids; three or four drops of acid will weaken the rope to a point where it can be pulled apart by hand. Remember that urine of men and animals contains acids.

Rope is likely to become twisted when it is improperly handled. When not in use it should be coiled neatly.

The rule to follow for coiling right laid rope is: Coil to the right—uncoil to the left.

When uncoiling new rope, select the rope end in the center of the bale as the starting end. If the rope is uncoiling to the right, turn the coil over and pull the end through the center of the bale and the rope will uncoil properly.

Strength. The safe load in tons for any rope is approximately equal to the square of the diameter in inches. For example, the safe load in tons for a 1-¼ inch rope equals D^2 equals $(1\text{-}1/4)^2$ equals 1-9/16, or approximately 1-½ tons. Table IV gives strength properties for various ropes.

TABLE IV. PROPERTIES OF CORDAGE[1]

Diameter (in.)	Weight per 100 ft. (lb.)	Minimum breaking strength (tons)	Safe load[2] capacity (tons)
¼	1.71	0.22	0.07
⅜	3.45	0.51	0.17
½	7.36	1.06	0.39
⅝	13.10	1.76	0.55
¾	16.40	2.16	0.72
⅞	22.00	3.08	1.03
1	26.50	3.60	1.20
1-⅛	35.20	4.80	1.60
1-¼	40.80	5.40	1.80
1-½	58.80	7.40	2.47
1-¾	87.70	10.60	3.53
2	105.00	12.40	4.13
2-½	163.00	18.60	6.20
3	237.00	25.60	8.53

[1] For quality manila the factors for minimum breaking strength and safe load capacity may be increased 20 per cent.
[2] Safe load capacity factors based on a safety factor of 3.

The strength of a rope fastened by knots or slung over a hook is reduced approximately 30 per cent. Sharp bends over corners reduce the strength approximately 50 per cent. Wear and exposure to weather have a cumulative effect in decreasing the strength of rope, and liberal allowance should be made for both when estimating the strength of used rope.

The safe working load that can be put on a rope is very much less than the breaking load. The recommended safe working load of a rope should be one third of the breaking load. This is called a safety factor of 3 to 1. A rope having a breaking limit of 6,000 lbs. will be used safely with a load of 2,000 lbs., which is one third of the breaking strength of the rope. Overloading a rope stretches the fibers beyond their elastic limits and reduces the strength.

When ropes are used at high speeds, the safety factor should be increased to 8 to 1.

KNOTS

There are many different kinds of knots used in rigging. Some of them bear the title of 'hitch' or 'bend', but they should be referred to as knots. A good knot is easy to tie and untie and is slip proof.

All knots are formed from two fundamental elements—the bight and the round turn.

In tying knots, the free end of the rope is called the 'running' end and the remainder is referred to as the 'standing' part (or end).

When forming a knot, be sure to remove all surplus slack within the fastening itself—this is called 'dressing.' It prevents slipping and jamming of the knot when tension is applied.

There is no problem in rigging with hemp rope that necessitates the knowledge of more than the square knot, the clove hitch, the half-hitches, and the bowline.

Square Knot: The square knot is sometimes called the reef knot or flat knot. It is used to join ropes of equal diameter. There are two methods of tying it.

First method: Bring the two ends together and cross them. Make an overhand knot, and then tie another overhand knot in the opposite direction. Check the knot for the following characteristics:

1. Two sliding loops.
2. Both ends on same side of knot. If the knot is improperly formed, a 'granny' knot is the result; the granny is worthless.

Second method: Form a 'bight' in the end of one rope and pass the running end of the other rope through the bight. The running end is brought completely around the neck of the bight and passed down through the bight. Check for the characteristics of a square knot. If the ends are not on the same side, a 'thief' knot has been tied; the thief knot is worthless.

Clove Hitch. The clove hitch is used to fasten a rope to an object. It can be tied at any point in a rope.

Clove hitch in end of rope: Give one end of the rope two turns about the object, crossing over the standing end (1), and place the short end beneath the second turn (2).

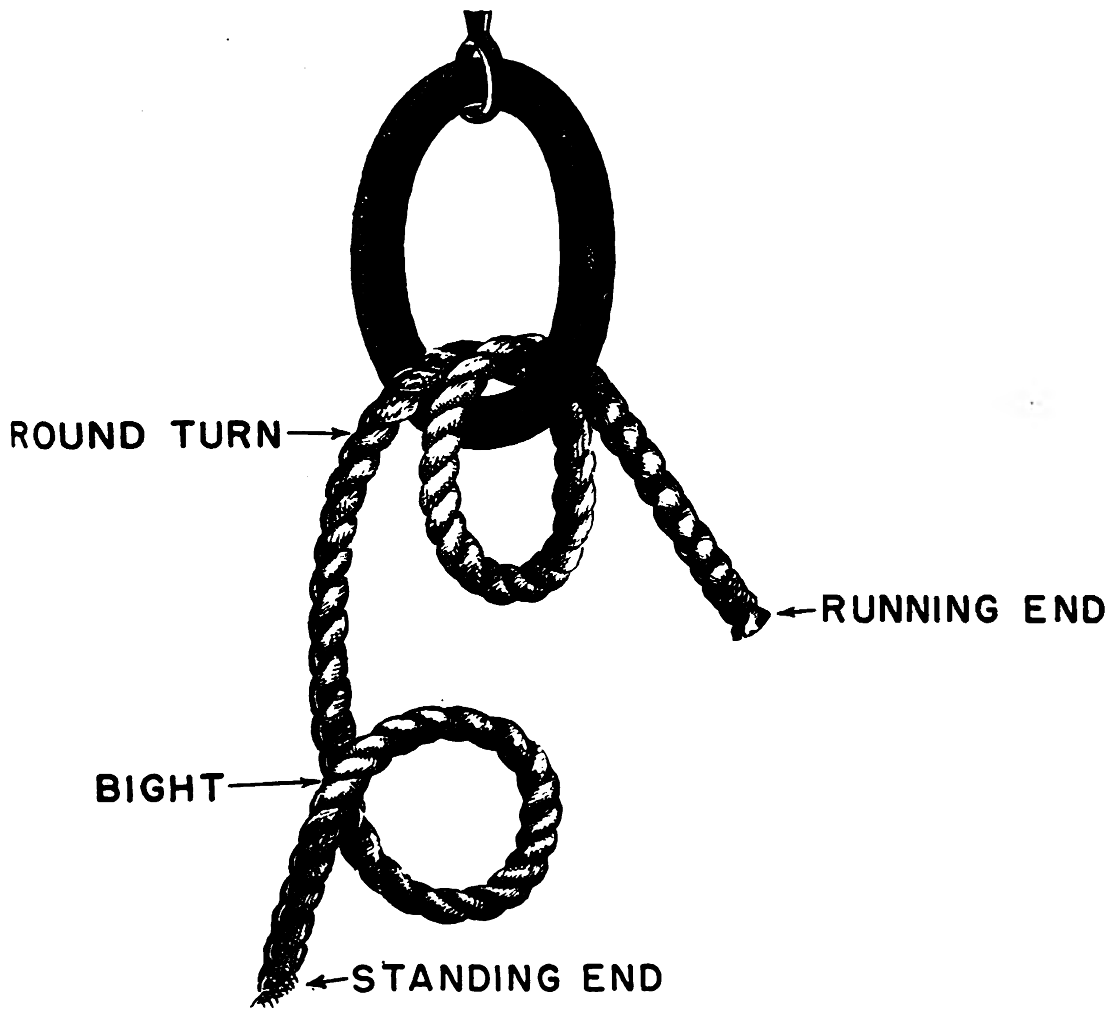


Figure 33. Elements of Knots, Bends and Hitches.

Clove hitch in middle of rope: Throw one bight to the right and another to the left, twisting the rope in the same direction for both bights (1), and move one bight over the other so that the running end is between the bights (2). Place the hitch over the end of the object and pull on both ends of the rope to draw the hitch tight.

Half-Hitches. Throw the running end over the standing part. Bring running end under itself forming a cross bight.

Duplicate this procedure to form the second half-hitch.

Seize the running end to standing part.

Bowline. The bowline is often called 'the king of knots'. It will not jam or slip. It is used to form a loop.

Throw a small bight in the rope by placing the running end over the standing

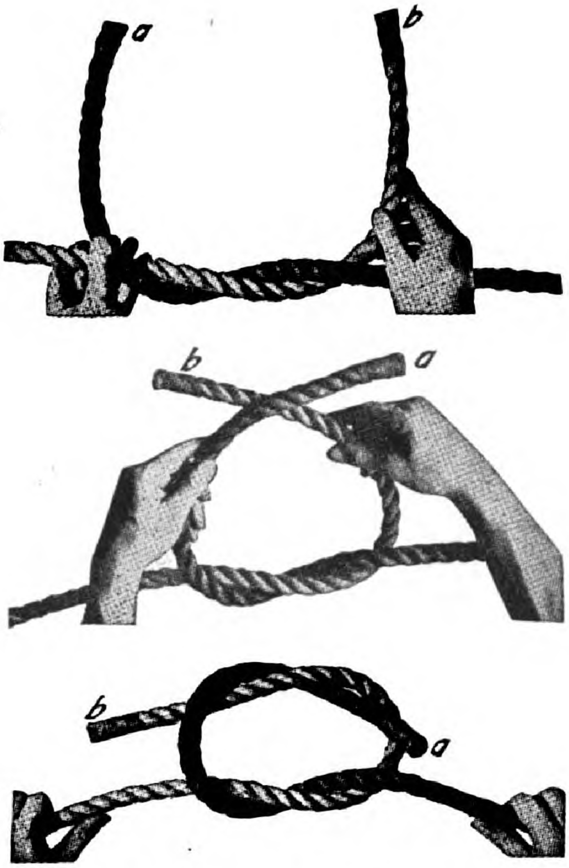
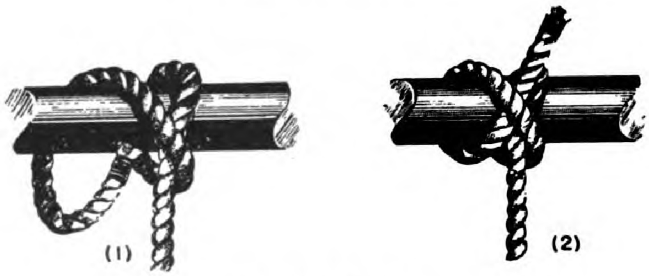


Figure 34. Square Knot.



In End of Rope.

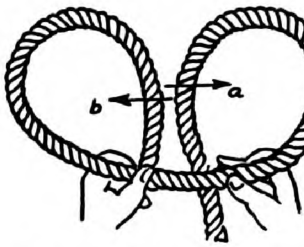


Figure 35. Clove Hitch.

In Middle of Rope.

Figure 36. Half Hitches.

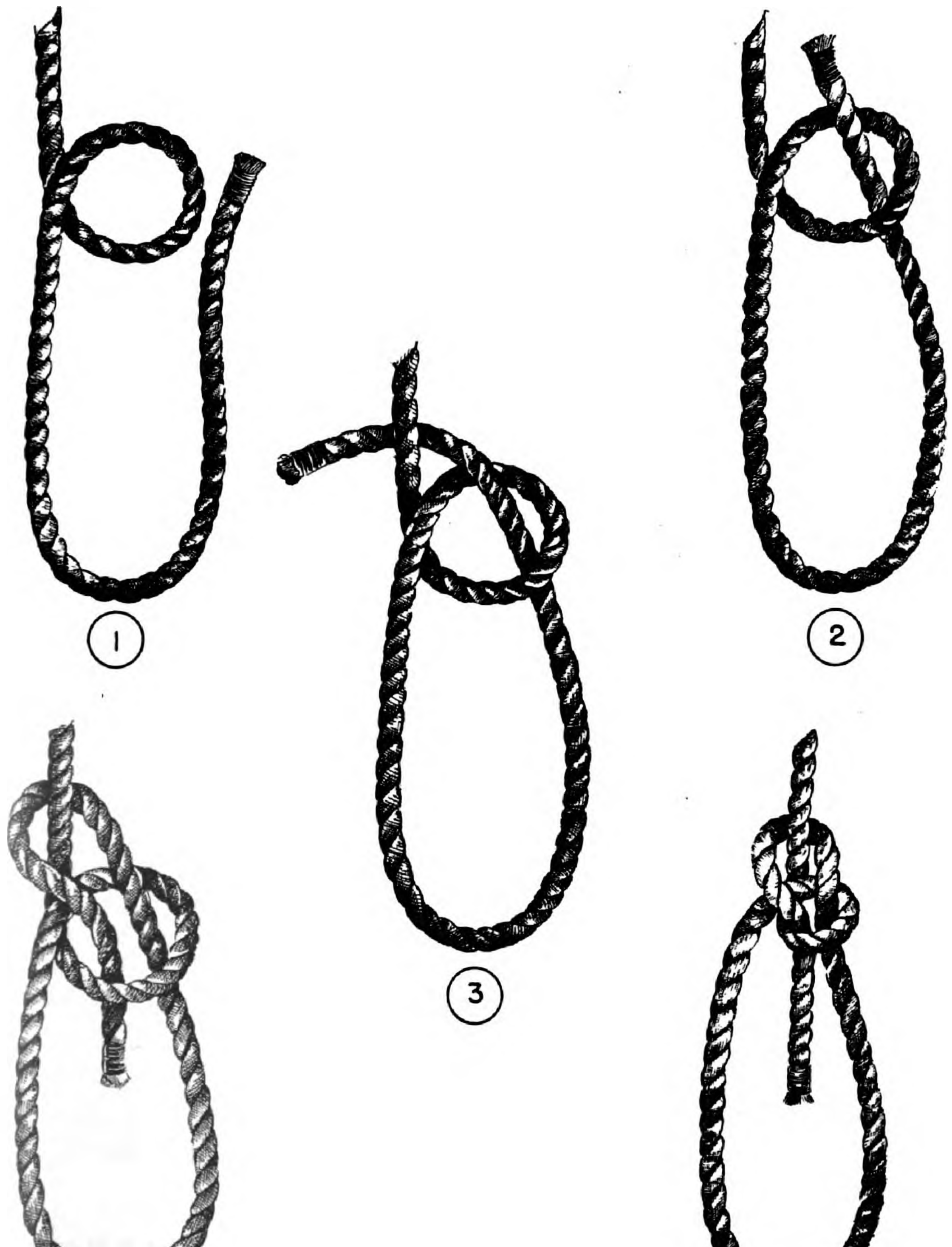


Figure 37. Bowline.

part. Pass the running end up through the bight and around behind the standing part. Pass the running end down through the bight and dress.

A knowledge of the following knots is nice to have but it is not essential. The overhand knot, is used as a stopper knot to prevent a rope from unlaying itself or to keep a rope from running through the sheaves of a block.

Figure 38. Overhand and Figure Eight Knots.

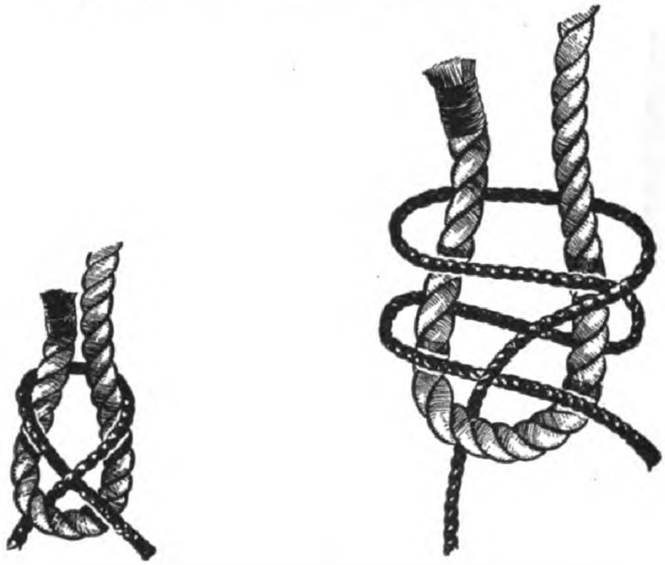


Figure 39. Single and Double Sheet Bends.

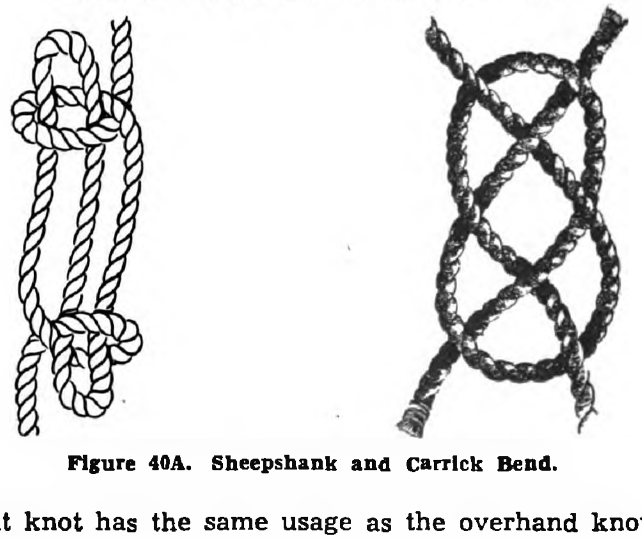


Figure 40A. Sheepshank and Carrick Bend.

The figure eight knot has the same usage as the overhand knot but it is easier to untie.

The single sheet bend, and double sheet bend are used to join together ropes of unequal sizes. The double sheet bend should be used in preference to the single as it is superior in holding qualities.

The sheepshank is used to shorten a rope or bypass a frayed section. Figure 40A.

Catspaws are used to provide additional bearing surface when placed in a loop or to protect the rope from bruising, as on a hook.

The carrick bend is used to join large ropes or hawsers.

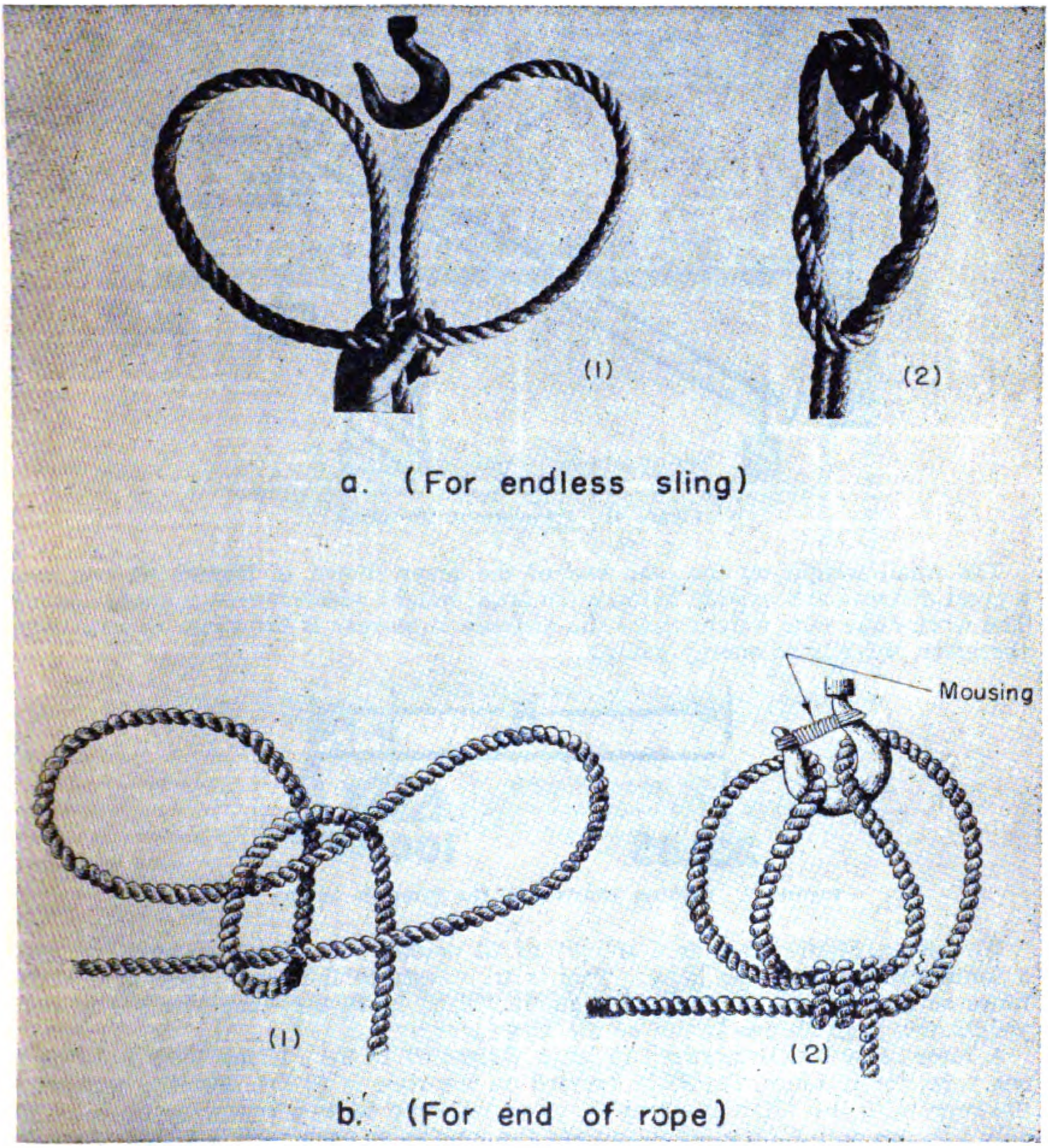


Figure 40B. Catspaw.

MECHANICAL ADVANTAGE

Rigging makes use of various devices which increase the force that a man ca exert, but in all these only one basic principle is involved. The principle is: *small force applied over a great distance will move a great load a short distanc* This is demonstrated by the lever.

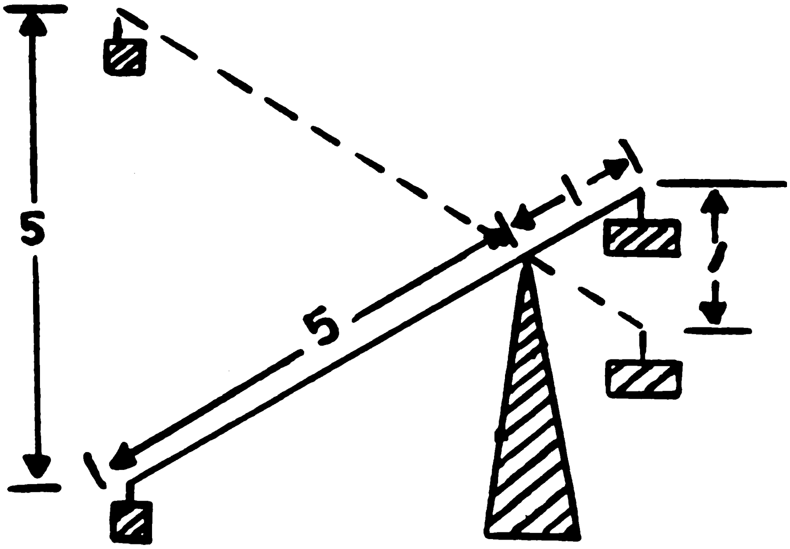


Figure 41. Principle of the Lever.

The small weight on the long end of the lever shown in Figure 41 can move a great distance and exactly balance the large weight which moves a short distance The work done (the weight times the distance it moves) is the same in both cases therefore, there is no energy gained.

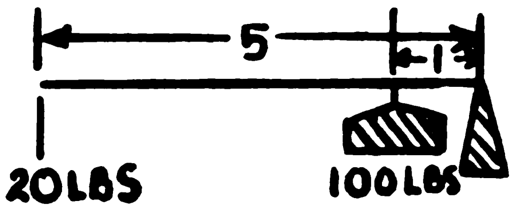


Figure 42. Problem Illustrating the Principle of the Lever.

We see in Figure 42 that a weight of 20 pounds will move another which is 5 times as heavy on the lever. This is true because the long lever arm is five times as long as the short and the small weight is on the long arm. The small weight moves five times as far as the large weight.

A force of 10 lbs. is required to lift a weight of 10 lbs. If the load is lifted by one rope, for instance, the force exerted on the rope is 10 lbs. and the tension on the rope is 10 lbs. If it is lifted by an equal force on two ropes, as on a pulley, only 5 lbs. on each rope is necessary and the tension on each rope is 5 lbs. Actually, the object of block and tackle in handling heavy loads is to increase the number of forces (or ropes) applied to the load. The relation between the load and the force exerted is the mechanical advantage. Thus, if a load of 30 lbs. is moved by a system to which a force of 5 lbs. is applied, the mechanical advantage of this system is 6 (6 to 1); that is, six units of weight are moved by each unit of force.

A rope is passing over a single sheave. Disregarding friction, if a pull P is exerted to raise the load W, the rope will have a tension of P equal to the pull. As the rope passes over the sheave to the load it has the same tension (P). Since there is one force (one rope) of P acting on the load, P equals W and the mechanical advantage is 1 (1 pound of pull will raise 1 pound of load). (Figure 43a).

In Figure 43b by the same reasoning, a force of P puts a tension of P into the

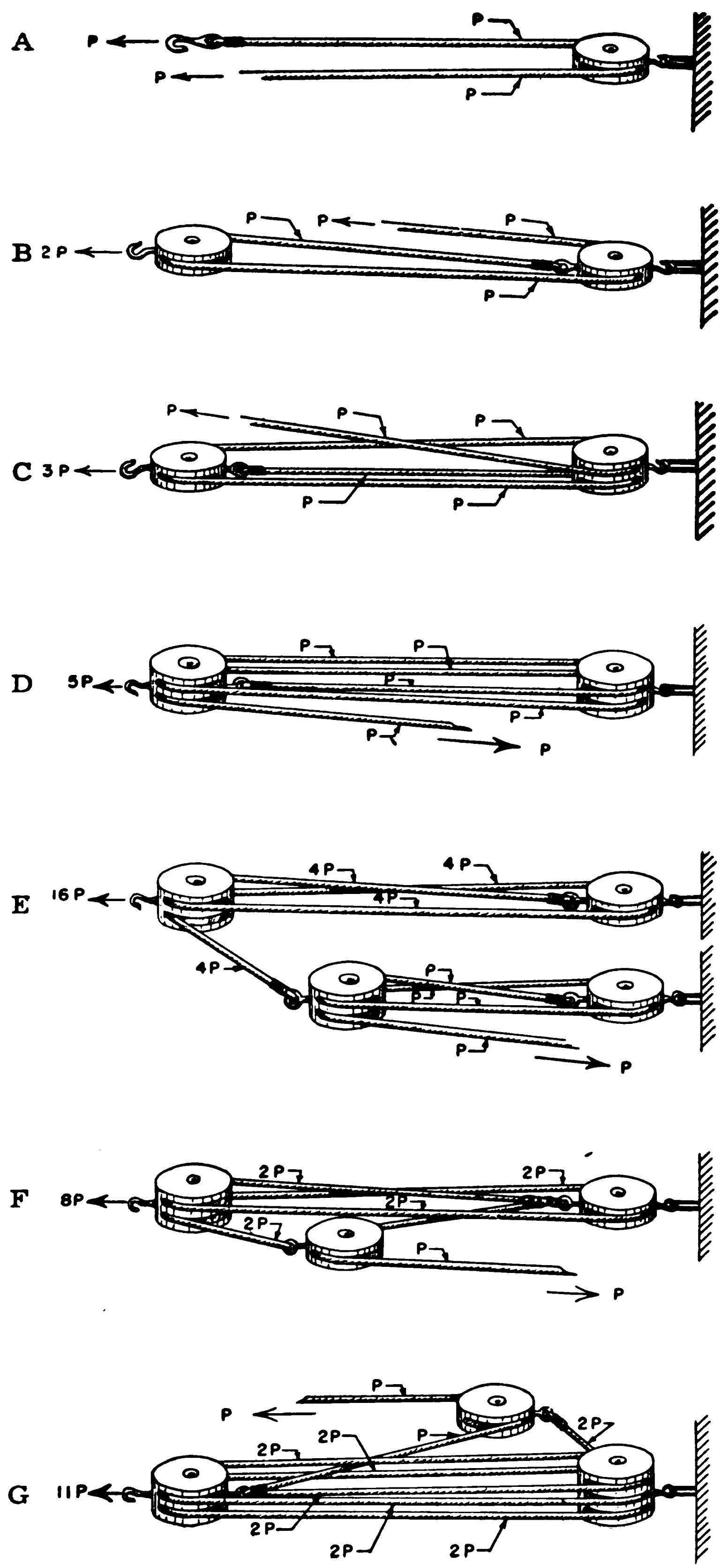


Figure 43. Mechanical Advantages in Tackles.

rope. As it passes over the sheave it has the same tension P; since there are two ropes supporting the load W, each under tension of P, the total force exerted on W is 2P which is equal to W. The mechanical advantage in this case, therefore, is 2 (2 to 1).

A comparison demonstrates the general rule that when the fall line moves in the same direction as the load, the fall line helps support the load and increases the mechanical advantage.

To determine the mechanical advantage in the simple block and tackle in figure 43-C, note that to raise the load W, a force of P is exerted. This puts a tension P in the rope. As the rope passes over each sheave, the tension remains the same and each line has a tension of P. There are three lines (each exerting a pull of P) supporting the load; therefore, W is equal to 3P and the mechanical advantage is 3 (3 to 1).

BLOCK AND TACKLE

A frame of wood or metal which incloses one or more sheaves or pulleys is known as a block. By leading a line over the sheaves, the power applied to the hauling part of a line may be conveniently multiplied before it reaches the object on which a pull is to be exerted. These combinations of lines and blocks are known as tackles.

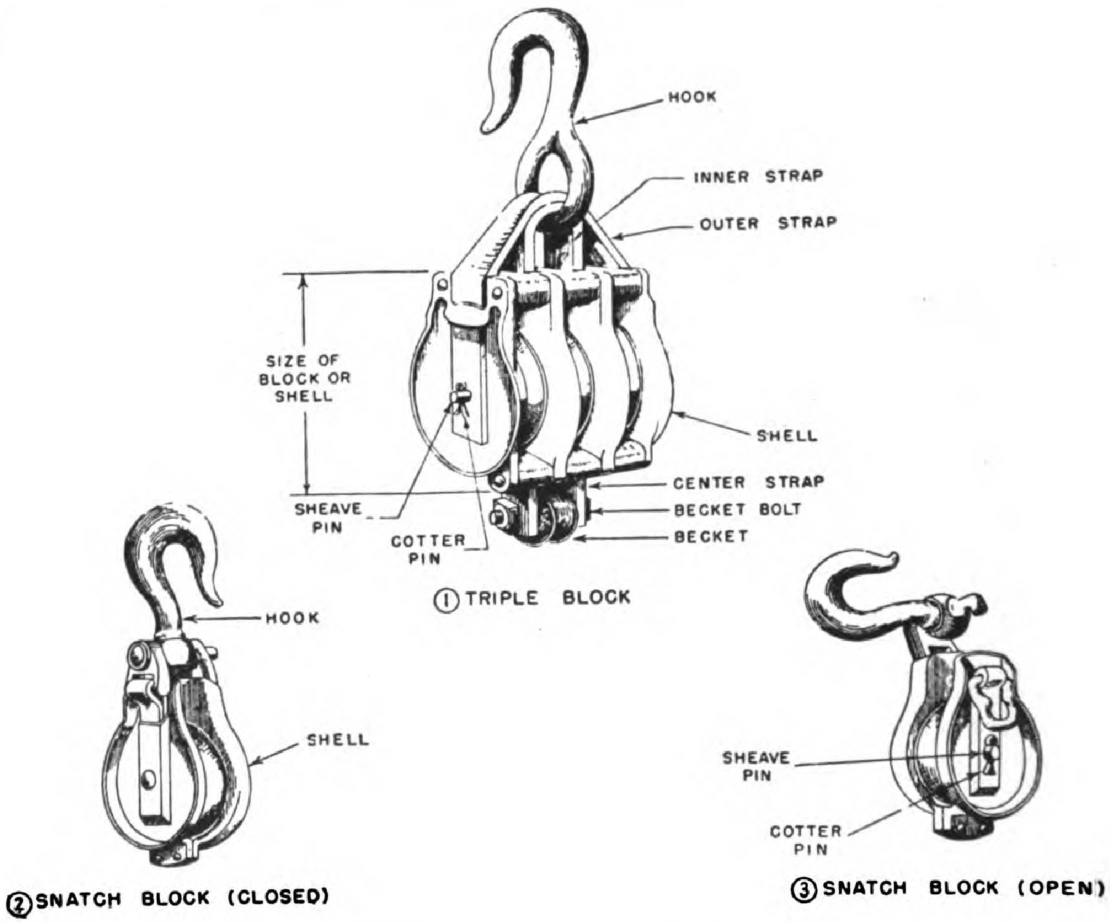


Figure 44. Block Nomenclature.

Snatch blocks are used to change the direction of ropes in block and takle rigging. Block and tackle rigging is a combination of one or more blocks and ropes by which an object or load can be moved in a desired direction with or without economy of power (mechanical advantage).

Reeving of Blocks. Reeving is the term applied to passing a rope through blocks to prepare a tackle.

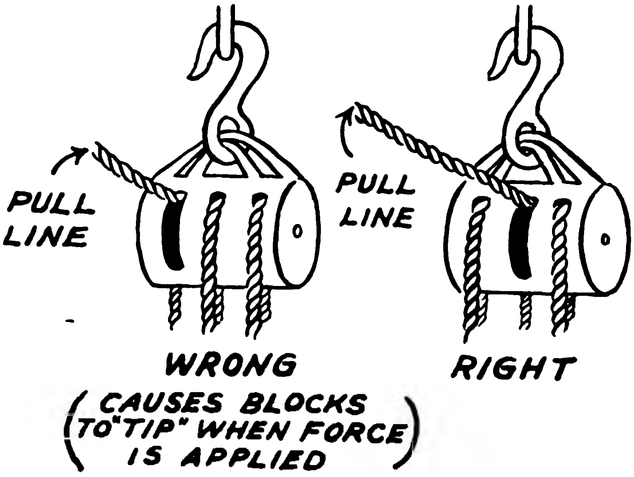


Figure 45. Pull-line "Centered".

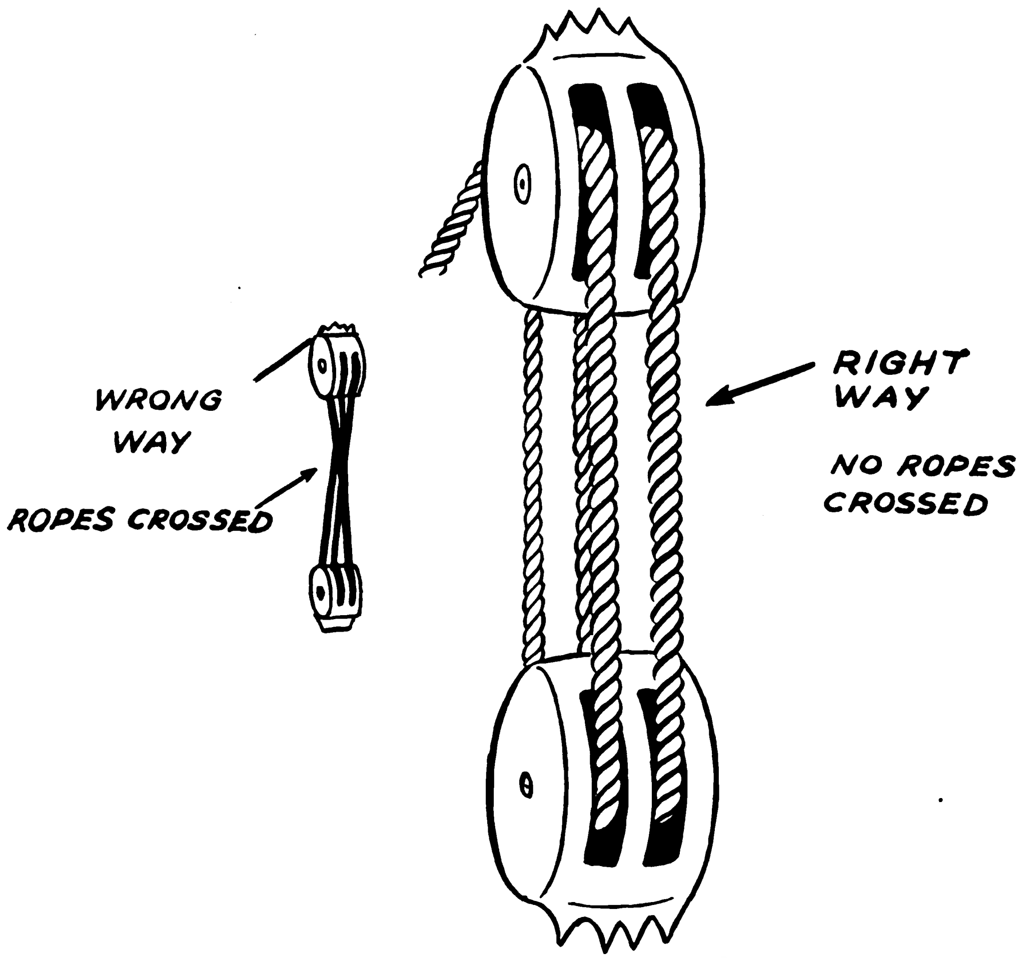


Figure 46. Friction Loss—Rubbing.

In reeving tackle combinations, the rope must be reeved to place the pull line through the sheave nearest the center of the block. This centers the pull line under the hook and prevents frictional loss due to tipping of blocks.

Ropes must not cross over each other, as this also causes frictional loss.

Reeving a set of double blocks: the blocks are positioned, the line is reeved through the bottom sheaves of each block to the upper sheaves of the blocks, and is attached to the becket of the starting block.

When reeving a set of blocks that have an unequal number of sheaves, the block having the greater number of sheaves is reeved first.

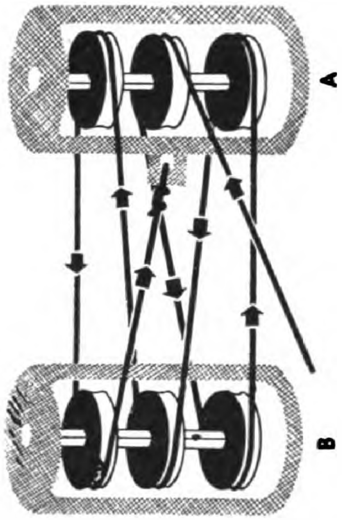


Figure 47. Reeving Set of Triple Blocks.

Reeving a set of triple blocks:

1. The blocks are positioned and the line reeved through the center of block 'A' from front to back.
2. Pass the rope through the bottom sheave of block 'B' from back to front.
3. Pass the rope through the bottom sheave of block 'A' from front to back.
4. Pass the rope through the center sheave of block 'B' from front to back.
5. Pass the rope through the top sheave of block 'A' from back to front.
6. Pass the rope through the top sheave of block 'B' from back to front.
7. Attach line to becket of block 'A'.

ANCHORAGES

Anchorage. In handling loads by means of tackle, shears, gin poles, and other rigging, it is frequently necessary to have some means of anchorage for holding tackle or guy lines. The best and quickest method is to use natural anchorages such as trees or stumps. In hasty field work, natural anchorages may be improved by anchoring one tree or stump to another nearby. They should be carefully tested to insure that they are sufficiently sound and strong. When natural means are not available, heavy vehicles can be used or anchorages can be constructed.

Deadman Anchorage. The strongest anchorage is the deadman anchorage. The deadman anchorage is recommended for heavy loads or permanent installations. The strength of the deadman depends upon two factors: the strength of the log or beam used as the anchor and the characteristics of the soil holding the anchor. In firm soil it is not necessary to fill in the trench holding the anchor providing that the trench is undercut and the leader line angle is not over 45°. In sandy or loose soil, filling in is always recommended.

Hold-Fasts. The most easily constructed anchorage is a picket hold-fast. This type of anchorage should be used only where the angle of pull is less than 45° from the horizontal, as greater vertical angles considerably reduce the efficiency of the hold-fast. The pickets used in this type of anchorage should be straight grained, free from knots, and five feet long and three inches in diameter.

The following table will serve as a guide for the use of ash pickets, which are three inches in diameter and are driven into the ground at an angle away from the direction of pull to a depth of three or more feet. (They should stand the following pulls in undisturbed loamy soil.)

Single picket	700 pounds
1-1 combination	1,400 pounds
1-1-1 combination	1,800 pounds
2-1 combination	2,000 pounds
3-2-1 combination	4,000 pounds

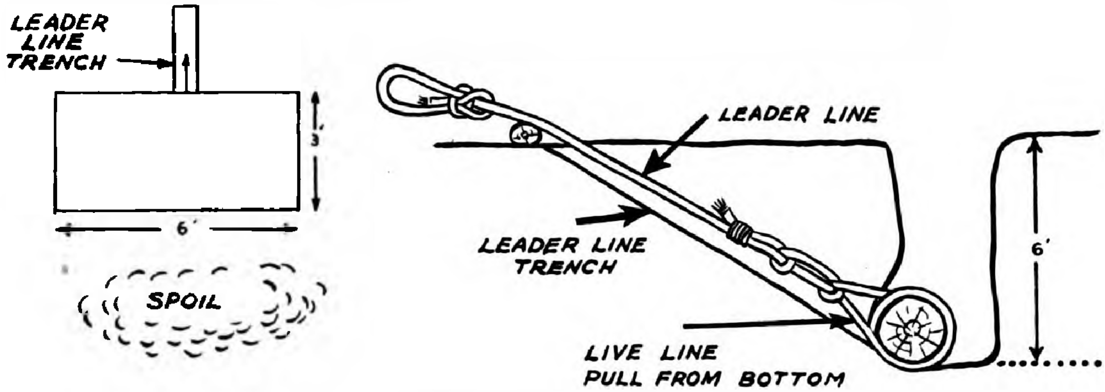


Figure 48. Deadman Anchorage.

For wet earth the holding power of pickets should be multiplied by the following factors:

Clay and gravel mixture	0.9
River clay or sand	0.5

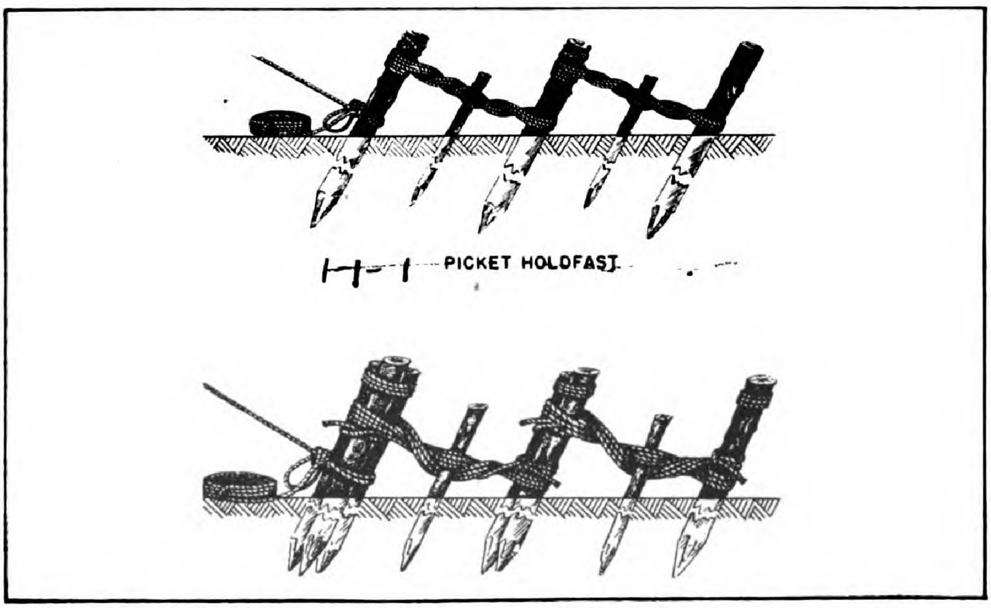


Figure 49. Picket Hold-Fasts. Top: 1, 1, 1, Combination. Bottom: 3, 2, 1, Combination.

Combination Log-Picket Hold-Fast. For heavier loads in soft or wet earth formations, the guy or anchor line can be fastened to a timber supported against four or six picket hold-fasts.

The timber acts as a beam and must bear evenly against each picket. As the strength of this type of hold-fast depends upon the strength of the timber as well as the pickets, it is necessary to select a timber of sufficient size to stand the maximum pull on the anchor line without appreciable bending.

Holmes Ground Anchor. The Holmes ground anchor is an item of issue. In use, the stakes should be driven into the ground until only six inches or eight inches remain above the frame. These anchors, if more than one is to be used, can be set in a single series as illustrated, or they can be set abreast of each other. The

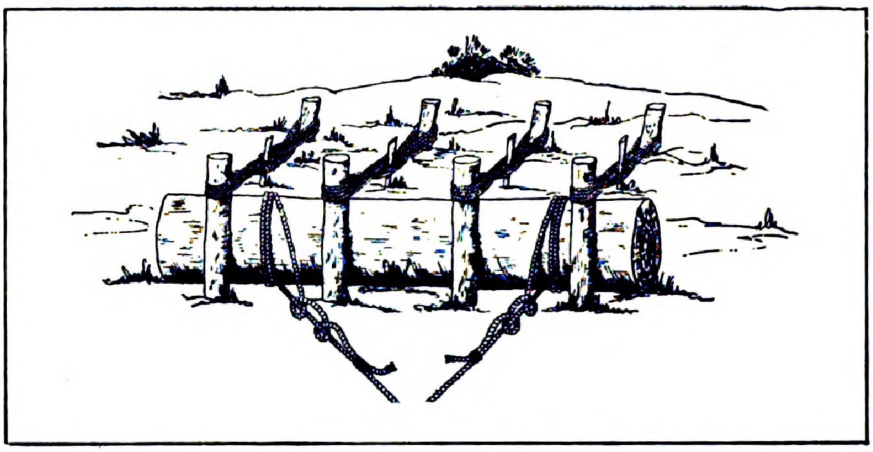


Figure 50. Combination Log and Picket Hold-Fast.

Figure 51. Holmes Ground Anchor.

tops of the stakes should never be struck when the anchors are being removed; in average ground, a solid blow at the base will usually loosen them enough for removal. If the ground is hard, the stakes may be removed by use of the wrecker boom.

CHAINS AND HOOKS

Chains. *Care of Chains.* Care should be taken to avoid excessive stresses, especially those due to impact and overloading of chains. The results of these abuses are not always immediately apparent, because the ruptures and strains they produce are mainly internal. They may, however, cause failure at a later date and under normal loading. The following are suggestions for proper care and use of chains:

(1) Take up all the slack and load slowly to avoid impact.
(2) Protect chain from sharp corners.
(3) Keep chain free from twists and kinks.
(4) Inspect chain frequently for worn, cracked, or broken links.
(5) Chain should be annealed periodically.

Safe Load Capacity. The safe load capacity in tons of a common or open-link chain is approximately eight times the square of the diameter in inches of the metal of one side of a link; for example, the safe load limit in tons for a ¾-inch chain is:

$$8\ D^2 = 8\ (3/4)^2 = 4.5 \text{ tons.}$$

This formula should be used when the grade of the chain is not known.

Hooks. *Use of hooks.* Hooks are used as attachments on chains, wire rope, blocks, and cord rope and are made in various shapes and types. The purpose of the hook is to afford a means of hauling or raising loads without tying the object directly with the rope or chain. The hook may fail by straightening and release the load.

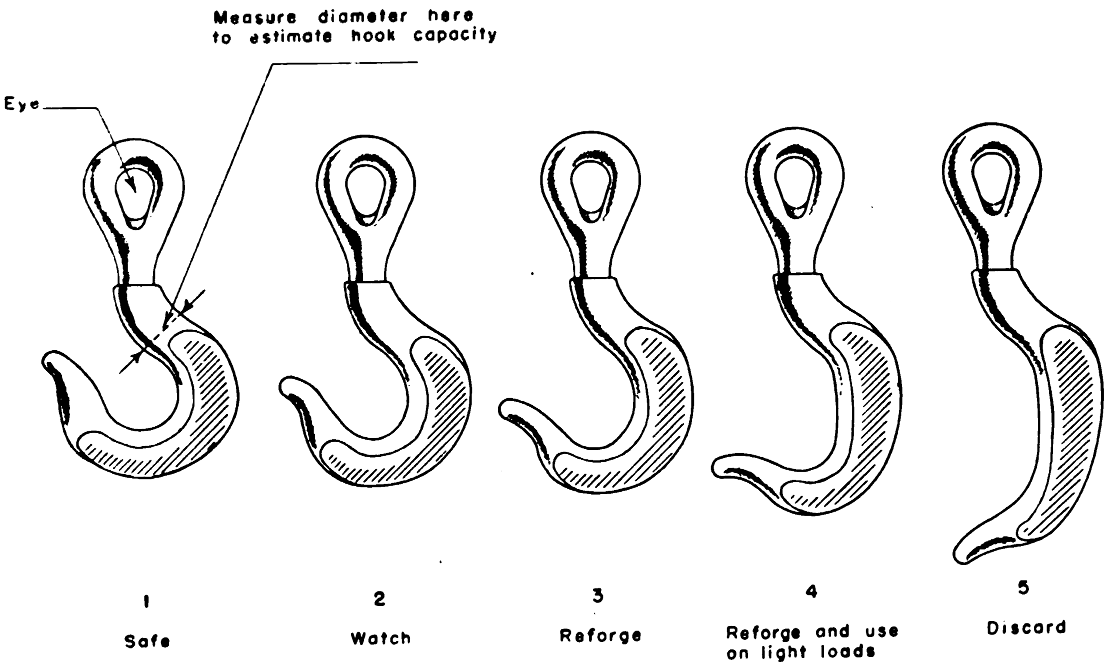


Figure 52. Effects of Overloading Hooks.

Mousing Hooks. With the exception of the grab hook, all hooks should be moused. Mousing helps to prevent straightening but should not be considered in the strength of a hook. It serves principally as a safety measure to keep slings or ropes from slipping off the hook when handling heavy loads. The rules for proper care and use of chains apply to hooks. Hooks that have been partially straightened should be reforged and annealed; if they show evidence of cracks or excessive wear, they should be discarded.

Strength of Hooks. The inside of a hook usually is an arc of a circle, and any deviation from this circular shape indicates that the hook has been severely overloaded. If it has spread or straightened as much as the hook in figure 52, it should not be used on heavy loads after it has been reforged, but if distortion is no greater than that of hooks, 1-2 or 3 in Figure 52, it may be reforged and used safely.

Safe Load of Hooks. The safe load capacity in tons of a hook may be taken as approximately the square of the diameter in inches of the metal at the point where the hook starts to take the shape of an arc. The safe load in tons of a 1¼-inch hook would, therefore, be:

$$D^2 = (1\tfrac{1}{4})^2 = 1\tfrac{9}{16} \text{ tons.}$$

Table V gives the properties of various hooks.

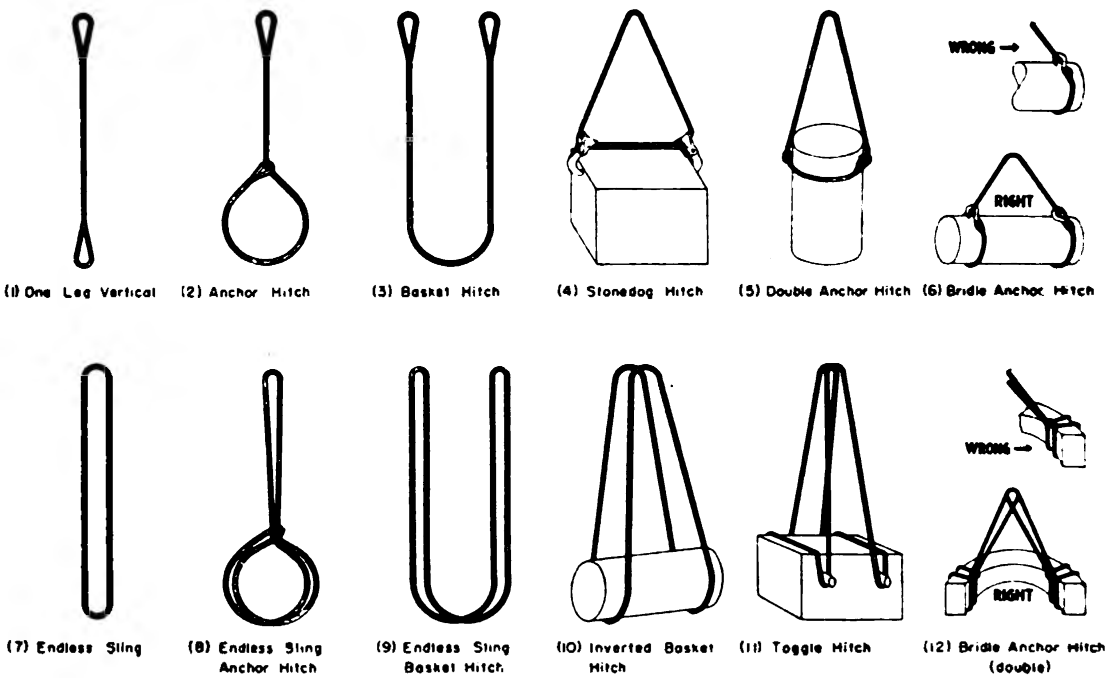
TABLE V. SAFE LOAD OF HOOKS

Diameter of metal (in.)	Inside diameter of eye (in.)	Width of opening (in.)	Safe load (tons)
⅝	¾	1	0.5
11/16	⅞	1 1/16	0.6
¾	1	1⅛	0.7
⅞	1⅛	1¼	1.2
1	1¼	1⅜	1.7
1⅛	1⅜	1½	2.1
1¼	1½	1 11/16	2.5
1⅜	1⅝	1⅞	3.0
1½	1¾	2 1/16	4.0
1⅝	2	2¼	4.7
1⅞	2⅜	2½	5.5
2¼	2¾	3	6.8
2⅝	3⅛	3⅜	8.5
3	3½	4	12.0

SLINGS AND GUY WIRES

Slings. Loads are handled with slings either by employing hitches or by direct connection. Hooks, links, shackles, sockets, or eyebolts are made use of when slinging loads with a direct connection. Direct connection to the load is preferable since the sling body is not subject to bending stresses or abrasion. However, when the sling comes in contact with sharp corners it must be padded.

The cradle or basket hitch may be used when the sling can completely surround



To compute safe-load for each type hitch multiply safe-load for One Leg Vertical, Table XII, by efficiency factor shown

Figure 53. Types of Slings.

the object and if the angle between the legs of the sling and the direction of pull does not exceed 60°.

Where two slings are used to handle a tilted load or where a single sling is used on a load, the anchor (choker) hitch may be used. The disadvantage of this hitch is that it is destructive to the sling body and is not as efficient as the same sling applied to a straight pull.

Sling Stresses. It is very important that slings of sufficient strength be selected, and in making the selection, consideration must be given to the fact that the stress in a sling varies with the angle of its legs. The diagrams in Figure 54 show how

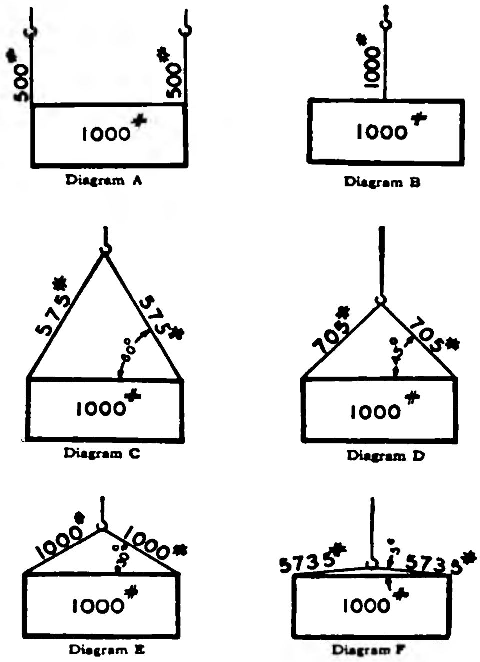


Figure 54. Stress on Sling Legs at Various Angles.

the stress is increased. If the sling is the same size as the lifting rope, it should make a minimum angle of 30° with the horizontal. At this angle (diagram E, Figure 54, the stress in each branch of the sling is equal to the stress in the lifting rope. If the angle is greater than 30°, the load is limited by the strength of the lifting rope; if less than 30°, it is limited by the strength of the sling. Table III gives the safe load in tons for various types and sizes of single leg slings. Table IV gives a method of determining stresses on multiple sling legs at various angles.

Table VI—Composite sling chart (one leg vertical 90°)
Safe loads in tons of 2,000 pounds for various materials, sizes, and safety factors

Iron chain slings				Manila rope slings				Wire rope slings			
	Safety factor				Safety factor				Safety factor		
Size (inches)	3	5	7	Size (inches)	3	5	7	Size (inches)	3	5	7
⅜	1.50	0.90	0.64	⅝	0.66	0.40	0.28	⅜	1.79	1.20	0.85
½	2.50	1.50	1.07	¾	.81	.49	.35	½	3.42	2.06	1.49
⅝	3.51	2.31	1.67	⅞	1.16	.70	.50	⅝	4.27	3.15	1.93
¾	5.63	3.38	2.70	1	1.37	.82	.58	¾	7.50	4.50	3.21
⅞	7.78	4.67	3.33	1¼	2.08	1.25	.89	⅞	9.44	5.67	4.06
1	10.33	6.20	4.43	1½	2.75	1.65	1.18	1	12.82	7.89	5.29
¼	16.00	9.60	6.83	1¾	4.08	2.43	1.75	1¼	16.81	10.09	7.20
½	22.60	13.60	9.70	2	5.00	3.00	2.14	1½	24.10	14.46	10.33
1¾	29.16	17.50	12.80	2¼	6.41	3.85	2.75	1¾	29.87	17.93	12.90
2	37.00	22.20	15.83	2½	7.25	4.35	3.10	2	38.75	23.25	16.60

Guy Lines. Guy lines can be made of wire or hemp rope, chain, or plain wire, and are used to brace derricks or similar objects. Wire rope, because of its high tensile strength, is the most commonly used material for guying.

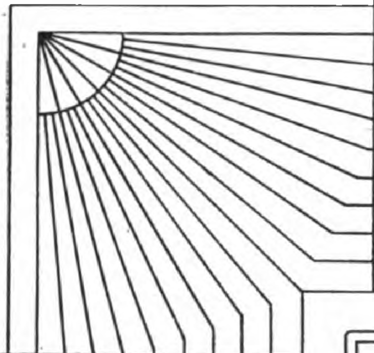
Since the stress increases very rapidly as the guy approaches the vertical, it is advantageous to install guys as nearly horizontal as possible. It is not advisable to have the inclination steeper than 45°. It is recommended that for level ground, guy lines have a length of from two to three times the height of the mast. Referring to Figure 55, if in a given load and position of a boom and mast the stress in a horizontal guy is represented by P, then at 45° the stress would be 1.41 P.

TABLE VII. SLING LOAD CHART.

This chart illustrates the variation of stress on one sling leg when applied to a constant 1000 pound load at various angles "A".

The stress on each leg of a sling assembly is found by the formula: $S = \dfrac{W}{N \times \text{Sin "A"}}$, **where "S" is the stress on one leg, "W" is the total load, "N" is the number of sling legs employed, and "A" is the angle of lift.**

LOAD CHART of Sling Stress at Various Angles of Inclination



VERTICAL LOAD	SINE of ANGLE "A"	SLING STRESS	ANGLE
			0°
1000 lbs.	.08716	11473 lbs.	5°
1000 lbs.	.17365	5759 lbs.	10°
1000 lbs.	.25882	3863 lbs.	15°
1000 lbs.	.34202	2924 lbs.	20°
1000 lbs.	.42262	2366 lbs.	25°
1000 lbs.	.50000	2000 lbs.	30°
1000 lbs.	.57358	1743 lbs.	35°
1000 lbs.	.64279	1555 lbs.	40°
1000 lbs.	.70711	1414 lbs.	45°

VERTICAL LOAD	SINE of ANGLE "A"	SLING STRESS	ANGLE
1000 lbs.	1.00000	1000 lbs.	90°
1000 lbs.	.99619	1003 lbs.	85°
1000 lbs.	.98481	1015 lbs.	80°
1000 lbs.	.96593	1035 lbs.	75°
1000 lbs.	.93969	1064 lbs.	70°
1000 lbs.	.90631	1103 lbs.	65°
1000 lbs.	.86603	1154 lbs.	60°
1000 lbs.	.81915	1220 lbs.	55°
1000 lbs.	.76604	1305 lbs.	50°
1000 lbs.	.70711	1414 lbs.	45°

EXAMPLE

Problem: 100,000 lbs. is to be lifted by a 4-leg sling assembly, each leg lifting at an angle of 45°. What will be stress on one leg?

Procedure: (See Formula at top of page)

W = 100,000 lbs.; N = 4; Sin 45° = .70711

$S = \dfrac{100{,}000}{4 \times .70711} = 35{,}355$ lbs. (Stress one leg)

Had the legs all been lifting vertically, (A = 90°; Sin 90° = 1), the stress in each leg would have been only

$\dfrac{100{,}000}{4 \times 1} = 25{,}000$ lbs.

The maximum stress in a guy line occurs when the line of load lies in the plane formed by the guy line and the support (gin pole mast or column). The following rule, Figure 56, Load Ratio on Guys, may be used to determine this stress: 'the shortest distance from the base of the support to the line of load divided by the shortest distance from the base of the pole to the guy line is the fraction of the load that is supported by the guy line.' Liberal allowances for imperfection in guy lines and measurements of distances should be made.

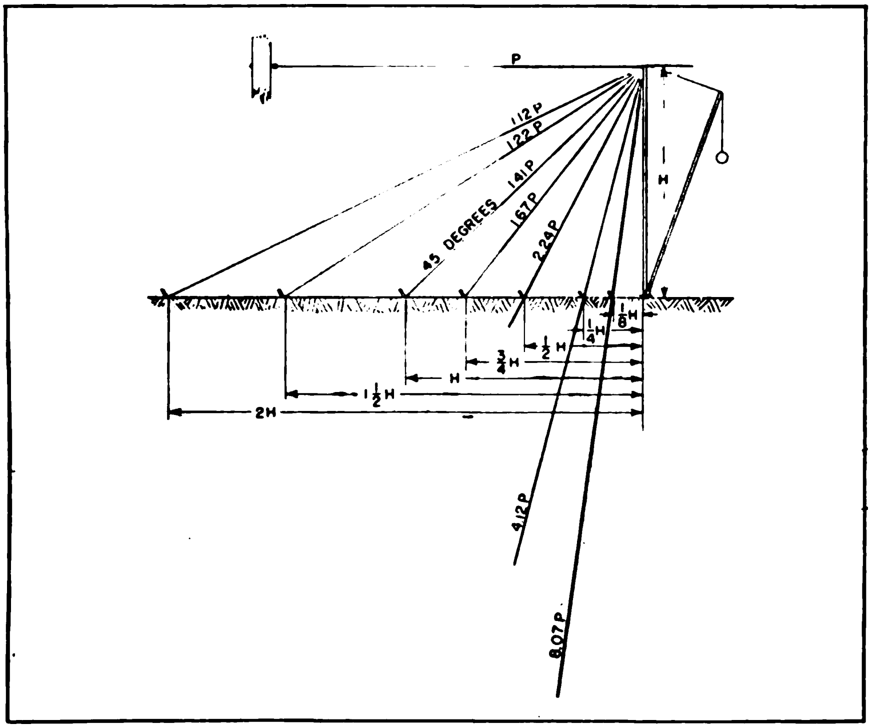


Figure 55. Stress in Guy Lines.

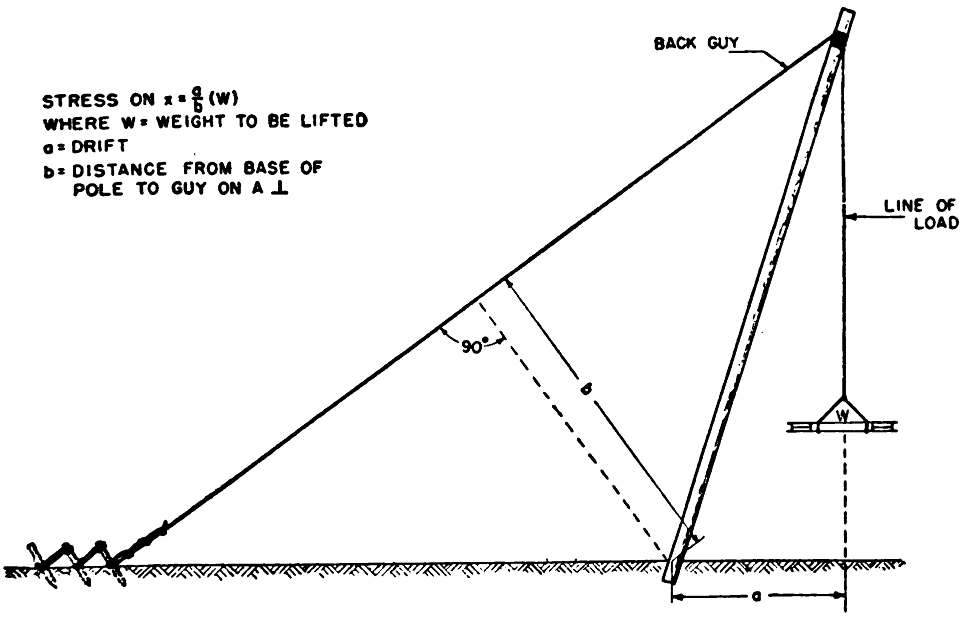


Figure 56. Load Ratio on Guys.

HEMP ROPE SPLICING

Splicing is an important factor in the repair and maintenance of rope.

In the everyday use of rope it is necessary to make slings, lengthen a rope, repair breaks and damaged sections, or to splice for an attachment.

In splicing, the jaws of the rope are opened to weave the strands. Figure 57 illustrates the use of a tapered wooden pin called a 'fid' to aid in the operation.

Short Splice. The short splice is used to join two rope ends together, to lengthen a rope, or to make an endless sling. This splice increases the diameter of the rope without decreasing its strength. It cannot be reeved through proper size blocks but can be used in oversize blocks in an emergency.

Figure 57. Use of a "Fid" in Opening the Jaws of a Rope.

Procedure. 1. Unlay rope ends approximately 12 inches and whip the strand ends. 2. Fingerlock the strands. This is called the 'marriage', Figure 58(A). 3. Force the marriage close together. (When splicing endless slings remove all twists and kinks from the rope before the ends are joined in marriage.) 4. Seize strand ends A, B, and C securely to standing part of rope, taking care not to disturb the lay of the strands, Figure 58(B). 5. Pass strand number 1 over one strand and under one strand, Figure 58(C).

6. Pass strand number 2 over one strand and under one strand, Figure 58(D).
7. Pass strand number 3 over one strand and under one strand, Figure 58(E).
8. Carefully remove all slack in strands 1, 2, and 3.
9. Remove seizing and replace on opposite side of marriage, Figure 58(F).
10. Repeat steps 5, 6, and 7 with strands A, B, C.
11. Carefully remove all slack in strands A, B, C. Each strand now has one tuck, Figure 58(G).
12. Take two additional tucks in strands A, B, and C.
13. Remove seizing.
14. Take two additional tucks in strands 1, 2, and 3. Three tucks have now taken on each side of the marriage. The splice is now complete.
15. Cut strands, leaving one inch ends; if strand ends are cut too short, the last tuck will be lost because strand ends will pull out as tension is applied, Figure 58(H).
16. Pound splice lightly with wooden block or roll under foot; this procedure dresses the finished splice. A good splice has no slack and is firm. The finished splice can be tapered by splitting the strands and taking an additional tuck; this does not increase the holding power but provides for a neater job.

Eye or Loop Splice. The eye or loop splice is used to form an eye or loop in the end of the rope. This forms a permanent loop that is approximately as strong as the rope itself. The eye splice will not pull out if properly used but caution must be observed to avoid its use on a load that might 'spin' causing the lay of the rope to open and release the holding power of the splice.

The only difference between the eye splice and the short splice is in the method of marriage.

Procedure.

1. Unlay rope ends approximately 12 inches and whip strand ends.
2. Determine the size of loop and form a bight, then pass strand number 1 under strand A, Figure 59(A).
3. Pass strand number 2 over strand A, tuck under strand B, Figure 59(B).
4. Pass strand number 3 over strands A and B, tuck under strand C, Figure 59(C).
5. Remove all slack in the marriage.
6. Place three additional tucks in each strand into the standing part as out-

lined for the short splice (over one and under one removing all slack) The splice can be tapered as in the short splice.

After the last tuck has been taken, cut off the strands leaving one-inch ends and allow them to fray out. The frayed ends will pull in as the splice is used. Roll the finished splice under foot, or pound lightly with a wooden block to dress the splice.

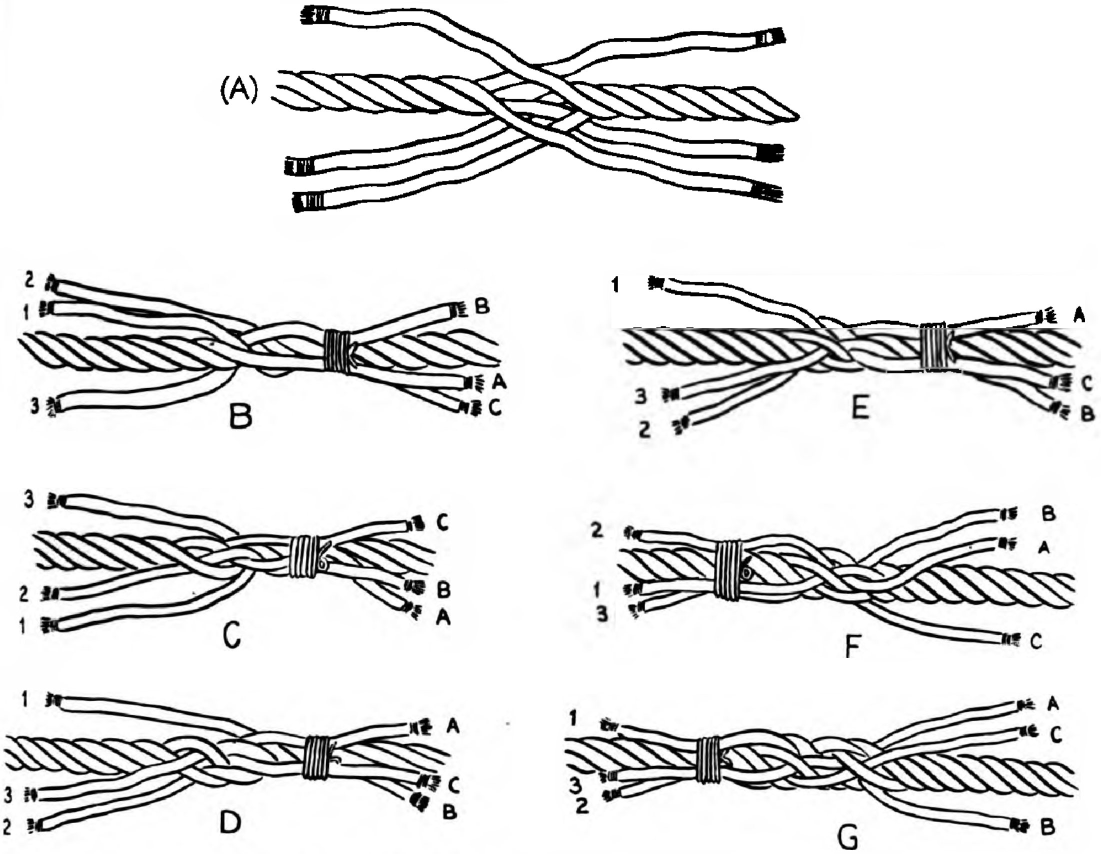


Figure 58. Making the Short Splice.

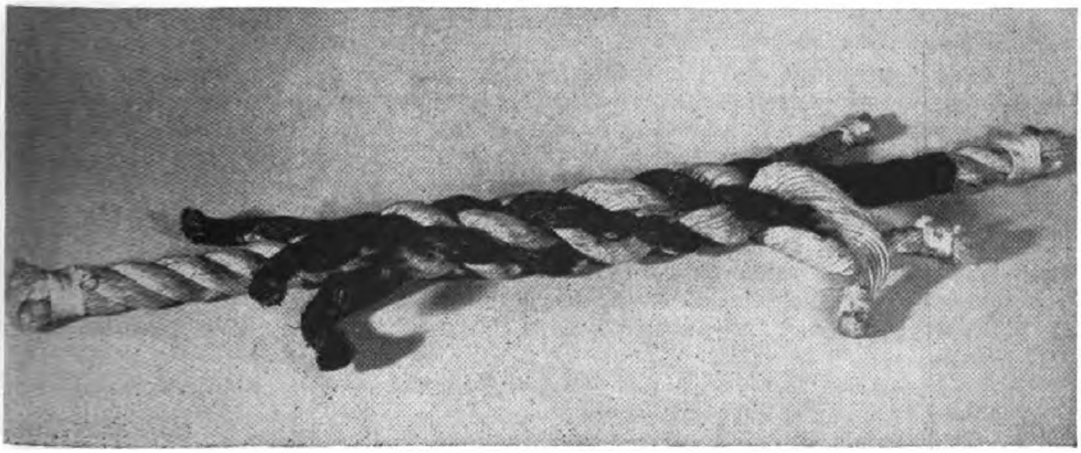


Figure 58. (Continued). The Finished Short Splice.

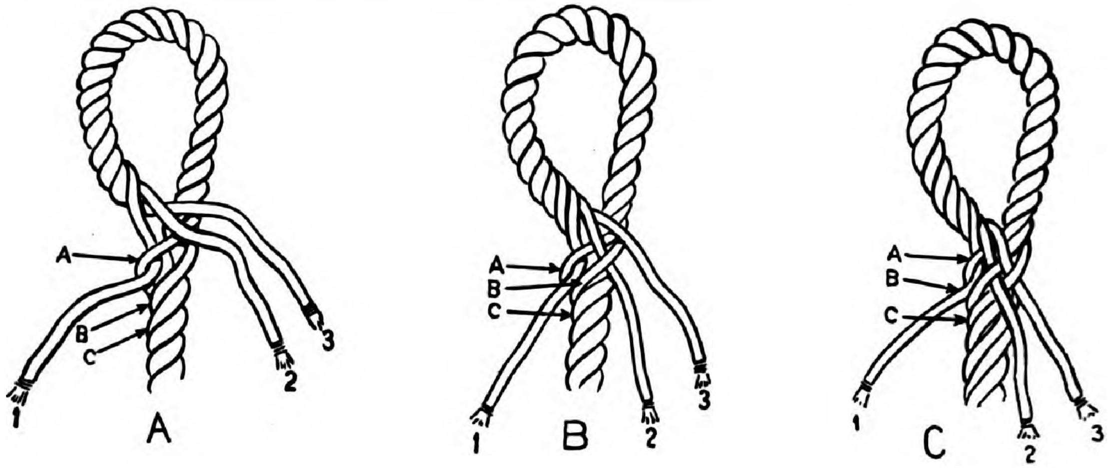
Long Splice. The long splice is a method of joining ropes that does not increase the diameter of the rope.

This method is generally used where the rope must be passed through a restricted opening, as in the reeving of block and tackle or passing through an eye.

The long splice follows the principle of rope making, and extreme care must be taken to prevent any loss of lay when splicing. The Long splice reduces the efficiency of a rope by about 25 per cent.

This splice is not recommended for endless slings; the short splice should be used.

The splice should cover an area approximately 20 times the rope diameter in feet. On a ½-inch rope, ½ x 20 equals 10 feet. Therefore, the rope ends should be unlayed about 5 feet and the splice will cover an area of approximately 10 feet.



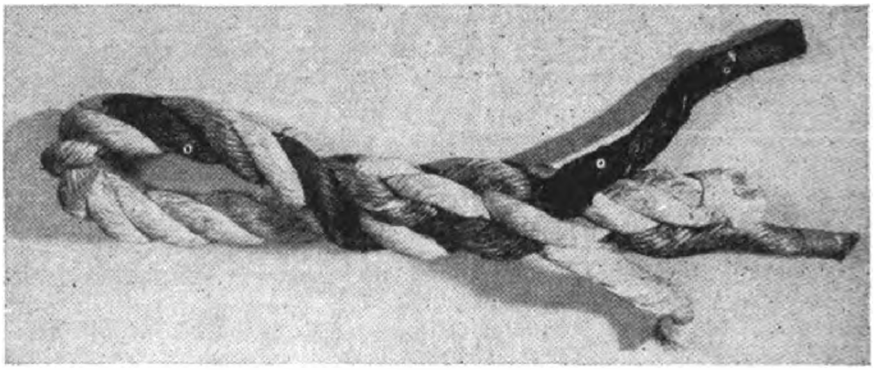


Figure 59. Making the Eye Splice.

Procedure.

1. Unlay each rope end the recommended distance.
2. Tape or whip each strand end to prevent loss of lay.
3. Fingerlock the strands (this is called the marriage).
4. Force marriage close together.
5. Seize strands B and C to standing part of rope, Figure 60(A).
6. Unlay strand A and replace with strand number 1; take care to retain the original lay of the strands when replacing one with the other, Figure 60(B).
7. Tie off strand ends with an overhand knot. Figures 60(C) and 60(D) show correct and incorrect method of tying the overhand knot.
8. Remove seizing from strands B and C, exercising care not to disturb the marriage.
9. Unlay strand number 2 and replace with strand B. This is a duplication of step number 6, Figure 60(E).
10. Tie strands B and 2 with overhand knot.
11. Tie an overhand knot in strands 3 and C; cut all strands, leaving 8-inch ends. This is for convenience in tucking, Figure 60(F).
12. Take two tucks in all strand ends (over 1 and under 1).
13. Cut off strands leaving 1-inch ends; the ends will fray out and disappear as the splice is used, Figure 60(G).
14. Pound tuck lightly with wooden block or roll under foot.

If it is desired to use the splice through a very limited space, the tucking can be eliminated and the overhand knot covered with a whipping, Figure 60(H).

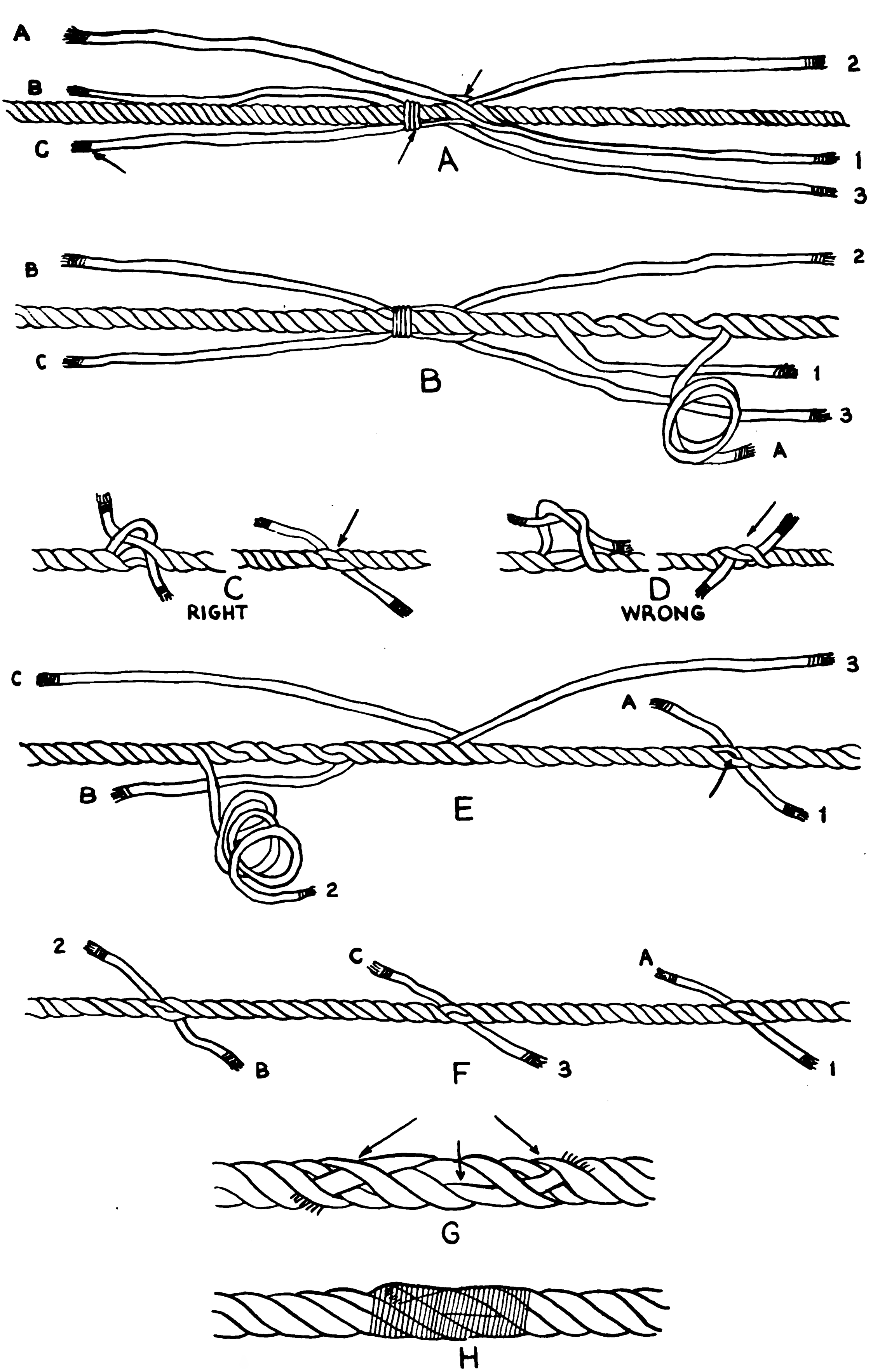


Figure 60. Making a Long Splice.

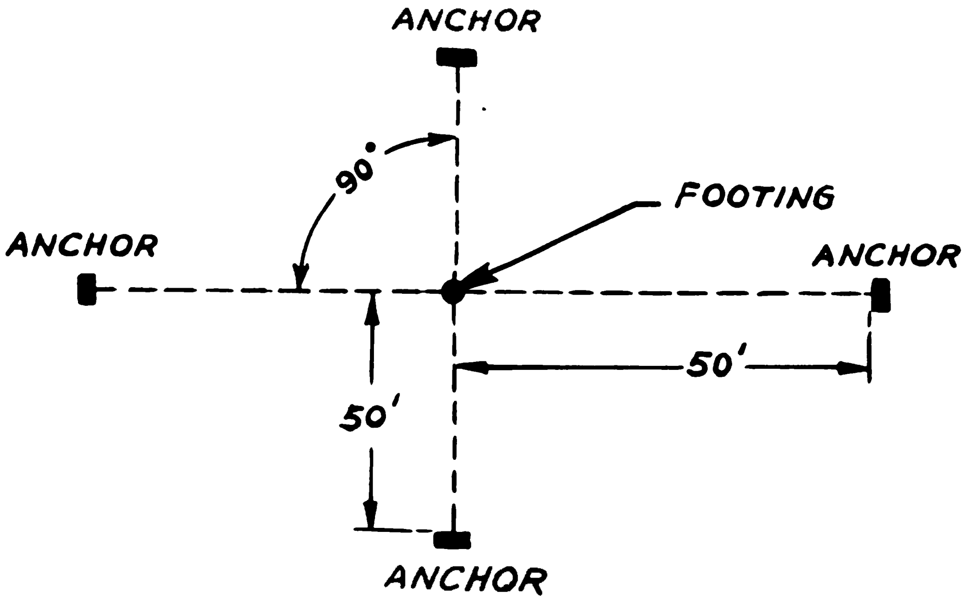
AUXILIARY HOISTING DEVICES

There are three common types of auxiliary hoisting devices using spars with block and tackle rigging. The spars or poles used in their construction will depend on local conditions.

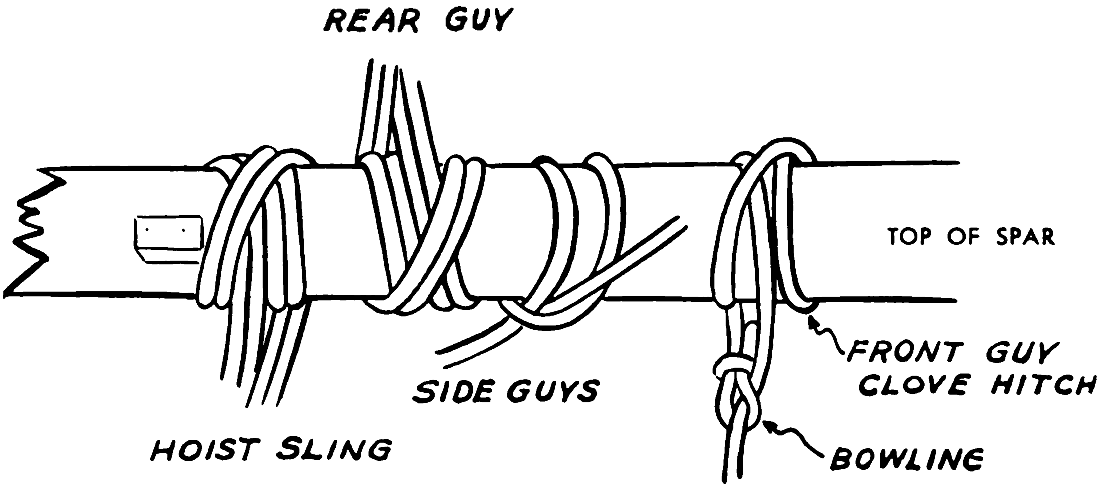
They should be selected with care to assure straight grained poles, free from knots, and as sturdy as possible. The use of unseasoned timber should be avoided and whenever more than one spar is used, as on the shear or tripod, the spars should be of equal diameters.

The following paragraphs will describe in step by step procedure, the installation of three different auxiliary hoisting devices: the Gin Pole, A-Frame, and Tripod.

Gin Pole. The gin pole consists of a single spar supported by guy lines and equipped with suitable hoisting tackle. The first step in erecting the gin pole is to determine the amount of weight to be lifted and to plan the rig accordingly. Cable (wire rope) or chains can be substituted for hemp rope to increase the strength and lifting power of the gin pole provided the spar is strong enough to carry the load.



A. Field Layout.



B. Attachment of Tackle.
Figure 61. Erecting a 25-foot Gin Pole.

The length of the spar determines the spacing of the anchorages. The anchors are located twice as far away from the spar as the spar is long. In this case the spar is 25 feet long; so the anchorages are 50 feet from the base, Figure 61(A).

Procedure.

1. Inspect all ropes.
2. Lay spar on shoring and attach hoist sling using a clove hitch, Figure 61(B). The hoist sling is attached about three feet from the end of the spar. All guys are attached above the hoist sling. (In case the hoist sling slips it will strip the guy lines if attached above them.) On smooth poles, nail cleats on the spar below the hoist sling to prevent slipping.
3. Attach sling for rear guy tackle with clove hitch. The direction of pull will be opposite the hoist sling, Figure 61(B).
4. Side guys are attached using a clove hitch in the middle of a rope that is long enough to act as both guys, Figure 61(B).
5. Attach front guy, Figure 61(B). The front guy is used for safety. It will keep the gin pole from toppling if the load should accidently be dropped. A long bowline with a clove hitch inside the loop is recommended for attaching the front guy to the spar. When single side guys are used, this combination of the bowline and clove hitch is recommended.
6. Secure the side guys to anchorages using a round turn and two half-hitches. Seize the half-hitches.

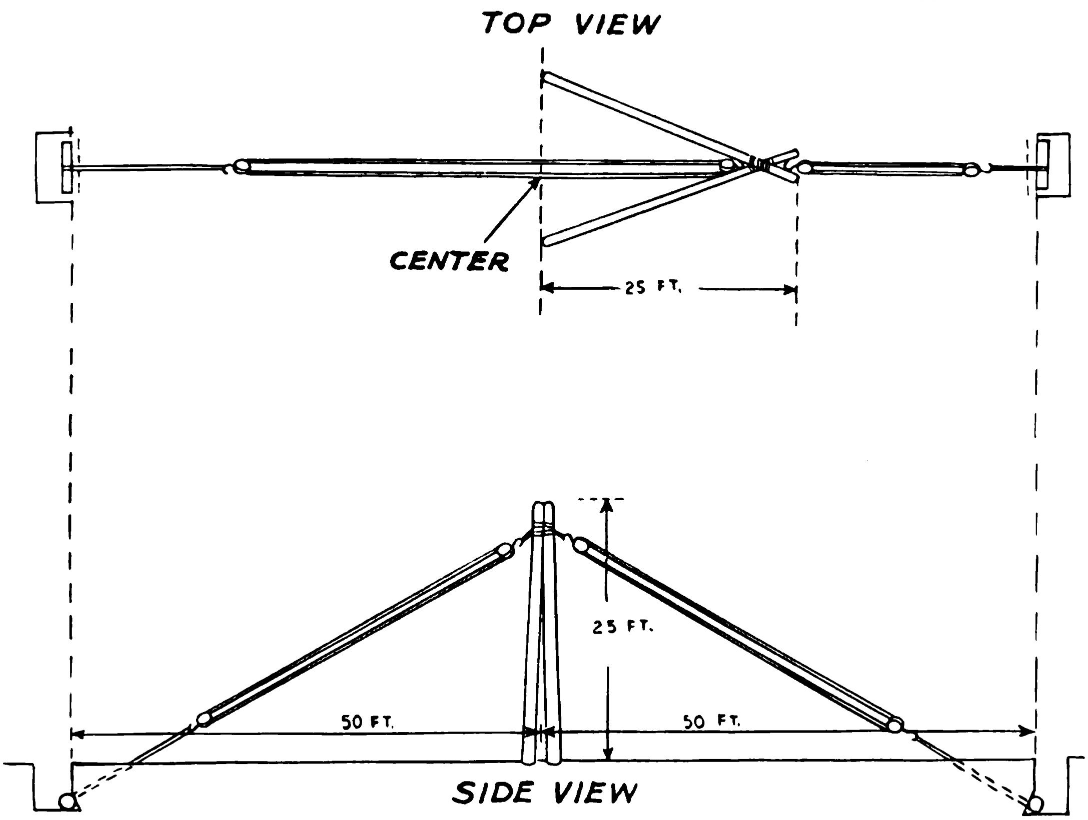
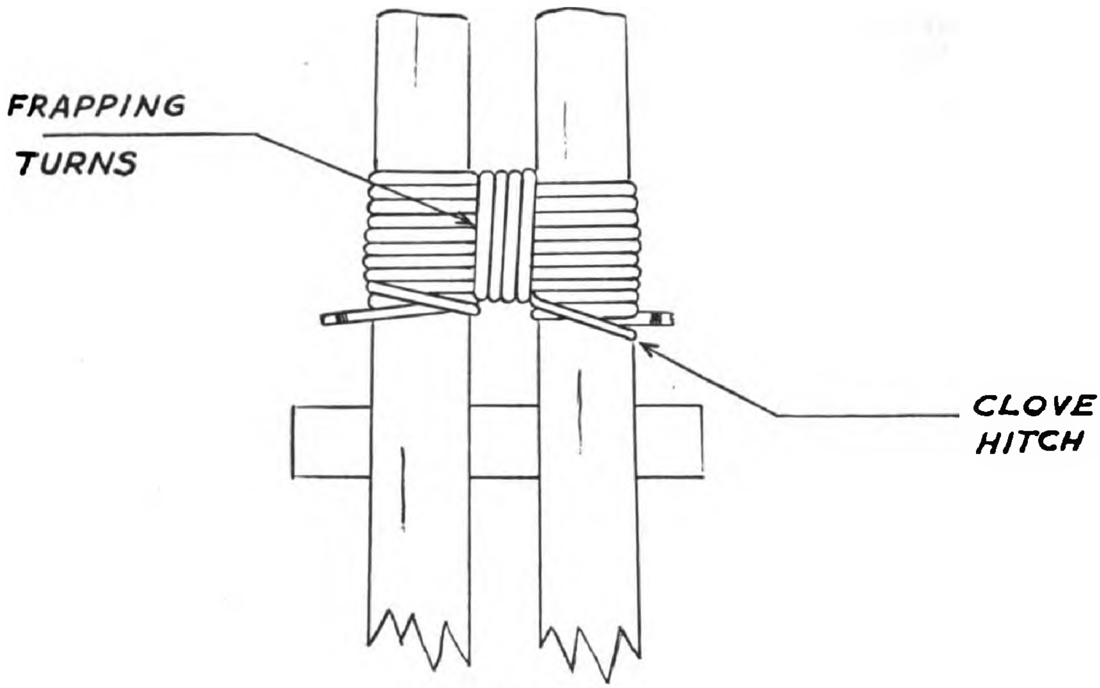


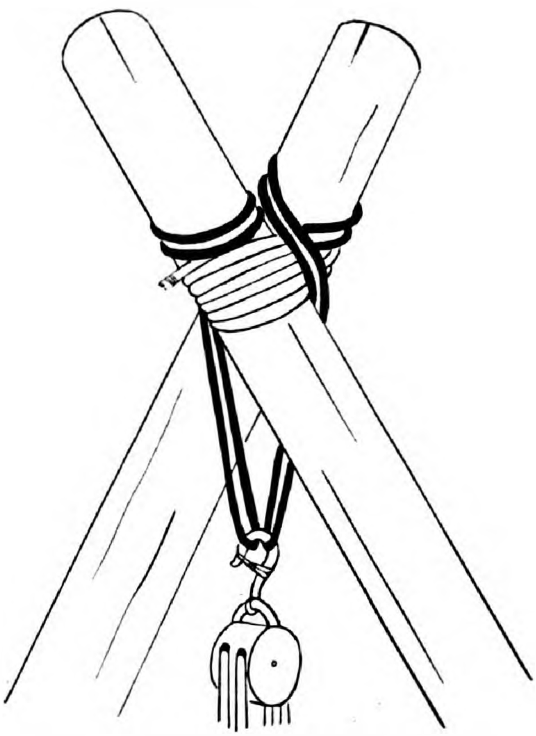
Figure 62. Anchorages for an "A" Frame.

7. Reeve hoist blocks and mouse into back guy sling. (The slings should be checked for proper direction of pull and dress of ends.)
8. Reeve back guy tackle and mouse into back guy sling and check slings for proper direction of pull and dress of ends.
9. Mouse back guy tackle into leader line of back anchorage. The gin pole is ready to be raised. Before Raising:

a. Check all anchorages.
b. Check all knots, bends, and hitches for dress and direction of pull.
c. Check all mousings.



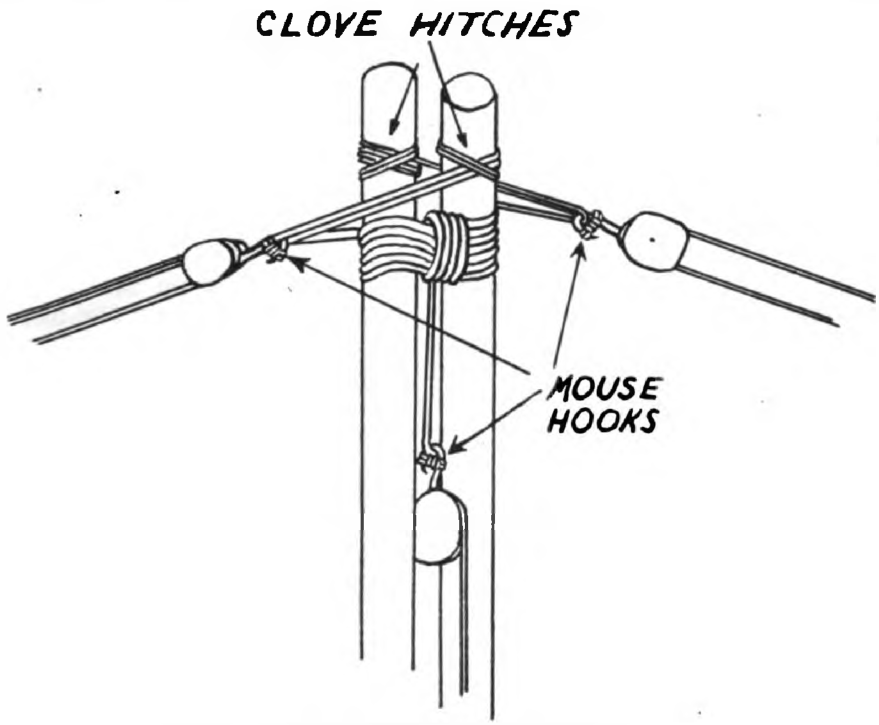
A Frame Lashing.



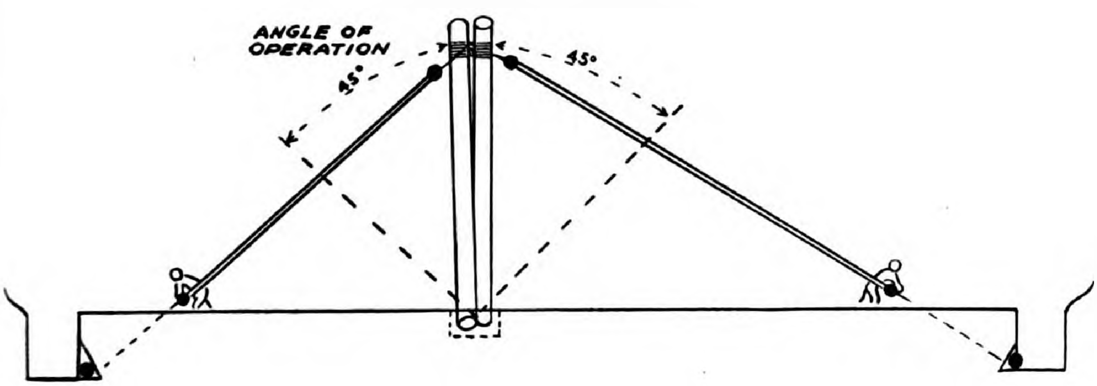
Hoist Block in Sling.
Figure 63. Erecting a 25-foot A Frame.

10. Place men on the pull line of the rear tackle.
11. Place one man on the front guy.
12. Place one man at the butt of the pole with a crow bar and sledge.
13. The remaining available men will raise the top of the spar about ten feet off the ground.

The crew on the rear tackle will only remove the slack in the rear guy until the top of the spar is about ten feet off the ground. Failure to observe this caution will result in the pole being pulled out of the footing. After the top



Attachment of Guy Lines.



Safe Angles of Operation.
Figure 63—(Continued). Erecting a 25-foot A-Frame.

of the spar is ten feet off the ground, men on the rear guy lines will raise the spar to the desired angle of operation. The man at the butt will see that the pole is properly seated in the footing and does not kick out. The man on the front guy will keep the pole from going past the vertical position. The crew leader will stand in position to note any discrepancies.

14. Take in on back guy till pole is about 20° from the vertical position.
15. Secure front guy to anchorage using a round turn and two half-hitches seized.
16. Pull back guy until all slack is taken out of front and rear guy.

This procedure brings the gin pole to the recommended angle of operation which is 15° from the vertical.

17. Tie off back guy tackle. It is recommended that the pull line of the back tackle be secured to the hook of the standing block of the back tackle using two half-hitches seized.

18. Check alignment of gin pole, and adjust side guys accordingly.

Caution: It is unsafe to operate the gin pole at a greater angle than 45° from the vertical.

The Shears or A-Frame. The shears is a device frequently employed as an auxiliary hoisting device. It is formed by lashing together suitable spars and suspending tackle from the intersection.

The shears possesses great lateral stability and can be operated 45° from the vertical position in either direction by manipulating the front and rear guy lines.

Procedure for Erecting a 25-Foot A-Frame. 1. Lay out Field. A line drawn through the center of the front anchorage to the center of the back anchorage will pass through the point of lashing and through the center of the spread legs of this A-frame. Anchorages should be located two spar lengths from footings, Figure 62.

2. Select spars that are straight grained, free from knots, and of the same diameter.

3. Lay spars with butts in line.

4. Placing shoring under spar about four or five feet from the top ends of the spars. A spacer should be placed between the spars. The space between spars should be one-half of the spar diameter.

5. Select point of lashing approximately 3 feet from top end.

6. With lashing rope place clove hitch on one spar, Figure 63(A).

7. Take eight or ten lashing turns around both spars, Figure 63(A). This lashing should be drawn smooth and dressed evenly. If poles are smooth, wooden blocks should be spiked to the spars below the lashing to keep the ropes from slipping.

8. Frap these lashing turns with three or four frapping turns.

9. Finish by placing clove hitch on opposite spar, Figure 63(A).

10. Cross legs of frame to form an A. The legs of the A-frame should be spread according to the length of the spars from the point of lashing to the butts.

Example. On 25-foot spars the lashing is placed 3 feet from spar tops. This leaves a distance of 22 feet from point of lashing to the butts; therefore, 22 feet is the maximum distance that the legs may be spread.

However, the recommended leg spread is 2/3 of the distance from the point of lashing to the butts, which is 2/3 of 22 feet or 14 feet.

11. Construct footings. In soft or muddy ground, reinforce footings using stones and timbers and drive stakes to keep the butts from kicking out. If spars are exceptionally heavy, the butts can be lashed to a picket hold-fast for additional safety.

12. Attach load sling using one half-hitch around each pole above the lashing: this helps to bind the poles together.

13. Be sure the ends of the sling are even, Figure 63(B).

14. Mouse hoisting tackle in this sling. Check pull line of hoist tackle for proper direction of lead if snatch block is to be used, Overhaul hoist tackle far enough so that it can be reached from the ground after the A frame is raised.

15. Attach guy slings to spar by making a clove hitch above lashing. The action of the guy lines pulls the poles together rather than apart. Figure 63(C).

16. Mouse blocks in both slings shown in Figure 63(C).

17. Place men on pull line from back guy.

18. Place one man at the butt of each spar with crowbar to prevent butts from kicking out.

19. Place balance of men around A-Frame.

20. Raise top of A-Frame to about 30° from horizontal.

21. Take in on back guy.

22. Raise A-Frame to the vertical by pulling on pull line from back guy.

23. Tie off front guy line.

24. Pull back guy line to take slack out of both guy lines.

25. Tie off back guy line.

This frame is operated most efficiently from a vertical position; however, it can be operated safely 45° from the vertical in either direction, Figure 63(D).

Tripod. Consists of 3 spars lashed together similar to the shears. The advantage of the tripod over other installations is that it requires no guylines. Its disadvantage is that the loads can be moved only up and down.

Erecting a 25-foot Tripod. When using a tripod it must be remembered that the working area will be limited due to the fact that the legs of the tripod are spaced one-half the distance of the length of the spars from the butts to the point of lashing.

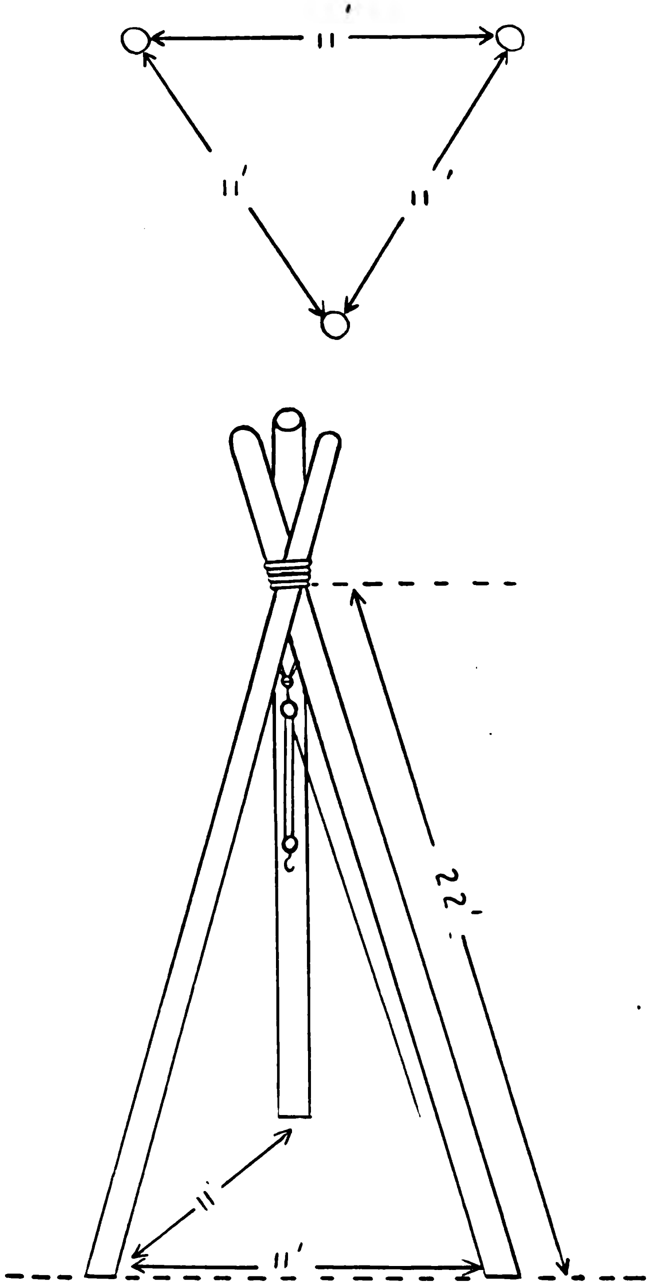


Figure 64. Footings for a Tripod.

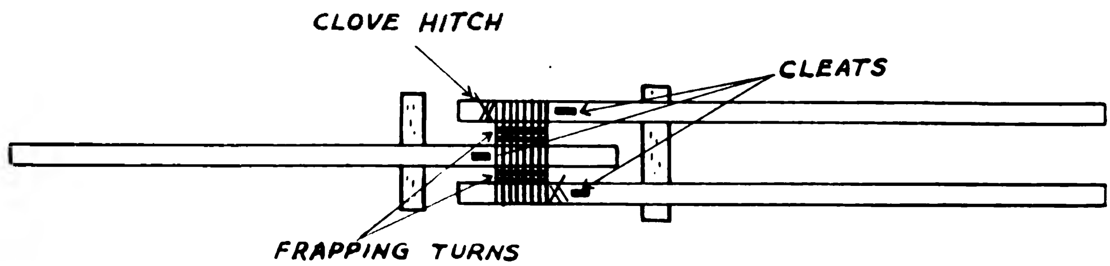
Example: Tripod spars are 25 feet long. Lashing is placed 3 feet from the end. Then the distance from the butt to the point of lashing is 22 feet. Footings are then 11 feet apart in a triangular formation, Figure 64.

Procedure:

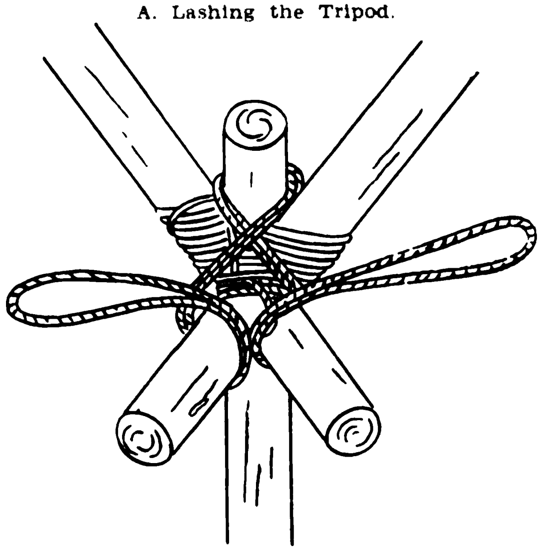
1. Select spars.
2. Place spars on shoring.

a. Butts of two spars are in opposite direction from third spar.
b. Distances from spar ends are equidistant.
c. Spars are spaced at a distance equal to the diameter of the spars at the lashing point.

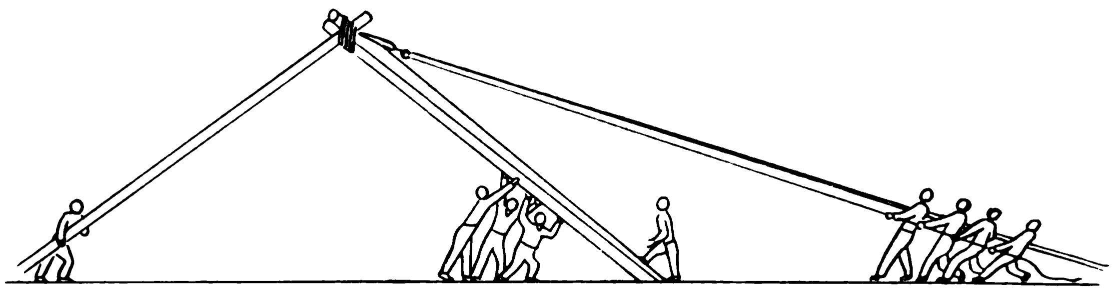
Example: If spars are 8 inches in diameter at the point of lashing, the spars must be spaced 8 inches apart. Proper spacing is essential to insure proper binding of the lashing.



A. Lashing the Tripod.



B. Attachment of Hoist Sling.



C. Raising the Tripod.
Figure 65. Erecting a 25-foot Tripod.

3. Attach lashing rope to one outside spar using clove hitch.
4. Place eight or ten lashing turns around all three spars, Figure 65A.
5. Place three or four frapping turns around lashing between all spars, Figure 65A.
6. Finish by securing lashing rope to opposite spar with clove hitch. Nail cleats on spars to keep lashing from slipping.
7. Cross two legs of the tripod.
8. Prepare footings for tripod. In soft or muddy ground, reinforce footing, using stones and timbers and drive stakes to keep the butts from kicking out. If spars

are exceptionally heavy. two of them can be lashed to a picket hold-fast for additional safety.

9. Raise point of lashing about four feet.

10. Place hoist sling on tripod as illustrated in figure 65B. Applying the sling in this manner reinforces the lashing.

11. Dress sling so that both ends are even, placing an equal amount of strain on each side of the sling.

This sling may slip during the raising of the tripod. It will then be necessary to send a man to the top of the spar cross to dress the sling after the tripod is set.

12. Mouse hoist blocks in hoist sling.

13. Secure the running block of the hoist tackle to an anchorage.

14. Place men at each leg of the tripod to lift frame.

15. Place men on pull line of hoist blocks.

16. Place men at butts of poles to keep butts from kicking out.

17. Raise tripod and place third leg in footing.

18. Release hoist blocks from anchorage.

19. Dig a shallow trench (about 6 inches deep) and lash the butts together to prevent them from kicking out.

The object of digging a trench for the butt lashing rope is to avoid tripping over it when working in the area and also to eliminate interference when moving objects to and from the hoist.

A snatch block can be attached to any one of the legs of the tripod; however, it should be placed on the leg in line with the pull line of the hoisting tackle. The tripod is recommended whenever the job will permit its use as it requires a minimum of rope. This is a desirable characteristic on permanent installations as there are no guy lines to slack off in case of rain and a minimum of rope is exposed to the weather.

Permanent installations of tripod, gin pole, or A-Frame can be set up using wire rope or chain lashings and slings. Block and tackle can be replaced with chain hoists and winch lines.

WIRE ROPE

Construction. Upon casual inspection all wire ropes appear to be the same. In spite of this fact they are of many different types. By changing the number and size of the wires, strands and centers, many different rope constructions can be formed. The difference in ropes of various construction is principally in flexibility and resistance to external wear. In general, ropes with larger wires provide greater resistance to external wear, and ropes with smaller wires have greater flexibility.

Wire rope is constructed by twisting wires together to form strands; the strands are then twisted around a core which assures uniform diameter. The core is usually of hemp rope; however, it may be wire strand or an independent wire rope. Its function is to support the strands and maintain uniform 'lay'. Rope may be twisted to the right or left as it is being manufactured. The direction of twists is usually designated by the term lay.

Different Lays of Wire Rope. The lay of wire rope has a dual meaning: the arrangement of wires in relation to the strand, and the arrangement of the strands in relation to the rope.

Regular Lay. In regular lay ropes, the wires are twisted in the opposite direction to the strands. In regular lay right construction the strands are laid to the right. and the wires are laid to the left, Figure 66(A). In regular lay left construction the strands are laid to the left and the wires are laid to the right, Figure 66(D).

Lang Lay. The strands and wires are both twisted in the same direction. It may be either right lang lay, Figure 66(B), or left lang lay, Figure 66(C).

This construction presents a larger wearing surface of the individual wires; therefore, the rope has a longer life. The disadvantages are that it will kink easier and be harder to handle.

Reverse Lay. Reverse lay applies to ropes in which the strands are alternately regular lay and lang lay. This construction balances the rope and keeps it from untwisting.

Preformed Wire. Most of the wire rope used by the Army is preformed, a process which applies to manufacture. In preformed lines the wires are permanent formed in the position that they will occupy in the finished strand; this operati also preforms the strand into the shape of the finished rope.

Some of the most important advantages of preforming are as follows:

1. It will not unravel or fly apart if the ends are not seized.
2. It is somewhat more flexible than non-preformed rope and is less likely become kinked.
3. It has a tendency for smoother drum winding where the winding is in sever layers.
4. It is better able to resist severe bending conditions, particularly with the sma sheaves or snatch blocks used by the army.
5. Broken wires do not protrude from the surface of the rope.

A. Regular Lay, Right.

B. Lang Lay, Right.

C. Lang Lay Left.

D. Regular Lay, Left.
Figure 66. Wire Rope Construction.

Table VIII. Breaking Strength of 6 x 19' wire rope [1]

Size (inches)	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 1/2
Approximate weight per 100 feet (pounds)	23	40	63	90	123	160	203	250	360
Grade	Breaking strength (tons) [2]								
Iron	2.1	3.6	5.5	7.9	10.6	13.7	17.2	21.0	29.7
Traction steel	4.0	6.8	10.4	14.8	20.0	26.0	32.7	40.6	56.6
Cast steel	4.5	7.7	11.8	16.8	22.8	29.5	37.0	46.0	65.0
Mild plow steel	5.0	8.5	13.1	18.7	25.4	33.0	41.5	51.0	72.5
Plow steel	5.5	9.4	14.4	20.0	28.0	36.5	46.0	56.5	80.5
Improved plow steel	6.3	10.8	16.6	23.7	32.2	42.0	53.0	65.0	92.5

[1] The strength varies slightly with the strand construction and number of strands.
[2] The strength varies with the square of the diameter. For example, 3 3/4-inch rope is 4 times as strong as a 3/8-inch rope of the same material $(3/4 \div 3/8)^2=4$.
[3] The maximum allowable working load is the breaking strength divided by the appropriate factor. (See par. 28c).

Grade. Strength, and Safety Factors. There are six common grades of wire rope. Table VIII shows the comparative strengths.

For practical purposes the diameter of wire rope can be used to calculate its safe load capacity in tons without consulting a book or table. The formula is: Multiply the square of the diameter in inches by 8 to obtain the maximum safe working load in tons. This value has a safety factor of from about 2 to 5 depending mainly on the type of rope. Example: To find the safe load carrying capacity of a ½-inch wire rope by using the formula; safe load in tons$=8\ D^2\ (\frac{1}{2})^2$ equals 2 tons.

It is difficult to set safety factors applicable to all ropes. The relationship between the weight lifted and the stress on the rope varies with such items as the loads applied, speed of operation, type of fittings, length of rope, number and size of sheaves and drums, and impact. Table IX is a guide for safety factors. Liberal allowances should be made for worn or old wire rope when calculating the safe load limit.

Table IX. Wire rope safety factors

Type of service	Minimum safety factor
Track cables	3.2
Guys	3.5
Cable tools	8.0 for depths to 500 feet.
	7.0 for depths 500 to 1,000 feet.
	6.0 for depths 2,000 to 3,000 feet.
	4.0 for depths 3,000 feet.
Miscellaneous hoisting equipment	5.0
Haulage ropes	6.0
Derricks	8.0
Slings	6.0

Proper Handling of Wire Rope. Wire rope usually comes to the user in coils or on reels. It is absolutely necessary that the coil or reel rotate as the wire rope is unwound. Any attempt to uncoil or unreel a wire rope from a stationary coil or from a reel will result in kinks; and once a kink is pulled tight, the rope at that section is ruined beyond repair.

Figure 67. Results of Kinks.

Coiling. Coiling of rope is accomplished by first laying the rope out straight and then forming a loop in one end and rolling it along the ground like a hoop, until the entire length has been coiled. The coil should then be seized in four places.

Uncoiling. The end of the rope should be held or anchored and the coil rolled along the ground. This will lay the rope out without kinks or bends. Figures 68 and 69 shows the proper and improper method of uncoiling wire rope.

Unreeling. If the rope is to be unwound from a reel, there are three correct methods.

1. The reel may be mounted on a shaft supported by cribbing or jacks. This allows the rope to leave the reel in the reverse direction from the one in which it was reeled, Figure 70 (A).

2. The reel may be mounted on an unreeling stand. It is then unwound in the same manner as before. Care must be taken to take the slack up so that the rope will not fall off the reel, Figure 70 (B).

3. In case either of the previous methods is not possible due to lack of equipment, this third method will suffice. Anchor the free end of the rope or let a man hold the free end, and roll the reel along the ground, laying the rope on the ground as the reel rolls, Figure 70 (C).

Unloading and Moving Reels of Wire Rope. Reels of wire rope should never be dropped. The reel is not built to withstand abuse. A large reel of wire rope may weigh several thousand pounds and if dropped would collapse, causing the rope to

Figure 68. Uncoiling Wire Rope, Correct.

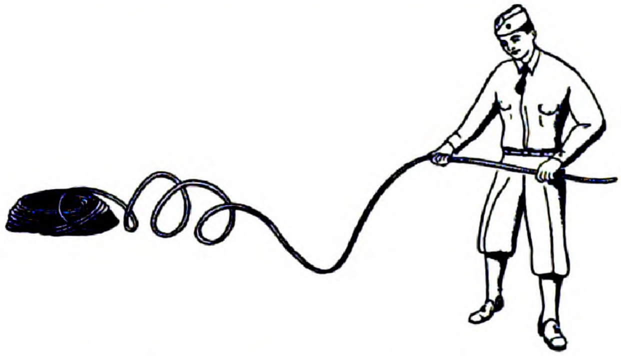


Figure 69. Uncoiling Wire Rope, Incorrect.

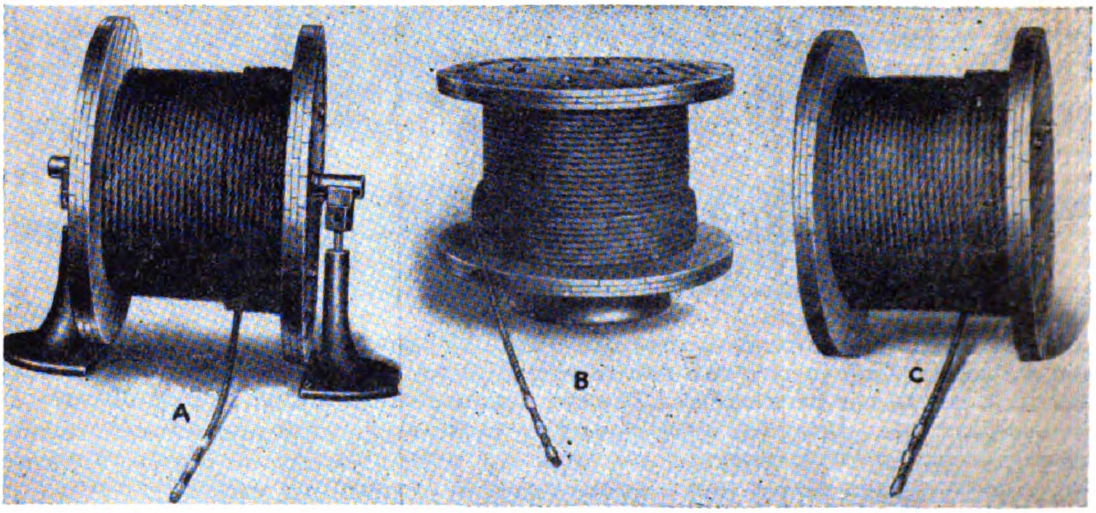


Figure 70. Unreeling Wire Rope.

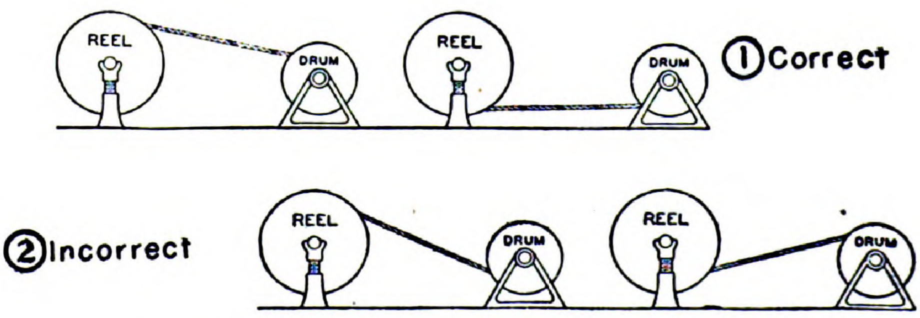


Figure 71. Spooling Wire Rope from the Reel to Drum.

become snarled and kinked. Often the rope will be seriously damaged and valuable time may be lost in salvage and repair. When using a bar to move a reel, always place the bar against the reel itself, never against the rope.

Placing Rope on a Drum from a Reel. The rope should travel from the bottom of the reel to the bottom of the drum, or from the top of the reel to the top of the drum. This is to prevent reverse bends in the rope. Reverse bends cause the rope to become more lively and harder to handle. They also place additional stress on the rope, causing unnecessary wear and shorter life. Figure 14 shows the right and wrong method of spooling from the reel to the drum.

Proper Starting Flange. Right laid ropes and left laid ropes are spooled differently. To wind these different ropes on a reel or drum the rule illustrated in figure 72 must be observed to determine the proper starting flange.

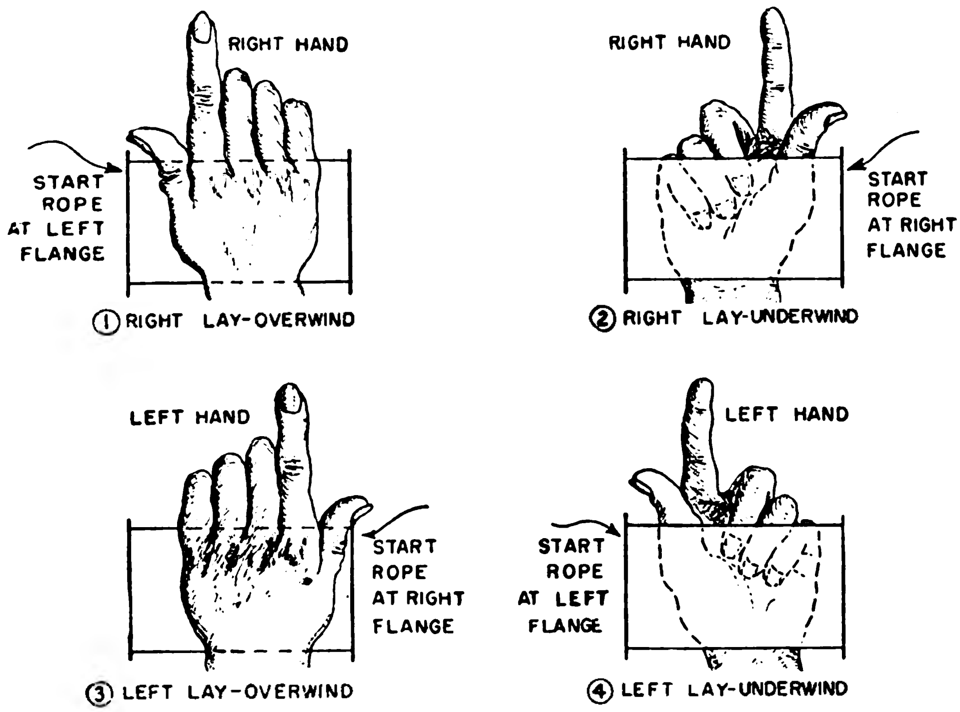


Figure 72. Hand Rule for Determining Proper Starting Flanges for Wire Rope.

Kinks. A kink in a rope starts with a loop that is permitted to be drawn tight under tension. Where a kink occurs there is a distortion of the relation of all the strands and all wires. This condition causes unequal tensions in the strands of the rope, resulting in an early failure at this point. Once a kink has been formed, it cannot be removed. The damaged portion of the rope must be cut out and the rope spliced. There are two distinct types of kinks: right- and left-hand kinks.

A right-hand kink will tighten the lay of a right laid rope. (The opposite is true in left laid rope.)

A left-hand kink will loosen the lay of a right laid rope. (The opposite is true in left laid rope.) Therefore, a left-hand kink can be easily detected in a right laid rope due to the opening of the strands, but a right-hand kink will require closer inspection to detect the distortion.

Distortion. Wire rope is so designed and constructed that when tension is applied the strain will be evenly distributed among all the wires of the rope. Distorting the wires will disturb the relationship between them and will result in unequal tensions. This affects the rope because part of the wires carry a load originally intended for all the wires. It is impracticable to accurately calculate the loss of efficiency due to distortion, because part of the distortion may be hidden. A distorted rope is unsafe. Any damaged section should be removed, and the rope spliced to permit a closer estimation of the rope's strength. The removal of this

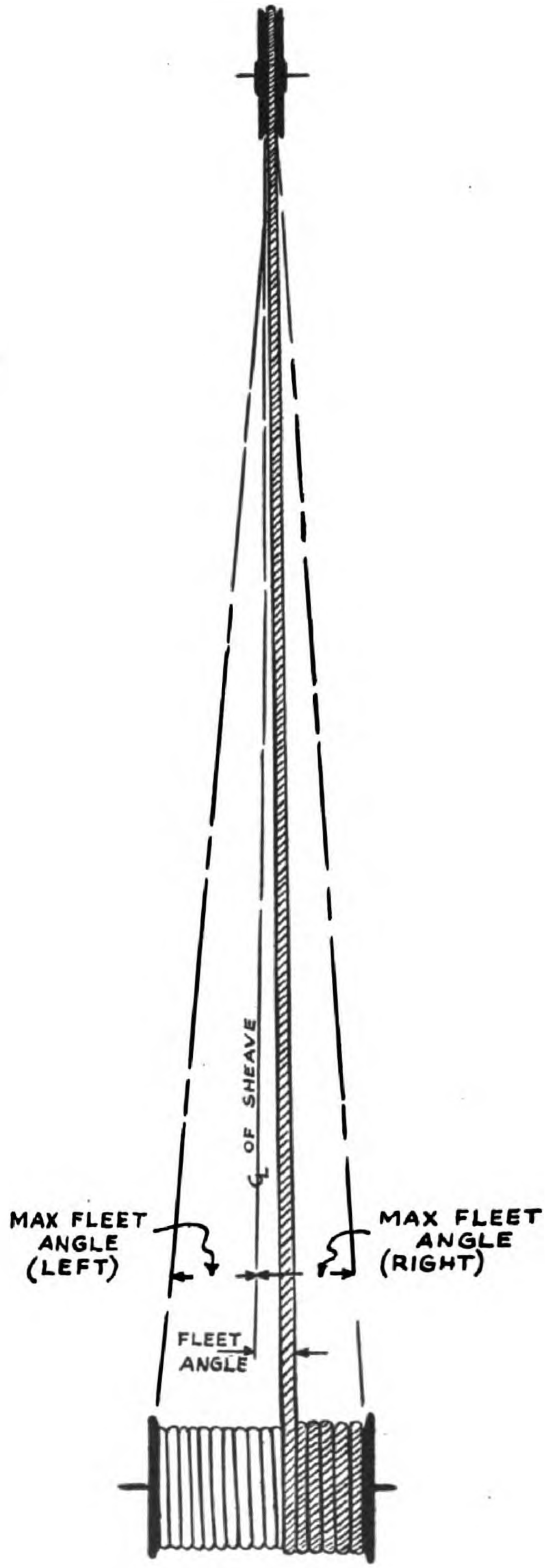


Figure 73. Fleet Angle.

damaged section must be made immediately to prevent the distortion from 'traveling' in the line, as it may move to a point far distant from its original location.

Distortion is the result of any of the following conditions:

Improper handling resulting in kinks or bruised sections.

Improper application on equipment, which includes: improper fleet angle; improper sheave, groove, and drum diameters; improper winding on drum; scored drums and sheaves, worn out drums and sheaves.

Improper attachment of fittings, and improper splicing methods.

Fleet Angles. On installations where the wire rope passes over a lead sheave and then on to a drum, it is important that the lead sheave be located at a sufficient distance from the drum to maintain a small 'fleet' angle at all times. The fleet angle is the side angle at which the rope approaches the sheave from the drum. It is the angle between the center line of the sheave and the wire rope.

The maximum fleet angle should not exceed one and one-half degrees for smooth drums, and two degrees for grooved drums. The maximum fleet angle is the angle between the center line of the lead sheave and the rope when it is at the end of its traverse travel on the drum. A fleet angle of one and one-half degrees is the equivalent of approximately forty feet of lead for each foot of rope travel on each side of the center line of the sheave. Two degrees represents 30 feet of lead per foot of rope travel each side of the center line. Thus, a drum with three feet of traverse travel, with its center of travel in line with the lead sheave, should be located approximately 45 feet from the lead sheave if the drum is grooved, and 60 feet if the drum is smooth.

Cleaning and Lubrication of Wire Rope. Wire rope is considered to be a fine machine. As one would not expect any other type of machine to operate satisfactorily without periodic lubrication and cleaning, one cannot expect maximum rope service unless wire ropes are properly preserved and lubricated.

Lubrication of wire ropes has a dual purpose: it interposes an oil film between rubbing surfaces, both externally and internally, and it protects against intrusion of moisture and corrosion internally.

There are four parts of a wire rope to protect.

1. The core.
2. The space between the core and the wire strands.
3. The space between the wires in the strand.
4. The outer surface.

Cleaning and Drying Wire Rope. To obtain the most effective results from a lubrication job, the lubricant must be applied to a rope that has been properly cleaned. The selection of the most practical method of cleaning depends largely on the local conditions and the facilities available. To clean ropes which operate through water, the prime requirement is to thoroughly dry the core. This can be done by using superheated steam or high pressure air, either of which will both clean the rope and dry the core.

Ropes operating under dry conditions pick up small particles of dirt and dust which combine with the lubricant on the outside of the rope to form a putty-like cake. This cake is tightly compressed in the valleys between the strands due to the pressure exerted when the rope is placed under tension. To clean these ropes it is necessary to break loose this foreign material so that the fresh lubricant may be applied directly to the clean wire surfaces. It is also advisable to clean and lubricate when the rope is not under tension, as the valleys between the strands are open when the rope is slack and closed when the rope is on a tension. Steam without super-heating is not advisable because of its tendency to leave moisture on the rope; however, it can be used if followed with high pressure air to insure drying. If the rope is dry, caked dirt can be removed by using wire brushes or stiff scrubbing brushes. This method is slow and laborious and super-heated steam or high pressure air should be used whenever possible.

Lubricating Wire Rope. Good lubrication reduces wear, protects the core, prevents corrosion, maintains strength, prolongs service, and materially influences safety. Tension on rope forces the inner lubricant to the outside, where it is removed by water and rubbing. The lubricant also picks up dirt and forms a cake, which flakes off under sheave and drum pressure, dragging, etc. To be a hundred per cent effective lubrication should be carried out in the following two-step method:

1. The application of a relatively light oil which will adhere to the individual wires and penetrate to the core, or hemp center.
2. The provision of a shield or protector to resist the washing action of rain and water.

The lubricant should be applied with a sheepskin cloth, if available, with the wool to the wire rope. The lubricant for the first step should be an oil of light quality, possessing good penetrating and lubricating qualities. The oil should be one that will not run off.

An efficient wire rope lubricant must be free from any material that will attack the constituent parts of the rope, and it must be neutral to commercial chemicals. Although such an oil will penetrate to a limited extent when cold, it is usually best that it be heated to about 200° F. before application. This heating is particularly important during winter months, or in any case where the wire rope is cold, as it adds to the penetration of the lubricant.

Lubricants serving as shields or protectors must be new, clean, and of good quality. The lubricant should be of a heavy tenacious (clinging) character, so that it will adhere to the rope surface.

Drip Method Lubrication. For ropes that are in continuous operation it is recommended that the drip method of lubrication be used in conjunction with the procedure described above. The equipment for the operation of the drip method consists of a container mounted above the head sheave with a valve set to drip oil on the rope just before it comes in contact with the head sheave. The constantly dripping lubricant replenishes that stored in the rope and keeps the protector plastic during the interval between regular application of the lubricant. This method is used in conjunction with, and not instead of, periodic lubrication. The efficiency of the lubricating methods as outlined will depend upon the frequency with which the rope is cleaned and fresh lubricant applied.

When to Lubricate. The condition of the rope will determine the frequency of the cleaning and lubricating. Any of the following circumstances will indicate the need for cleaning and lubricating: lack of lubricant; evidence of dampness; evidence of rust or corrosion; or evidence of caked dirt or grit.

Storage Precautions. While in storage wire ropes should be thoroughly lubricated and kept in a cool dry place, protected from weather, acids, or acid fumes. New ropes should be inspected to determine the possibility of exposure to corrosion during shipment and to see that the rope has been properly lubricated.

Inspection of Wire Rope. Wire rope inspection must be taken seriously. In cases where the manufacturer's charts on wire rope inspection and previous test records are available, the job is fairly easy and reliable. However, under field conditions where these records are not available, the inspector's judgment and reasoning may mean the difference between serious damage to life and property and a job well done.

One of the surest means of prolonging the life of wire rope is proper inspection. The practice of discarding wire rope when it begins to show signs of wear and tear is needless and wasteful. Instead of waiting until rope faults are obvious and the cable is fit only for salvage, defects should be corrected as they appear through a systematic program of inspection.

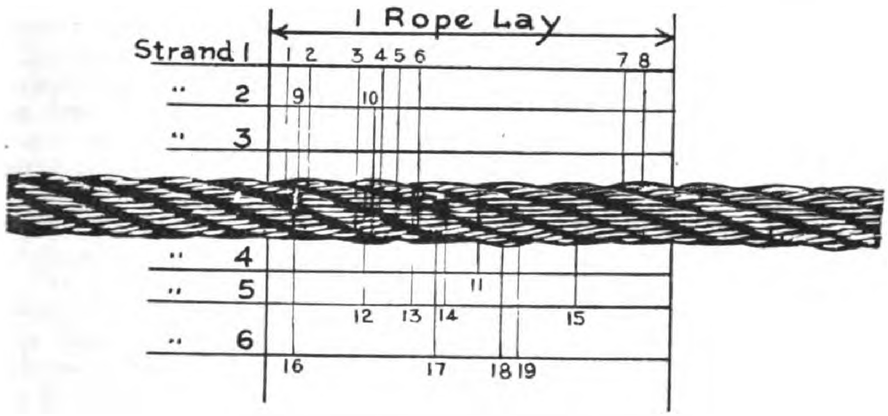
Causes for Failure of Wire Rope. The following are the main causes for failure of wire rope on equipment.

1. Drums and sheaves too small in diameter.
2. Reverse bends or bends over sharp corners.
3. Overwinding on drums (causes serious distortion).
4. Crosswinding on drums (causes serious distortion).
5. Slackwinding on drums (permits rope to snap as tension is applied).
6. Improper lubrication.
7. Faulty guides or rollers.
8. Sheaves out of alinement.
9. Deeply worn or scored grooves.
10. Improper size rope in sheaves.
11. Improper size sheaves.
12. Stones and dirt wound in with line.
13. Sticky, grabbing clutches.

14. Faulty operation of equipment.
a. Jerking.
b. Slack in rope.
c. Sudden starts and stops.
15. Vibrations.

Deterioration. Allowances should be made for the use to which the rope is put, and for the type and condition of the equipment employed. Traces of wire rope deterioration will, in a broad sense, be the same no matter where or how the line is used. Such deterioration will be shown by: broken wires; worn wires; pitted or corroded wires; drastic reduction in rope diameter and excessive lengthening of the lay; marks of mechanical abuse, such as flattening and distortion.

Inspection Procedures. Proper inspection of wire rope means a detailed inspection of the rope from one end to the other. If the rope is so heavily coated with lubricant that worn and broken wires cannot be seen, it must be cleaned sufficiently for the inspector to detect where breaks are occurring and what degree of abrasion or abuse the rope has suffered. In the majority of cases in the field, however, a simple visual inspection will reveal the badly worn sections of a line. Such inspections should take account of the number of broken wires in each lay, so that the worst lay can be detected. A rope lay is measured by the distance it takes for one strand to make a complete revolution around the rope.



Counting Broken Wires in a Rope Lay.

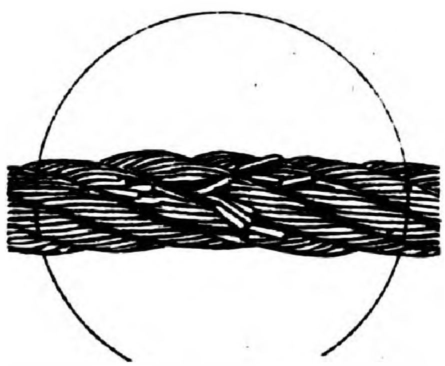
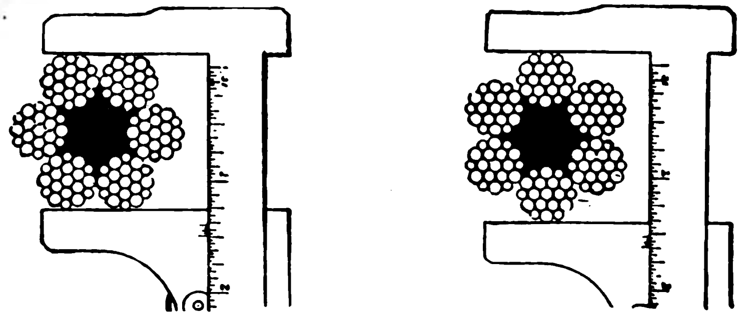


Figure 74. Counting Broken Wires in a Rope Lay.

Position of Wear on Rope. The lay showing the worst deterioration and containing the most broken wires constitutes the weakest part of the rope. The distribution of these breaks should be noted, for if the majority are found in one or two strands the rope will be considerably weaker than if the breaks had been evenly divided among all the strands. Attention should also be given to the position of breaks on the strand. If the majority are crown breaks—that is, breaks appearing on the top sides of the strands—normal deterioration is indicated. If the majority are valley breaks, occurring in the valleys formed by the meeting o adjacent strands, there may be an abnormal condition.

Diameter Check-Up. Carefully check the diameter of the rope throughout it length. Sharp reduction from the original diameter indicates that the hemp cente has collapsed, that the rope has been stretched beyond its capacity, or that interna corrosion has taken place. In any case, a drastic difference between actual an original diameters shows that the rope in question is near the end of its useful ness (figure 75).



① Incorrect. ② Correct.

Figure 75. Method of Measuring Diameter of Wire Rope.

Stretch. The stretch of a wire rope under load is the result of a structura stretch caused by lengthening of the lay, compression of the core and adjustmen of the wires and strands to the loads, and the elastic stretch of the wires.

1. The structural stretch varies with the construction of the rope, type of core length of lay, load imposed, and amount of bending over drums and sheaves. With average loads an approximately estimate of this stretch is ½ of 1% or .005 times the length of the rope under load. With light loads, the stretch can be calculated a ¼ of 1% or .0025 times the length of the rope under load. With heavy loads, the stretch can be calculated as 1% or .01 times the length of the rope under load.

2. The elastic limit of a wire is the point to which the wire can stretch and still return to its original diameter without damage to the wire. The elastic limi of a bright wire rope is approximately 55% of its breakng strength; it is approximately 65% for galvanized ropes. It can be readily seen that the entire structure of a rope can be seriously affected by overloading. Elasticity is affected by length of service of a rope; the intensity of the working loads, whether the loads are constant or variable, and the amount of bending and vibration to which the rope is subjected.

Abrasion. The degree of abrasive wear showing on the wires must be checked thoroughly. If the rope's period of service is unknown, a diameter check must be made on the individual wires. Accurate measurement of wear is difficult, especially when the wires of the ropes are of small diameter, but this check on individual wires is essential.

Peening. Many times peening is mistaken for abrasion. When peened each wir appears badly worn. Close examination will show that the metal has merely bee hammered over and the individual wire has been flattened into a triangular shape Practically all of the metal is still there and the peening effect tends to harde the wire so that only a small amount of strength has been lost. In abrasion, hal of the wires have been rubbing against an abrasive substance and are actuall worn nearly halfway through. Examine ropes thoroughly and determine whethe the worn appearance is due to abrasion or peening.

Reserve Strengths. The reserve strength of a wire rope is the strength of th rope after the outer wires have worn out. The outer wires are the first to be destroyed through wear and abrasion. The more numerous the wires in each strand, the more reserve strength is present in the rope. The following table will show how the reserve strength of a rope increases with flexibility. Two ropes of equal diameter but of different construction will vary in reserve strength.

Table Reserve Strength of Wire Rope

Construction	*Outer Wire Strength*	*Inner Wire Strength*
6 x 7-	83%	17%
6 x 17	73%	27%
* 6 x 19	64% ± 5%	36% ± 5%
* 8 x 19	57%	38% ± 5%
6 x 29	50%	50%
6 x 33	48%	52%
6 x 37	43%	57%

* Variation of ±5% in reserve strength due to types of cable construction.

Rust. Inspect the entire length of the rope carefully for rust. The appearance of rust in the valleys between strands is evidence of internal corrosion. It is the valleys, too, that pitting is most likely to be found. Every effort should be made to spot internal corrosion, which will sometimes occur without giving external clues.

Grouping of Breaks. It should be determined whether breaks and abrasions occur in one portion of the wire, or whether they are found in the entire length. Wire breaks will generally be found in the sections of rope that pass most frequently over the sheaves during normal operations, or in those sections where wear is concentrated by mechanical abuse.

Causes of Breaks. The condition of wire rope near attached fittings must be given special attention. If wear is noted near an attachment, the rope should be trimmed 8 or 10 feet and the attachment replaced. Where breaks are present near the point of attachment, the line should be checked closely for distortion. Distortion has been found to travel hundreds of feet from the point of break in the line.

While the number of breaks in the wire gives certain clues to the condition of the rope, undue stretch is concrete evidence that a wire rope is reaching the end of its life. Application of loads up to one-half of the rated strength of a 6 x 19 rope will stretch the rope from 0.2% to 0.3%. This stretch will be from 30% to 50% less in correctly handled rope. When first put into service new rope stretches rapidly and then settles into a long period of constant yet negligible stretching. When the hemp core deteriorates the wires break more quickly and the rate of stretching becomes abnormal. When this last stage is reached, the rope should be taken out of service immediately.

TYPICAL CHARACTERISTICS AND CAUSES OF BROKEN WIRES WIRE ROPE

Identification of Breaks. The following illustrations will enable the inspector to distinguish between fatigue, tension, abrasion, cuts, and corrosion types of breaks found in wire rope.

Figure 76(A) shows a fatigue type break without abrasion, and figure 76(B) shows a fatigue type break with abrasion.

Fatigue Type Break. The wire break will be traverse; cross sectional view of the broken ends will show a granular structure.

Causes. Where fatigue breaks occur the rope has been bent around too small a radius too often, or it has been subjected to vibration or whipping. Fatigue also occurs after wire has been damaged by corrosion.

Tension Type Break. Figures 76(C) and 76(D) show tension breaks.

Characteristics. Tension breaks will show one side of the broken wire coned and the other side cupped. The wire may also show signs of abrasion or corrosion.

Causes. Where tension breaks are found, the rope has been subjected to too great a strain (overloaded) either for its original strength or for the remaining strength after other factors of deterioration have weakened it. Frequently, tension breaks are caused by suddenly applying a load to a loose rope, thereby setting up severe impact stresses.

Abrasion type break. Figure 76(E) shows a wire worn through by abrasion.

Characteristics. The break will show the wire broken and worn smooth to a knife-edge thinness. Wire broken by abrasion in combination with another factor will show a combination of characteristics.

Causes. Abrasive wear will obviously be concentrated at points at which the rope is rubbed most frequently. These points are usually the grooves of sheaves and drums or any other object with which the rope comes into contact. Unwarranted abrasive wear indicates improperly grooved sheaves and drums, or other localized abrasive conditions.

Cut Type Break. Figure 76(F) shows a cut or gouged wire.

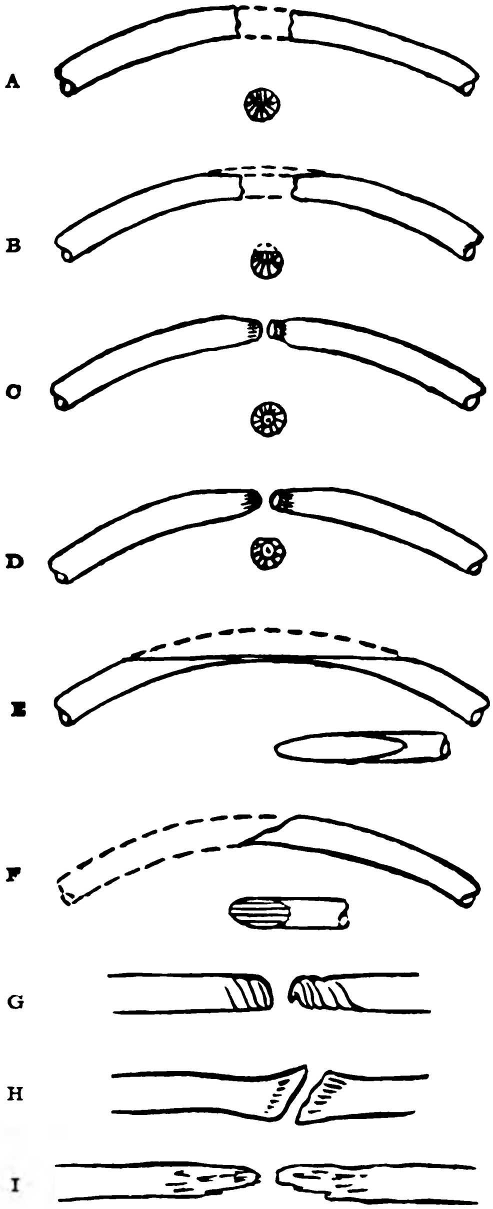


Figure 76. Identification of Breaks in Wire Rope.

Characteristics. On cut wire the wire ends will be pinched down and will show evidence of a shear-like cut. The wire will show evidence of twisting at the broken ends in the case of a torsion break or will be flattened and spread for a mashing break, Figures 76(G) and (H).

Causes. These conditions are evidence of mechanical abuse caused by agents outside the installation or by something abnormal or accidental on the installation itself.

Corrosion Type Break.

Characteristics. Corrosion can be noticed by a pitted surface on the wire, Figure 76(I).

Causes. Corrosion indicates improper lubrication. The extent of damage by corrosion to the interior of the rope is extremely difficult to determine; consequently, corrosion is one of the most dangerous causes of rope deterioration. If the hemp center of a wire rope is not lubricated and is allowed to dry out, it will collapse and fail to afford proper support for the strands, thereby causing marked reduction in rope diameter and extreme internal wear.

Replacement Inspection. To decide, in any particular case, whether a new rope is needed or whether the one in use can be made to serve longer, a thorough inspection, following the procedure in the above paragraphs must be made.

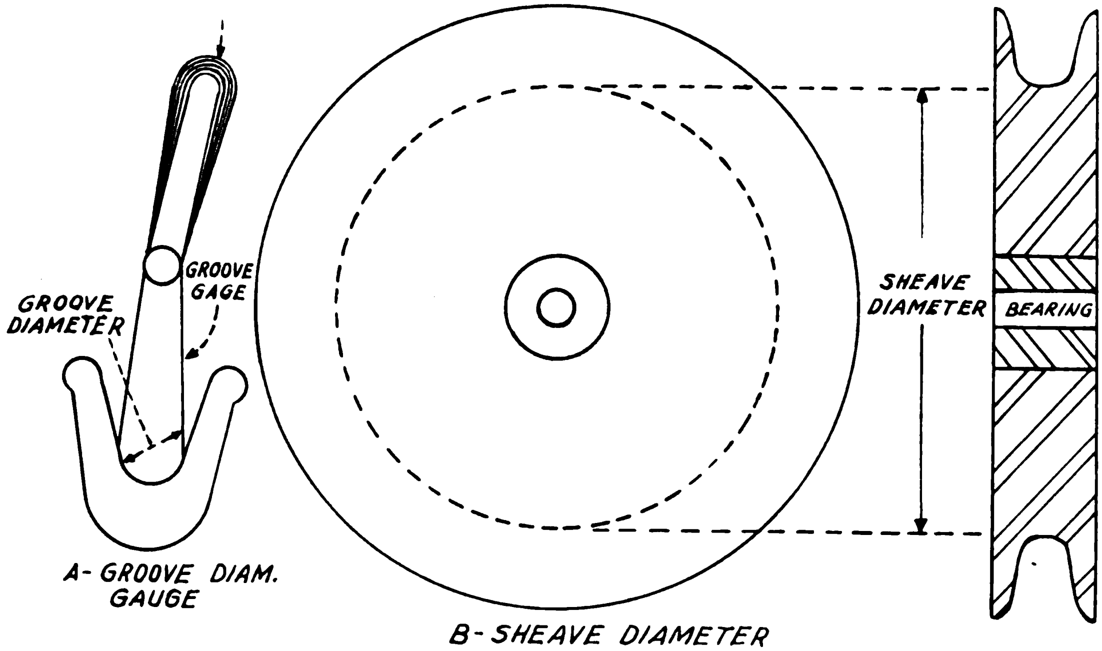


Figure 77. Sheave and Groove Diameters.

Inspection of Gear. No rope inspection, however rigid, is complete without a careful check of the sheaves, drums, reeving, and general rigging equipment involved.

Sheave Inspection. The diameter of a sheave must be measured from bearing surface to bearing surface and not from flange to flange, since it is the radius of the bearing surface that governs the degree of bending to which the rope is subjected in traveling over the sheave. The tables give the recommended and minimum sheave diameters to be used for ropes in various rigging set-ups.

Table X. RECOMMENDED AND MINIMUM DIAMETERS FOR SHEAVES AND DRUMS

Rope	Recommended diameter: number times rope diameter	Minimum diameter: number times rope diameter
6 x 6	72	42
6 x 19	45	30
6 x 30	45	30
6 x 37	27	18
8 x 19	31	21
18 x 7	51	34

In addition to the inspection of sheave diameters, there are certain other characteristics of sheaves that should be checked.

Sheave Grooves. A definite relationship must be maintained between the diameter of the bearing grooves of sheaves and the diameter of the wire rope that is used with them. Wear on the sheave grooves must be watched constantly, for as the rope passes over them the grooves are worn deeper. The rope's diameter, in turn, becomes steadily smaller until it is less than that of a new rope of the same listed diameter. A new rope placed in such a distorted groove would soon be pinched out of shape. Figure 77(A) shows the groove diameter and the use of the groove gauge, and figure 77(B) shows the sheave diameter.

Figure 78(A) shows how rope is properly supported in a sheave groove of proper diameter and flattening of the rope where the grove is too large.

Figure 78(B) shows the rope diameter decreased as a result of a worn sheave groove, and also the distortion caused by using a new rope in a worn groove. The rope will become distorted and worn in a short time.

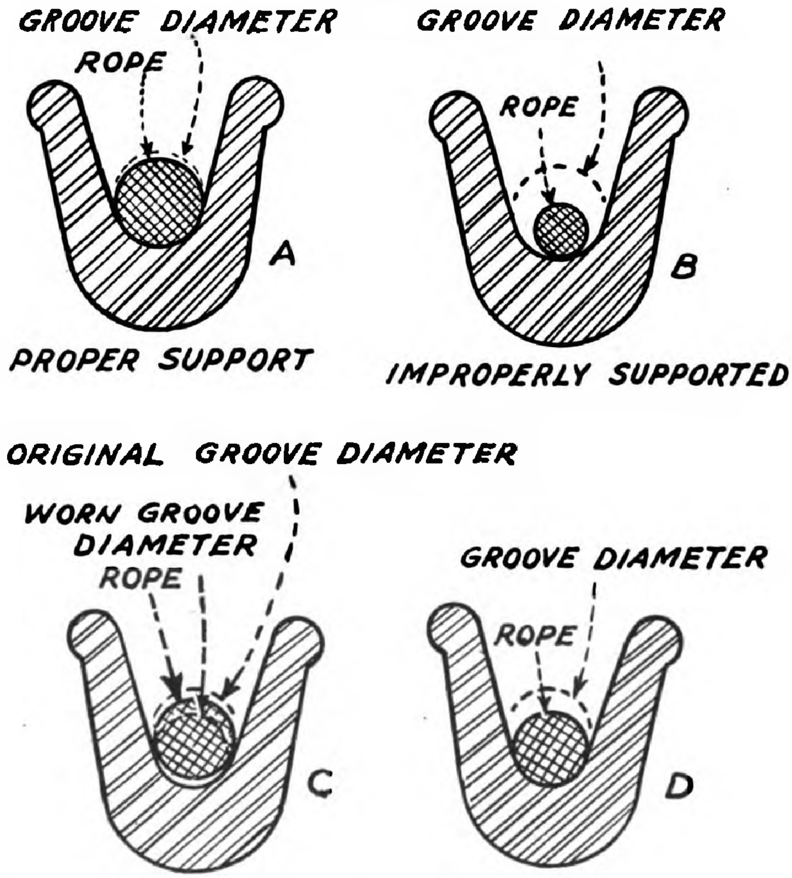


Figure 78. Wear Effects Due to Relation of Groove and Rope Diameter.

Size of Grooves. A rope placed in a groove whose diameter is too large will not receive proper support and will tend to flatten out as radial pressure is applied

TABLE XI

TOLERANCE BY WHICH GROOVE DIAMETER SHOULD EXCEED NOMINAL ROPE DIAMETER

Nominal rope diameter in inches	Recommended tolerance
¼-5/16	1/64
⅜-¾	1/32
1-3/16-1⅛	3/64
1-9/16-2¼	3/32
2-5/16 and larger	1/8

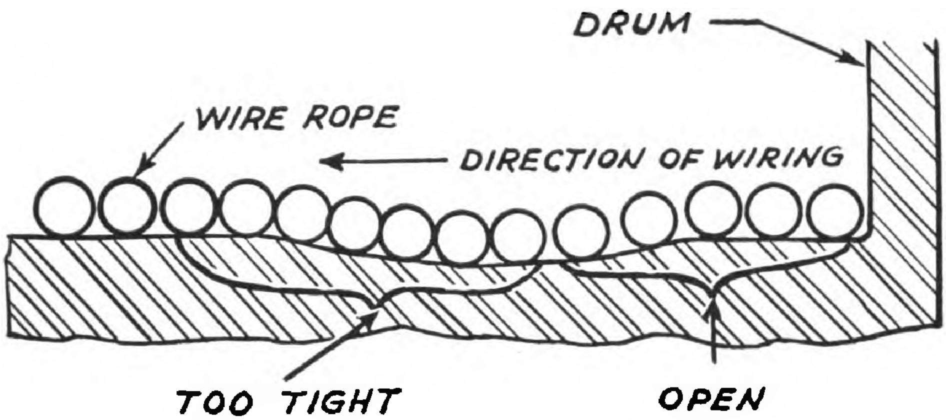


Figure 79. Effect of Worn Drum on Winding.

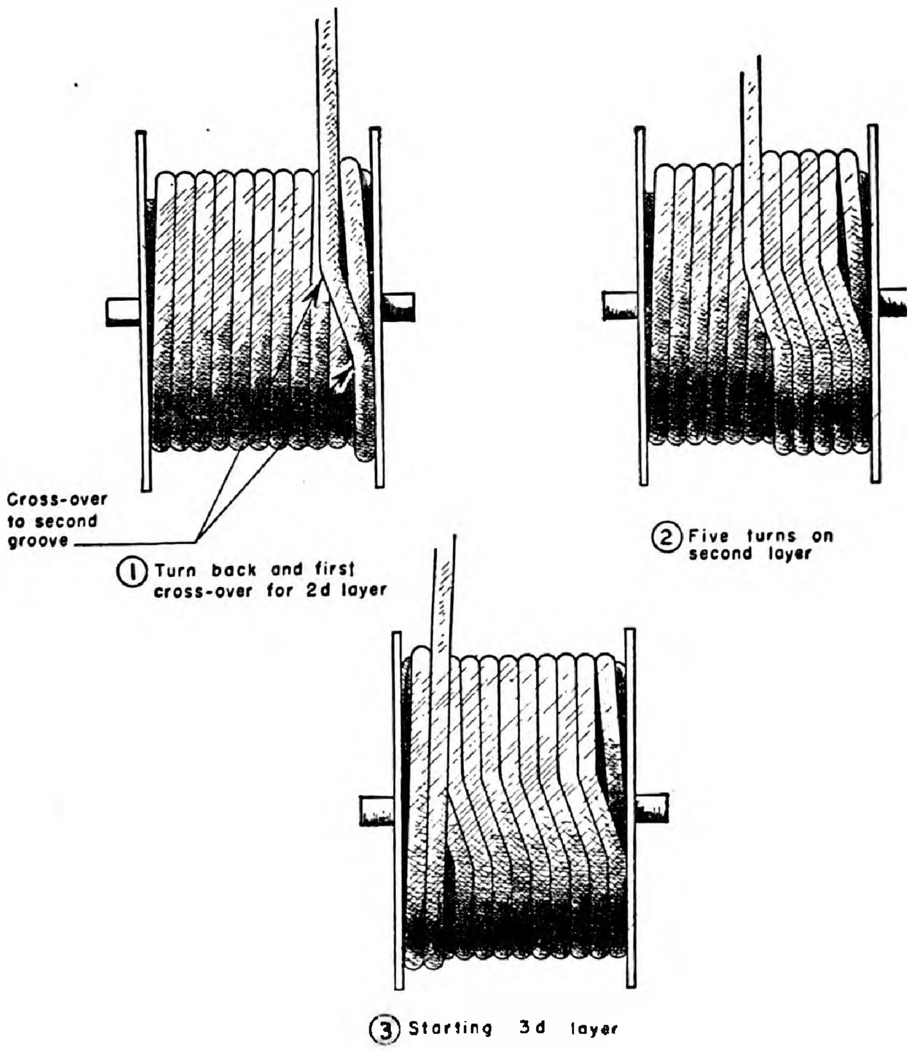


Figure 80. Method of Spooling Second and Third Layers of Wire Rope on a Drum.

upon it. The ideal condition is one in which the wire rope is supported by a sheave groove about one-half of the depth of the rope's circumference. A slight tolerance is recommended for groove diameters, figures 78(C) and (D).

Sheave Materials. Sheaves manufactured from soft materials will soon be cut by wire rope and their bearing surfaces will become corrugated to fit the rope in use. The rut so formed will not fit a new rope. As a result, the new rope will be cut and worn by the old corrugation. Scarred sheaves must be remachined or replaced with sheaves of harder material.

Sheave Operation. Sheaves will wobble or revolve eccentrically when their bearings are defective. This sets up a whipping action in wire rope which should be remedied immediately.

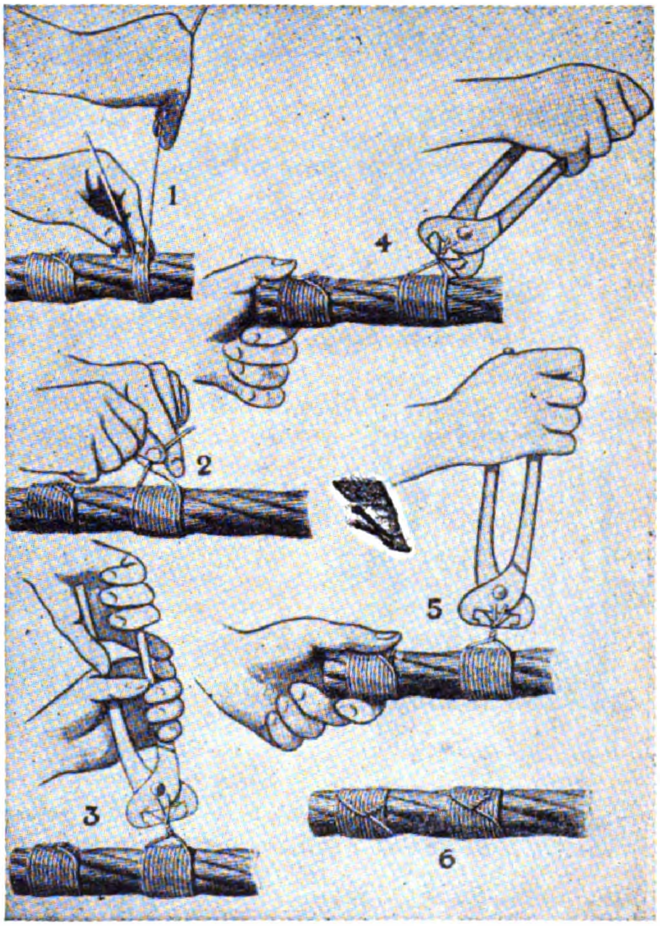


Figure 81. Seizing Wire Rope, Finish on Top of Seizing.

Condition of Sheaves. An out-of-round sheave, or one that has a flat spot on its bearing surface, will also cause whipping and will lead to a premature breakdown of wire rope. Sheaves in this condition should be repaired immediately.

Drum Inspection. The diameter of a drum must also be measured from bearing surface to bearing surface, rather than from flange edge to flange edge, as the rate of wear on wire rope depends to a large extent on the radii of the bends it must take in normal operation. The recommended diameters should be equalled or exceeded in every case since internal wear on wire rope may often be caused by improper diameter of drums.

Grooved drums are recommended in preference to smooth drums as the grooves furnish better support for the rope than the flat surface of smooth drums and more uniform winding results in less abrasive wear on the rope.

Drum Inspection. *Contour of drums.* Corrugation on the surface of plain faced drums will cause the same damage to wire rope as corrugated sheave surfaces.

Drums that have been corrugated must be remachined. If the shell has been worn thin, it may be lagged with steel plate.

Symetry. No low spots on the face of drums should be allowed to go uncorrected. Rope tends to pile up when it reaches a low spot and will wind in too open a wrap, while rope on the sides of the low spot will wind too tightly, causing harmful scrubbing and chafing, see Fig. 79.

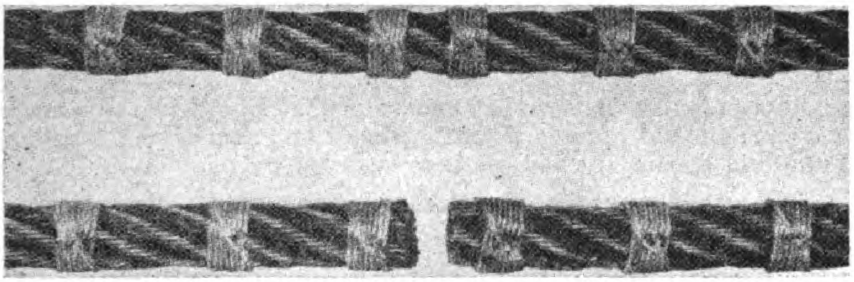


Figure 82. Seizings Applied for Cutting.

Winding. No winding difficulties arise when grooved drums are used with the ropes designed for them. In plainfaced drums, however, care must be exercised in winding. Each wrap should lightly touch those adjacent. To wind tightly is to invite undue friction, causing excessive abuse to the rope. The rope should be under tension during winding to insure the removal of all slack and to avoid slipping of the wraps on the drum.

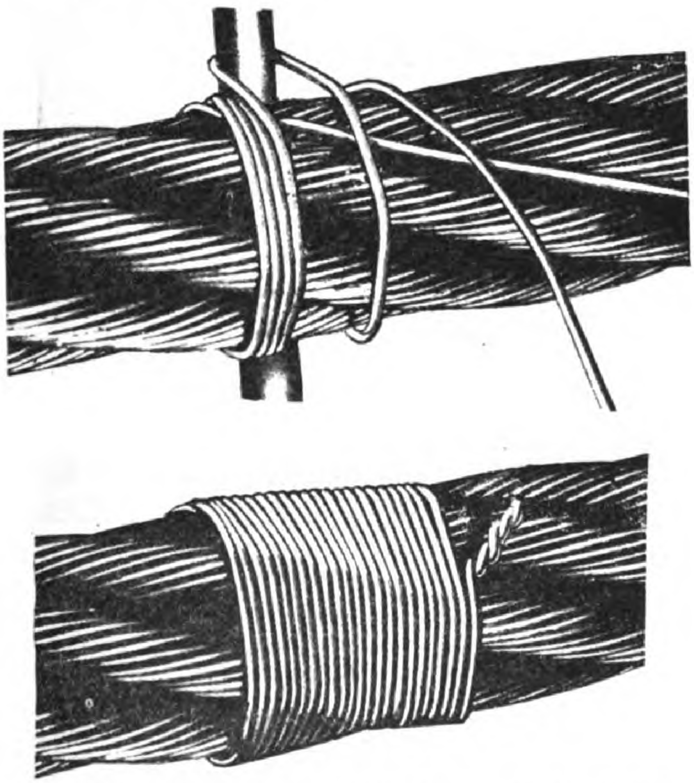


Figure 83. Seizing Wire Rope, Finish on End of Seizing.

Seizing Wire Rope. The ends of wire rope should be seized with wire, using one of the following methods when special clamps are not available. Figure 81 shows the steps to follow:

Method 1.

Procedure. 1. Wind annealed wire on the rope for a distance of from 1 to 1½ times the diameter of the rope. The wire should be wound with considerable tension to assure a tight seizing.

2. Twist the ends of the wire together above the middle of the seizing.
3. Tighten the twist just enough to remove the slack. Do not try to tighten by twisting; this will break the wire.
4. Remove additional slack by prying cutters against the rope and then twisting. Repeat this until all slack is removed.
5. Cut off ends of the wires.
6. Pound the twisted ends close to the seizing.

Method 2.

Figure 83 shows another method of applying a seizing with a screwdriver or a round bar. This method assures a tight seizing and leaves the twisted ends of the wire on the end of the finished seizing.

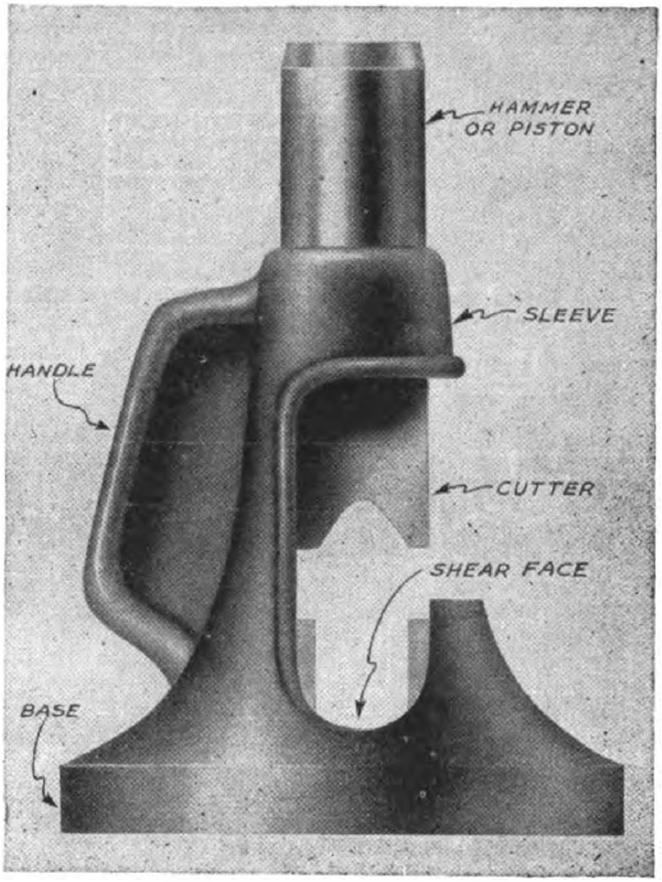


Figure 84. Wire Rope Cutter.

Cutting. It is recommended that three seizings be placed on a rope end at all times prior to cutting. Seizing, however, is not necessary in cutting preformed rope. Figure 83 shows a series of six seizings applied before and after cutting. After the seizings are in place the rope can be cut by:

1. A sledge hammer and a special wire rope cutter made for the purpose as shown in figure 84.
2. Cutting with welding torch.
3. A hammer and chisel.
4. Placing the wire rope on the cutting edge of an axe and hitting it with a hammer, as shown in figure 85.

Clips. Clips are used to fasten the running end of a rope to the standing part of the rope. A clip consists of a U-bolt, saddle, and clamping nuts. There is a correct way and an incorrect way of attaching wire rope clips, as shown in figure 86.

Referring to figure 87, it will be noted that the correct way is to place all U-bolts on the running end (dead end) of the rope to prevent crushing and distortion on the live end of the rope.

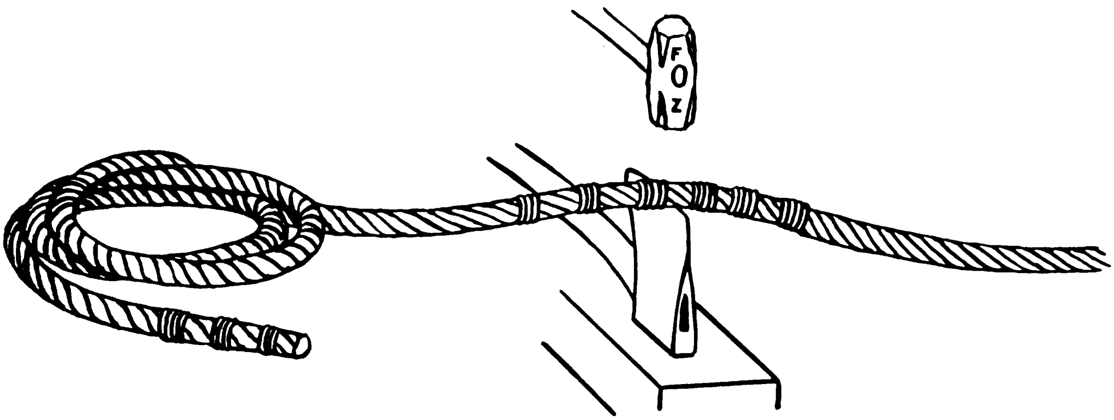


Figure 85. Cutting With Axe.

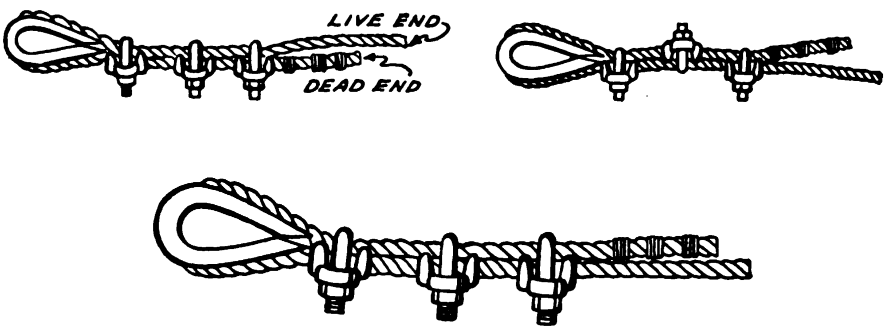


Figure 86. Correct and Incorrect Method of Attaching Wire Rope Clips.

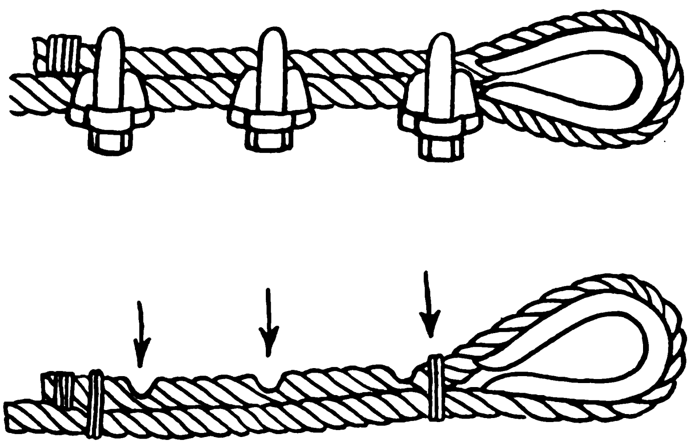


Figure 87. Proper Clipping and Results.

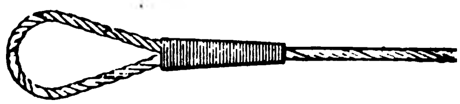
The saddle or flat bearing seat and the extended prongs of the flat bearing seat were designed to protect the rope. The stress in the dead end of the rope is dissipated by the friction of the rope passing around the thimble and through each clip. The distortion on the dead end of the rope is therefore of less consequence. A convenient rule to follow to determine the number of clips to use is: Three times the diameter in inches plus one, for example, on a ¾ inch rope:

Number of clips $= 3D + 1$

$= (3 \times \frac{3}{4}) + 1$ or $3\frac{1}{4}$ (Use 4)

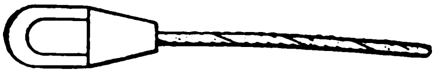
When the calculations result in a fraction always use the next larger whole number. To assure maximum holding power, clips should be spaced six rope diameters apart. After the rope has been placed in service and is under tension, the nuts should be tightened again to compensate for any decrease in rope diameter caused by the load.

Use of Knots in Wire Rope. In cases of emergency, knots can be used in conjunction with wire rope if proper precautions are observed. Knots tied in wire ropes decrease the efficiency of the rope approximately 50% due to distortion when the knot is drawn tight.



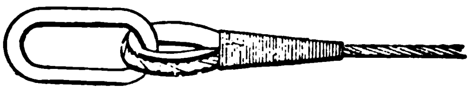
① Loop.

② Thimble.

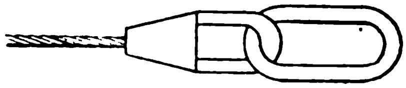


③ Closed socket.

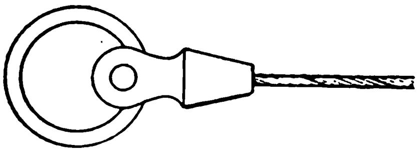
④ Open socket.



⑤ Link and thimble.

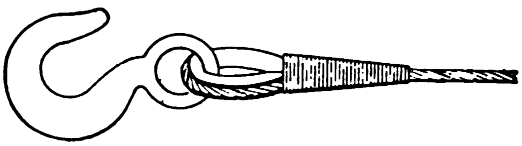


⑥ Link and closed socket.

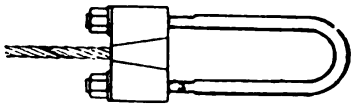


⑦ Ring and open socket.

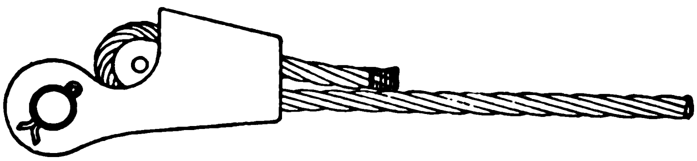
⑧ Shackle and thimble.



⑨ Hook and thimble.



⑩ Bridge socket.



⑪ Wedge socket connection.

Figure 88. Wire Rope Fittings.

The knots must be secured or seized with wire as tension is applied in order to permit the knots or bends to dress properly. Remember that a knot can be tied into a wire rope but cannot be untied after tension has once been applied and then removed. A square knot, half hitch, or bowline (see preceding section on Field Rigging) are the types most commonly used.

Attachments. Fittings or end attachments for wire rope vary in accordance with their use. The standard wire rope fittings are thimbles, clips, open and closed sockets, bridge sockets, hooks, shackles, and rings. Proper methods of attaching these fittings must be used to obtain maximum strength and to avoid unnecessary wear on the rope.

Method of Attaching Sockets. All socket fittings require special methods of attachment.

Wedge Socket. Wire rope should lead out of a wedge socket in a straight line and the dead end of the rope should be secured in the offset side of the wedge. The wedge socket is attached by placing the wire rope in the socket around the wedge and pulling the rope tight. This type is not as efficient as the basket type socket due to the shearing effect of the wedge. When the rope has been used for about one-fifth of its normal life, or when circumstances require, the rope should be cut about a foot from the socket and the socket reset. This removes fatigued wires near the socket and increases the life of the rope.

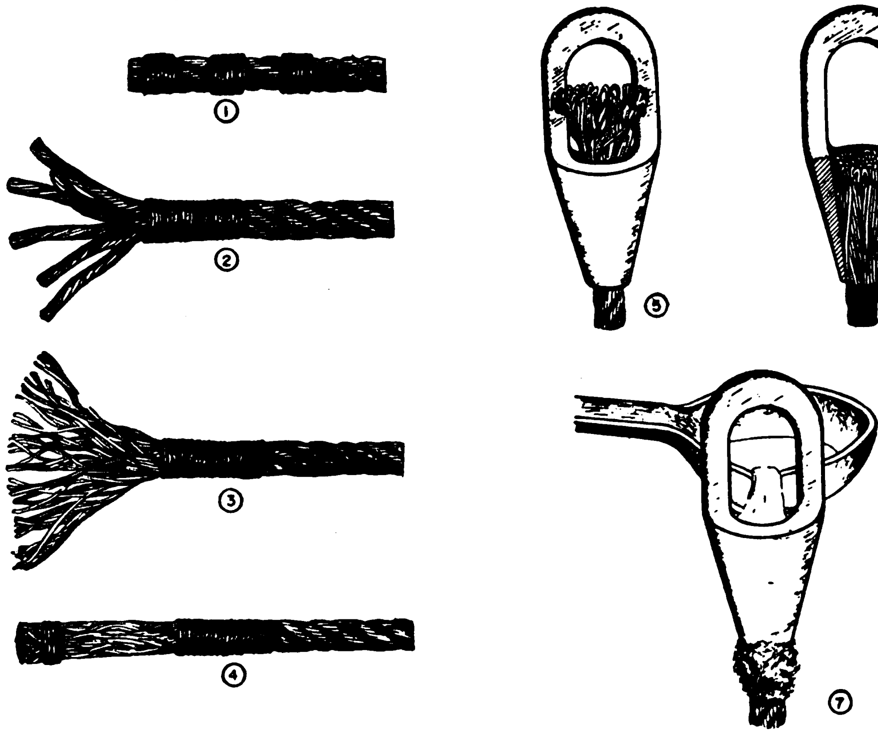


Figure 89. Approved Method of Attaching Basket Socket.

Basket Socket. Wire rope should lead from the basket socket in a straight line. Where properly attached, this type of fitting is as strong as the wire rope. The most satisfactory method of attaching the basket socket is shown in Figure 89.

The rope should be seized in three places as shown in (1). Place an additional seizing on the rope at a distance from the end of the rope equal to the length of the basket of the socket (2). It is important that this seizing be applied carefully and be of sufficient length to prevent any untwisting of the strands which would result in unequal tension of the strands. Place the rope end upright in a vise, remove the seizing from the end, unlay the strands, spread the wires in each strand, and cut the hemp center at the large seizing (3). The wires should be cleaned carefully with a solvent and dilute solution of acid and then washed with a boiling soda solution. Care must be taken to prevent acids and solvents from penetrating beyond the loose wires, otherwise the core and the rope lubricant are damaged. In the absence of solvents and acid solution the wires can be cleaned by holding them in an open flame only long enough to burn off the rope lubricant (the wires should not be heated to a visible glow). Draw the ends of the wire together with a temporary seizing and force the socket over the rope (4). Remove the temporary seizing, allowing the wires to expand. Turn back the end of each wire about ½ inch (5), this keeps the wires from pulling out of the socket. Pull the rope back into and in line with the socket. (6). Be sure the axis of the socket is in line with the axis of the rope. Seal the base of the socket with putty, clay, or other similar substance. It is advisable to preheat the basket of the socket. Fill the socket basket with molten zinc (7). When the molten metal has solidified, the socket can be plunged into water to cool. The seizing at the base of the socket should be left on the rope.

WIRE ROPE SPLICING

Splicing is an important factor in the repair and maintenance of wire rope. In the everyday use of wire rope it may be found necessary to lengthen a wire rope, repair a break, or splice for an attachment. In the splicing of wire rope, unnecessary splicing should be avoided. The proper splice should be used in the proper place, and extreme caution should be taken to prevent distortion due to improper handling of tools and equipment.

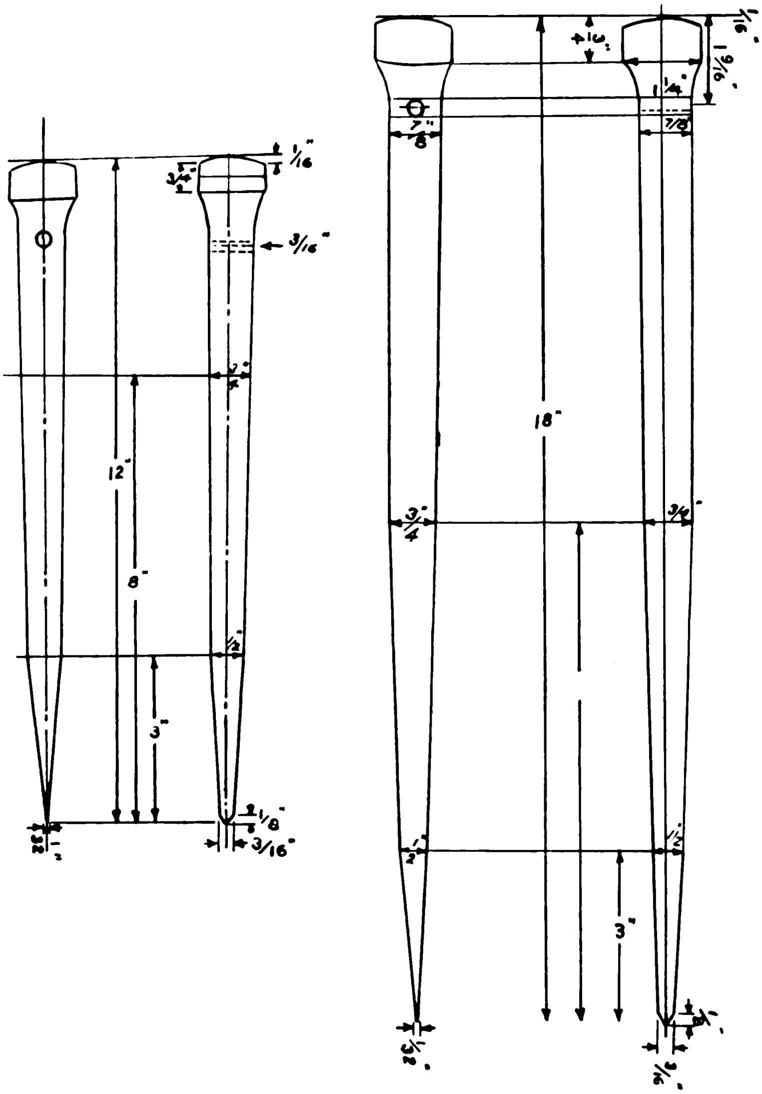


Figure 90. Marlinespikes.

Tools For Splicing Wire Rope: There are only 6 tools necessary to make a splice: a hammer and cold chisel for cutting, 2 marlinespikes for opening the strand, a pair of pliers for seizing and a pocket knife for cutting hemp coils.

A rigger's vise is not necessary to hold the wire rope during the splicing. A machinist's vise will serve. If either vise is not available the rope may be held in place by nailing the rope to a stump or block of wood.

Marlinespikes. "Marlinespike" is a term applied to pointed steel tools used to separate the strands in splicing wire rope.

The length and diameter of the marlinespike is determined by the size of the rope to be spliced. For ropes up to ⅜" in diameter, marlinespikes can be made from ¼" round stock steel 6" or 8" long, pointed at one end. The illustrations contained in figure 90 will serve as a guide for the construction of marlinespikes adaptable for ropes from ⅜" in diameter up to 1½" in diameter.

Axles and drive shafts furnish ideal stock for the marlinespike. It is advisable to turn them on the lathe, although a good blacksmith can fashion marlinespikes on the anvil.

The marlinespike must be tempered to a point where it is tough but not hard, as the spike will chip and break if too hard. The approximate "temper color" is from Deep Straw to Peacock.

Note: Additional information on tempering will be found in T. M. 5-225.

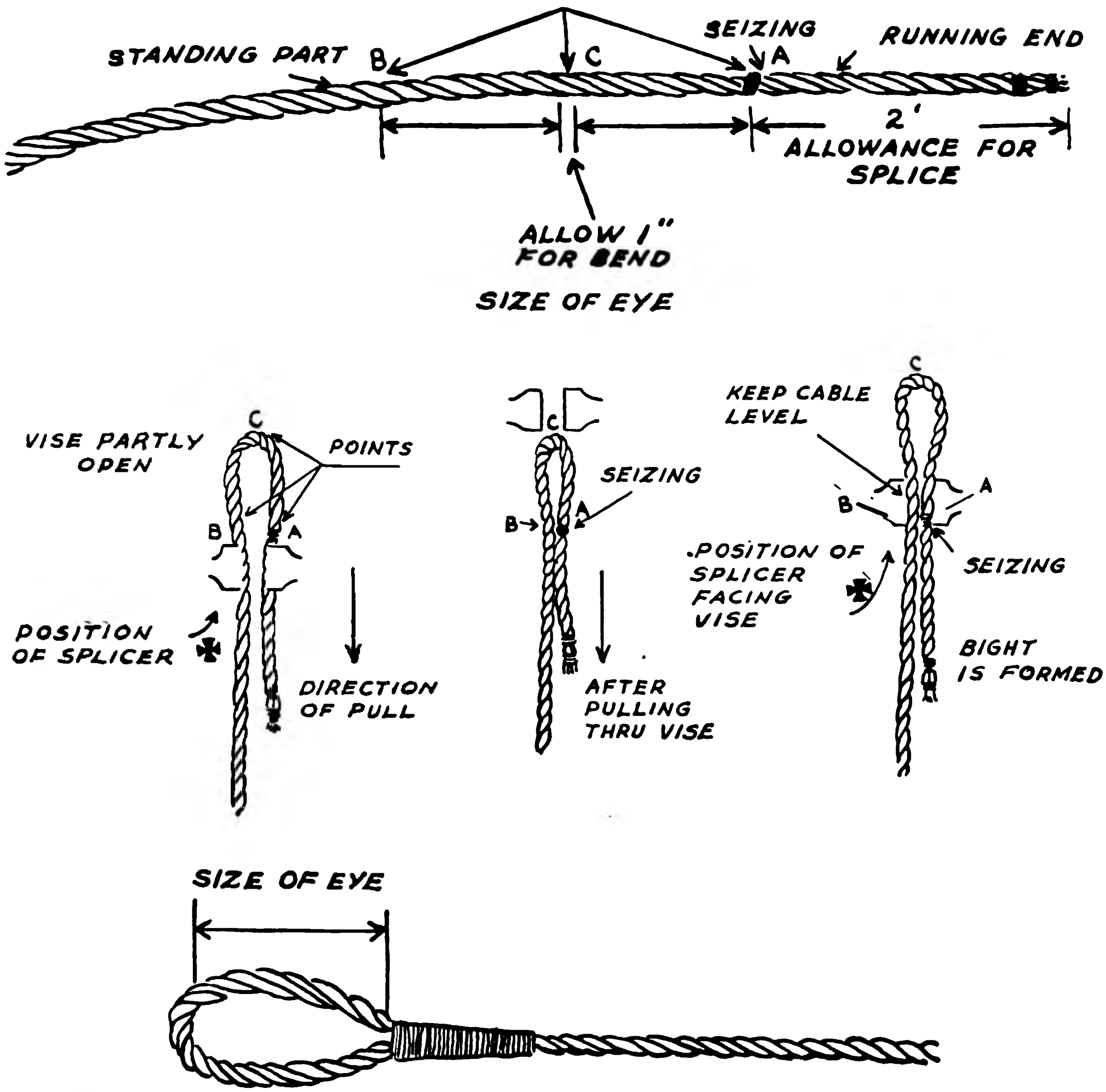


Figure 91. Method of Making the Maritime Eye Splice.

In cases of emergency when there are no marlinespikes available, a good marlinespike can be fashioned from a screwdriver ground to a tapered point.

Small ropes up to ⅜" in diameter, can be spliced with icepicks in an emergency.

Maintenance personnel using marlinespikes must be advised of saftey precautions to avert injury from dropping or other mishandling of this tool.

EYE SPLICE

The 'Eye' or 'Loop' splice is used to form an eye or loop in the end of a rope. There are many styles of eye splices used in wire rope, and of all these one of the most efficient is the Maritime Eye Splice.

The Maritime Eye Splice is considered one of the most efficient, because in tests it proved that it caused a minimum of distortion in the line and maximum holding power. The maritime eye splice will not pull out if properly used. However, caution must be taken to avoid its use on a load that might spin or rotate, causing the lay of the rope to open and release the splice.

Procedure to form a bight for a maritime eye splice:

1. Select cable (wire rope).
2. Determine size of eye (see fig. 91).
   Note: Drawings on formation of bight are of ½-inch ropes.
3. Lay cable out straight, (figure 91(A)).
4. Measure two feet on running end and mark. Place seizing at this point, (Point A, figure 91(A)).
   Note: This is allowance for splice itself. On larger ropes (¾-inch to 1-inch) allow 30 to 36 inches.
5. From point A measure two times the length of determined eye plus 1 inch allowance for bend and mark, (Point B, figure 91 (A). For larger ropes allow two inches for bend.
6. Find center point between A and B and mark. (Point C).
7. Pick up running end with right hand.
8. Pick up standing part with left hand.
9. Form bight by bringing hands together so that points A and B are side by side, Figure 91 (B). The bight must point away from the body.
10. Insert bight below partially closed jaws of vise so that midpoint mark (point C figure 91(B) is in the center of bight.
11. Draw bight through vise putting crimp in center of bight, Figure 91 (C).
12. Place bight in jaws of vise, lining up points A and B flush with jaws of vise, Figure 91 (D).
13. Tighten vise firmly.
14. The bight is now formed, Figure 91 (D).

MAKING SET-UP FOR EYE SPLICE

1. Secure hemp rope to standing part of cable with mooring hitch about four feet from vise (See Figure 92).
2. Secure other end of rope to anchorage. (See Figure 92) and pull the cable tight. Using the Dutchman Hitch or block and tackle.

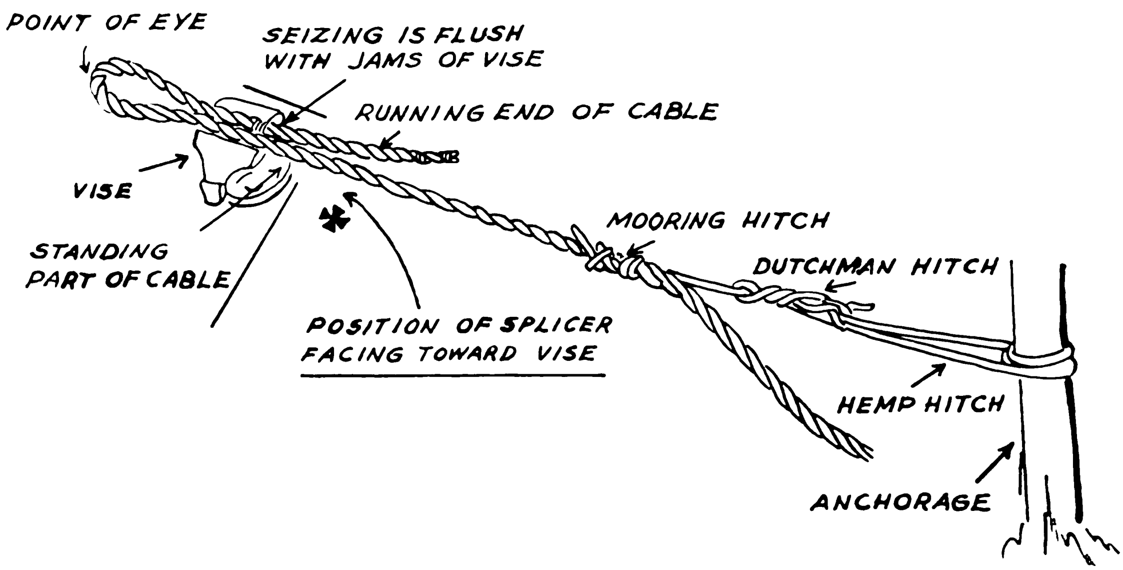


Figure 92. Making Set-up Eye Splice.

3. Remove seizing from running end of cable.
4. Unlay running end back to jaws of vise.
5. Whip or tape the end of each strand.
6. Wipe and clean each strand of running end thoroughly.

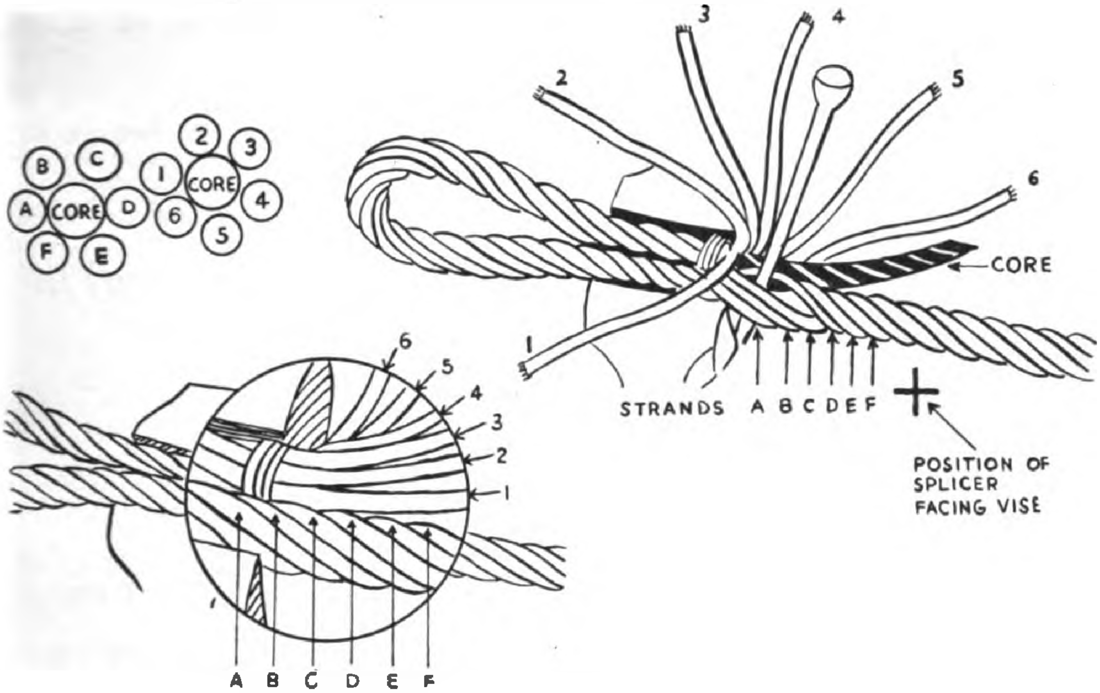


Figure 93.

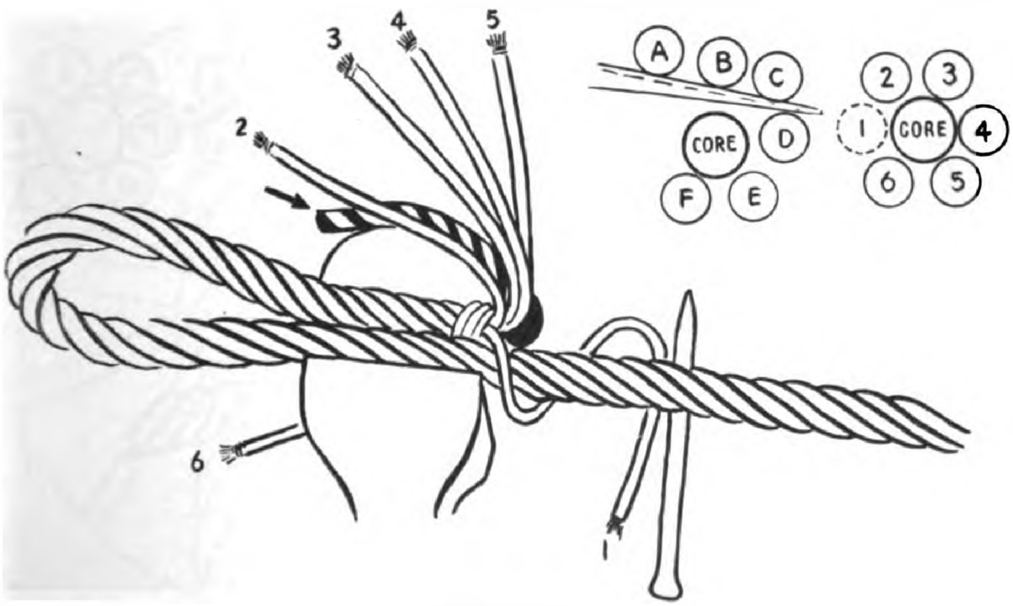


Figure 94.

Making the Maritime Eye Splice (6 Strand Ropes). 1. Top strand nearest standing part of cable is strand No. 1. Continue clockwise around cable naming strands 2, 3, 4, 5, and 6. (Figure 93).

Note: Splicing should be done from position shown in Figure 93.

2. Select strands A, B, C, D, E, and F in standing part of cable.

Note: The valley selected for No. 1 strand to enter is between strands C and D. Name remaining strands in alphabetical order. (See insert, Figure 93).

3. Bend strands 1, 2, 3, 4, and 5 over top of vise. Pass the ends through eye to hold in place. Pass No. 6 under jaws of vise. This keeps the strands from interfering with splicer.
4. Insert marlinespike under strands A, B, and C.
5. Rotate marlinespike counterclockwise one full turn.
6. Pass No. 1 strand around standing part in the same direction as the lay of the cable.
7. Insert strand No. 1 through cable at butt of marlinespike.
8. Remove spike and insert in opposite direction. (See Figure 94).
9. Rotate spike toward vise forcing strand No. 1 ahead of needle. To remove all slack, pull on strand while rotating spike.
10. Holding strand back over vise remove the spike.
11. Insert spike between strands A and B picking up strands B and C. (See Figure 95).

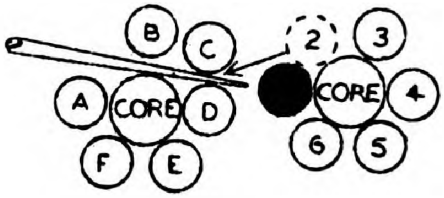


Figure 95.

12. Rotate spike one full turn away from vise.
13. Take strand No. 2 and pass around cable in same direction as No. 1 strand.
14. Insert strand No. 2 in front of spike, entering at point of spike.
15. Rotate spike toward vise, keeping slack out of strand No. 2 with free hand.
16. Pull strand No. 2 back over vise.

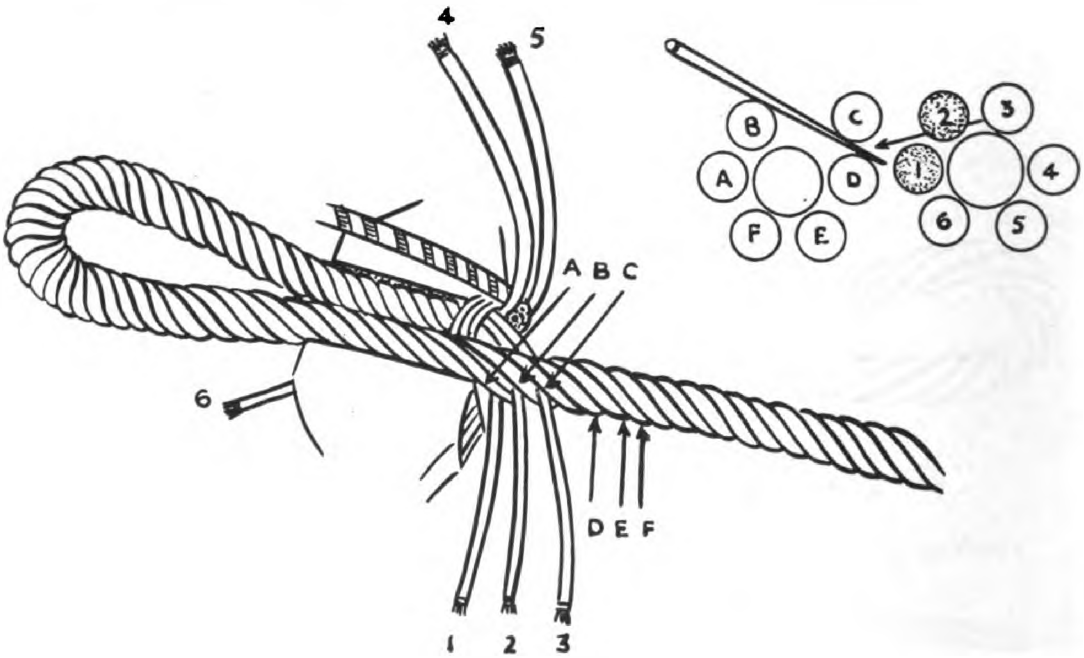


Figure 96.

17. Remove spike and lock strand.
18. Insert spike between B and C to pick up C. (Figure 96).
19. Rotate spike one turn away from vise.
20. Pass strand No. 3 around standing part in same direction as before.
21. Insert strand No. 3 in front of spike, entering at point of spike.
22. Rotate spike toward vise keeping slack out of strand.

23. Hold strand No. 3 over vise and remove spike.

Strand No. 1 passes under strands A, B, and C. Strand No. 2 passes under strands B and C. Strand No. 3 passes under strand C. Notice strands 1, 2, and 3 enter in the same valley. (See Figure 96).

24. Insert spike between strands C and D picking up D. (Figure 97).

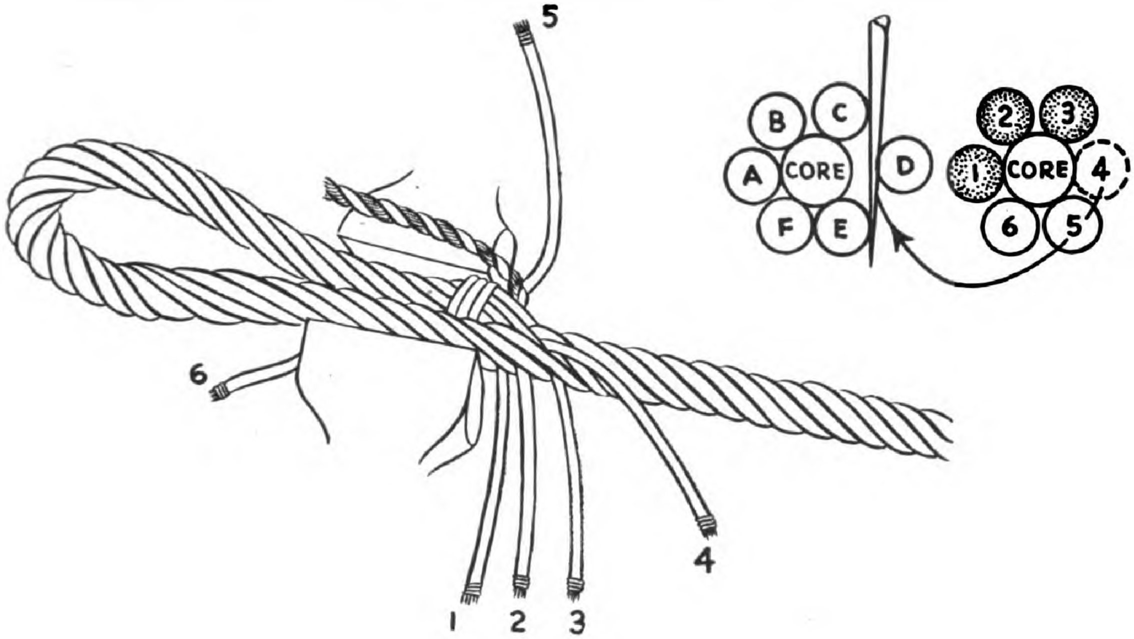


Figure 97.

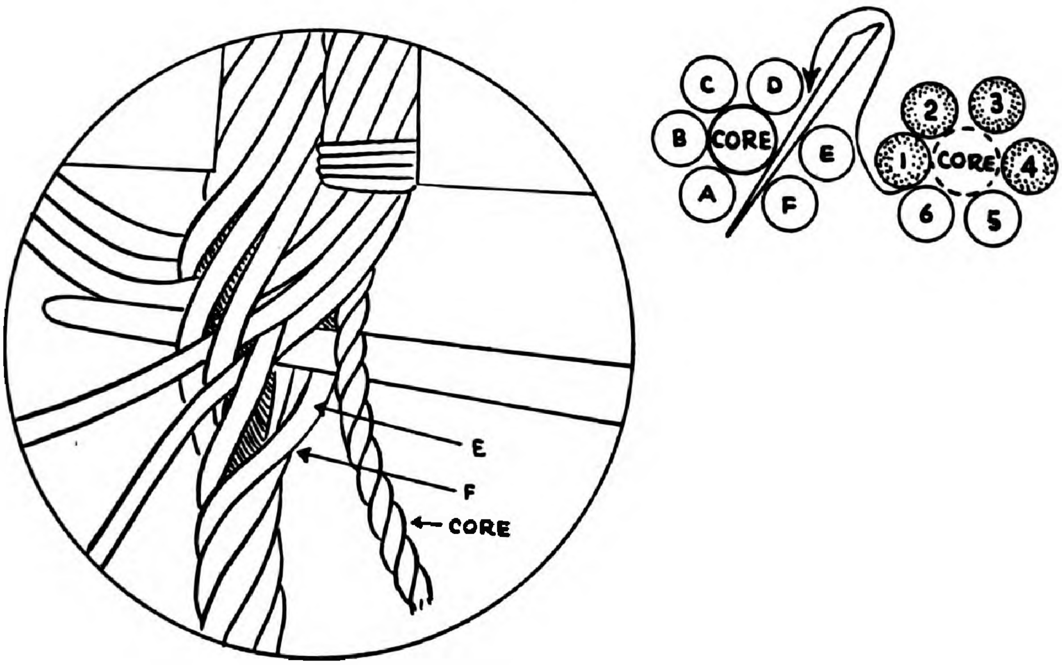


Figure 98.

25. Rotate spike one turn away from vise.
26. Pass strand No. 4 around standing part as before.
27. Insert strand No. 4 in front of spike.
28. Rotate spike toward vise, keeping slack out of strand.
29. Hold strand back over vise and remove spike.

30. Insert spike between D and E picking up strands E and F.
31. Rotate spike toward vise. Lay core on top of spike. (See Figure 98).
32. Force core in with spike and rotate spike two full turns away from vise laying cores side by side; then remove spike.
33. Insert spike between D and E picking up strand E. (Figure 99).
34. Rotate spike one turn away from vise.
35. Pass strand No. 5 around cable in same direction as before.
36. Insert strand No. 5 in front of spike. (Figure 99).

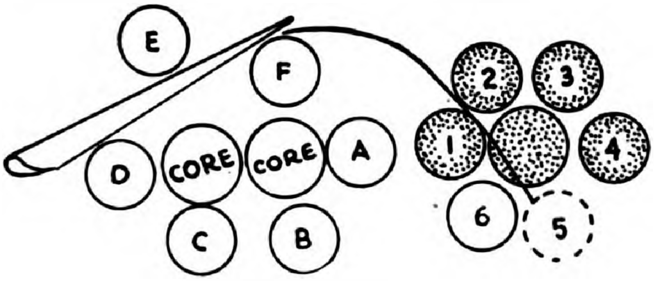


Figure 99.

37. Rotate toward vise, keeping slack out of strand.
38. Hold strand back over vise, remove spike.
39. Insert spike under strand F and rotate spike one turn away from vise. (See Figure 100).

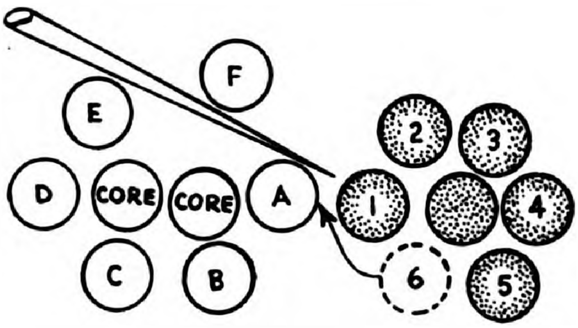


Figure 100.

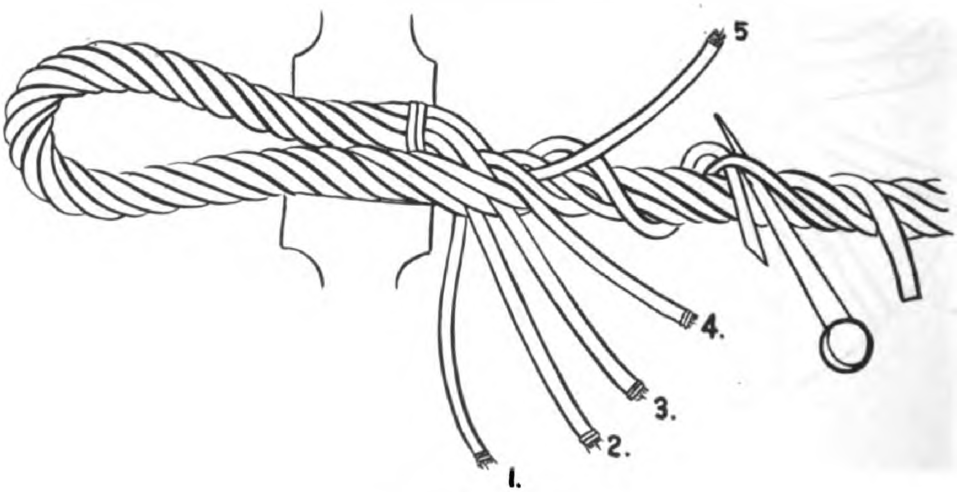


Figure 101.

40. Give strand No. 6 one-half twist, unlaying it at jaws of vise.
41. Pass strand No. 6 around cable in same direction as before.
42. Insert strand in front of spike.

43. Rotate spike toward vise, keeping slack out of strand.
44. Hold strand back over vise and rotate spike one turn away from vise.

Note: From this point on each strand is unlayed one-half twist before each tuck.

45. Pass strand No. 6 one turn around the cable.
46. Insert strand No. 6 in front of spike. (See Figure 101).
47. Rotate spike toward vise, keeping slack out of strand.

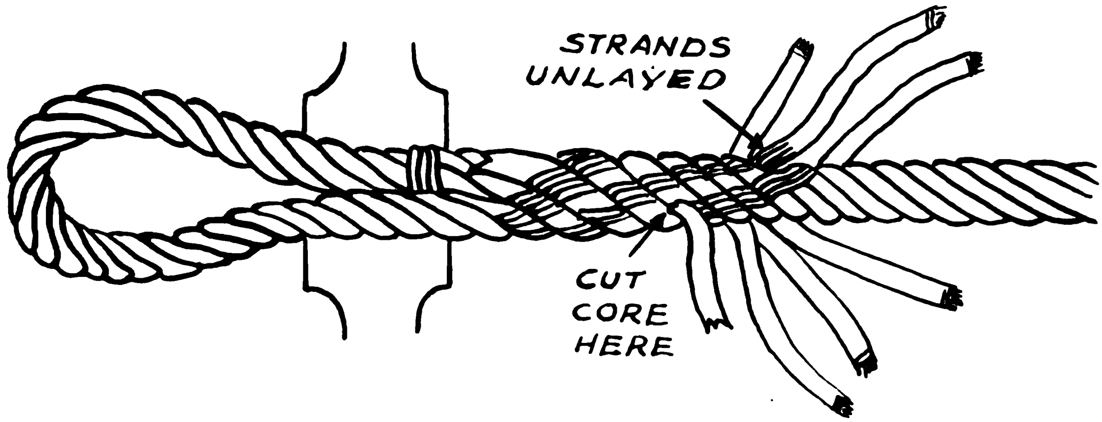


Figure 102.

48. Repeat steps 40 to 44 (inclusive) until 4 tucks have been taken in strand No. 6.
49. Make 3 additional tucks in each strand (following steps 40 to 44 inclusive), with strand No. 5 around E, strand No. 4 around D, strand No. 3 around C, strand No. 2 around B, and strand No. 1 around A.

Note: After tucking is completed with each strand unlay it one turn. (See Figure 102).

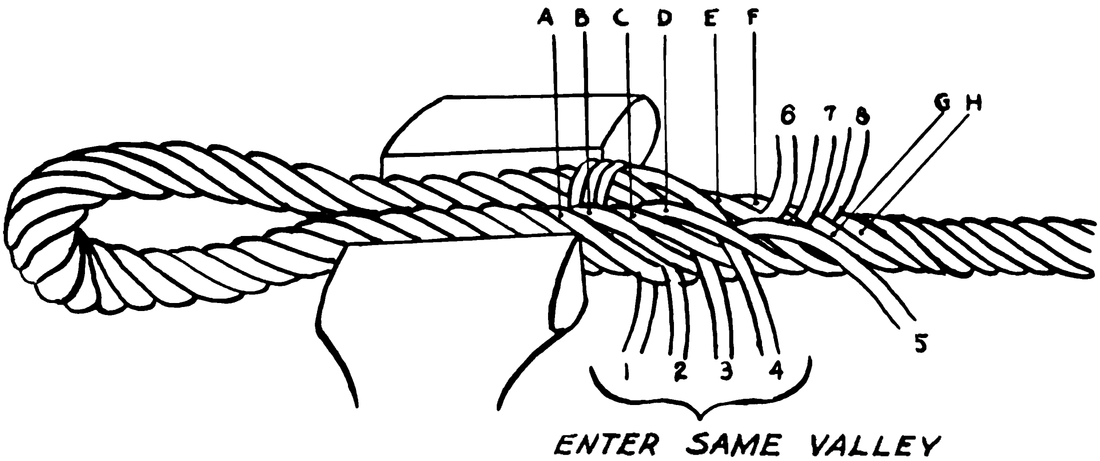


Figure 103.

50. Cut off each strand as close to the standing part as possible.
51. Insert spike where core protrudes and rotate spike to middle of splice.
52. Cut core and force end into center of the splice. (See Figure 102).

Splice should be dressed down from the eye by hammering it on a solid surface with a brass or wooden hammer. This removes all slack from the finished splice.

Maritime Eye Splice in Eight-Strand Wire Rope. Eight-strand ropes are spliced into the maritime eye splice similar to six-strand ropes. In splicing six-strand ropes the first tuck splits the rope and lifts three strands. Strands No. 1, 2, and 3 enter the same valley and respectively lift one strand. Strands No. 4, 5, and 6 each lift one strand and then three additional tucks are taken in all six strands.

In eight-strand ropes No. 1 strand splits the rope and lifts four strands. Strands No. 2, 3, and 4 enter the same valley and each lifts one strand. Strands No. 5, 6, 7, and 8 each lift one strand and then three additional tucks are taken in each strand as outlined for six-strand ropes.

The only difference is that in eight-strand ropes, No. 1 strand enters under four strands and strands No. 2, 3, and 4 enter the same valley. Figure 103 shows the first tuck of strands No. 1, 2, 3, 4, 5, 6, 7, and 8.

Thimble Splice. A thimble protects the eye splice by shielding the rope from cutting and abrasion and increases the efficiency of the rope at the point of attachment by permitting the rope to break over a larger area and equalize the strain on all strands.

1. Bend points of thimble up to open the throat of the thimble. This permits all slack to be taken out of splice.
2. Wire thimble to eye.

Care should be taken to wire thimble as firmly as possible. (See Figure 104).

3. Put in vise and splice as outlined for maritime eye splice.
4. Remove wire bindings from thimble.
5. Hammer down points of eyes to original position.

Running Splice. The Running Splice is used to join ropes without increasing or decreasing their original diameters. The amount of rope used or consumed in the running splice will depend on the type of work to be done and the kind and condition of equipment used in conjunction with the rope.

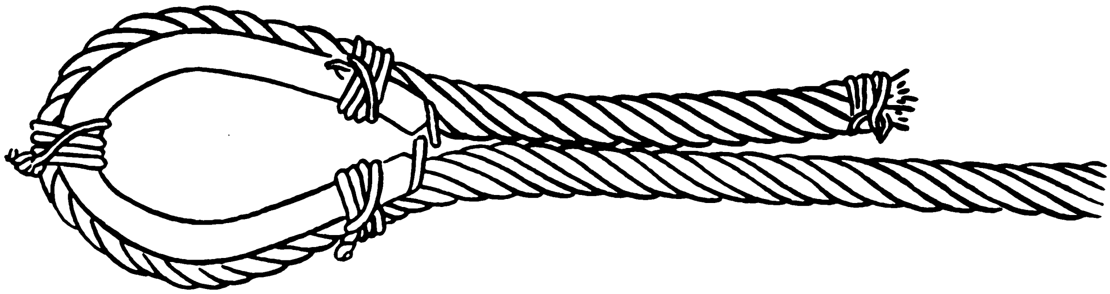


Figure 104.

A table of allowances for the standard short splice and the standard long splice will be given.

STANDARD SHORT SPLICE (RUNNING) FOR SIX-STRAND ROPES

Allowances For Endless Splices

Diameter of Wire Rope, Inches		¼-⅜	½-⅝	¾-⅞	1-1⅛	1¼-1⅜	1½
Length of Rope to Allow in Feet	Standard Short Splice	15	20	24	28	32	36
	Long Splice	30	40	50	60	70	80

Note. Allowances shown are for the standard short splice, and should be used for general purpose splicing. The long splice should be used for extra heavy duty. and where the rope is used over sheaves or drums of minimum diameters.

Marriage. There are various methods of joining wire ropes together in splicing. The joining together of the ropes is called the marriage, and the placement of the strand ends into the center of the rope is referred to as 'tucking'.

One method of marriage will be explained; it is the side-by-side marriage and is recommended for the following reasons: it provides a closer marriage; it is faster; it is easier to handle.

Side by Side Marriage (On Six-Strand Ropes). The following procedure is listed for average rope and calls for the strands to be laid in pairs. (However, the strands can be laid in one at a time or, in cases of preformed ropes, three strands can be started at a time and each one dropped at its respective place.)

Note. Cable allowances shown in drawings are for ½-inch rope. (Standard short endless splice.) The 20 foot marks are for the total length of splice. The 40 inch markings are for tucking points, and the laying and unlaying of the strands are stopped at these points.

1. Measure and mark the cable ends to be spliced. (See Figure 105.)
2. Unlay one pair of strands in both ropes to Point 1. (See Figure 106.)

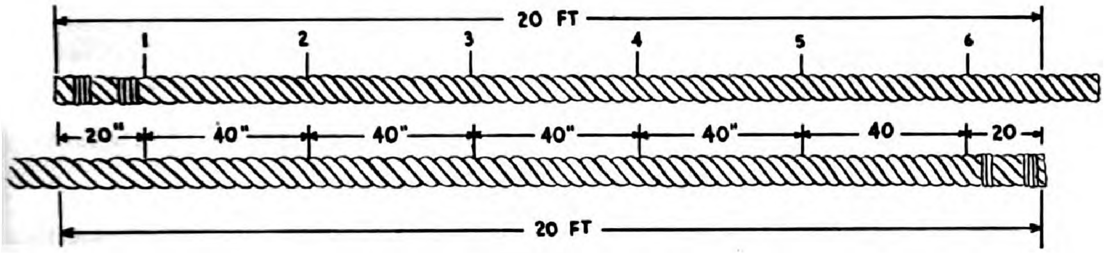


Figure 105.

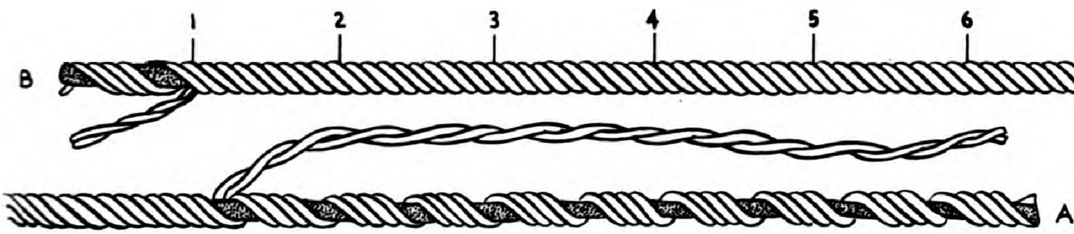


Figure 106.

3. Lay ropes side by side. Unlay one pair of strands in rope B, and at the same time replace with a pair from rope A to Point 5, and lock strands. (See Figure 107.)

Note. To lock a pair of strands to prevent unlaying, place strands coming from the left in front of strands coming from the right.

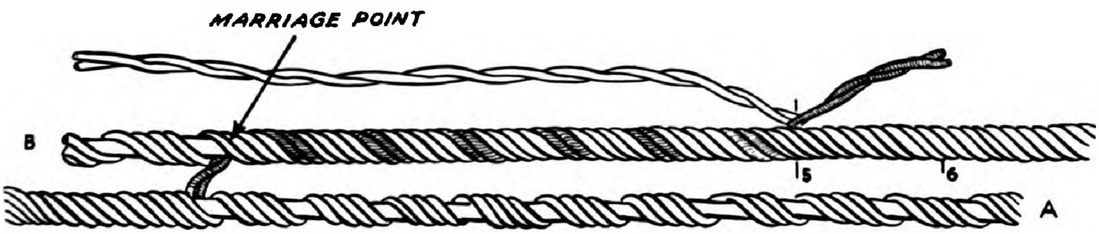


Figure 107.

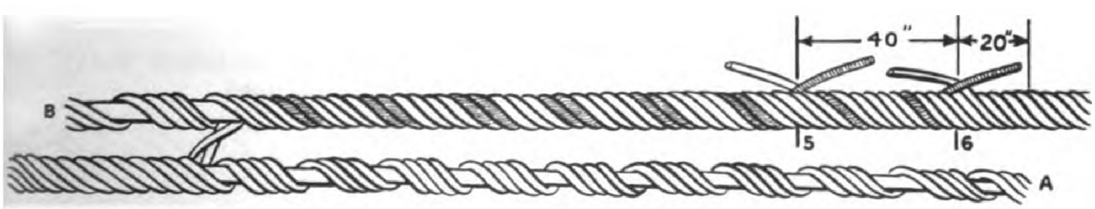


Figure 108.

4. Separate strand pairs and lay one strand to Point 6. (See Figure 108.)

Caution. Care must be taken to lay proper strand in proper channel after splitting strand pairs, or the splice will be improperly formed. If the wrong strands have been selected, there will be an extra strand between the one removed and the one laid in its place.

5. Unlay one more pair of strands in rope A to marriage point, and repeat the procedure as in the first pair of strands, splitting strands at Point 3 and stopping single strand at Point 4. (See Figure 109.)

Check pairs of strands to be sure they match without crossing over any strands

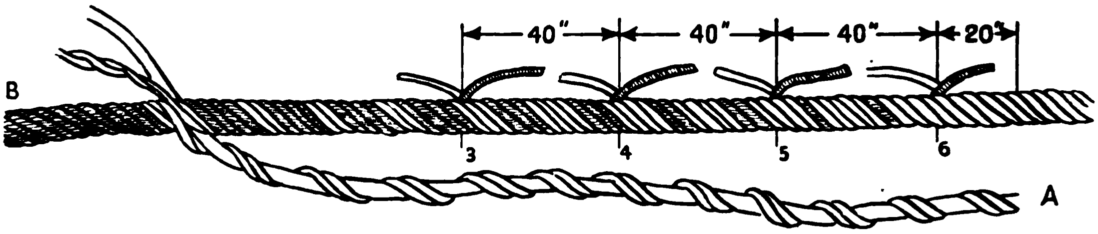


Figure 109.

at marriage point. If the wrong pair has been selected, take the remaining pair from cable B, and it will match the pair from cable A.

6. Remove core from remaining pair and lay into rope B. Separate the pair at Point 1 and stop single strand at Point 2. (See figure 110.)

7. Trim strand ends and prepare to tuck. When cutting strand ends, leave 2-inch space between ends to prevent them from overlapping when tucked.

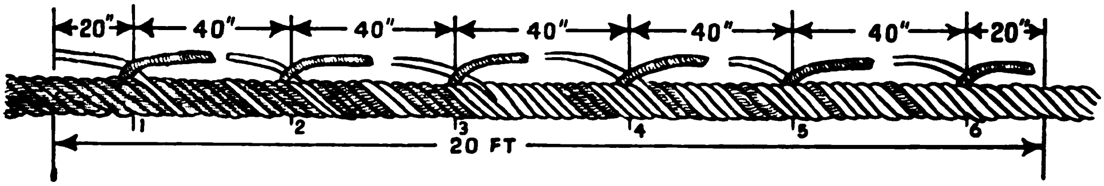


Figure 110.

Tucking on Six-strand Ropes. Tucking is a term applied to the insertion of the strand ends into the center of the rope, forming a new core and at the same time removing the old core.

This process eliminates all strand ends, and as tension is applied the ends are tightly gripped, holding them in place.

In six-strand cable each tuck will be the same length in inches as the length of the splice is in feet. (See Figure 111.)

ALLOWANCES FOR TUCKS

Diameter of Rope, Inches		1/4-3/8	1/2-5/8	3/4-7/8	1-1 1/8	1 1/4-1 3/8	1 1/2
Length of Tuck in inches	Standard Short Splice	15	20	24	28	32	36
	Long Splice	30	40	50	60	70	80

1. Straighten ends of strands to be tucked.
2. Wrap ends of strands with twine or friction tape. This operation builds up the strand ends to the same size as the core space it will occupy.

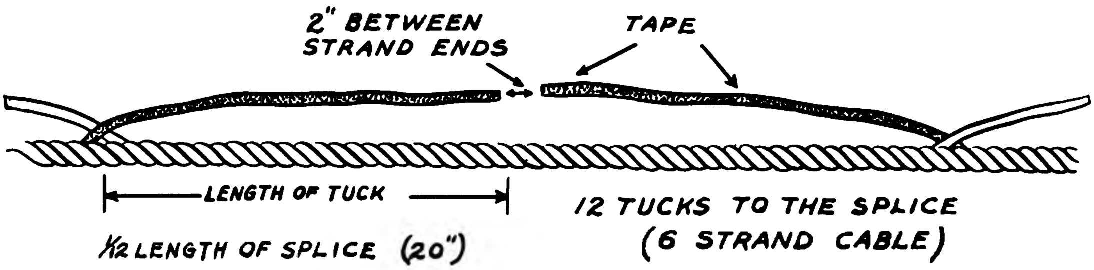


Figure 111.

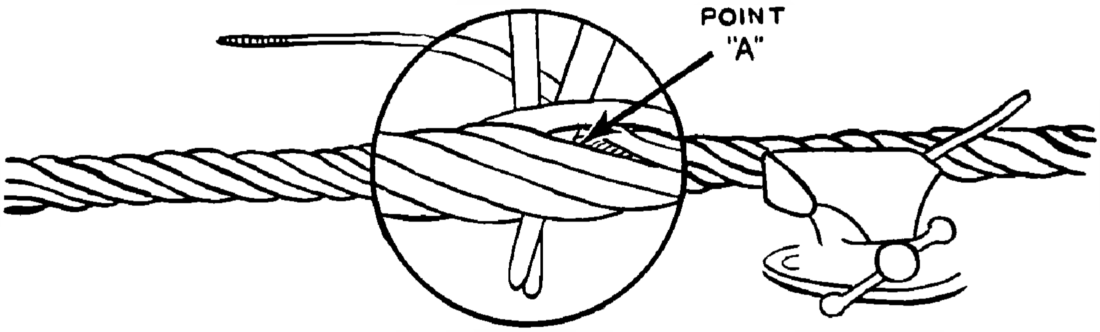


Figure 112.

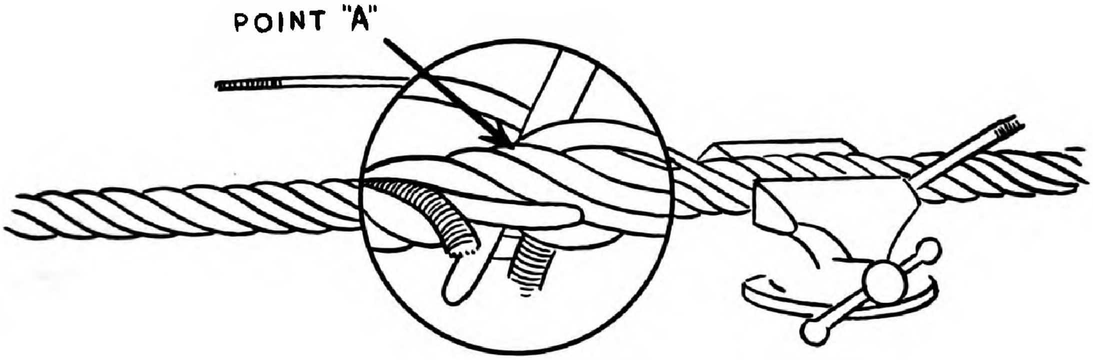


Figure 113.

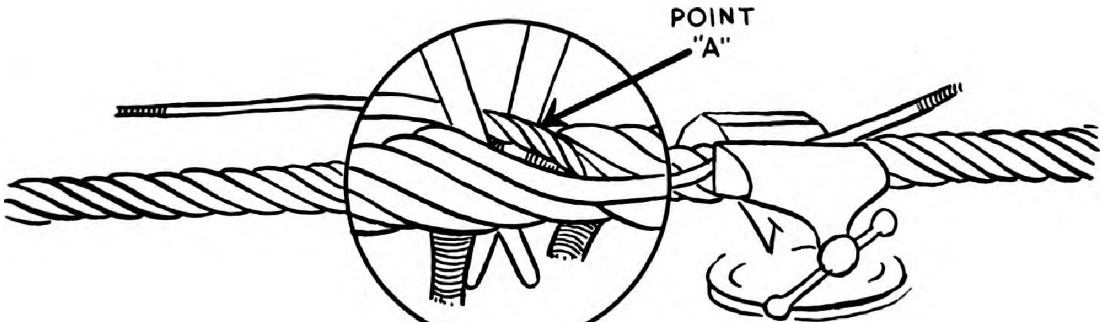


Figure 114.

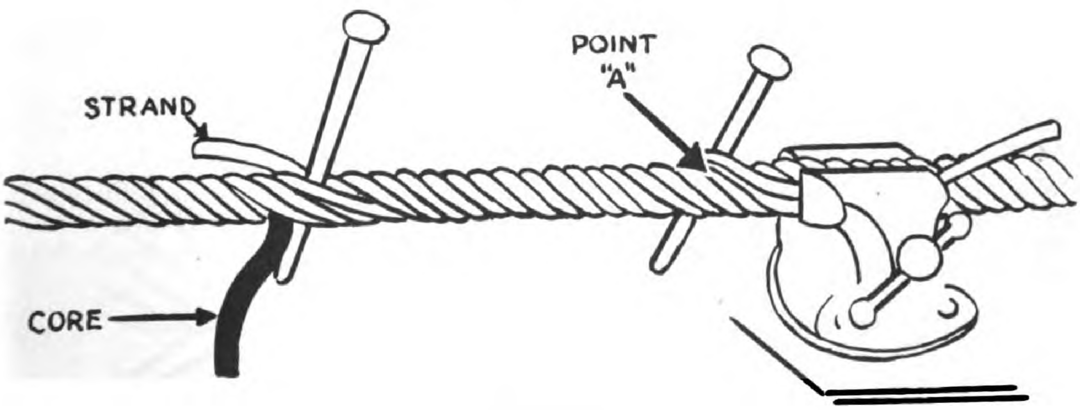


Figure 115.

3. Place rope in vise 6 inches from first pair of strand ends, so that the vise grips rope and one strand end. (See Figure 112).
4. Drive marlinespike under 3 strands at point A.
5. Insert second spike on opposite side of core. (See Figure 113).
6. Cross spikes, forcing cable open and cut core. The core ends should come out the same place as the points of spikes. (See Figure 114).
7. Lay strand end in between crossed spikes and force strand into space vacated by core, and unlay strand end one full twist at Point A. (See Figure 114).
8. Rotate spike and tuck entire length of strand end into the cable. (See Figure 115).
9. Remove spike.
10. Regrip rope in vise leaving strand end free. (See Figure 116).

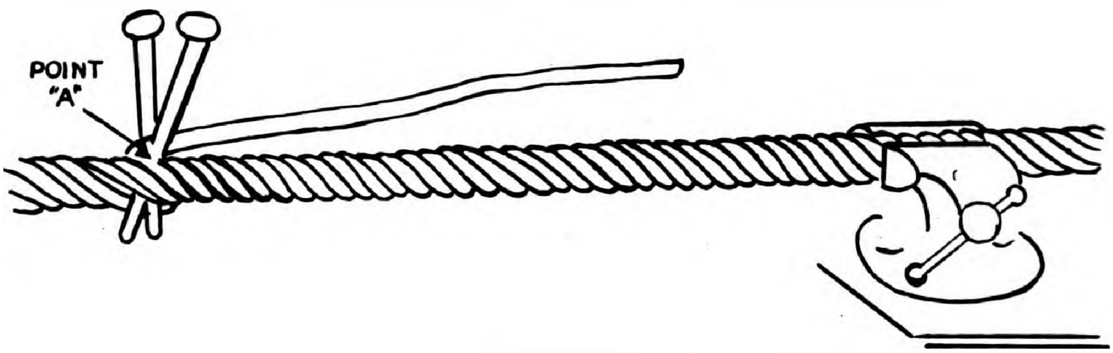


Figure 116.

11. Replace spikes in same position as before at Point A. Before tucking second strand, unlay the strand by twisting at Point A. This causes the strand ends to mesh at the tuck.
12. Cross spikes.
13. Lay strand between spikes and tuck strand as in steps 4 to 8, inclusive.
14. To remove deformities caused by tucking, hammer with a wooden mallet or brass hammer. (See Figure 117).

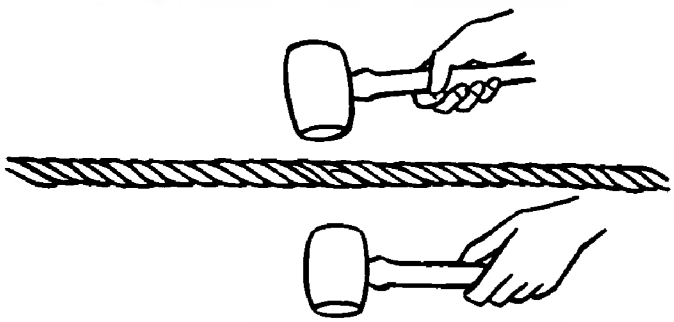


Figure 117.

15. Check for deformities at tuck point. (See Figure 118).
16. Tuck remaining five sets of strands ends using same procedure.

When splicing regular lay ropes the strand ends should not cross at point where tucks begin. (See Figure 118). When splicing Lang lay ropes it is advisable to cross the strand ends at point where tuck begins. This increases the holding power of the splice.

Figure 118.

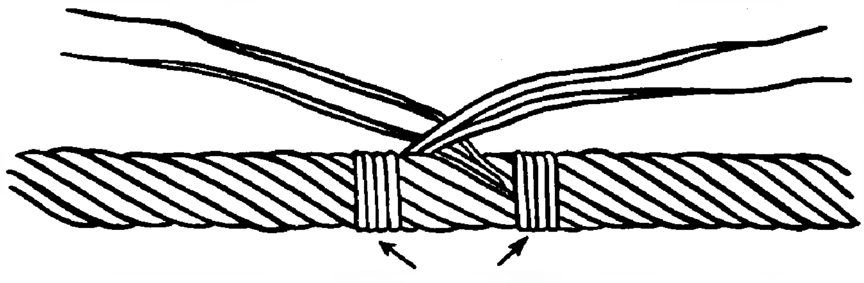


Figure 119.

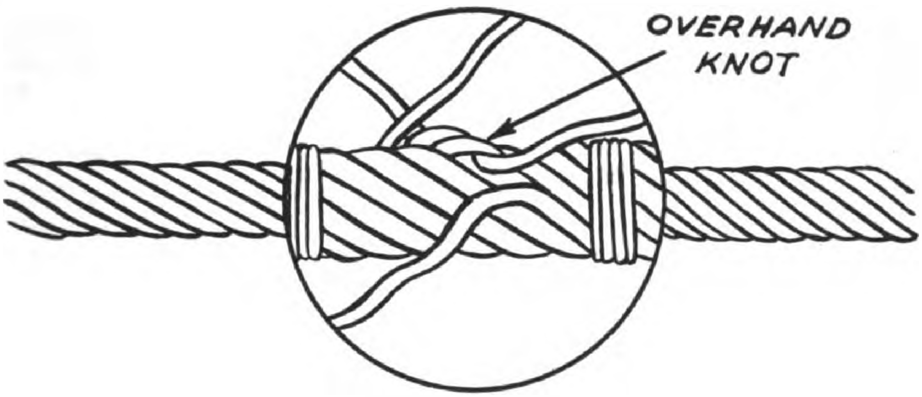


Figure 120.

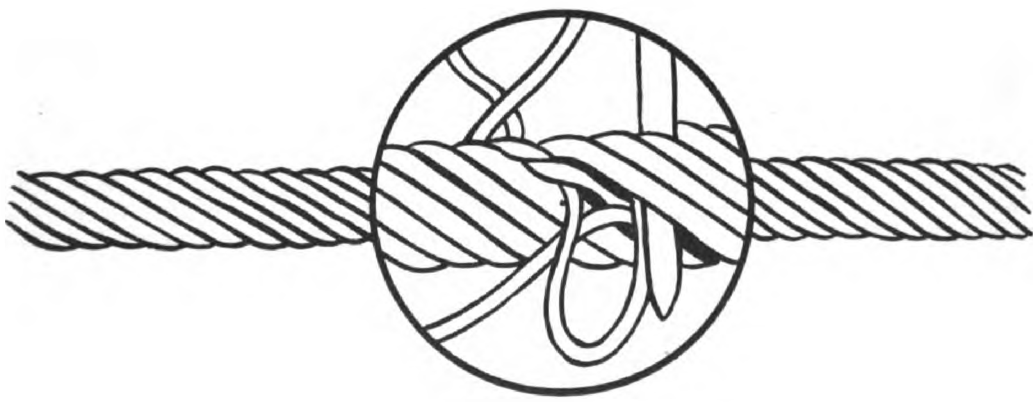


Figure 121.

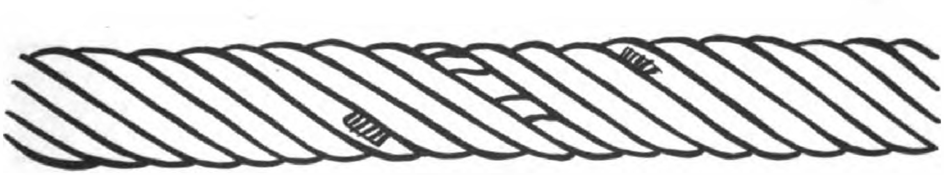


Figure 122.

Standard Short Splice (Endless) for Eight-Strand Ropes. Because the hemp center in an eight-strand rope is much greater in diameter than the strands, it is not practical to tuck the strand ends as outlined for six-strand ropes. The strand ends are secured by twisting or tying them together. This is known as the *Nash Tuck.*

Tucking on Eight-Strand Ropes. 1. Proceed with the splice as outlined for six-strand ropes to the point of tucking.

2. Place seizings on rope each side of the point where strands project.
3. Split the strand ends in two, back to the seizings. (See Figure 119).
4. Take one-half of each strand end and tie an overhand knot. (See Figure 120).
5. Draw knot down tight and remove seizings using hand clamp or similar tool.
6. Insert spike under three strands adjacent to knot. (See Figure 121).
7. Insert the half strand, that formed the knot, at point of spike. Pull strand through tightly.
8. Remove spike.
9. Insert spike under three strands on opposite side of knot and tuck other half strand.
10. Tuck remaining two half strands on opposite side of cable in the same manner.
11. Cut off strand ends close and force ends into valley between strands. (See Figure 122).
12. Remove any uneveness by hammering.
13. Tuck remaining seven pairs of strands using the same procedure.

CHAPTER 7

ORDNANCE TROOPS—ORGANIZATION AND EMPLOYMENT

INTRODUCTION

The operations common to most types of ordnance units are considered in detail in the first portion of this chapter to avoid repetition later, while the functions peculiar to specific types of units are taken up in the sections following.

It was deemed advantageous to discuss certain groups of units in conjunction with the technical phase of their work rather than in a general chapter on troop units. In this connection the reader is referred to Chapter 4, Volume II for a discussion of Aviation Ordnance units; to Chapter 4, Volume III for a discussion of Ammunition Companies, and to Chapter 5, Volume III for a discussion of Ordnance depot companies.

It is recommended that Chapter 6, Volume I, Staffs be studied prior to the material presented here for the Light Maintenance Company, the Ordnance Battalion, the Ordnance Group, and the Headquarters and Headquarters Company, Ordnance Base Depot. Further, prior to taking up this chapter's treatment of Security of Ordnance Units and Morale for Ordnance Troops, the reader is referred to allied topics given detailed coverage under Troop Training, Chapter 5, Volume I.

During formulation of this text a few new units have appeared and are taken up to the limit of available information. Reference is made to the Headquarters and Headquarters Company, Ordnance Base Depot (TO and E 9-620-1T) and the Ballistic and Technical Service Teams for Field Operations (TO and E 9-500, and changes thereto).

The information contained in Tables of Organization and Equipment is based on the latest approved War Department data. As used in this book it is for the information of our readers and not to be construed as official.

Mission, Organization, and Administration of Ordnance Field Units

The mission of the Ordnance Department in the field is: placing required quantities of the proper types of ammunition and ordnance general supplies in serviceable condition within easy reach of the using troops, and distributing and issuing those items when and where they are needed in order that the using troops may accomplish their mission; maintaining and repairing all ordnance materiel which is damaged beyond the capabilities of the using troops to repair: providing adequate facilities for recovery, evacuation, and reclamation of all damaged ordnance equipment; providing technical information and guidance to commanders, staffs, and using troops; inspecting ordnance materiel in the hands of using troops; receiving and reclaiming captured or abandoned enemy materiel and ammunition; destruction of ammunition when required; removal and disposal of duds or delayed action bombs, shells, and other ammunition; collection of technical information about enemy ordnance materiel and ammunition including cooperation with Chemical Warfare Service in obtaining samples of the chemical filler of any enemy ammunition for analysis; and the administration of field establishments operated by ordnance personnel.

The organization of ordnance service embraces the establishments, facilities, and troop units available to the Ordnance Department for carrying out its field mission. The echelons of ordnance service are organized in conformity with both the geographical and tactical organization of the Army of the United States. The relationship of the various elements of ordnance service and the ordnance officers controlling them are shown in Chapter 6, Vol. I, Staffs.

The wide scope and technical nature of ordnance service and the fact that ordnance service begins in the zone of the interior and extends to the combat troops on the front line of the theater of operations, require a large variety of highly trained, technically skilled troop units, each of which is specifically designed to render some phase of ordnance service. These ordnance troop units are classified in two ways:

By Function Types. Ordnance troop units are divided according to the kind of ordnance service rendered in their normally assigned mission into the following types: maintenance, including evacuation and vehicle assembly units; depot, including vehicle distribution units; ammunition; and composite.

By Assignment Types. Ordnance units are also divided according to forces to which they are normally assigned into the following types:

Army Service Force Units. All those ordnance organizations which are not assigned or attached to a tactical unit. Base organizations, operating only in the communications zone, are considered to be in this class and are normally assigned to the theater services of supply.

Army Ground Force Units. Those ordnance units normally assigned or attached to Army Ground Forces tactical units.

Army Air Forces Units. Those ordnance organizations normally assigned to Army Air Forces units.

Since ordnance troop units are organized primarily to furnish the necessary technical specialists, tools, and supplies for the performance of particular missions, it is necessary to provide a technical organization for the employment of these means. In addition, these units are military organizations designed to funtion in the field, and consequently must be organized along military lines for discipline, military administration, and their own defense. Details of organization and personnel are given in the appropriate Table of Organization or Table of Organization and Equipment in the 9-series.

The military organization of an ordnance unit follows in general that of a corresponding infantry unit. A unit headquarters, or headquarters and supply section is provided for military administration. The unit commander keeps the number of men engaged in military administration to the minimum, and keeps the maximum number of men employed in the accomplishment of the mission of the unit.

The technical organization is established along functional lines. The unit is divided into sections, or platoons and sections. Each of these is responsible for the supervision and operation of some particular technical activity.

Organizational equipment for ordnance units is prescribed in the 9-series Tables of Organization and Equipment or Tables of Equipment, or in Table of Basic Allowances No. 9, and in Army Service Forces Catalog, Ordnance 11, SNL Group N.

In order to accomplish its mission, each ordnance unit must receive adequate military and technical training. The military training is essential in order that the unit be able to protect itself and to accomplish its own military administration, discipline, subsistence, and transportation. Thorough technical training of each individual and of the unit as a whole is essential to the accomplishment of the technical mission for which the unit is organized. The basic training of each unit will be carried out in accordance with the pertinent mobilization training program. (See FM 21-6 for current MTP's.)

Many ordnance soldiers will complete their basic military training prior to being assigned to an ordnance unit; others may be assigned with little or no basic military training. It is the responsibility of each unit commander to determine not only the number of hours of training which each soldier has received prior to being assigned to the unit, but also the knowledge, skills, and aptitude acquired by the soldier from that training. It is the duty of the unit commander to put into effect a training program designed to insure that every individual in the organization has received basic military training in accordance with the pertinent MTP and that each soldier has developed the required military skills, aptitude, and knowledge. The nature and use of Mobilization Training Programs (MTP) is discussed in Chapter 5, Vol. I. When a unit has completed the basic military training required by the pertinent MTP, the commander should provide for additional military training whenever technical training and operations permit. The requirements of the MTP's are minimum requirements. Additional training increases the military efficiency of the unit by means of greater knowledge, higher degrees of skills, and improved aptitudes. Moreover, continued training is necessary in order to perpetuate the knowledge, skills, and attitudes acquired from previous training. Special emphasis should be placed upon the following subjects:

(1) Map reading and use of the compass.
(2) Security measures and defensive tactics in the protection of bivouac areas and ordnance establishments against air, ground, airborne, and chemical attacks, including the use of available natural cover, camouflage, and strict discipline in compliance with all security regulations.
(3) Individual protection and firing of weapons.
(4) Physical conditioning.
(5) Night operations and blackout discipline.
(6) Development of initiative and aggressive spirit.
(7) Military courtesy and discipline.
(8) Responsibility and leadership of commissioned and noncommissioned officers.

All personnel in an ordnance unit should have a general knowledge of the technical mission of the unit, and each individual must be thoroughly trained in all technical operations to which he may be assigned. In order to have a flexible organization adaptable to the varied technical missions to which it may be assigned, it is essential that each individual be trained to perform essential duties in addition to those normally assigned to him, and that two or more men be thoroughly trained for each key position. Many ordnance soldiers will have received a certain amount of technical training in an ordnance training center before being assigned to an ordnance organization, and some will have received little or no technical training. The organization commander must institute a technical training program which will insure that each man is qualified to perform all technical operations incident to his normal duties. Selected men will be sent to ordnance schools for advanced technical training in accordance with quotas prescribed by War Department orders, but most of the technical training must be accomplished in the organization itself. In addition to the technical training of individual personnel, the organization must be trained as an efficient, coordinated operating unit. The technical training of individuals and of the unit as a whole requires actual experience in technical operations, preferably under field conditions.

The technical training of all ordnance organizations should develop full understanding of the mission of ordnance service and the basic ordnance doctrines, diligence upon the part of all ordnance personnel to improve ordnance service, familiarity with sources of ordnance technical information, continuous liaison with the units being supported and with next higher ordnance echelon. The technical training of maintenance units should stress the following: proficiency in maintenance of ordnance materiel; use of improvised methods, equipment, tools, and parts, when necessary; operations under field conditions, with emphasis on concealment, camouflage, and dispersion; and inspection procedures. The technical training of depot units should place emphasis on the following: stock control procedures; operation from vehicles to insure mobility of field installations; identification of parts; and familiarity with interchangeability references. In the technical training of ammunition companies, emphasis should be given to the following: identification of ammunition; inspection of ammunition, including surveillance and maintenance; proper methods of handling, loading, and stacking; safety precautions and regulations; ASP and depot layout; and proficiency in maintaining records.

The technical training of evacuation units should stress the following: field rigging; field recovery operations; proficiency in driving; and first and second echelon maintenance.

The number and type of ordnance troop units assigned to army depend upon the quantity of each major item of ordnance materiel authorized for units within the army, the type of action contemplated, the terrain, climatic conditions, the extent of the army sector both laterally and in depth, and the degree of maintenance and supply support furnished by the communications zone.

Third echelon maintenance companies are normally grouped together into battalions, composed of two to five maintenance companies and a depot company under a headquarters and headquarters detachment (T/O 9-76). These battalions and the component companies are highly mobile. They operate in close support of the combat units. They are located in corps areas or in the forward portion of the army area in situations in which the corps area is very shallow. Each company is capable of operating independently of the others, and the component companies may be widely dispersed for closer support of combat units. The composition of any battalion will depend upon the requirements of the tactical situation and the nature of the combat units to be supported. Component companies are readily detached and assigned to other battalions when changes in the tactical situation require. In certain instances, these battalions may include evacuation companies and ammunition companies.

Army ordnance companies, other than those furnishing third echelon support to combat units, are also grouped into ordnance battalions. Being less mobile and operating installations which are heavier and more permanent these battalions are located to the rear of the third echelon battalions. In certain situations, various types of companies are combined into a single battalion which is designed for general supply work and fourth echelon maintenance of all ordnance materiel. In other situations, each battalion may be composed of companies of a single type or similar types to do specialized work as required.

Ammunition companies assigned to army normally are grouped into ammunition battalions (T/O 9-15), composed of from two to six companies each. These companies operate army ammunition depots and ASP's. Bomb disposal units assigned to army may be attached to one of the ammunition battalions or to other ordnance battalions.

Ordnance battalions may be combined into ordnance groups under a headquarters and Headquarters Detachment, Ordnance Group (T/O & E 9-12), as the situation warrants.

In certain situations, a corps operating under army may perform some of the service functions normally carried out by the army. In this event, the corps ordnance officer will have the duties and responsibilities which are incident to the particular ordnance service function.

In a separate or detached corps, the facilities, operations, and organization of ordnance service in an independent corps are similar to those of an army.

Ordnance units which are organic in divisions comprise the light maintenance company for infantry divisions, the medium maintenance company for cavalry divisions, an ordnance maintenance battalion for armored divisions, and special units for airborne or mountain divisions. The mission of these units is the performance of such of the third echelon maintenance of ordnance materiel for the division as is within their capabilities. They also perform the functions of ordnance supply of materiel for second echelon maintenance to the regiments, battalions, and separate companies of the division. Divisional maintenance organizations normally must be reinforced by the services of nondivisional maintenance units under army control. This will be particularly true if combat units such as tank or tank-destroyer battalions are attached to the division.

The basic ordnance unit is the company. Each company is designed to have the number and kinds of technically trained personnel and specialized equipment required to accomplish the particular mission for which it has been organized. Ordnance companies, with the exception of maintenance companies organic to infantry or cavalry divisions, are normally organized into battalions for the purposes of administration and control. When the situation warrants, ordnance battalions in the communications zone are organized into groups under a group headquarters and headquarters detachment, and/or ordnance base depot (T/O & E 9-620-1); and battalions in the combat zone may be organized in army ordnance groups under a headquarters and headquarters detachment (T/O & E 9-12). Each ordnance company maintains its own property records, and any separate or detached company maintains its own personal records as well as making its own authorized promotions.

Normally, any ordnance unit will operate directly under the control and direction of the ordnance officer of the command headquarters to which it is assigned. Depending upon the situation (duration of attachment, local commanders, tactical situation, etc.), this control may revert to other headquarters to which the ordnance troops may be attached. The tendency in some theaters is for Army to retain a tight control of Army troops even though these troops may be used by Corps or Divisions.

For a more detailed discussion of ordnance organization and for administration and control within a tactical unit, see chapter 6, volume I, "Staffs".

An example of administration, control, and operations of an ordnance company is illustrated by the following company S.O.P.

HEADQUARTERS

ORD MED MAINT CO

APO......, c/o Postmaster
8 Aug 1944

STANDING OPERATING PROCEDURE

The following SOP for this Co is published for the guidance and compliance of all concerned. Any previous directions in conflict with the following are hereby rescinded.

Points not specifically covered in this SOP will be acted upon without delay by all commissioned personnel.

Reports will be submitted to this Hq indicating the problem encountered, the solution used, and the points recommended for inclusion in a later revision of this SOP.

Other operational instructions to the Co will be issued as required.

(s) John J. Doe
JOHN J. DOE
Capt Ord Dept
Commanding

I. Mission

a. The mission of this Co is to provide ordnance service to the combat and service units it is supporting.

b. The Hq section is responsible for the administrative details of the Co. It will operate the Co mess and handle Co supply except for ord gen supplies. It will comply with all existing regulations.

c. The shop office is responsible for all records and reports concerning the shop. It is responsible for the initial inspection of incoming materiel and the final inspection of outgoing materiel. This section is responsible for making out the work order and assigning work to sections of the field shop. It is responsible for dispatching all contact parties (see par VI), inspection teams, and recovery parties. It will keep the necessary shop files and technical information for shop operation.

d. The automotive section is responsible for automotive repair on materiel brought to the shop for repair. It will make inspections as required by the shop office.

The automotive platoon will operate the motor pool for the Co. All requests for additional transportation by a section will be made to the motor pool. The officer in command of the automotive platoon will be the Co transportation officer. The motor pool will conform with existing regulations concerning the storage of gas, oil, and lubricants.

e. The recovery section will do all the recovery and evacuation work assigned by the shop office.

f. The artillery section is responsible for all artillery repair on materiel brought into the shop. It will make inspections as required by the shop office.

g. The small arms section is responsible for repair on small arms materiel brought into the shop. It will make inspections as required by the shop office.

h. The instrument section is responsible for fire control instrument repair on materiel brought into the shop. It will make inspections as required by the shop office.

i. The service section will do all work possible for other sections of the shop, such as welding, machine work, metal work, forging, etc.

j. The supply section will supply all ord gen supplies for the use of the Co and for issue to the units being serviced by the Co.

II. Administration

a. All official correspondence will be routed through either command or technical channels. All official correspondence will provide for the signature of the Co commander and will clear through Co Hq.

b. Mail will be taken to the APO once daily at 1400; incoming mail will be delivered to the men at 1900 daily. All pertinent censorship regulations will be followed. Outgoing mail will be placed, unsealed, in the box provided in the vicinity of the Co Hq.

Personnel using unauthorized channels for private correspondence will be punished. Each man in the Co will be allowed to use one blue envelope per month.

c. No leaves or furloughs will be granted except in case of emergency. One day passes will be allowed 10 per cent of the Co at one time. Pass privileges will not be transferred without permission of the C.O.

d. The mess schedule will be as folows:

Breakfast—0630
Dinner —1200
Supper —1800

All personnel will be prompt at meals. Personnel requiring late meals because of duty will notify the 1st sgt. The mess sgt will draw rations from the QM depot on their schedule. One 2½-ton 6 x 6 truck and one 1-ton trailer will be available for use of the mess section at all times. Mess gear will be sterilized and inspected before each meal.

e. Sick call will be at 0730 daily. All injuries and casualties will be reported to the 1st sgt. The utmost safety precautions will be followed.

f. The uniform for work will be fatigues. Rifles and gas masks will be kept available at all times, but will not be worn. The uniform for pass will be khaki in summer and wool OD in other seasons.

g. Promotions of enlisted personnel will be made on Co order based on merit and seniority after recommendation by platoon leaders.

h. The Co supply sgt will maintain a stock of supplies necessary to supply the Co, except for ord gen supplies. In drawing supplies, he will abide by schedules laid down by depots concerned. All pertinent regulations concerning supply will be adhered to. Ammunition for the Co will be drawn from the depot concerned.

i. Maximum use will be made of any existing communications. If phone or radio is unavailable, messengers will be used. Maximum use will be made of liaison personnel for communication.

j. Personnel from this Co will obtain drinking water from lister bags only. When away from the bivouac area, only purified water will be consumed. Purification tablets will be drawn from the mess sgt before leaving the bivouac area. Water discipline will be STRICTLY enforced.

III. Security

a. *Bivouac Security.*

1. Signals will be used to indicate air, gas and ground attack. These signals will appear on the guard roster and will be posted daily on the Co's bulletin board. All personnel will familiarize themselves with these signals and obey them immediately.

2. An interior guard system will be maintained at all times. The strength and number of guard posts will be assigned by Co Hq and will depend on the combat situation. The 1st sgt will keep a guard duty roster. Outposts will be used when and as required.

3. All defensive weapons will be emplaced immediately upon occupancy of an area and personnel manning these weapons will be assigned duties in the vicinity of their weapons. In case of an attack, all available weapons in the shop will be used to the greatest advantage. Co personnel will be trained in the operation of all weapons serviced by the Co. This training will be the responsibility of the shop officer.

4. Each man will dig fox holes or slit trenches immediately upon occupying an area. Men will be trained in the defense of an area, this training to be the responsibility of the CO. No firing of any kind will be done without the authorization of the officer or NCO in command of the detail, except in case of actual attack.

5. All vehicles will be dispersed with a distance of 50 yds between adjacent vehicles in all directions.

6. All vehicles will be parked facing out of bivouac to allow immediate evacuation. All supplies and equipment will be kept on vehicles, removing them for

work only and replacing them after use. Platoon leaders may authorize temporary removal of equipment from vehicles for longer periods. Evacuation of bivouac area will be carried out only on the order of the CO, his direct representative, or by order of a higher Hq.

7. All possible means will be used to camouflage the bivouac area immediately upon occupancy. Camouflage discipline will be observed and enforced at all times, the 1st sgt making a daily check of the bivouac area for camouflage discipline.

b. *Movement Security.*

1. Every vehicle, except when towed, will have a guard placed so as to have a clear view of the sky in all directions. Security patrols will be used as the tactical situation requires.

2. Automatic weapons will be mounted on ring mounts on the trucks for AA and ground protection. Additional weapons will be used if available in the shop.

3. Personnel will remain in trucks until ordered to dismount by the convoy commander, except in an air attack, when all personnel will take cover on the ground surrounding the road. On attack by enemy aircraft, gun crews will remain with their weapons. They will fire only when the convoy is under actual attack. If the attack is continuous, all men bring fire upon the attacking aircraft. No lights other than approved blackout lights will be used during movements in blackout.

4. Vehicle interval will be 100 yds in daylight, and 15 yds in blackout.

5. All wreckers will be camouflaged to look like 2½-ton GMC's by erecting a tarp over the body of the wrecker.

6. Maximum advantage will be taken of roadside cover at halts. At this time the men will remain in the trucks or rest in a camouflaged area chosen by the convoy commander for this purpose.

7. The convoy commander will command all movements.

IV. Maintenance

a. This Co will repair all ord materiel that can be repaired in 24 man-hours. Repairs requiring more than this allowed time will be evacuated to the next higher echelon of maintenance by the recovery section or by any other transportation going to the rear.

b. The field shop will repair all materiel received except that governed by *par.* a above. Major unit exchange will be attempted on all damaged materiel brought into the shop. The shop will perform inspections as required. The recovery section will aid all sections of the shop to move heavy materiel. The shop will immediately evacuate all materiel that cannot be repaired because of parts shortage.

c. Contact parties (see par VI) will carry third echelon maintenance to the using troops. They will operate on a published schedule and make additional trips as required. These parties will repair all materiel possible in the hands of the using troops, evacuating the remainder to the Co field shop.

d. Work orders in triplicate will be prepared by the shop office. The original copy will remain on the job, duplicate copy will stay in the shop office, and the triplicate copy will be used to draw parts and equipment from the supply section. Workmen will date and initial items of work as performed. When all items of the work order in the section are complete, the section foreman will inspect and clear the work order by initialing it. Completed copies of original work orders will be filed in the shop office for reference for 30 days, the duplicate will be given to the using troops or destroyed, the triplicate will be filed by the supply section. No work will be performed without a work order or substitute (in emergency), except on direct authority of the shop officer or his authorized assistant.

e. Each section will maintain its own stock of fast moving parts. Approval of the shop officer on section want lists will be obtained before an item is stocked within the section.

f. The shop will perform 2nd echelon repair on all materiel brought into the shop, utilizing men from the using unit to the utmost for these repairs.

g. No cannibalization will be practiced within the Co except as authorized and controlled by the shop officer.

h. Tool shortages will be reported to the shop officer immediately. Each tool chest will have a list of component tools attached to the inner side of the top of the chest. Platoon leaders will be responsible for all tools used by the sections of the platoon. A tool inventory will be made once every three months by the platoon leader. A tool and equipment inventory will be made by the shop officer once every six months.

i. Training of Men.

1. Personnel will be rotated through the sections of the shop to familiarize the men with all work done in the shop. They will remain in the section until they become reasonably proficient in the work done by the section; the shop officer will be responsible for this training, keeping the men in the Co trained as completely as the situation will permit.

2. The shop officer will schedule and conduct training classes for personnel from the using units as required.

V. Inspections

a. Formal inspections will be made by the Co as required. Personnel will be drawn from the sections concerned to form a contact party for the inspection. All reports will be made out by the shop office for the CO's signature and forwarded to pertinent Hq.

b. Spot inspections may be made by contact parties when making regular scheduled or any unscheduled trips. Other spot inspections will be made by either officers or EM when the need for them is seen.

c. All pertinent instructions concerning inspections will be followed. Particular attention will be paid to TM 9-2810, TM 9-1100, and AR 850-15.

VI. Contact Parties

a. Contact parties which make regularly scheduled trips normally will be organized along the following lines:

2 Automotive mechanics;
1 Artillery mechanic;
1 Small arms mechanic;
1 Supply clerk.

One of the above men will be an NCO in command of the party. This party will have one ¾-ton WC or its equivalent for transportation. Contact parties for special jobs will be organized and equipped as required by the shop officer.

b. Contact parties will:

(1) Repair all materiel possible in the hands of using troops;
(2) Supply units serviced;
(3) Recover and evacuate materiel beyond the capabilities of the contact party to repair on the spot;
(4) Instruct personnel of units serviced;
(5) Act as liaison between ord Co and units serviced;
(6) Observe 2nd echelon maintenance as practiced by the using troops.

VII. Recovery and Evacuation

a. The Co will aid the units serviced in battlefield recovery as directed by the shop office.

b. The Co will evacuate damaged materiel from using units and collecting points to the Co's shop. The Co will evacuate materiel from the shop to a higher echelon as required. When the Co moves, the shop officer will report to the Bn. all materiel it is unable to evacuate.

VIII. Ordnance General Supply

a. Contact parties will carry ord gen supplies to the units serviced, returning receipted requisitions or receipts for supplies to the shop.

b. Supply procedure within the Co.

1. The supply section will maintain the basic load of supplies at all times. Items not on hand will be consolidated daily and requisitioned at once. Stock items will be requisitioned when the evel of these items drop to ¾ths of the basic load. The supply officer will be held personally responsible for efficient reordering of stock and posting of supply records.

2. The shop officer must approve all expenditures.

3. All items not on hand but supplied by the Co will be backordered; an adequate backorder follow-up system will be maintained at all times. An up-to-date record on all dues in and dues out will be kept, so that backorders may be filled immediately upon receipt.

4. All parts common to two or more major items must be binned in one loca-

tion and the records cross referenced so that substitute issues may be made. Full parts interchangeability must be posted at all times.

5. Supply will be by direct exchange to the maximum extent practicable. Damaged supplies will be turned over to the shop for reclamation and repair. Items beyond the capabilities of the shop will be tagged, crated, and shipped for reclamation to the depot supplying the shop. They will not be allowed to accumulate. No one will be allowed to strip parts from damaged supplies unless authorized by the shop officer or his authorized assistant.

6. There are two accepted methods for dropping supplies used in shop repair sections. As both methods are correct, the procedure used will differ in the various Service Commands and TOUSA's.

The more accurate method, which is the one generally favored academically, makes use of the Parts Requisition Form WD AGO 9-79. Parts will be issued to repair sections upon presentation of this parts requisition form (small blue form).

Immediately upon issue of the item requisitioned it will be dropped by the supply section. This method is the more accurate and the more convenient for the supply section. It is set forth in FM 9-10.

The other method eliminates WD AGO 9-79, and, by using the shop work order as a basis for drawing supplies and parts, saves paper work. The parts and materials used are listed on each work order and may or may not be consolidated daily. The work orders stamped with the voucher number are presented to the shop officer (the accountable officer) for his signature. When signed, these work orders become the voucher authorizing the supply section to drop the supplies per AR 35-6620.

c. The supply section will requisition supplies from the depot concerned, observing all regulations laid down by the depot in drawing supplies.

d. The supply section will assign one man as a 'parts chaser'. This man will investigate any delays or errors in the supply system. He will work with the sections to facilitate the supply of needed parts to them. All reports concerning critical parts will be made to the shop officer through the supply officer.

e. All pertinent regulations concerning supplies will be observed.

f. Trucks going to the rear to draw supplies will carry damaged materiel to the next echelon of maintenance.

IX. Liaison

a. One officer will be detailed by Co order to act as liaison officer between this Co and Bn Hq. in addition to his regular duties.

b. Liaison with units serviced will be maintained by contact parties. Liaison officers and/or EM will be sent to these units frequently, or will be placed on DS when warranted by the CO.

c. The shop officer is responsible for liaison between this Co and other ord Cos. He will use such men as necessary for this work.

X. March

a. The Co will be organized for marches as follows:

Point	¼-ton 4 x 4
	¾-ton WC
Main Body	¼-ton 4 x 4
	¾-ton WC
	*2½-ton kitchen truck
	2½-ton 6 x 6 w/water trailer
	2½-ton 6 x 6
	2½-ton electric repair
	2½-ton 6 x 6
	2½-ton 6 x 6
	2½-ton instrument repair
	2½-ton 6 x 6
	2½-ton 6 x 6
	2½-ton small arms repair
	2½-ton 6 x 6

*To be placed in middle of convoy when troops will eat en route.

2½-ton 6 x 6
2½-ton small arms repair
2½-ton 6 x 6
2½-ton 6 x 6
2½-ton machine shop repair
2½-ton 6 x 6
10-ton wrecker
2½-ton 6 x 6
¼-ton 4 x 4
¾-ton WC
¾-ton WC
4-ton wrecker
¼-ton 4 x 4

b. Reconnaissance Party

The reconnaissance party will be organized as follows:

One officer (CO or alternate)
One NCO (shop foreman)
10 EM (1 EM per seven sections, 3 EM administrative)

They will carry their weapons and one launcher, rocket. One ¼-ton 4 x 4 and one 2½-ton GMC will be used by this party.

This reconnaissance party will reconnoiter new bivouac sites, pick the route of march for the Co, and prepare the area for occupancy. The Rcn officer will return as soon as possible to the old site with such information as he has found.

XI. Bivouac

a. General areas for bivouac will be assigned by higher headquarters, but the Rcn officers will pick the exact location for the unit within the designated area. Reconnaissance of new areas will be carried out as required. An alternate area will be chosen by the Rcn officer for the Co's use in an emergency.

b. The shop will be laid out as follows:

(1) Shop office at the entrance;
(2) The service and supply platoon in the center of the area;
(3) The automotive platoon on a good road near the parking area as close to the entrance as possible;
(4) The artillery section on a good road near the entrance;
(5) The instrument section in an area affording good observation;
(6) The small arms section in the remaining area.

All available roads will be used. No new roads will be constructed unless authorized by the CO. Traffic flow within the shop will be marked by signs; one way traffic will be used whenever possible. The CO is responsible for the layout of the shop and the bivouac.

c. The Co Hq, mess, Co supply and bivouac area for the men will be located away from intra-shop traffic.

XII. Captured Materiel

a. All enemy materiel turned in to the Co will be reported to the CO at once. Pertinent reports will be forwarded as required.

b. Enemy materiel will be disposed of as required by pertinent instructions from higher Hq. These instructions will be published as received.

FIELD SHOP LOCATION AND LAYOUT

Assignment of Area: The service area of any combat zone will be so controlled that sites for bivouacs and service installations will be assigned by G-4 of the major unit in that area. It is normal practice for G-4 to assign an area much larger than needed by the occupying units. This puts the responsibility for choosing the exact location for the installation on the shoulders of the CO of the unit concerned. It is important that care be exercised when choosing a location for the shop and bivouac. Always uppermost in consideration is the mission of the company, which is to supply ordnance service to the unit supported. Then, consideration is given to cover and concealment, water, etc. Often it will be necessary to sacrifice one feature to obtain a more desired feature.

Reconnaissance Patrol: Seldom will circumstances justify a movement without trial reconnaissance. The route to the new area must be reconnoitered, the area

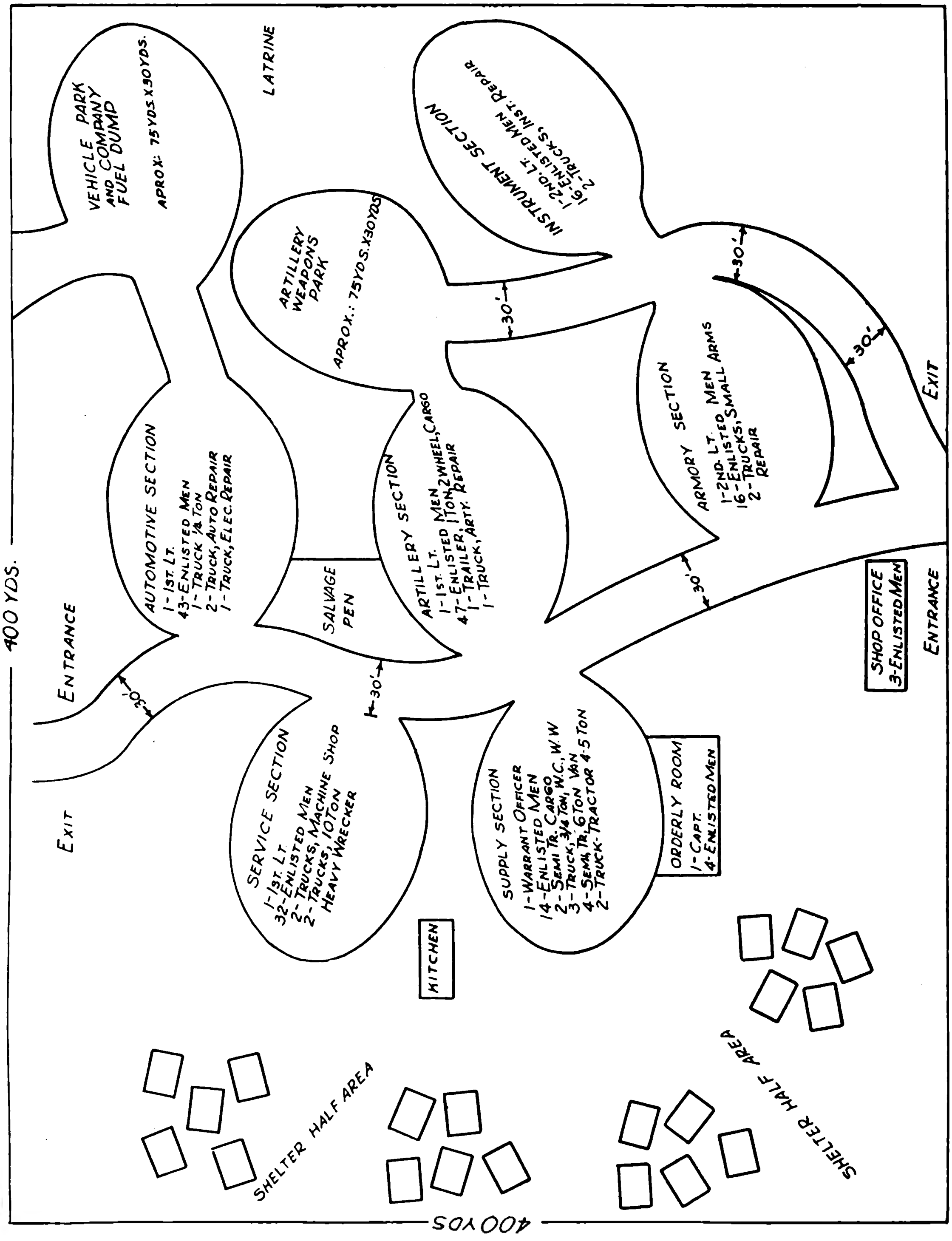


Figure 1. Typical Company Shop Area.

must be examined to select the best site for the shop, and the surrounding ground must be looked over for security. Advanced reconnaissance involves both the study of maps and aerial photographs and the inspection of the ground to be traveled. Responsibility for careful study of maps and aerial photographs rests with the unit commander. In view of the fact that aerial photographs will be available more frequently than detailed up-to-date maps, all officers should be able to interpret aerial photographs with facility. The reconnaissance party should be organized as follows: one officer; one NCO, assistant commander; appropriate number of EM, at least one from each section; and guides, if necessary. At least two vehicles should be used. Individual arms should be carried. The officer in command of the reconnaissance party should be the CO of the company or one of his junior officers. If the CO does not go with the party, the alternate officer should be one trained in reconnaissance. He should be fully acquainted with the policies of the CO with special emphasis placed on shop layout. The reconnaissance officer will be responsible for picking out the site of the bivouac and laying out the shop. The NCO should be a high ranking one. (The shop foreman would be an excellent man for this job.) He is the assistant to the reconnaissance officer and has the responsibility of carrying out his orders. He will coordinate the work of the men and efficiently lay out the shop based on the reconnaissance officer's decision. At least one man from each section of the shop should be included in the party. To lay out the section area and to prepare it for occupation, he should guide each truck into the exact location within the section. The patrol must investigate for signs of enemy activity, mark roads, and select sits for temporary halts and for the location of the bivouac area.

The patrol will investigate the suitability of roads for the passage of all vehicles in the column. If dirt roads are used, consideration must be given to the effect of adverse weather conditions. Even light rainfall may turn unpaved, heavily traveled roads into quagmires, particularly when drainage is poor. Bridges along the route will be inspected and estimated for capacity. If bridges have not been posted with load-class markers by the engineers, they should be examined to insure their ability to support the heaviest vehicle in the column. Where bridges of insufficient capacity are encountered, they should be so posted and the direction of the detour clearly indicated. All bridges should be examined for presence of mines and weakening of understructure. (See Chapter 6, Vol. III for bridge reconnaissance.)

The patrol should be constantly on the alert for signs of enemy activity. Interrogation of civilians and military personnel encountered along the route will be one source of information.

Although the objective of the unit is known, the patrol must reconnoiter the final bivouac area to insure its tenability. Where only the general location of a unit is designated by higher headquarters, the officer in charge of the patrol must select a specific site for the bivouac and plan the movement of the unit into that area. As soon as the initial reconnaissance has been completed, the reconnaissance officer should return to the company with all the pertinent information regarding roads, the bivouac area, surrounding troops, and enemy activity in the area. If the reconnaissance is efficiently done, the company can begin operations immediately upon occupying the new area.

Location of Bivouac: In picking out the site for the company bivouac some of the factors that require consideration are:

Cover and Concealment: To have good cover, it is necessary to be hidden from ground observation of the enemy. Masking hills or forests will give excellent cover. Concealment means being hidden from aerial observation of the enemy; again forests will be suitable. In combining the two, an ideal site would be one located in a forest behind some hill. Ordnance units will seldom find adequate natural cover. Partial cover is less important than concealment, but, where available, should be used to its fullest extent. At times, it will be necessary for the company to occupy bivouac areas where there is little or no cover and concealment. In this case, artificial camouflage methods should be utilized to the utmost. Camouflage materials for this work may be drawn from the nearest engineer supply point. The work of camouflaging the company's equipment must be done by members of the company.

Internal Road Nets: This is a 'must'. Maximum use should be made of existing roads; do not cut any large trees, and disturb the landscape as little as possible.

The nature and amount of work done in the shop will require roads capable of withstanding heavy traffic regardless of weather conditions.

MSR: The main line of communications is the MSR (main supply road) and the shop should be located near it. Supplies coming from the rear, evacuation of disabled materiel, supplies of using troops, and maintenance requirements indicate that the MSR will be used by people coming to or going from the company shop.

Convenience to Using Troops: To facilitate transportation of damaged materiel by using troops, the shop should be located near the unit being serviced and near the route used by the unit's transportation when going to the rear for supplies. Good liaison will result and you may add to the security of your position by being located in the vicinity of combat troops.

Parking Area: The shop should be allowed enough ground to provide parking areas for materiel awaiting repair, finished materiel, and organic transportation. At least fifty yards should be maintained between all vehicles in the company. This will, of course, depend entirely on the amount of cover and concealment available. The interval between vehicles is increased if required by the situation.

Observation: A good field of observation for the instrument section is desirable. This allows the calibration of fire control instruments to be done correctly and efficiently.

Water: The location of the bivouac near water is desirable. Water will allow the men bathing and washing facilities and supplement the water supply for the kitchen. Only purified water from water points will be used for cooking and drinking, but the local water can be used for other purposes.

Towns: The use of towns for bivouac by Ordnance companies may be good. Determining factors will be: tactical situation, location along MSR, building facilities, work area and local sanitation. Towns will provide housing facilities for the men, shops that can supplement the tools and equipment of the company, and civilian labor (some skilled which may be hired to help the men of the company. A difficulty lies in the inability to camouflage towns. The enemy will bomb and shell towns that have undue activity in them.

Alternate Site: When choosing the site for the company bivouac, the reconnaissance party should look around and pick a second site that can be used in an emergency. This site should be laid out far enough from the original so that the enemy will not be able to locate the alternate from the original bivouac site. All the consideration used in locating the original bivouac should be followed in locating the alternate site. This alternate is picked so the company will have a place to move to if attacked and forced to evacuate the original shop bivouac.

Dummy Bivouac: It is an excellent idea to set up a dummy bivouac and shop in the vicinity of the one actually used. Practice has proved that the dummy installation has saved many units from being bombed and strafed. An area at least one thousand yards or more away from the real bivouac should be chosen. In this area, place materiel that has been wrecked beyond repair and is awaiting salvage; space and camouflage it poorly to simulate a shop. This dummy area should attract the attention of the enemy and cause him to waste his bullets and bombs. An Ordnance company in Africa installed a dummy shop area fifteen hundred yards from the actual shop. This dummy was bombed and strafed three times while the actual bivouac escaped detection.

Bivouac Layout: The bivouac should be laid out so that work can be efficiently performed by each section of the company. The sections should be separated far enough to allow each to perform its duty.

The Headquarters Platoon: The headquarters platoon should be located out of intershop traffic. The *mess section* should be located near water if any is available. This section should be in area which will allow excellent camouflage and sufficient parking area for the vehicle. It should have good drainage and be on a road. The company supply section should be located on a road, convenient to the bivouac area of the men, but out of intershop traffic.

The Company Shop: The heart of any shop is the shop office. This section is small and handles the administration of the shop. It should be located at the entrance to the shop area in a place where there is plenty of camouflage. The office should be located at the entrance so that all incoming traffic will have to pass it. The road coming into the shop office should have a covered approach of at least

Figure 2. Automotive Section at Work.

Figure 3. Instrument Repair.

100 to 200 yards to allow vehicles waiting to transact business with the shop office to remain in a concealed position. A good sized parking area should be near the shop office where a preliminary inspection of incoming materiel can be made, and materiel awaiting transportation to some other location can be kept.

Figure 4. Small Arms Section.

The Automotive Platoon: The choice location of sectors within the area assigned to the shop should be given to the *automotive section* of the automotive platoon. This section will do approximately fifty per cent of the work done by the shop. The size of the materiel worked on (one quarter ton 4 x 4 to large prime movers and tanks) requires that it be located on a good road. To prevent all heavy traffic from going entirely through the shop area, this section should be located near the entrance. To allow continued operation, regardless of the weather, firm dry ground is also a necessity. An adequate parking area should be included in the layout for parking vehicles waiting to be worked on, vehicles being worked on, and completed vehicles. Since all artillery prime movers are automotive materiel, and all self-propelled artillery and tanks incorporate automotive materiel, the automotive section should be located near the artillery section of the armament platoon. The recovery section of the automotive platoon should be located adjacent to the automotive section and should incorporate all the features required of the automotive.

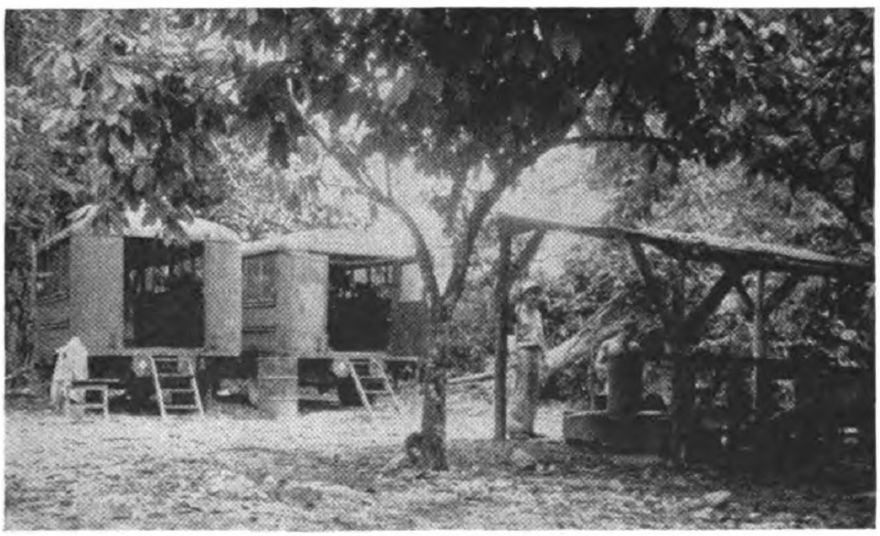


Figure 5. Service Section.

The Armament Platoon: The *artillery section* of the armament platoon is closely allied to the automotive section of the automotive platoon for the reason listed in the preceding paragraph. It should be located near the automotive platoon and close to the entrance of the shop area. The size of materiel repaired in this section requires a good road capable of sustaining a normal flow of traffic in inclement weather. The section should be located in a dry area affording good cover and camouflage and large enough to have a large parking lot.

The Instrument Repair Section: This section requires the driest, dust free area in the shop. It should be located out of intra-shop traffic and up-wind to reduce the dust. The calibration of instrument means that a field of observation is necessary. This section performs repair on fire control instruments, so the size of the materiel will allow it to be easily carried by one man. There is no need for good roads for the reasons mentioned. There is usually only one repair truck in this section and replacements are very few, so there is no parking problem.

The Small Arms Section: This section does not require special consideration in its location within the shop since the materiel repaired is small and easily carried.

Figure 6. Supply Section.

The Service and Supply Platoon: The *service section* of the platoon does all work common to two or more sections of this shop (welding, forging, machine work, etc). The *supply section* of this platoon will provide ordnance general supplies for all sections of the shop. Both sections work for the other platoons with the majority of their work being done for the automotive platoon and the artillery section of the armament platoon. This requires that the service and supply platoon be centrally located in the shop, nearest the automotive platoon and the artillery section. It must be on a good road and have a parking area. The quantity of supplies carried requires a dry camouflaged location as well.

An Ordnance company will seldom, if ever, be assigned a bivouac which incorporates all of the above mentioned features. It is the responsibility of the unit commander to assure the location of his company shop at the best possible place within the area assigned him by the G-4 of his unit. The mission of the company is to provide Ordnance service for the combat units supported. This means that occasionally one feature must be left out and more important ones substituted. Maximum effort should be used to provide a suitable location for the company shop so that its operation may be carried on at a high level of efficiency.

COMPANY OPERATION

Close cooperation between administrative and shop personnel is necessary to avoid conflict and ensuing difficulty. It should be distinctly understood in the operation of a field shop that the 1st sergeant must not select men for details without consultation with the shop foreman or shop officer. Manning the necessary guard and fatigue details without crippling shop operations is a problem that calls for close coordination and considerable attention from the commanding officer. If there are personality clashes between administrative and shop personnel, changes should be made without delay. If such conditions are permitted to continue, the morale of the organization will suffer and it will be reflected in the work turned out for the using units. Great care must be taken by ordnance officers to prevent such failures in ordnance service as they are magnified many times in the minds of the using troops. Guard and fatigue details are necessary and must be performed, but care must be taken that the primary duty of the unit is not impaired by indiscriminate choice of personnel for details.

Guard. One overseas unit had considerable success with a guard system under which all men except cooks on duty participated in guard details. First three graders were used when necessary but not normally. The bivouac area was divided into sections or posts and the men were apportioned equally. For purposes of illustration, let it be supposed that there are five posts and 150 men. This would place 30 men at each post with a noncommissioned officer in charge of each. Double guards were posted during the dark hours from 1800 to 0600, with each pair on duty for a one hour period. During daylight single guards were posted for one hour periods.

Such arrangements require only one hour of guard duty a day from the men and it was found that such a tour of duty, regardless of when it came, does not impair efficiency the following day. Each guard detail was held responsible for getting its relief on post and the entire system was coordinated by the officer of the day, who was the only man failing to obtain a good night's sleep.

Inspection of Incoming Equipment. When equipment is brought to a maintenance unit it passes through the company or battalion control section or the shop office. A work order is made out after a thorough inspection is completed to determine exactly what work is required. All possibilities should be explored in the inspection; do not confine the examination to the obvious defects as stated by the unit submitting the equipment.

For purpose of illustration, let it be supposed that an M7 motor gun carriage is brought to the shop and the driver reports that the clutch is not functioning properly. The inspection crew goes to work and discovers that the trouble is in the transmission, but it also learns that the engine is out of time and that the tracks need reversing or changing. The shop foreman recognizes that more than 24 hours will be required to put the equipment in combat condition and he requests a decision from the shop officer as to whether the vehicle should be evacuated to a higher echelon. As it is a highly critical item, the shop officer decides to repair it and return it as quickly as possible.

One crew starts on the transmission removal and another begins tuning up the engine. The driver and his assistant are told to change the tracks.

Vehicles sent to maintenance units should be accompanied by a driver and an assistant, particularly when the item goes to an organic Ordnance unit. If it is necessary to evacuate the materiel to a higher echelon, it will probably be necessary to obtain a replacement in which case the two men will either be returned to their unit or take the replacement item back to their unit with them.

Radio Repair Sections. Occasionally radio repair sections will be attached to Ordnance units to coordinate and expedite repair of radio equipment in vehicles. In the case of the M7, the radio section is notified and the signal corps personnel checks the radio closely for any adjustments needed. This is a form of preventive maintenance as well as coordinated repair between services.

Artillery and small arms on the vehicle are checked by the proper ordnance personnel although no request for work on the guns was submitted. This is necessary to make certain that all parts and equipment will have been checked and that the materiel is ready for combat; it must be done even though it may be necessary to perform a few second echelon functions. Before the vehicle leaves the shop it must again clear the shop office and inspection crew as another check on the complete repair.

Summary. The materiel arrives at the shop office which is in an easily accessible spot. The work order is made out, the inspection crews check the work to be done, and the crew chief signs the order. Upon completion of the work, the repair crew chief signs the work order and lists new parts used (if such a requirement is made by the commanding officer). The vehicle is then inspected again and is receipted for upon release to the using unit.

The procedure calls for the least possible amount of paper work and at all times definitely allocates the responsibility to those who do the work. Men who have had combat experience advocate this system. In addition to the work orders, the shop office should maintain a log on all jobs so that inquiries as to progress may be answered quickly.

In evacuating materiel to higher echelons, the usual procedure is to move it on the proper work sheet (AGO Forms 461, 462, or 463) and possibly a certificate of fair wear and tear if such action is required in the theater.

When several vehicles are in the shop for repair and parts are lacking, a decision must be made as to whether they should be repaired or evacuated. In some cases cannibalization is permissible to obtain the necessary parts, but if such procedure is used, it should be complete. The cannibalized vehicle should be completely torn down and parts not needed should be put in stock or returned to the depot.

Conservation of Materiel. As there will always be a certain shortage of parts, constant conservation of material is very necessary. The welding shop and the machine shop are partial answers to the problems of parts shortage but they are always overworked, while the shops can make most of the needed parts, they will never be able to keep up with the demands on them. The machine shop is a definite bottleneck in forward maintenance and often it is necessary to operate it on a shift basis. This can be done as it is possible to black out the truck.

Much of the repair work that falls on maintenance outfits is to be expected under any circumstances and is not a result of combat operations. Maintenance on maneuvers in the United States may be just as heavy as in a theater of operations. Ordnance personnel must at all times be ready to give extra effort, to work diligently and intelligently for long, hard hours under the worst possible conditions. This applies to ordnance men in the rear areas as well as those close behind the combat troops, as they are all part of a highly complicated machine which must function smoothly and efficiently at all times.

All Ordnance maintenance organizations require carefully planned standing operating procedures and an intelligently conceived system of procedure. Responsibility must be fixed in the proper place at all times. The mission requires that the organization operate efficiently in the absence of commissioned officers with noncommissioned officers trained to carry on the work. The noncommissioned men are the backbone of Ordnance service for they must be leaders as well as technicians.

Ordnancemen to fulfill the Ordnance mission must be ready to perform their maintenance functions in a variety of circumstances and conditions, close to the firing line and far back at night and during the day, in a well-equipped shop or under emergency field conditions. Their responsibility is great but so is their performance, for in all theaters ordnancemen have met and solved problems in such a fashion as to win commendation from high authority.

Company Supply. The following discussion, as indicated by the title, is limited to the supply of ordnance materiel and pertains to the supplies handled by the supply section of the organization concerned. It does not cover supplies of the Chemical Warfare Service, Engineering Corps, Quartermaster Corps, or Signal Corps which are handled by the supply sergeant, or supply officer of a company or battalion.

The following problems will confront the supply officer of an ordnance company who is charged with the supply of ordnance material to the organizations he is supporting and to his own company:

(1) What supplies will be needed?
(2) When and where will they be obtained?
(3) How will items be stocked?

(4) How will interchangeability be shown?
(5) How will they be issued?
(6) What level of stock will be maintained?

The following discussion of the foregoing questions should be of assistance to both new and experienced supply officers. It has often been said that the problem of field maintenance is a problem of supply, the job can usually be done if the material with which to do it is available. It is the responsibility of the supply officer to see that the ordnance material is available at the time and place it is needed.

What Supplies Will be Needed? The first step in solving this problem is to determine what major items will be maintained. If your organization has been assigned a specific mission, that is, the support of certain specified units, a detailed list should be made of all major items in those units including make, model, and modifications, all on-vehicle and on-carriage materiel, and shop equipment. This list should be discussed with the ordnance officer and G-4 of the unit (or units), to be supported in order to make certain that it is complete and accurate and to consider any possible substitutions in the major items to be maintained. The ordnance officer and G-4 will usually be of great assistance in preparing such a list—if they cannot furnish one which is absolutely complete. A slight difference in the quantity of major items to be supported is not nearly so important as a difference in the make and model of major items to be supported. For example, it matters little whether 95 or 105 tanks, medium, M4A3 are to be supported, but it is very important to know whether tanks, medium, M4A3 or M4A2 are to be supported. The commander of the unit to which your organization is assigned will very likely have prepared an SOP. An SOP usually includes operating instructions for all supporting ordnance units. Make a study of this SOP and follow the instructions contained therein for your organization. An N-series SNL has been published for practically all ordnance maintenance units, listing 50 to 85 per cent of the replacement major items, replacement tools, spare parts, standard hardware, stock metal, and cleaning and preserving materials to be carried by the supply section for maintenance purposes of the unit. These SNL's are prepared from the latest T/O and E's and supply catalogs available at the time they are published. This load will probably include some items that you will not need in your particular assignment, but it will be very helpful in arriving at your initial combat load. Compare your list of major items to the major items for which parts are listed in the N-series SNL. Delete from the N-series SNL parts for the major items you will not maintain and, using the appropriate SNL addenda (Army Service Forces Catalogs) as a guide. make up a list of spare parts for the major items not covered by the N-series SNL. Consult the various specialists in your unit and have them help you make up these lists. When these lists are compiled, get as close an estimate as possible of the total weight of the load to be carried. compare it with the carrying capacity of your supply section, and adjust the lists to include the parts you can carry. 15 to 50 per cent of the carrying capacity of your supply section is left unallocated in the prescribed load in the N-series SNL to assist you in making this adjustment. When you have completed the list of material to be stocked, request the commanding officer of your unit and the ordnance officer of the organization your unit is supporting to check it with you. Make up your requisitions on the appropriate SNL (Army Service Force Catalog) for each major item for which parts are required.

When and Where Will the Initial Working Load of Supplies be Obtained? Get an answer to this question as soon as possible. Read your SOP and consult your commanding officer and the ordnance officer of the organization you are now supporting. If you are to leave the States with a task force for a new operation, all supplies for a definite period of time may have to be carried with you. It takes some time to obtain these supplies, prepare them for overseas shipment, stock them and index them properly. If you are supporting a small task force you may have to handle all the ordnance supplies for the force, or if you are with a large task force there may be ordnance depots accompanying the force which will be able to re-supply you with parts within a short period of time. If you are going into a theater where American troops are already operating, find out what the SOP or supply procedure is there. It may be that your initial working stock of ordnance supplies will be issued to you automatically when you arrive in the theater of operations before going into the combat zone, but don't count on this until you know it's a fact.

How Will the Supplies Be Stocked? Your location when you receive your initial load of supplies will, in most cases, determine whether or not you are to carry the supplies overseas. Supplies that are to be transported over water must be properly prepared with rust preventives and packages, or boxes, and securely lashed into place. In some cases you may have to do this job yourself. In all cases it will be your responsibility to see that it is done properly. In packing parts for overseas shipment only the parts for one major item should be packed in one container. Each box, crate, or container must have clearly and permanently marked on the outside of it who it belongs to and what it contains. There have been numerous boxes of spare parts lost during the present war in shipment overseas because they were not properly marked or the markings came off. In other instances it has been necessary for ordnance troops to open dozens of boxes on arrival overseas to find a few vitally needed parts because the contents of each box was not properly marked on the outside or the marking became illegible or lost in transit. Spare parts and supplies are usually stocked according to size and the major item to which they belong. The chances are that you will have spare parts bins for about half the spare parts vehicles in your supply section. Number each drawer on all spare parts bins with a number of permanent or semi-permanent nature, leaving enough space on the end of the drawer to paste a slip of paper listing the general contents of the drawer. Number each spare parts vehicle. Compare the total weight of each group of items to be stocked with the carrying capacity of your vehicle and allot bin space and vehicles according to the size and weight of the load to be carried. Small instrument repair parts may be carried entirely by the instrument repair section of your unit. You will also have to supply the small arms, artillery, automotive, welding, machine shop, and other sections of your unit with an initial working stock of parts and supplies. However, all parts and supplies which are to be issued to lower echelons of maintenance and the bulky supplies for use by your own unit are carried by the supply section. When you have carefully allotted bin space and vehicles to each group of supplies you may start loading several vehicles simultaneously. Make sure that each part has the proper identifying number and nomenclature on the package in which it is enclosed, on a tag attached, or on a slip of paper inclosed in the drawer compartment with it. See that, an accurate record is kept of the location of each part as it is stowed; this data will be used to make up your locater cards. When each drawer is filled, paste a small slip of paper on the end of each drawer listing essentially what the drawer contains. For example: Drawer 1, 2, and 3 may have, in addition to the number of the drawer, "A-5, M.G.Cal. 30 Browning 1917A1," pasted on the end. Drawers 75, 76, and 77 may be labeled, "G-508, 2½ ton G.M.C. Carburetor." Large crated parts such as axle assemblies, engines, transfer cases, transmissions, etc., will be loaded on vehicles without bins and recording the number of the vehicle on which each of these items is loaded will suffice.

How Will Interchangeability Be Shown? When all parts have been stocked, take the record of the location of each item and make up a Stock Record Card (AGO 9-72 or equal) for each item. Reader should refer to Ordnance General Supply, Chapter 5, Volume III. These cards should have recorded across the bottom: first, the SNL for the major item to which the part belongs; second, the part number most commonly used to identify the item; and third, the nomenclature of the item. The vehicle number and drawer number in which the item is stowed should also be recorded where it can be conveniently read. Record also the quantity of each item stocked and the maximum and minimum quantity to be kept on hand. Check with your depot or source of supply and the Army Service Forces Supply Catalogs (SNL's) to determine what system of numbering will be used to identify each group of items. The number system most commonly used by field troops at present is as follows: ordnance piece mark or drawing numbers for small arms, artillery, and fire control items and for standard hardware and combat vehicles; manufacturer's numbers for general purpose (transport) vehicles; Federal standard stock numbers for tools; and both Federal standard stock numbers and item stock numbers for cleaning and preserving materials. It is contemplated that at some future date 'official ordnance numbers' will be used to identify all ordnance items.

When you have decided upon the system of numbers to be most commonly used, place this number first on your stock record cards along with the other information as described above. Group the stock record cards according to major item SNL's, and arrange the cards in alphabetical order by nomenclature and then in numerical order where the nomenclature is the same. This will be the standard arrangement for the cards as they serve also as locator cards. The only interchangeability you will be interested in is that which exists between the parts for the major items your unit is to maintain. To arrive at this interchangeability, arrange all the cards in the "A" group in order by parts numbers. If you are using SNL A-19, "Parts Common to A Group materiel," make up a stock record card on A-19 for all the items which are listed on two or more cards, write a reference to A-19 on each of the duplicated cards, and keep the stock record on the A-19 card. If you are not using SNL A-19, transfer all data on the duplicated cards to the card which carries the greatest number of the items and write a reference to this card on each card from which the items were taken. Do the same for those items in SNL groups B, C, D, E, and F. The items which are found to be common to two or more SNL groups should be stocked under the SNL which lists the greatest variety of that particular class of items. For example, a screw that is listed in SNL's A-19, B-6, and H-1 should be stocked under SNL H-1. The same system of tracing interchangeability of automotive parts may be used for all the parts identified by ordnance numbers or by the same manufacturers' numbers. Interchangeability charts, manufacturer's numbers, item stock numbers, and official ordnance numbers may be used to trace interchangeability between parts stocked by different manufacturers' numbers. When interchangeability is established on such parts, a stock record, or locator card should be made up for each of the major items using the interchangeability part to show a reference to the stock record card under which the part is stocked. There will be cases where certain bolts, screws, etc., are listed in only one of the major item SNL's under which you are stocking parts, but can be traced to one of the standard hardware group or H group SNL's. Such parts should usually be stocked under the H-group SNL's. All items procured by the Ordnance Department should be stocked under some SNL (Army Service Forces Catalog), even though some of the SNL's may not have been revised recently enough to include all the items they should carry. When the existing interchangeability has been recorded it will be advisable to restock certain small interchangeable items to gain storage space. However, it may not be advisable to stock all interchangeable items in the same space when no storage space is to be gained. There is some advantage, for example, in keeping most of the 2½ ton G.M.C. parts in one place and most of the Dodge parts in another even though some of them may be interchangeable.

How Will Parts Be Issued? As far as possible have the units to whom you supply parts use the same numbers on their requisitions (see Chapter 5, Vol. III) that you have on your stock record cards. This will prevent the necessity of making up additional locator card indexes. When a requisition is received look through your stock record file and record the location of each item on one copy of the requisition. It may be necessary to edit the requisition at this time by locating some of the parts in the Army Service Forces Catalogs (SNL's) and correcting the numbers (and nomenclature). Send a parts clerk around with the requisition to pick up the items. Make an extract from the requisition of all parts not supplied and requisition them from your supply depot. The parts clerk, who collects the items for issue from the spare parts vehicles, should note on his copy of the requisition the exact quantities of each item issued. Use this copy of the requisition to post on your stock record cards for all items issued. Requisitions which are not completely filled should be placed in a separate file for filling as soon as the items are obtained. These unfilled requisitions will give you a back order file for each unit which has submitted an unfilled requisition. It may be necessary to consolidate the items on these unfilled requisitions from time to time to reduce the number of papers handled. The length of time these unfilled requisitions are kept in a back order file will be determined by the demand for the parts. In some cases where the parts required for the repair of a major item cannot be obtained within a short period of time the parts must be manufactured in the machine shop, or the major item evacuated to a higher echelon of maintenance. In either of these cases the demand for parts will change and the back orders should be changed accordingly. Parts which are required by your own maintenance unit may be requisitioned on a work order requisition or a simple want list. Regardless of the form used, the requisitions will be handled essentially the same as any other requisitions. Wherever practical, unserviceable items will be presented for direct exchange for serviceable items. Unserviceable items presented for exchange should have attached to them a tag (WD AGO Form 9-81, Exchange Part and Unit Identification Tag), which is used in lieu of a requisition. (See C4, FM 9-10, 21 June 1944 for complete description.) This form is made up into three sections. The make of the major item to which the part belongs, the U.S.A. registration number or serial number of unregistered major items, the part number, and the organization to which the unserviceable item belongs should be filled in by the unit submitting the part for exchange. When such parts are presented to the supply officer, he will have an inspector inspect the parts and fill in the disposition to be made of the item on the attached tag. Where the part is to be repaired and returned to the unit later, the third section of the card is detached and given to the vendor of the part as a receipt. The second section of the tag is detached by the supply section and kept on file until the part is repaired and returned to the supply section. When a new item is issued in exchange for an unserviceable item, such issue will be noted on the third section of the tag and held by the supply section for posting on the appropriate stock record card. When an exchange item is repaired in the shop it is returned to the supply section in exchange for the second section of the tag. The supply section either issues the part to the unit which presented it for exchange, or (if a new item has already been issued in exchange) the repaired item is put into stock and the proper entry made on the stock record card. Items present for exchange which cannot be repaired may be disassembled and the parts salvaged or presented to the next higher echelon or supply depot in exchange for a serviceable item. The SOP or the ordnance officer of the organization you are supporting will usually give instructions for the issue of major and non-expendable items. In addition to the stock record, there should be a list made in duplicate of all the items loaded on each vehicle. One copy of this list should be kept by the supply officer so that in case any vehicle and its load of spare parts is lost, a complete list of the items lost will be readily available. The second copy of this list should be kept in the vehicle to which it pertains. The supply officer should require the parts clerks to take a physical inventory of their respective vehicles approximately once each month as a check against the stock record file. The list of all parts stowed on each vehicle may be used for this purpose: room for several columns on these lists will permit their being used several times without completely retyping them. Where a large amount of supplies are handled, for example in the headquarters of an armored division, it may be arranged to have the requisitions brought in and the parts collected one day and actually delivered the next day; however, parts which are needed immediately must be supplied as quickly as possible. This system of presenting the requisitions one day and picking up the parts the next day works very efficiently between you and your supply depot provided you send vehicles to the depot daily for parts.

What Level of Stock Will Be Maintained? When sufficient experience is gained for your particular theater of operations, the maximum and minimum quantities listed on the stock record cards as a guide to requisitioning should be changed to reflect your specific needs. Such changes should be based upon the rate at which parts are used and the time required to replenish your stock.

Past experience in combat indicates that certain items are usually salvageable from wrecked, demolished, and burned vehicles. These parts consist of the items which are not always destroyed when the vehicle is burned, such as the suspension system for tanks (including track), tow clips, tow cables, wheels, torsion bars, tank sirens, etc. A minimum quantity of such items should be kept in stock until sufficient quantities can be salvaged on the battlefield. The supply officer of a unit should stay on the alert and take advantage of every opportunity to adjust his load of stock so that he can supply the parts needed at the proper time and place.

INSPECTIONS BY ORDNANCEMEN

The ability to carry out effective inspection procedure with the using unit is an essential requirement for ordnance maintenance personnel. While this duty of ordnancemen has perhaps been less emphasized than the duty of performing repairs, it is of vital importance in carrying out the ordnance mission.

The word 'inspection' has acquired a disagreeable connotation because the procedure has not been properly administered in many cases. The inspection procedure gives ordnance personnel an excellent opportunity to impress on the using units that the intention of ordnancemen is to be helpful, not critical, and to aid the combat unit in fulfilling its mission by making certain that its equipment is in the best operating condition at all times.

If properly administered, inspections will not only assist the using unit but will definitely ease the burden on repair facilities by uncovering trouble before it becomes serious; by revealing wear before replacement of a major assembly becomes necessary. Ordnance inspections illustrate the truth of the old adage, "An ounce of prevention is worth a pound of cure."

In training camp days, inspections were identified with the 'gig' system and inferred criticism or punishment for failure to come up to standard. While this was true in a certain sense, inspections were really held to check the condition of equipment and to keep operation at the peak of efficiency.

The first requirement for effective inspection is competent personnel to make the inspection. Ordnancemen assigned to the duty must be experts in their line. They must know their work completely and be able to spot latent trouble before it causes unserviceability. They must be able to tell whether or not first and second echelon maintenance has been properly carried out. They must be able to make recommendations that will solve difficulties encountered by the using units. They must be able to give instructions to the combat troops in the care and treatment of their equipment.

It is too late to develop that ability when the Ordnance unit goes into the field; the training period is the time to fit the technicians for their jobs. Too often in training, work has been moved up to a post or service command repair shop when it should be done by the unit or organic ordnance. A steady flow of varied repair problems and their solution while in training is the best training; it will fit the unit for its work in the field by giving the personnel experience and practice. The training period is the time to perfect operating procedures, for then mistakes and delays won't cost lives.

The better Ordnance unit is more than just a crew of repairmen. The men are teachers and advisors. It is their job to smooth relations with the using units and to instruct the combat personnel in the proper care and use of equipment. Such a job requires that the Ordnanceman be not only an expert in his field, but a good will ambassador, and a liaison agent. This faculty is an essential requirement for an Ordnanceman who conducts inspections of materiel in the hands of troops. He must 'sell' the members of other branches of the service on the following accepted ordnance procedures.

Inspections of materiel in the hands of troops are required at periodic intervals but the manner in which they are conducted can make them highly effective or practically useless. The primary reason for inspections is to make certain that the equipment is serviceable—that it will function in the manner intended and at the time required. An improperly conducted inspection will give using troops the impression that ordnancemen are 'snoopers', trying to find something wrong so that an uncomplimentary report can be forwarded to headquarters

Before inspections are made, using troops must be fully informed as to just what is expected of them in regard to maintenance of their equipment. Competent ordnancemen can conduct educational programs to achieve this end. Formal schools are not necessarily required. for often a few explanatory words (in addition to material in the manuals) will suffice. It is highly effective to explain the reasons for certain requirements as Americans like to know why they are required to do things; a good ordnanceman is in a position to tell combat personnel the 'WHY' of maintenance requirements.

If the using units are failing to perform their maintenance work properly, perhaps it is the fault of the attached ordnance personnel. It is easy to write a report that first echelon maintenance is faulty, but ultimately, the burden falls on ordnancemen. It is easier to teach users the proper care of equipment than it is to make a major repair. Ordnance units can save themselves a lot of work by intelligent selling of using units on maintenance requirements.

Inspections must be made with a helpful attitude if they are to be effective. Ordnancemen are not trying to cause trouble; they are trying to prevent it. When using units look on ordnance personnel as friends and counsellors and are anxious to accept advice and instruction, a great step has been taken toward fulfillment of the ordnance mission.

If deficiencies are discovered, they should be pointed out to individuals concerned with a full explanation of the proper procedure and the reasons why it is necessary. Plans should be made for a later inspection to determine if the instruction has been effective. Of course, repeated violations may call for drastic action, but in the great majority of cases a helpful attitude on the part of ordnance inspecting personnel will correct the situation quickly.

Inspections will also reveal whether or not the proper manuals are available to the using units, and if they are accessible. Ordnancemen can be of assistance in assuring that this material is at hand and not hidden by someone desiring to accumulate a private library. Inspections will also permit determination of whether or not proper spare part levels are maintained and whether the correct tools are available for those charged with first and second echelon maintenance.

Inspections should not be undertaken without considerable preparation and planning. First of all, capable men must be selected as members of the inspection crews and they must be fully instructed as to their duties. If more than one party is to make inspections, great care should be taken to make certain that there will be a uniformity of procedure; all parties must have the same standards if the inspections are to prove effective.

An officer should precede the inspection parties to make contact with the commanding officer of the unit concerned so that proper preparations can be made; and further, an officer should be available during the inspection to make decisions when there is a conflict of opinion among the inspection personnel.

Inspection boils down to an educational program. The ordnance personnel must be adequately trained so that the inspections will be effective and standard. Poor training will result in spotty inspection with the standard varying over a wide range.

Ordnance is a repair and maintenance service to be sure, but the need for much of this work can be obviated by a carefully prepared and intelligently handled inspection program. Ordnance repair facilities are always strained in combat where the toll of equipment is heavy. Any method by which this strain can be relieved merits full attention and consideration from every man in ordnance.

Shop Inspection. Experience proves that the only efficient manner of running shops is to inspect materiel on its entrance and upon its exit from the shop. The information obtained from the inspector initially will give the shop officer an opportunity to give the proper priority and position of the job. It also saves the crew chief time as he doesn't have to give the vehicle a general inspection and specific items have been indicated for repair or replacement. The same inspection of the job on completion assures a standard quality of job leaving the ordnance shop. It also allocates the responsibility of poor workmanship. The key to this system is the inspectors; they must be top notch men who are recognized as such by the rest of the command.

Technical Inspection. A technical inspection is made prior to committing a division to combat, or when a division is in the rest area. A technical inspection should not be confused with a command inspection. It is strictly technical and is carried out by the divisional maintenance company or maintenance battalion may be done under their close supervision.

Planning. Planning a technical inspection, the DOO will instruct the divisional maintenance company or battalion commander when the inspection will begin. The divisional maintenance company or battalion commander will have to arrange a schedule so the inspection will be completed in the allotted time. The company commander will call his officers for a conference to decide the schedule of inspection, organization of contact parties for the inspection, and to settle any question concerning the inspection. Usually inspections are carried out in the divisional area so the problem of carrying tools and parts to the area arises. On this type of inspection, only hand tools and a very few parts will be carried; any large job will be evacuated to the 3rd echelon shop. Technical personnel (including specialists of each type) will be utilized for the contact parties. Typical contact parties for this type of inspection may be organized as follows:

Party No. I

One (1) Officer—Lt. in command
One (1) Sergeant—Crew Chief
Two (2) Mechanics—Auto General
Two (2) Mechanics—C & I
Two (2) Repairmen—Chassis
Two (2) Mechanics—Small Arms
Two (2) Mechanics—Artillery

Party No. II

One (1) Officer—Lt. in command
One (1) Sergeant—Crew chief
Two (2) Mechanics—Auto General
Two (2) Mechanics—C & I
Two (2) Repairmen—Chassis

Four contact parties can be formed for this inspection without undue injury to the efficiency of the shop; so two are organized as party No. 1 above, and two as party No. 2 above.

The contact parties will take all necessary equipment to perform the inspection and to remain on the job until its conclusion. Time is a very important factor and work will be done from daylight until dark. Another very important factor in the planning phase is contacting the maintenance officer of the unit you are about to inspect, instructing him as to the time you will arrive, how many men you will have in your contact party, and how many vehicles you estimate that you can handle the first day. He will have the vehicles in his area cleaned and ready to be inspected together with all tools, equipment, and maintenance personnel that he has in his jurisdiction.

Functions. Contact parties will leave the maintenance company or battalion bivouac area at daylight the first morning of the inspection. They will go directly to the unit maintenance shop of the unit they are to inspect. Upon arrival, inspectors will arrange the area in bays so that they may function as specialists; each specialist does his type of work on the vehicles as he passes through his particular bay.

The inspection by this time is in full swing. Assume that several vehicles have passed through the bays, when a vehicle comes through the engine bay and is found to have very low compression. This calls for a further check at the third echelon repair shop and necessary inspection requests are issued. The vehicle is taken by one of the unit drivers or mechanics back to the divisional maintenance company or battalion area along with the job order request that the vehicle has been inspected by the contact party and that certain deficiencies have been found.

We will assume that two and a half days have elapsed since the contact party arrived at this unit's particular bivouac area. The vehicles in the unit have all been inspected and those that require major repairs have been evacuated. We are ready to move on to the next unit on our list. The officer in charge of the contact party will immediately contact the maintenance officer of the unit to which he intends to move. The move will be made and shop set up that evening so work can be started at daylight the next morning. These contact parties will continue to move in this manner until the division's vehicles have been inspected. We must not forget that liaison between the contact party and the ordnance maintenance company or battalion commander must be made daily as this work continues and a progress report must be turned in to him. Upon completion of the entire division, contact parties will return and assume their regular duties in the company area.

PREVENTIVE MAINTENANCE

Preventive maintenance is those measures and safeguards adopted in the Army for eliminating sources of harm and damage to materiel or undue wear and defect thereto from other than normal causes.

The general principles of preventive maintenance are to insure dependability and economy of materiel, as well as maintenance facilities, and to require a rational degree of discipline from personnel detailed to be responsible for government property.

It is the duty of Ordnance officers to impress upon all using arms and services, the necessity of strict adherence to the fundamental requirements of preventive maintenance since they are particularly qualified and so situated to be aware of its importance.

Object. The object of preventive maintenance is to prevent equipment breakdowns by getting at underlying causes before failure has had the opportunity of occurring.

Basic Principles. Training must emphasize and inculcate the principles of preventive maintenance into every officer and enlisted man.

A plan should be drawn up and followed, outlining the duties required of all concerned.

The preventive maintenance program must be continuous and receive periodic command check-up.

Breeches in preventive maintenance, regardless of whether encountered in your own unit or while in inspection details, must be promptly reported through command channels.

Operators and organizations must use equipment for the purpose and in the manner intended, and when repairs or adjustments are necessary they must not attempt to do work for which they are neither trained nor equipped.

Every assistance necessary to obtain preventive maintenance is provided by ordnance personnel. Within the limits of time and an ordnance unit's mission, ordnance will provide technical assistance in mapping out preventive maintenance instruction programs when so directed by proper authority.

Responsibility. Each person entrusted with the use, care, operation, or supervision of government property will take the necessary precautions classified as preventive maintenance. The responsibility for supervising and maintaining preventive maintenance is a command function.

Performance. The duty of performing preventive maintenance falls primarily upon the first echelon (the individual charged with the care and use of materiel), and secondarily upon the second echelon (unit maintenance facility). Officers should note that: persons concerned with materiel have two proper duties in relation to such materiel: (1) use or operation and (2) preventive maintenance.

Generally the actual performance of preventive maintenance consists of:

(1) Visual check of item for completeness, presence of cracks, burrs, foreign matter, lubrication, and general matters, such as oil and water levels of a vehicle, fan belt tension, tire pressure, etc.

(2) Operation check of item, to include such points as proper functioning of a machine gun, operation of engine, operation of instruments in a vehicle, horns, lights, etc.

(3) Cleaning, drying, oiling, or preserving the item.

(4) Use within range of operation intended. Excessive speeding will increase the maintenance burden in motor vehicle operation.

(5) Inspection of the item before use, while in use, and after use.

(6) Promptly reporting all operational deficiencies to second echelon.

(7) Making authorized repairs promptly, or forwarding the unserviceable item to third echelon.

The basic weapon issued an enlisted man affords an excellent example of preventive maintenance. From the beginning of his training, the soldier receives an adequate grounding in every phase of use, operation, and care of his weapon. The rifle is fitted with certain equipment to protect both it and the user from damage and injury; for example, the front sight cover and automatic cut-off. Further the weapon has an oiler and thong set for cleaning and preservative purposes. It is the soldier's individual responsibility to keep the weapon clean and in operative condition at all times. When malfunctions occur he will make necessary adjustments or corrections of the piece as directed in basic training. In the event that first echelon repair is inadequate for servicing the piece, he will report such fact, through proper channels (squad or platoon leader), to the company artificer. Where repair cannot be effected within the unit due to parts shortage

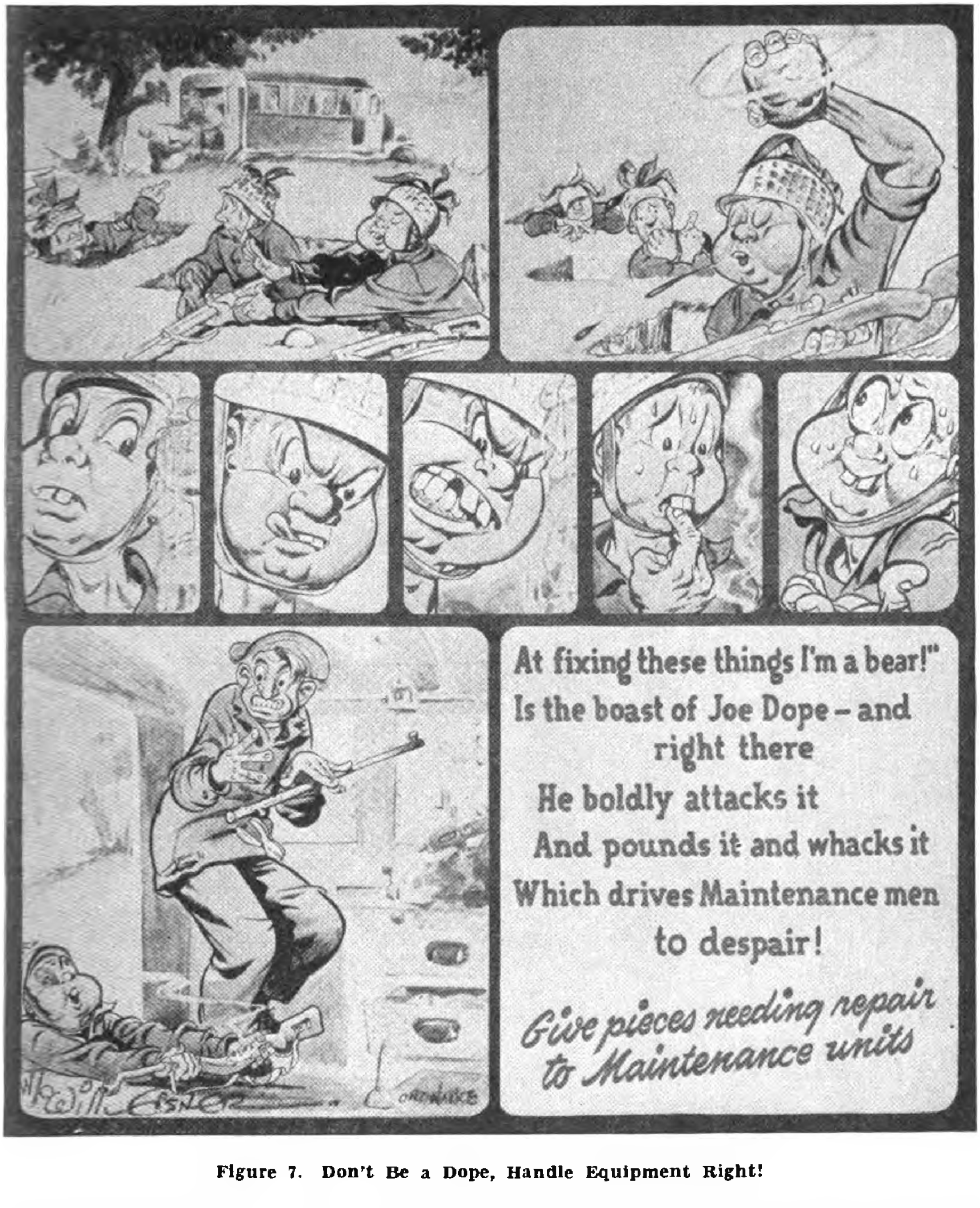


Figure 7. Don't Be a Dope, Handle Equipment Right!

(considering here the unit's organization spare parts set), the parts required will promptly be requisitioned. However, if repairs are not within the scope of the unit, the weapon will promptly be evacuated to maintenance. In this case, while repair is being accomplished, the soldier is furnished with a substitute weapon. These principles are similarly applicable to all equipment used in the Army.

Vehicle operation is a large field for the application of preventive maintenance. A modification of the old stables inspection, which was used in horse-

Figure 8. Don't Be a Dope, Handle Equipment Right.

drawn artillery and cavalry units, has been carried forward as a motor stables plan and is found to be very effective in supervising and controlling preventive maintenance of motor vehicles. In this plan, the drivers and vehicles are assembled in the motor park each day, usually in the morning prior to dispatching the vehicles from the pool. The commanding officer or motor officer will check a particular vehicle or vehicles at random. Following the inspector's selection the other drivers are released from the formation to resume normal duties. The inspecting officer then requires the driver to make a complete 'before-operation' check of his vehicle, verifying the various points as they are brought out. Completeness of tools, accessories, and equipment will also be checked during the inspection. Inspecting officers must give meticulous attention to detail and correct every minor delinquency on the spot. Where satisfactory explanation for discrepancies is not furnished, the inspector should make appropriate recommendations. A similar procedure is followed in making spot inspection checks of organizational equipment or in highway inspections when directed by higher authority.

In order to assist the first and second echelon maintenance personnel to perform their duties and to provide a convenient method whereby a hasty check of their operational procedures may be made, the preventive maintenance duty roster is available. The form used for this roster is WD AGO Form No. 6. This form is now prescribed by AR 850-15. The official title of this form is "Motor Vehicle Inspections and Preventive Maintenance Services." WD AGO Form No. 6 is the regular duty roster with which every one is familiar. A sample of the preventive maintenance roster will be found in the chapter on Automotive. It will be noted that the heading of the roster is modified to read "Motor Vehicle PM Roster," and that it is a monthly record. All vehicles of the unit are listed by WD registration number, grouped by vehicle type in the column to the left of the guard roster, and the various services performed are shown in the appropriate block opposite. The meaning of the various symbols is indicated in the legend. The four digit figures indicate the mileage of the vehicle at the time of service. The circling of a symbol indicates that this service was performed at other than the normal time. By this means the unit commander can, at a glance, check over the status of the motor transport of his unit. This knowledge, plus a visual inspection of the vehicles, will give him an excellent picture of how his drivers and mechanics are assisting him in the discharge of his maintenance responsibilities.

There is no official form for the preventive maintenance services of armament. It would be an excellent idea if unit commanders would require, within their unit, records of a similar nature to the motor vehicle records, kept up to date on all organic armament. On this improvised record all pertinent information covering preventive maintenance services should be kept. The duty roster for automotive preventive maintenance services forms an excellent model upon which to build improvised forms to record the services rendered any armament by the first and second echelon maintenance of the unit. The use of this record would be the unit commander's assurance to himself that the correct preventive maintenance services were being maintained within his outfit. It would also serve as an excellent means of checking any unit for their services rendered.

It is emphasized again that those using equipment will perform the major portion of preventive maintenance and will be backed up by unit facilities for the remainder. Regardless of who does or does not take care of the job, the commanding officer remains responsible for preventive maintenance.

DON'T LET THIS HAPPEN TO YOU!

Probably the most outstanding example of lack of maintenance discipline which had a detrimental but not fatal effect on the outcome of a campaign in the theater and which would undoubtedly have been much more serious except for the timely arrival of replacement vehicles and the performance of 1st and 2nd echelon maintenance by an Ordnance MAM company was that of a ——— Regiment which comprised the bulk of a Corps train of the ——— Corps in ———.

A disregard of maintenance discipline in the organization, coupled with the disregard of the staff in allowing any time for maintenance, caused the entire regiment to fall apart like the proverbial 'one horse shay,' at a time when an offensive was being launched over a comparatively long supply route.

The lack of maintenance discipline in this organization had been so general that as many as 50 per cent of their vehicles were on deadline at a critical time and it took several days to get them replaced, causing the supply train to operate at greatly reduced strength. The moving forward of ammunition, rations, fuel, and lubricants was seriously retarded by the complete disregard of maintenance discipline by the organization itself and the failure of the corps staff to realize that in the long run nothing was actually gained by running the trucks 24 hours a day without any time being allowed for maintenance over a period of weeks.

Closely allied to maintenance discipline is driver discipline. As an example, failure of tank crews to lock the 75-mm gun on medium tanks while traveling in administrative or approach marches caused wholesale failures of the splined shaft on the turret rotating mechanism. 35 to 40 medium tanks were deadlined in ordnance shops of the division during the campaign from these failures alone. As an example of how discipline can correct such situations, the C. G. finally started fining personnel responsible for such failures $50. The failure of this nature immediately fell to zero.

Failure of using personnel to grease clutch release bearings in half-tracks of the —— Armored Division, caused wholesale failures and consequent loss of the vehicles while they were in 2nd and 3rd echelon shops. Approximately 75 half-tracks were lost to the combat troops during the Tunisian campaign at critical times, due to failure of those concerned to properly enforce maintenance discipline on this one item alone.

Failure of using personnel to grease bogie wheels on medium tanks was also responsible for the deadline of tanks during the campaign and their subsequent loss to the using troops.

From the isolated instances cited above, the Army soon learned the lesson that lack of maintenance discipline can and will have a detrimental effect on the outcome of a campaign.

IMPROVISATION AND FIELD EXPEDIENTS

The adage *necessity is the mother of invention* is perhaps nowhere else more appropriate than to ordnance service in the field. Unforeseen needs, unplanned-for maintenance problems, inadequacy of equipment for certain types of work, and shortages of supplies have each, in all overseas theaters, at one time or another, required personnel of all grades and ranks to exercise great ingenuity in improvisation and adoption of field expedients to solve the problem at hand. Our splendid reputation in Ordnance stems from the flexible service provided units supported, among which it is common knowledge that no job is too large, too small, or too tough for ordnance supply and maintenance units to handle. In various situations ordnance units have modified materiel to enable performance not previously considered practical or possible. One good example is the use of tanks for clearing underwater and land obstacles, and as mine exploders; another is the use of mortars for projecting a device capable of engaging and retrieving barbed wire. Other examples are the production of special surgical instruments, magnetic nail and tack pickers, construction of highly useful gasoline-fired hot water heaters, design and mounting of winch operated lifting frames on ¾-ton and 2½-ton cargo trucks, the design and use of many special tools, gages, and fixtures for quantity-production, handling of large maintenance problems, and many other projects too numerous to consider in detail here. Technical information and developments on such devices and expedients will be found in such publications as the Ordnance Sergeant, Army Motors, Fire Power, and various technical bulletins.

A maintenance survey conducted during an operation in which spare parts supply shortages were extremely critical indicated that only 15 percent of the total repair jobs were possible by using replacement items. While the infeasibility of such a situation is recognized, it is also readily seen that the principle of "getting farthest with the leastest" (as the saying goes) is readily reflected in ordnance units imbued with a real understanding of the importance of improvising in the field. When improvisation involves the permanent modification of materiel, officers should ascertain before starting the work that the particular item itself is not critical in supply or demand, or that its use will not render another item critical, and finally that there is a definite, well-defined requirement

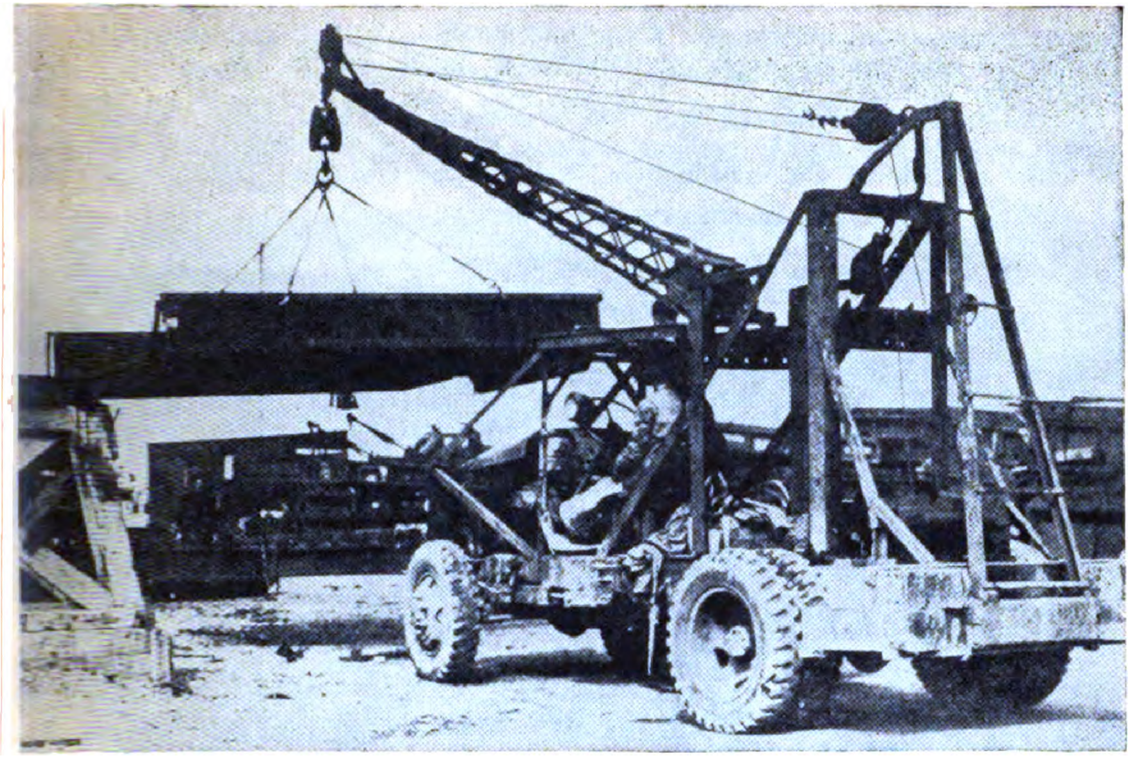


Figure 9. Making it Work.

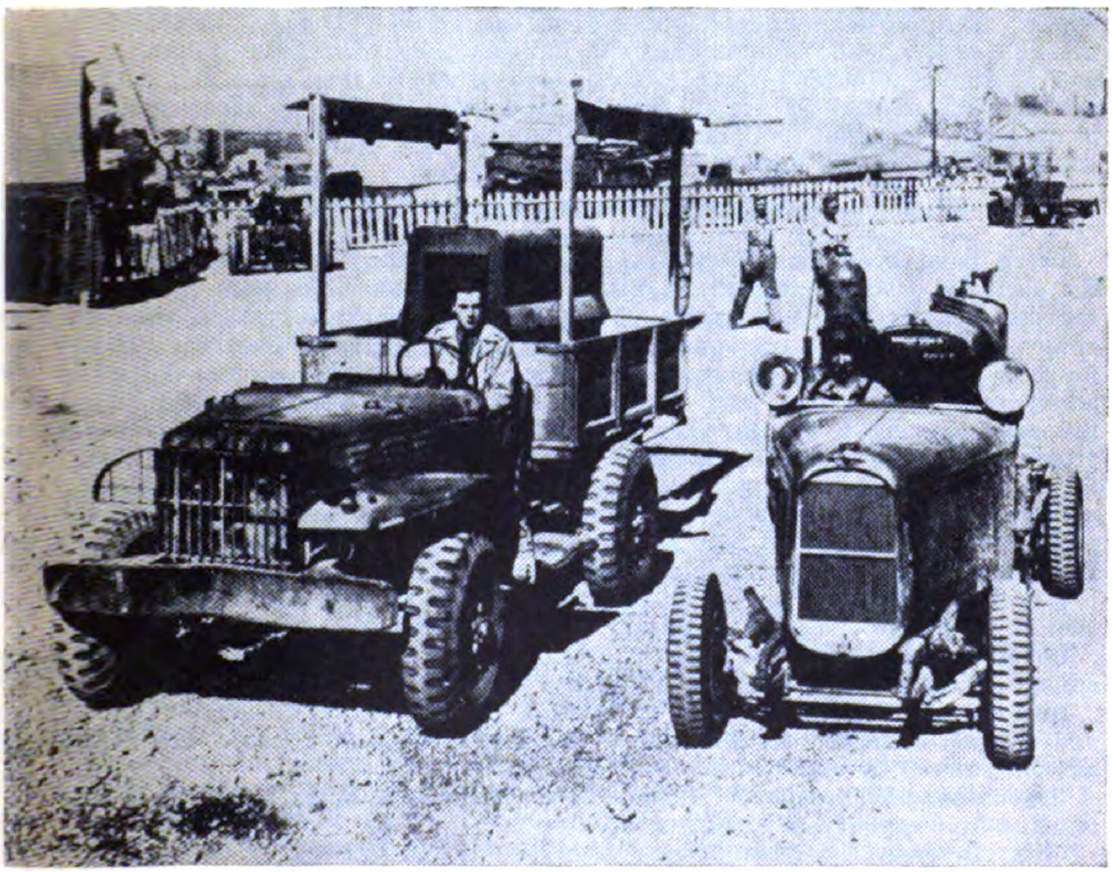


Figure 10. Comic Strip Comes True, a Rube Goldberg.

for the project to be undertaken. These considerations will alleviate any tendency toward promiscuousness in improvisations by junior officers and enlisted men under their control.

In the main, improvisations and field expedients are temporary measures intended to solve the specific problem at hand. Much of the experience gained is of broad application and considerable value to the Ordnance Department as a

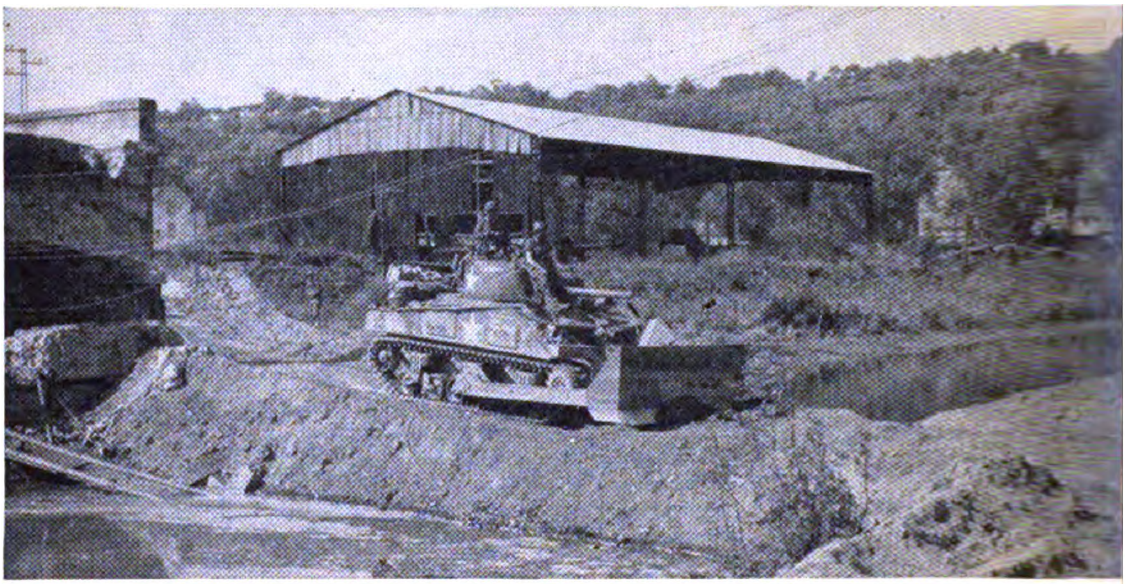


Figure 11. A Tankdozer on its Way to the Moselle River in France.

whole. The above mentioned publications are actively engaged in disseminating this data to the field. Commanders and junior officers will render a distinct service and assistance to other ordnance troops everywhere if they send in meaty write-ups on such matters as are in their opinion important. For security reasons it is necessary to clear the data through appropriate higher channels before forwarding it out of the theater.

SECURITY OF ORDNANCE UNITS *

There have been many examples in this war of a unit's complete disregard for security. The commanding officer of an ordnance company is responsible for the security of his company. This responsibility begins when the company enters the theater of war and continues until it leaves. Security can be defined as embracing all measures taken by a command to protect itself against annoyances, observation, and surprise attack by the enemy. It depends upon preparedness and a specific plan of conduct to be followed in the event of an attack. A strong chain of command is essential, and each individual should be thoroughly trained in the performance of his duty.

Security Plan. It is essential that a plan be developed within the unit to prepare for anything that may happen which will be dangerous to the command. Every well-rounded security plan will take into consideration:

Warning System. The establishment of observers and means of communication to warn the company of enemy disposition and operations.

Cover and Concealment. The utilization of natural terrain features and camouflage measures to protect against enemy observation and fire.

Dispersion. The deployment of materiel and personnel in irregular positions and at such distances as will reduce the target value and lessen the damage of any hits scored by enemy fire.

Evacuation. The removal of materiel and personnel from one area to another, which may occur before or during an attack.

Fire. Defense of a position by delivery of fire power.

* See also Chapter 5 on Troop Training in Vol. I.

When faced with the problem of planning a course of action or a standing operating procedure, the unit commander must consider the major types of attack. The location of an ordnance unit may subject it to an attack by one, or a combination, of the following:

Non-mechanized attack: Foot troops, including airborne troops, utilizing infantry weapons.

Mechanized attack: Tanks and vehicles containing small arms and artillery.

Air attack: Bombing and strafing.

Chemical attack: Ground or air attack, utilizing mines, smoke pots, gas cylinders, artillery, bombs, or spray.

Security on the March. Seldom will circumstances justify a movement without prior reconnaissance. Advance reconnaissance safeguards the movement of a unit by furnishing the unit commander detailed information of the route he expects to follow and conditions he may expect to meet. Failure to make route reconnaissance or failure to appreciate the true conditions of the route selected has resulted in undue loss of ordnance personnel and loss of ordnance equipment. Advance reconnaissance involves both the study of maps and aerial photographs and the inspection of the ground to be traveled.

Responsibility for careful study of maps and aerial photographs rests with the unit commander. In view of the fact that aerial photographs will be available more frequently than detailed, up-to-date maps, all officers should be able to interpret aerial photographs with facility. The unit commander must consider: control orders from higher headquarters, time allotted for movement, passable routes to new locations, directness of routes, types of roads, effects of weather conditions, traffic, terrain, enemy activity, rest points, and contact points for supplies. Having made the above preliminary consideration it then becomes necessary to send out a reconnaissance patrol to substantiate the decisions of the unit commander. For any reference to the reconnaissance patrol see Chapter 5, where the entire organization and duties of the reconnaissance patrol are covered.

Disposition of Unit on the March. Application of security requirements to the organization of the unit in movement will normally establish the order of elements as advanced guard, flank guards, main body or column, and rear guard.

Ordinarily, ordnance units in a combat zone will move under cover of darkness. Foot movements are seldom used as the company will have, or can obtain, sufficient vehicles. If foot movements are necessary, they will be conducted according to standard infantry procedure. (See FM 7-10.)

Column Movement. To facilitate control at night, vehicles will move at close interval governed only by safety measures required in the operation of the vehicles themselves. The distances between vehicles will range from twenty to sixty yards. By day, the distance between vehicles will be greater so as to afford protection from aerial attack; it should range from one hundred to one hundred and fifty yards. Vehicles should be arranged by sections, but it is desirable that no two vehicles of the same type follow one another. Cargo trucks armed with automatic weapons should be dispersed throughout the column; antimechanized weapons will be concentrated in the front, center, and rear of the column. Vehicle and column distance data are given in Staffs, Chapter 6, Volume I.

Infiltration is a method of motor movement where vehicles are dispatched individually or in small groups over a carefully marked route to approximate normal traffic density, usually about five vehicles per mile. Infiltration should be used when a maximum degree of secrecy is called for and little air protection is available. In areas where cross-traffic is heavy, infiltration causes the least interference.

Shuttling is a movement involving two or more trips or partial trips by the same motor vehicles between two points. Shuttle movements are used when there are not enough vehicles available to move a unit intact.

Security Elements. The leading element of the advance guard is the point; it should proceed the column by two to five minutes. It is designed to contact and forewarn of hostile presence and should consist of at least two vehicles and eight men. Each vehicle should be in charge of a noncommissioned officer. The first vehicle will act as the contact element and will be armed with grenade launchers and automatic shoulder weapons. The second vehicle will serve as a getaway vehicle and will follow the first at an interval limited by the factor of visibility.

The advance party supports the point and should consist of at least one vehicle and ten men. An officer familiar with the defense employment of small units will be in charge. The advance party will also serve as the connecting unit between the point and the main body and will oscillate between the two by increasing and decreasing its speed. The advanced party will be armed with automatic and antimechanized weapons.

Flank guards will be posted on each flank and should consist of at least one light vehicle and two or more men under the supervision of a noncommissioned officer. Where possible, the flank guard should travel parallel to the main column. Communications should be by radio. Where radio communication is not available, the use of flank guards may be confined to the investigation of limited portions of connecting roads and danger areas along the route.

The rear guard is merely the advance guard in reverse order. It will consist of the same number of personnel and type of armament and will function in a similar manner.

Normally ordnance troops move under division or corps supervision on well defined routes. The above security measures may be used in areas where troops move through an uncertain area of possible by-passed pockets of enemy troops.

Air-gas sentries should be posted throughout the column. It will be their duty to give timely warning of air and gas attack. Owing to the interval between vehicles and the noise of traffic, some form of loud sounding device is necessary. Where sirens or claxons are not available, gun fire may be utilized.

Temporary Halt. Upon arrival at a halting point during the day, vehicles will draw off the road and, taking maximum advantage of cover and concealment, will disperse at regular intervals. To the extent possible, the vehicles will maintain their march order with distances from one hundred to one hundred and fifty yards between them. The location of cover and concealment may cause different arrangement. At each temporary halt, all-around protection must be provided for. The advanced and rear guards are drawn in to at least one thousand yards and serve as march outposts. Side roads in the vicinity should be posted with special patrols. As patrol duties are tiresome, it will often be desirable to change advance, rear, and flank guards at halting points.

Conduct in Event of Attack. *Air Attack.* When a moving column is attacked by hostile aircraft, all vehicles should stop, and personnel other than those manning antiaircraft weapons should abandon the vehicles and disperse widely. For safety, personnel should be at least fifty yards beyond the road.

Accumulative fire power of the number of rifles, together with that of every other available weapon, will contribute effectively to the protection of the column against low flying aircraft. Experience has shown that when enemy aircraft meet such a volume of fire from ground troops, they cease attacking at low altitudes. It is the duty of every individual soldier to contribute his share of fire when ordered by an officer.

Ground Attack: As the direction of ground attack will usually be unknown until the enemy is in close proximity, the unit commander must rely on general dispersion of fire power throughout the column and on the consolidation of personnel under section direction, each section acting as a fighting platoon. Vehicles should not be abandoned or the column halted unless the road is blocked or unless an attempt to run the line of fire would prove too costly. When attacked by superior forces, the column should withdraw. Personnel in the area of primary assault will detruck and conduct a rear guard action under the direction of the nearest officer or noncommissioned officer. Standard signals should be adapted for reversal of column to facilitate smoothness of evacuation.

Chemical Attack: When confronted with chemical attack, individual protective measures will be taken. The column will continue its march unless headed in the direction of attack.

When at a halt or in a concealed area, troops should not fire on hostile aircraft unless actually attacked or if it is obvious that their position has been located. When attacked, all available fire power should be brought to bear. Ground attack must be met by section formations operating as fighting teams. Where enemy fire power is superior, immediate steps should be taken to evacuate the area. The section closest to the point of attack will cover the withdrawal by a rear guard action. In event of a chemical attack of a persistent nature, the area will be evacuated immediately. The area should be marked showing date of attack and type of gas used.

Security in Bivouac. The general locality of operation and the selection of the designated locality in a general area is covered in chapter 5, Vol. I.

The security of a bivouac area is dependent in large measure upon the establishment of an effective warning system. The system should provide warning against all types of attack and should be organized so as to insure receipt of alarm in time to permit cessation of normal activities and the adoption of defensive measures. Ordnance units are limited by personnel and equipment in the measures that they can adopt. Within these limits close-in, all-around protection should be established, and when the unit is operating independently, outlying observation posts should be located overlooking the avenues of approach as required by the situation.

If the situation requires it, outposts should be located around the perimeter of the bivouac area at distances ranging from two hundred to five hundred yards from the area. They should be placed at points covering the road network, at entrances and exits to the area, and at natural avenues of approach. The primary duty of the outposts will be to warn the unit of the approach of enemy forces. In addition, it will be their duty to fight a delaying action pending reinforcements in the event of enemy attack. The outpost should be armed with automatic weapons. Outposts will be linked with a visiting patrol of two or more men.

Independently operating units will find it advisable, in addition to close-in protection, to establish a few outlying observation posts. They should be so located that key roads may be kept under surveillance. They may be radiated at distances ranging up to five miles from the bivouac area.

Gas sentries should be posted during all resting hours. They will be familiar with the location of sleeping positions of all men and should be located upwind from such areas. If the area is organized on the basis of sections, it may be advantageous to designate a sentry to each section. It will be necessary to post air sentries as well; however, it is convenient and normal to have the gas sentries act as air sentries as well. This means that the sentries must be located so as to get a clear view of the sky in all directions. A simple but adequate signal system must be devised and put into effect to warn the entire command of the approach of enemy aircraft.

It is necessary for ordnance officers to become guard conscious. Interior guards must be posted so as to give adequate protection from enemy attack. However, it must be kept in mind that the principle of an ordnance company is to provide ordnance service for the unit supported. Thus, the situation, the surrounding friendly troops, and air superiority will be taken into consideration in posting interior guards and outposts.

Organization of the Area. Upon occupation of an encampment area, the unit commander should take prompt steps to establish positions for the defense of the area in the event of attack. Combat platoons will be organized, and each platoon will be assigned a sector of responsibility. In the organization of these platoons, the integrity of the sections should be maintained as far as possible. Areas from which attack may be anticipated should be prepared for the placement of the unit's automatic weapons, and for the individuals protecting those weapons.

In defense against air attack, the unit's chief weapons are the cal .50 machine guns. They should be located in or near the bivouac area at points affording maximum observation. Where removal from vehicles is desirable, improvised pedestal mounts may be profitably employed.

Combat. Ordnance units will normally fight only as a last resort. When an air attack is imminent, all activities should be stopped in the area and troops should take protective cover. Fire from aircraft should be returned by all available weapons. When attacked by ground forces, the platoon whose area is attacked will deploy and resist enemy action. The unit commander will make an estimate of the situation and will either deploy the other platoons to resist the attack or proceed to evacuate the area. Ordnance officers overseas have considered the designation of organic Ordnance Units as combat troops (See Troop Training, Chapter 5, Volume I).

Evacuation. Evacuation of a bivouac area may be an emergency measure caused by the proximity of hostile forces, or it may be the normal movement of the unit in fulfilling its mission. In either case, careful preparation is necessary to insure speed of the operation and to prevent confusion. Forethought and a definite plan will not only prevent annihilation in an emergency but in addition will reduce the 'down time' of the unit in the accomplishment of its mission. To effect a well-ordered evacuation, the unit commander must know where he is going, and the route by which he will proceed to his destination. The necessity for the preselection of an alternate bivouac area has been treated in chapter 5. In addition, the unit commander must keep himself constantly informed as to the condition of all roads within the radius of probable movement. The possible need for rapid evacuation will be borne in mind in the organization of the unit while in bivouac. Vehicles will be located and immediately serviced to permit rapid evacuation from the area. If possible, heavy equipment should not be removed from shop vehicles. Kitchen equipment may be permanently mounted on suitable vehicles. Materiel in for repairs should be dismantled only to the extent necessary to complete the repair and, in addition, should be handled with the view to means of evacuation.

If the principles outlined above are followed, there is no reason why any ordnance unit in any theater of war should not be able to operate with reasonable security and expect sufficient notification of enemy activity to fight or evacuate the area as the situation requires.

DESTRUCTION OF ORDNANCE MATERIEL

The Plan. At times, it may be necessary for ordnance personnel to destroy the materiel in their possession to prevent its capture by the enemy. It is the responsibility of the unit commander to prepare a plan for the destruction and to thoroughly train his personnel in its execution in order to insure success when the application of such a plan is necessary. The plan should provide for destruction orders to be issued by the army commander or by authorized lower commanders or responsible orders in the event that communication with the army commander is impossible.

Two considerations require that this plan be flexible.

1. The materiel under consideration is subject to wide variation as to type and quantity. In depots, this variation will be caused by changes in stock levels; in maintenance shops by changes in materiel to be repaired; and in ammunition installations by the types and quantities stored.

2. The second requirement for flexibility is due to the fact that means for evacuation may become impaired. Trucks may be knocked out by accident or enemy action, roads may become jammed with traffic, and the time required for complete destruction may be lacking.

The plan is divided into the following steps:

a. The determination of what is to be destroyed and what is to be evacuated by available transportation.

b. The determination of the items required for complete destruction of the materiel. These items will include demolition materials, oxygen and acetylene, welding rods, incendiary grenades, gasoline, and inflammable materials, depending on the methods of destruction chosen. The materiel to be destroyed should be listed by types, the method and degree of destruction stated, the materials required for one article, the number of articles, the total materials required, and the time required for the destruction of one item listed. The time in manhours for destruction of the required number of items should also be given.

c. The assignment of personnel to the task. This should be planned so that all destruction is completed at approximately the same time.

(1) After the plan has been carefully balanced, the men available for the work should be trained in its execution. Every man should know exactly what he is to do and be trained by simulation of the operation.

(2) A plan for complete destruction as outlined above will probably require more time or more materials than the organization can reasonably expect to have. Therefore, it should be revised as to the degree of destruction of the individual items on the basis of expected available time, listing priorities. The required materials should then be obtained and kept on hand at all times.

(3) The above plan assumes the evacuation of certain materiel. An addendum should be prepared for the destruction of this materiel to be used in the event that its evacuation is impossible.

(4) If actual destruction becomes necessary, it is very probable that the prepared plan will require revision on the spot. The unit commander or his principal assistants should be on hand to render such decisions as may be necessary and to supervise the work.

(5) A sample plan prepared as outlined above follows in this section.

Methods of Destruction. The approved method of destruction of each item of ordnance materiel is published in the pertinent field manual. This method should be used whenever possible in order to obtain uniform results throughout the army. However, the specific method to be employed is a decision of the unit commander and should be based on the considerations given below.

a. Selection of methods of destruction requires imagination and initiative and should be the simplest which will accomplish the desired purpose. For example, if only a few rifles are to be destroyed, individual methods of destruction can be applied in a matter of minutes. If a large number of rifles in original containers are in stock, mass destruction by fire or explosives is required. However, demolition of large quantities of materiel requires considerable space and time, and reasonable safety precautions must be observed.

b. Care should be taken to destroy repair parts as well as major items. Little is accomplished in destroying a ring gear if the enemy finds a new one in a spare parts truck.

Destruction By Welding and Cutting. Destruction by means of acetylene cutting torches and electric welding may be applicable where only a few large items are affected. It should be under the supervision of the shop foreman or section chief, since a high degree of technical knowledge is necessary to discern between effective and ineffective operations.

Ordnance depot. The destruction of materiel in an ordnance depot is associated with inherent difficulties which are due in part to the packing of much materiel in original containers. Normally, destruction of a depot should be accomplished by explosives and fire.

SAMPLE PLAN FOR DESTRUCTION

General. Preparation of a plan for the destruction of ordnance materiel in the hands of ordnance units as outlined in the preceding section is illustrated below. The plan is based on the requirement for the destruction of materiel on hand in a maintenance shop. As it is intended only to illustrate a method for developing a plan, all numerical quantities are taken at random.

Plan for Destruction of Materiel. *a. Small Arms.*

Item	Number	Time each (minutes)	Total man-hours	Instructions	Materials									
					TNT		Gasoline		Oxygen		Acetylene		Rod	
					Each	Total	Each	Total	Each	Total	Each	Total	Each	Total
Pistol	125	1.5	3.1	Flatten recoil spring, remove link, mash magazine.										
Rifle, M1903	43	1.0	.7	Bend barrel, break striker point										
Rifle, M1	67	2.5	2.8	Bend barrel, break striker point, break hammer hooks.										
Gun, submachine	15	1.5	.4	Break pivot plate										
Machine gun, caliber .30	48	2.5	2.0	Smash cover, back plate, T-slot lock frame, barrel extension.										
Machine gun, caliber .50	21	3.5	1.2	Smash cover, back plate, depressors, barrel extension.										
Carbine	82	2.0	2.7	Bend barrel, break striker point, bend operating rod.										
Rifle, automatic	6	1.0	.1	Bend barrel, break striker point, bend operating rod.										
Total			13.0											

b. Artillery.

Item	Number	Time each (minutes)	Total man-hours	Instructions	Materials									
					TNT		Gasoline		Oxygen		Acetylene		Rod	
					Each	Total	Each	Total	Each	Total	Each	Total	Each	Total
Mortar, 81-mm	3	5	0.3	Cut tube and base cap, cut screws					20	60	20	60		
Gun, AT, 37-mm	8	13	1.7	Cut breech ring, firing pin, weld, recoil rod, cut elevating and traversing racks, cut axle and pintle.			0.2	1.6	40	320	40	320	0.5	4.0
Howitzer, 105-mm	6	30	3.0	Cut breech ring, firing pin recuperator cylinder, elevating and traversing racks, axle, and pintle.					60	360	60	360		
Howitzer, 155-mm	1	30	.5	Weld breech threads, cut breechblock threads, recoil cylinders and elevating rack.			0.2	0.2	40	40	40	40	1.0	1.0
Total			5.5					1.8 gal.		780 cu. ft.		760 cu. ft.		5.0 lb.
Total welding time			.7											
Total cutting time			4.8											

c. Instruments.

Item	Number	Time each (minutes)	Total man-hours	Instructions
Glass, field	11	1.0	0.1	Smash with hammer
Binocular	15			Evacuate
Finder, range, 1-meter	7			do
Circle, aiming, M1	6			do
Circle, aiming, M1916	9	1.0	.1	Smash with hammer
Telescope, panoramic, M5A2	11			Evacuate
Telescope, panoramic, M6	3			do
Sight, quadrant, M1918A1	2			do
Telescope, battery commander's	5			do
Total time			.2	

d. Automotive.

Item	Number	Time each (minutes)	Total man-hours	Instructions
Truck, ¼-ton	1	8	0.1	Burn
Truck, 2½-ton	5	3	.2	do
Truck, command	2	3	.1	do
Car, half-track	3	3	.2	do
Tank, light	1	10	.1	Demolition on engine, transfer case, and differential.
Total			.7	
Time for demolition			.1	

Materials									
TNT		Gasoline		Oxygen		Acetylene		Rod	
Each	Total	Each	Total	Each	Total	Each	Total	Each	Total

Materials									
TNT		Gasoline		Oxygen		Acetylene		Rod	
Each	Total	Each	Total	Each	Total	Each	Total	Each	Total
		5	5						
		10	50						
		10	20						
		10	30						
7	7								
	7 blocks; 8½ lb.		105 gal.						

e. Miscellaneous. Organizational equipment not listed to be evacuated.

Item	Number	Time each (minutes)	Total man-hours	Instructions	Materials: TNT Each	TNT Total	Gasoline Each	Gasoline Total	Oxygen Each	Oxygen Total	Acetylene Each	Acetylene Total	Rod Each	Rod Total
Range, field, M1937 (QMC)	3	2	0.1	Smash with hammer										
Paulins	5	2	.2	Burn			0.5	3.0						
Typewriters	3	2	.1	Smash with hammer										
Unit, generating (Signal Corps).	1	5	.1	Burn			5.0	5.0						
Earth auger (engineer)	1	10	.2	Demolitions on engine, transmission, and driving head.	10	10								
Total			.7			10 blocks; 5 lb.		8.0 gal.						
Time for demolition			.2											

f. Special crews formed.

Crew	Squad	Men
Demolition	1	3
Welding (1 machine available)	1	3
Cutting (5 torches available)	5	15
Evacuation [1]		18
Moving [2]		18
Total		57

[1] To gather up, load, and otherwise assist in preparation of materiel for evacuation.
[2] To move vehicles and artillery to areas convenient for destruction, and otherwise assist as may be necessary.

g. Men available for destruction.

	Total	Supervisory	Net
Service section	15	1	14
Small-arms section	12	1	11
Artillery section	22	2	20
Instrument section	12	1	11
Automotive section	88	4	84
Total			140
Special crews			57
Available for hand destruction			83

h. Total man-hours required.

Section	Welding	Cutting	Demolition	Hand	Destruction
Small arms					13.0
Artillery	0.7	4.8			
Instrument					.2
Automotive			0.1		.6
Miscellaneous			.2		.5
Total	.7	4.8	.3		14.3

i. Total time required.

Hand destruction	$14.3/83 \times 60 = 10.3$ minutes.
Welding	$0.7/1 \times 60 = 42$ minutes.
Cutting	$4.8/5 \times 60 = 58$ minutes.
Demolition	$0.3/1 \times 60 = 18$ minutes.
Evacuation	20-30 minutes (estimated).
Moving	20-30 minutes (estimated).

j. Changes. It is apparent that less destruction must be accomplished by welding and cutting. Welding time may be saved by reducing the amount of bead applied to the recoil rods on the 37-mm gun, reducing the time for this task from 4 minutes to 2 minutes each. Cutting may be reduced by effecting destruction of the axle and pintle of the 37mm and 105mm weapons by means of demolitions. This will eliminate 5 minutes each on the guns, and 15 minutes each on the howitzers. Time required for the additional demolitions will be 14 weapons at 5 minutes each. TNT required will be 8 guns at 2 blocks each, plus 6 howitzers at 3 blocks each, or 17 pounds. Two extra demolition crews may be organized for the job, reducing the number of men available for hand destruction to 77.

k. Revision. The plan is revised accordingly; the revised artillery sheet is given in *l* below.

(1) Revised times are:

Hand destruction	14.3/77 × 60	11 minutes (11.14)
Welding	0.4/1 × 60	24 minutes
Cutting	2.4/5 × 60	29 minutes
Demolition	1.5/3 × 60	30 minutes

(2) The distribution of the men who are to perform hand destruction is as follows:

Small arms	13.0 × 60/11.14	69	
Artillery	None	..	
Instruments	0.2 × 60/11.14	2	(no section
Automotive	0.6 × 60/11.14	3	should have
Miscellaneous	0.5 × 60/11.14	3	less than 2
		—	men)
		77	

l. Artillery (revised).

Item	Number	Time each (minutes)	Total man-hours	Instructions
Mortar, 81-mm	3	5	0.3	Cut tube and base cap, cut screws.
Gun, 37-mm, AT	8	11	1.5	Cut breech ring, firing pin, elevating and traversing racks, weld recoil rod. Demolition on axle and pintle.
Howitzer, 105-mm	6	20	2.0	Cut breech ring, firing pin, recuperator, cylinder, elevating and traversing racks. Demolition on axle and pintle.
Howitzer, 155-mm	1	30	.5	Weld breech threads, cut breechblock threads, recoil cylinder, elevating rack.
Total			4.3	
Total welding time			.4	
Total cutting time			2.4	
Total time for demolitions			1.2	

Materials									
TNT		Gas		Oxygen		Acetylene		Rod	
Each	Total	Each	Total	Each	Total	Each	Total	Each	Total
--------	--------	--------	--------	20	60	20	60	--------	--------
2	16	0.1	0.8	25	200	25	200	0.3	2.4
3	18	--------	--------	30	180	30	180	--------	--------
--------	--------	.2	.2	40	40	40	40	1	1
-------- --------	34 blocks; 17 lb.	--------	1 gal.	--------	480 cu. ft.	--------	480 cu. ft.	--------	4 lb.
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------

Assignment of Personnel, Exclusive of Supervisory Personnel. A roster will be prepared giving the assignments by name, including supervisory personnel. The duties of each team or squad will be specifically stated in detail.

From	Small arms	Artillery	Instruments	Automotive	Miscellaneous	To: Welding squad	Cutting squad	Demolition squad	Evacuation squad	Moving squad	Total
Service section						2	10	2			14
Small arms	11										11
Artillery section	7					1	5	7			20
Instrument section	9		2								11
Automotive section	42			3	3				18	18	84
Total	69		2	3	3	3	15	9	18	18	140

Summary of Materials Required. This material should be obtained and kept on hand at all times. The demolition material should include an abundant supply of nonelectric detonators and slow burning fuses, even if electric equipment and detonators are available.

Team or squad	TNT (pounds)	Gasoline (gallons)	Oxygen (drums)	Acetylene (drums)	Welding rod (pounds)
Small arms					
Artillery	17	1	3	3	4
Instrument					
Automotive	4	105			
Miscellaneous	5	8			
Evacuation					
Moving		10			
Total	26	124	3	3	4

THE ORDNANCE GROUP

Every group of men requires a 'boss' to assign them work and to coordinate their joint activities. If there are several 'gangs' working on a job, a foreman is needed to supervise the work of the gangs. Comparing civilian organization to Army organization, the company commander is the 'boss' of the company, the battalion commander is the 'foreman' of the companies, the group commander is the 'supervisor' of the battalions, etc. The Ordnance Department has no regiment in its organization. In its place is an organization known as a group. Therefore, in

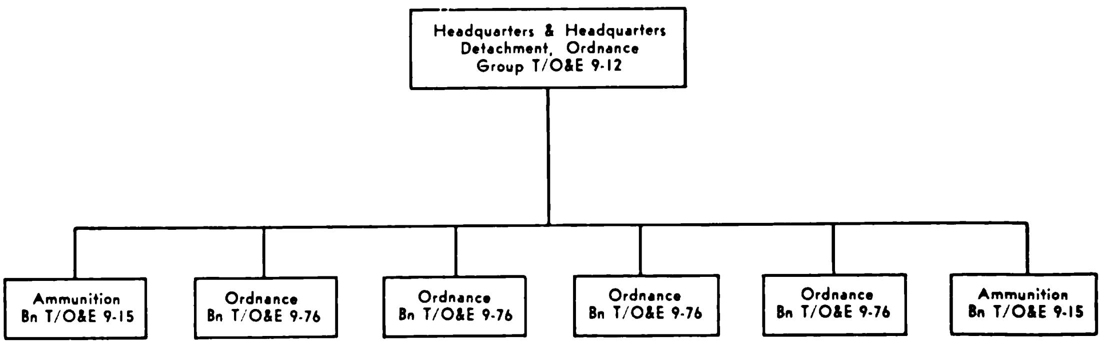


Figure 12A. The Ordnance Group.

1	1	2	3	4
1	Unit	Specification serial No.	Technician grade	Headquarters
2	Colonel, including			1
3	Group commander	4512		([p]1)
4	Lieutenant colonel, including			1
5	Executive	4512		([p]1)
6	Major, including			3
7	Ammunition	4514		([p]1)
8	Operations, S-3	2162		([ap]1)
9	Supply, and maintenance, S-4	4010		([p]1)
10	Captain, including			3
11	Adjutant and S-1	2110		([b]1)
12	Maintenance	4813		([d]1)
13	Orientation, assistant S-3	5060		([e]1)
14	Captain or first lieutenant, including			
15	Chaplain	5310		
16	Dental	3170		
17	First lieutenant, including			1
18	Athletic and recreation, assistant S-1	5000		([e]1)
19	Total commissioned			9
20	Warrant officer, including			2
21	Administrative	2120		(1)
22	Supply, administrative	4411		(1)
23	Master sergeant, including			2
24	Master mechanic	342		(1)
25	Operations	814		(1)
26	First sergeant	585		
27	Technical sergeant, including			5

5	6	7	8	9	10	11
Headquarters detachment	Total headquarters and headquarters detachment	Attached chaplain	Attached medical	Aggregate	Enlisted cadre	Remarks
----------	1	----------	----------	1	----------	
----------	(1)	----------	----------	(1)	----------	
----------	1	----------	----------	1	----------	
----------	(1)	----------	----------	(1)	----------	
----------	3	----------	----------	3	----------	
----------	(1)	----------	----------	(1)	----------	
----------	(1)	----------	----------	(1)	----------	
----------	(1)	----------	----------	(1)	----------	
----------	3	----------	----------	3	----------	
----------	(1)	----------	----------	(1)	----------	
----------	(1)	----------	----------	(1)	----------	
----------	(1)	----------	----------	(1)	----------	
----------	----------	2	1	3	----------	
----------	----------	(([f]1)2)	----------	(2)	----------	
----------	----------	----------	([g]1)	(1)	----------	
----------	1	----------	----------	1	----------	
----------	(1)	----------	----------	(1)	----------	
----------	9	2	[g]1	12	----------	
----------	2	----------	----------	2	----------	
----------	(1)	----------	----------	(1)	----------	
----------	(1)	----------	----------	(1)	----------	
----------	2	----------	----------	2	2	
----------	(1)	----------	----------	(1)	(1)	
----------	(1)	----------	----------	(1)	(1)	
1	1	----------	----------	1	1	
----------	5	----------	----------	5	5	

† Insert number of group.
[a] Also intelligence S-2.
[b] Commands detachment.
[c] Armed with carbine, cal. .30, unless otherwise indicated.
[d] Also assistant S-4.
[e] Special Services, branch immaterial.
[f] Authorized only when aggregate strength of unit is 2,000 individuals or more; exclusive of subunits wherein chaplains are included.
[g] To be furnished only as required and available within the continental limits of the United States. Will be furnished prior to departure for oversea duty.
[h] Drives truck, ¼-ton.
[i] Attached to unit to which detachment is attached for mess. (Includes 1 for officers' mess.)
[j] Drives truck, ¾-ton.
[k] Drives truck, 1½-ton.
[l] Deduct 1 when only 1

28		Ammunition	505		(1)
29		Antiaircraft fire control inspector	917		(1)
30		Artillery and fire control inspector	802		(1)
31		Motor inspector	413		(1)
32		Supply	821		(1)
33		Staff sergeant, including			2
34		Message center chief	674		(1)
35		Repairman, small arms	903		(1)
36		Supply	821		
37		Sergeant, including			1
38		Clerk, general	405		(1)
39		Technician, grade 4 including			
40		Technician, grade 5 including			
41		Private, first class including			13
42		Private including			
43		Athletic instructor	283	5	(1)
44		Chaplain's assistant	534	5	(([f]1) [h]2)
45		Clerk, ammunition	505	4	(1)
46		Clerk, general	405	4	([r] 1)
47		Clerk, general	405	5	
48		Clerk, general	405		(2)
49		Clerk, typist	405	5	([r] 1)
50		Clerk, typist	405		([h] • 1)
51		Cook	060	4	
52		Cook	060	5	
53		Draftsman	070	5	(1)
54		Driver, truck, light	345	5	
55		Driver, truck, light	345		
56		Entertainment director	442	5	(1)
57		Mechanic, automotive	965	4	
58		Messenger	675		([h] • 1)
59		Orderly	695		
60		Stenographer	213	4	(1)
61		Technician, dental	855	5	
62		Basic	521		
63		Total enlisted			23
64		Aggregate			34
65	O	Carbine, cal. .30			23
66	O	Gun, machine, HB, cal. .50, flexible			
67	O	Gun, submachine, cal. .45			([i]1) 4
68	O	Launcher, rocket, 2.36-inch			
69	O	Pistol, automatic, cal. .45			5
70	O	Rifle, cal. .30, M1903			2
71	O	Trailer, ¼-ton			
72	O	Trailer, 1-ton			
73	O	Truck, ¼-ton			2
74	O	Truck, ¾-ton, weapons carrier			
75	O	Truck, 1½-ton, cargo			

Figure 126 T/O & E 9--12, Headquarters and

	(1)			(1)	(1)
	(1)			(1)	(1)
	(1)			(1)	(1)
	(1)			(1)	(1)
	(1)			(1)	(1)
1	3			3	1
	(1)			(1)	
	(1)			(1)	
(1)	(1)			(1)	(1)
	1			1	
	(1)			(1)	
13	5			5	
	9		1	10	
	4			4	
	8			8	
	(1)			(1)	
	(2)			(2)	
	(1)			(1)	
	(1)			(1)	
(1)	(1)			(1)	
	(2)			(2)	
	(1)			(1)	
(1)	(2)			(2)	
(i 1)	(1)			(1)	
(i 1)	(1)			(1)	
	(1)			(1)	
(j • 1)	(1)			(1)	
(j • 1)	(1)			(1)	
	(1)			(1)	
(k 1)	(1)			(1)	
	(1)			(1)	
(h • 2)	(2)			(2)	
	(1)			(1)	
			(1)	(1)	
(r 4)	(4)			(4)	
15	38		1	39	9
15	• 49	2	2	53	9
7	30			30	
1	1			1	
4	8			8	
2	2			2	
	5			5	
4	6			6	
		(f 1) 2		2	
1	1			1	
2	4	(f 1) 2		6	
2	2			2	
1	1			1	

chaplain's assistant is authorized.

[p] Armed with pistol, automatic, cal. .45.

[r] Armed with rifle, cal. .30, M1903.

[s] Armed with gun, submachine, cal. .45.

Normal assignment: Army or Independent Corps.

Normal function: Supervision of training and operation of 4 or 5 ordnance battalions.

For specification serial numbers shown in column 2, for enlisted men see AR 615-26: for officers and warrant officers see TM 12-406 and 12-407.

Headquarters Detachment Ordnance Group. 15 April 1944.

the Ordnance Department's organization, the group is the controlling and administrative head for several battalions.

In the combat zone, the Ordnance Group is merely a Headquarters and Headquarters Detachment (T/O & E 9-12) to which any or all ordnance battalions located in the combat zone are assigned in the proportion, normally, of from two to six battalions to one group. The Headquarters and Headquarters Detachment, Ordnance Group, is assigned to Army as required to meet the situation. This detachment provides the necessary personnel for the control and administration of the battalions assigned to it.

Note: Ordnance Units located in the combat zone may be assigned to this Headquarters. Normally ordnance service is organized into echelons such that medium maintenance companies assigned to a battalion will represent an element of 3rd echelon maintenance and similarly, heavy maintenance companies assigned to a battalion will constitute an element of 4th echelon maintenance.

The Headquarters and Headquarters Detachment (T/O & E 9-12) is responsible for all the battalions assigned to it. These battalions consist of ordnance battalions (T/O & E 9-76), and ammunition battalions (T/O & E 9-15) which are assigned follows on pages 684 and 685, fig. 12b.
in numbers depending upon the particular situation and conditions.

Headquarters and Headquarters Detachment, Ordnance Group (T/O & E 9-12), on pages 683 and 684, fig. 12b.

THE ORDNANCE BATTALION

The Headquarters and Headquarters Detachment, Ordnance Battalion (T/O & E 9-76) is the 'foreman' of ordnance companies assigned to it. This detachment is assigned in the combat zone to army as required. It provides necessary personnel for the administration and control of two to five companies. Companies of any type may be combined into battalions and placed under this Headquarters and Headquarters Detachment. The number and kind of companies so combined will depend upon the particular situation and condition. In the combat zone, these battalions operate under the direct control of the Army Ordnance Officer or may be combined into groups under a Headquarters and Headquarters Detachment, Ordnance Group (T/O & E 9-12).

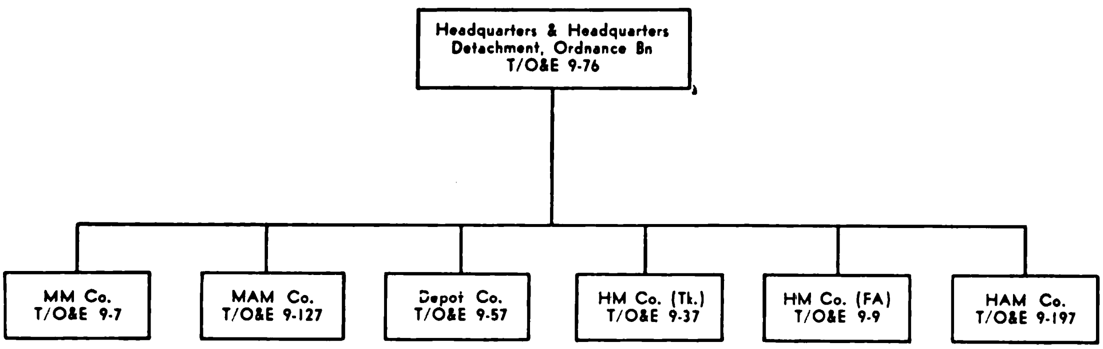


Figure 13A. Organization of an Ordnance Battalion.

The Headquarters and Headquarters Detachment (T/O & E 9-76) is divided into three sections: administrative, maintenance, and supply. It is responsible for the receipt, issue, and transmittal of orders to the companies under its control. In order to maintain coordination of operations the battalion will publish a standing operating procedure outlining the operation of the battalion and the companies in it. For further information concerning this unit see chapter 6, Staffs.

The Headquarters and Headquarters Detachment, Ordnance Battalion (T/O & E 9-76) is shown on page 686, fig. 13b.

THE ARMORED MAINTENANCE BATTALION

Mission. The mission of the maintenance battalion of an armored division is to maintain the ordnance materiel of the division and attached troops (T.D., A.A., etc.) in a state of readiness for battle and to replenish and repair this equipment both during and following combat. The battalion is responsible for the inspection, maintenance, and repair of all arms and vehicles. It must make provisions for general ordnance supplies and replacements, and evacuation and repair of damaged materiel both friendly and enemy, as the tactical situation permits or dictates.

If a weapon or vehicle requires repairs which the troop, battery, or company does not have the tools or equipment to perform, they may evacuate the job to the maintenance battalion, or to the maintenance platoon in service company if in a combat battalion or squadron of the division. From here a job may be evacuated to the maintenance battalion, if necessary. Here the mechanics are better able

	1	2	3	4	5
1	Unit	Technician grade	Headquarters and headquarters detachment	Enlisted cadre	Remarks
2	Lieutenant colonel		[a] [p] 1		†Insert number of battalion.
3	Major		[b] [p] 1		*Staff*
4	Captain		[d] [c] 2		
5	First lieutenant		[e] [c] 1		[a] Battalion commander.
6	Total commissioned		5		[b] Executive officer and maintenance officer.
7	Warrant officer		[f] [c] 1		[d] 1 supply officer; 1 assistant maintenance officer.
8	Master sergeant, including		1	1	[e] Adjutant.
9	Sergeant major (502)		([c] 1)	(1)	
10	Technical sergeant, including		3	3	[c] Armed with carbine, cal. .30.
11	Operations (814)		([c] 1)	(1)	[f] Clerical, general (also supply general).
12	Personnel (816)		([c] 1)	(1)	
13	Supply (821)		([c] 1)	(1)	[g] Drives truck, ¾-ton.
14	Staff sergeant, including		1		[h] Drives truck, ¼-ton.
15	Supply (821)		([c] 1)		[p] Armed with pistol, automatic, cal. .45.
16	Sergeant, including		2	1	
17	Clerk, personnel (368)		([c] 1)		[r] Armed with rifle, U. S., cal. 30, M1903.
18	Message center chief (674)		([c] 1)	(1)	
19	Technician, grade 4 } including		2	1	[s] Armed with submachine gun, cal. .45.
20	Technician, grade 5 } including		3		
21	Private, first class } including		3		
22	Private } including		4		Normally from two to five ordnance companies will be attached to this headquarters and headquarters detachment, as required.
23	Clerk, general (055)	4	([c] 1)		
24	Clerk, general (055)		([r] 1)		
25	Clerk, mail (056)	5	([g] [c] 1)		
26	Clerk, record (405)		([c] 2)		When battalion consists of 900 men or more, the following will be included:
27	Clerk, requisition (405)	5	([c] 1)		
28	Clerk, typist (405)	4	([c] 1)	(1)	
29	Clerk, typist (405)	5	([c] 1)		Chaplain, first lieutenant.
30	Driver, truck, light (345)		([c] 1)		Chaplain's assistant (534), technician, grade 5 (in headquarters and headquarters detachment).
31	Orderly (695)		([h] [c] 1)		
32	Basic (521)		([r] [s] 2)		
33	Total enlisted		19	6	The medical detachment, shown on reverse side, will be attached *only* when a battalion of 2 or more companies has been formed.
34	Aggregate		25	6	
35	O Carbine, cal. .30		18		The serial number symbol shown in parentheses is an inseparable part of the specialist designation. See AR 615-26.
36	O Gun, submachine, cal. .45		2		
37	O Pistol, automatic, cal. .45		2		
38	O Rifle, U. S., cal. .30, M1903		3		
39	O Trailer, 1-ton, 2-wheel, cargo		1		
40	O Truck, ¼-ton		1		
41	O Truck ¾-ton, command		1		
42	O Truck, 2½-ton, cargo, w/winch		1		

*This table supersedes T/O 10-46, April 1, 1942, and headquarters and headquarters detachments of T/O 9-75, April 1, 1942, including C1, February 23, 1943, T/O 9-115, July 22, 1942, and T/O 10-25, April 1, 1942

Figure 13B. T/O & E 9-76 Headquarters and Headquarters Detachment, Ordnance Battalion, 31 March 1943.

to work; there is more equipment to do the work, and there is more time. Also there is a larger quantity of spare parts, so that a large variety of replacement items are available. Unit replacement of some parts might take place in the line battalion maintenance platoon. Such accessories as generators, starters, etc. might be replaced here. However, a vehicle or weapon may need more work than unit replacement. It is the function of the division's organic ordnance maintenance battalion to perform this work or to evacuate those repair jobs beyond its capabilities to a higher echelon.

It is through technical inspections that the division ordnance officer insures that all ordnance materiel of his divisions is in a high state of readiness for combat

	1	2	3	4	5
1	Unit	Technician grade	Total	Enlisted cadre	Remarks
2	Captain		1		†Insert number of battalion. [a] Drives truck, ¼-ton. [d] Dental officer.
3	First lieutenant		[d] 1		
4	Total commissioned		2		
5	Staff sergeant, including		1	1	The medical detachment will be attached only when a battalion of 2 or more companies has been formed.
6	Medical (673)		(1)	(1)	
7	Corporal, including		1		
8	Medical (673)		(1)		The serial number symbol shown in parentheses is an inseparable part of the specialist designation. See AR 615-26.
9	Technician, grade 5 } including		3	2	
10	Private, first class } including		1		
11	Private } including		2		
12	Dental technician (855)	5	(1)		
13	Medical technician (409)	5	([a] 1)	(1)	
14	Medical technician (409)		(1)		
15	Surgical technician (861)	5	(1)	(1)	
16	Surgical technician (861)		(1)		
17	Basic (521)		(1)		
18	Total enlisted		8	3	
19	Aggregate		10	3	
20	O Trailer, ¼-ton		1		
21	O Truck, [a]¾-ton, weapons carrier, w/winch		1		

Figure 13B Continued. T/O & E 9-76 Medical Detachment, Ordnance Battalion, 31 March 1943.

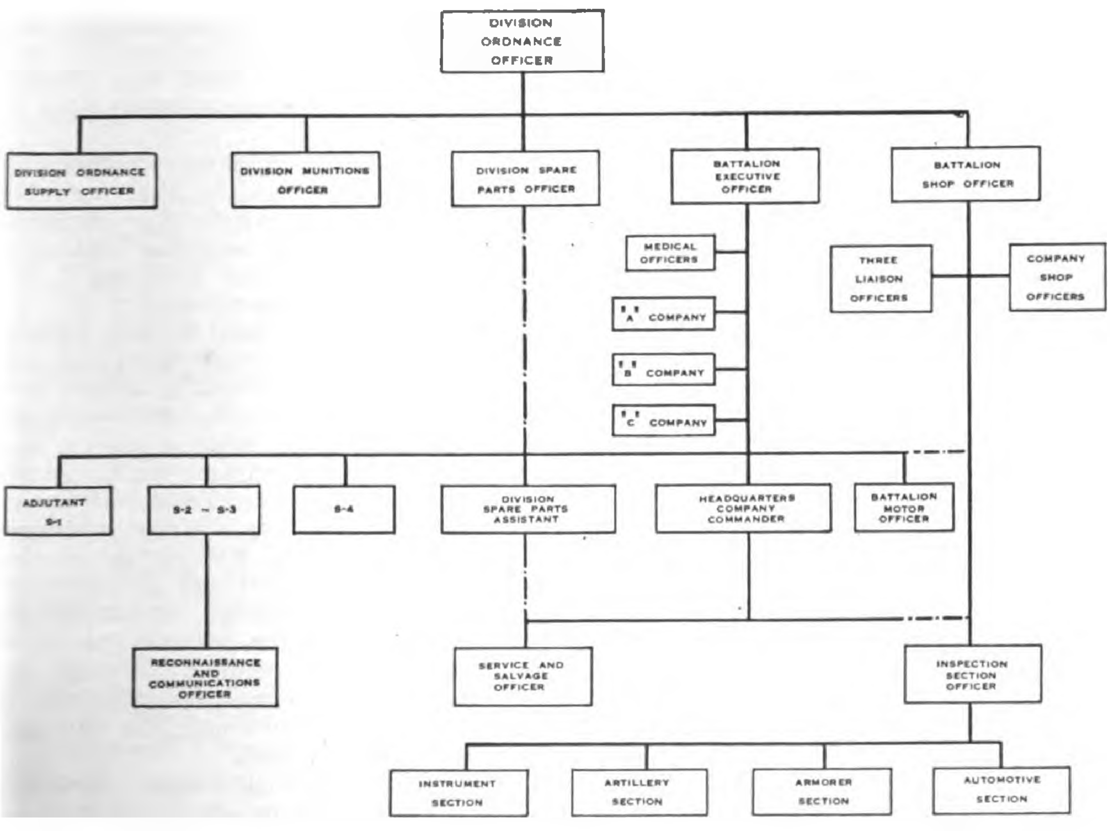


Figure 14A. Organization of the Ordnance Maintenance Battalion, Armored Division.

These intensive technical inspections are accomplished in their assigned combat commands by inspection crews from the maintenance companies of the battalion. The time used for technical inspections is during a lull in the tactical situation or as training activities permit. A great deal of planning and organization is necessary to set up inspection crews and arrange schedules to cover the entire division competently.

Normally, the armored division maintenance battalion does third echelon repair (unit replacement, *i.e.*, motors, starters, radiators, final drive assemblies, etc.) with some fourth echelon (unit repair). This is no hard and fast rule as experience has proven. It may be necessary to do more and higher echelons of repair work in order to maintain the combat efficiency of the divison. The mission can be to *accomplish any given or necessary maintenance or supply task*.

The maintenance battalion is the source of ordnance technical information and advisory guidance of the Commanding General and the Staff. The personnel of the armored division's maintenance battalions are the technical inspector's of that division.

The battalion also furnishes the necessary contact or liaison and maintenance to the various combat commands as the tactical situation warrants. The battalion must function with complete mobility and flexibility of organization. Maintenance troops of an armored division must be able and willing to follow combat troop operations in close, continuous support.

In general, maintenance companies and maintenance platoons and sections within the maintenance companies should be leap-frogged as the using units move, so that each company will have as long a time as practicable to complete its work. This may involve frequent regroupings in the battalion.

An important part of the mission of the maintenance battalion is inspection of newly issued materiel. In the normal course of supply it is essential that a final inspection service be rendered at the point where major items, in particular, are turned over to using troops. The check will include mechanical condition, serviceability of all parts and component units, stowage items, ammunition, and, where applicable, food and water. Signal personnel should be available at this point to check radios. Recent practice has been to detach from the division signal company a section or sections to work in the maintenance companies as needed.

Most division commanders will hold the division trains commander responsible for the tactical training of ordnance troops. Experience has proven that technical training in the maintenance battalion must never cease. Therefore close cooperation and understanding between the train commander and battalion executive officer is necessary to accomplish both training needs of the battalion. The tactical and technical proficiency of the personnel must be maintained.

The probable standard organization for an armored division is two combat commands and a division reserve plus division trains. In normal operation, one letter company is attached to each combat command. Experience has shown it is best for this company to operate tactically directly under the combat commander to prevent conflicting orders. The division ordnance officer must cultivate this combat commander and use the liaison officer so that the decisions made by the combat commander will give him the best ordnance service. Technical supervision must come to the ordnance companies always from the division ordnance officer or battalion commander, and never directly from the division or combat command G-4's, except in emergencies. Cooperation can be attained only through efficient liaison. The third letter company is situated, if possible, to handle the surplus work of the other two companies and the work of the reserve command. Headquarters company is generally located near the third company, though the present trend is to have headquarters company stay in division rear echelon. In any case it provides additional support to the surplus of work and has the concentration of heavy machine shops and supplies and equipment.

The bottle neck in getting out work is often spare parts shortages. Unavailability of needed parts throws an extra load on the machine shops since many tools and parts are made in the machine shops.

Reclamation and salvage of parts is another important function of the maintenance battalion. Experience has shown that the supply of parts seldom keeps up with the need. It has been found that careful coordination of salvage sections, machine shops, and welding shops has enabled a maintenance company to use a great many parts that otherwise would have to be lost to use. Salvage is necessary for the conservation of parts but there should be some control of this so called cannibalization.

	1	2	3	4	5	6	7	8
1	Unit	Headquarters and headquarters company (T/O & E 9-66)	3 companies (each) (T/O & E 9-67)	Total	Attached medical (for details see page 4)	Aggregate	Enlisted cadre [a]	Remarks
2	Lieutenant colonel	1		1		1		†Insert number of battalion. [a] Ordnance only. For medical see page 4. [b] To be furnished only as required and available within the continental limits of the United States. Will be furnished prior to departure for oversea duty.
3	Major	4		4		4		
4	Captain	5	1	8		8		
5	Captain or first lieutenant				2	2		
6	First lieutenant	7	4	19		19		
7	Second lieutenant	2	2	8		8		
8	Total commissioned	19	7	40	[b] 2	42		
9	Warrant officer	3	1	6		6		
10	Master sergeant	4	1	7		7	7	
11	First sergeant	1	1	4		4	4	
12	Technical sergeant	12	7	33		33	31	
13	Staff sergeant	14	9	41	1	42	31	
14	Sergeant	3	3	12		12	7	
15	Corporal	2	1	5	1	6	4	
16	Technician, grade 3	1	11	34		34	22	
17	Technician, grade 4	26	42	152	1	153	34	
18	Technician, grade 5	36	64	228	2	230	10	
19	Private, first class	16	18	70	1	71		
20	Private, including	28	34	130	2	132		
21	Basic	(13)	(17)	(64)	(1)	(65)		
22	Total enlisted	143	191	716	8	724	150	
23	Aggregate	165	199	762	10	772	150	
24	O Carbine, cal. .30	109	161	592		592		
25	O Carrier, personnel, half-track, M3A1, w/o armament	1	1	4		4		
26	O Gun, machine, cal. .30, light, flexible	10	6	28		28		
27	O Gun, machine, HB, cal. .50, flexible	11	9	38		38		
28	O Gun, submachine, cal. .45	51	38	165		165		
29	O Launcher, rocket, AT, 2.36-inch	11	8	35		35		
30	O Pistol, automatic, cal. .45	5		5		5		
31	O Trailer, 1-ton	30	12	66		66		
32	O Truck, ¼-ton	8	5	23	1	24		
33	O Truck, ¾-ton, command	3		3		3		
34	O Truck, ¾-ton, weapons carrier	1	5	16	2	18		
35	O Truck, 2½-ton, artillery repair		1	3		3		
36	O Truck, 2½-ton, automotive repair (Load A)		1	3		3		
37	O Truck, 2½-ton, automotive repair (Load B)		1	3		3		
38	O Truck, 2½-ton, cargo	31	12	67		67		
39	O Truck, 2½-ton, electrical repair		1	3		3		
40	O Truck, 2½-ton, instrument repair		1	3		3		
41	O Truck, 2½-ton, machine shop (Load A)	1	1	4		4		
42	O Truck, 2½-ton, machine shop (Load C)	1		1		1		
43	O Truck, 2½-ton, machine shop (Load D)	1		1		1		
44	O Truck, 2½-ton, machine shop (Load F)	1		1		1		
45	O Truck, 2½-ton, small arms repair		1	3		3		
46	O Truck, 2½-ton, welding	1	1	4		4		
47	O Truck, 4-ton, cargo		1	3		3		
48	O Truck, heavy wrecker	2	3	11		11		
49	O Truck, trailer, 40-ton, tank recovery		3	9		9		

Figure 14B. T/O & E 9-65 Ordnance Maintenance Battalion, Armored Division, 15 Sept. 1943.

Cannibalization is the robbing of parts and assemblies from unserviceable vehicles or guns and thus, in effect, rendering them salvage. Usable parts or unit assemblies are removed for the purpose of using these parts to put other vehicles back into operation.

When unit assemblies or miscellaneous parts are removed from salvaged major items, the old used part or unit assembly should be remounted or attached to the old major item which is to be evacuated for salvage. The major item is then tagged. This tag should note what usable part or assembly has been removed and replaced with a damaged, worn or otherwise unserviceable item. Sometimes this is not possible, say for instance, when the item has been destroyed by fire, mine explosion, etc. A little care in tagging evacuated equipment to show what usable parts have been removed and replaced will greatly aid base shop repair. The salvage section works in close cooperation with the division spare parts section where these reclaimed parts are restocked.

For example a ¼-ton truck backed onto a mine and blew up the whole rear end. We might remove the good motor, accessories, front wheels and axle and replace with like items that were not good. This stripping or cannibalization would give us a few usable spare parts. A tag would be attached stating items removed. The replacement of cannibalized parts with unserviceable items and tagging should always be carried out, though it is not always possible.

Organization. The armored maintenance battalion (T/O & E 9-65) comprises a battalion headquarters and headquarters company (T/O & E 9-66) and three letter companies, A, B, and C. (T/O & E 9-67). The date of the present T/O & E is 15 September 1943 corrected to 10 July 1944.

There is a total of 772 personnel, comprising 42 officers and 730 men (including the medical detachment) in an armored maintenance battalion as compared with 147 total for an infantry division ordnance company. This is necessary because of the greater amount and nature of ordnance materiel in an armored division.

Normal employment of this battalion in an overseas theater is difficult to explain as 'normal' situations are not to be expected. In Africa at different times the battalion drew supplies and equipment direct from base as well as corps, (independent) and even sometimes from a British army depot. Similar cases are reported from other campaigns and other theaters of World War II.

Headquarters and headquarters company has been reduced in maintenance personnel by this last revision of T/O. It is now intended that this company act more as the control and coordinating headquarters of the three letter companies. The technical personnel of headquarters company are the battalion's working reserve. One of the primary jobs of headquarters company is inspection of the division. The heavy machine shop section and the division's rolling stock of supplies are concentrated here. There is as large a tonnage of supplies carried in the division supply platoon as in the three letter companies. All together, there are enough ordnance supplies to make the division self-sufficient in this department for 5 to 15 days of normal operation; which does not take into account the elements of weather, battle, and extensive maneuvers and the ensuing drain on maintenance resources.

The battalion headquarters contains a command section (which includes the battalion staff) and personnel section. The division ordnance officer's section is another section of ordnance troops, but usually travels with the battalion under the new T/O. Headquarters company, maintenance battalion, is usually found in or near division rear-echelon. The letter companies usually bivouac near the assigned combat commands that they support.

The lieutenant-colonel in command of the battalion is also the *Division Ordnance Officer*. (See division ordnance staff discussion in Staffs, Chapter 6, Volume I.) The division ordnance officer should not be tied down in either office. He spends his time with the division staff and combat commands and greases the slides on matters of ordnance policy and operation. He is in immediate contact with the commanding general and is familiar with the needs of the division. By anticipating ordnance problems and securing the cooperation of the other unit commanders of the division, the division ordnance officer can smooth out operating difficulties and increase the efficiency of the maintenance battalion.

The *Division Munitions Officer* is charged with the supply and accounting for all division ammunition. He is a more or less independent operating unit and seldom stays with the battalion. He establishes the division ammunition supply point and, on orders from G4 and G3 through the division ordnance officer, sets the allocations. For more information on functions of this office see Chapter 6, Volume I on staffs.

The *Division Ordnance Supply Officer* is the assistant division ordnance officer. He is in charge of the issuance of all major items of equipment to units of the division. It is his job to see that the lieutenant-colonel is not tied down in the division ordance office. On the request of this division ordnance supply officer to the battalion shop officer the newly issued equipment (not always new, but newly issued) is given a T I (technical inspection) before being turned over to using units by the supply officer. It is his responsibility that ordnance statistical reports are kept correctly and up to date. Here the division Status of Ordnance Materiel Reports are consolidated for the division ordnance officer's information.

In one tactical situation where the division ordnance supply office was not near the Headquarters Company, Maintenance Battalion, a second method for new

	1	2	3	4	5
1	Unit	Technician grade	Total	Enlisted cadre	Remarks
2	Captain or first lieutenant		[a] 2		†Insert number of battalion. [a] To be furnished only as required and available within the continental limits of the United States. Will be furnished prior to departure for oversea duty. [b] Drives truck, ¾-ton. [c] Drives truck, ¼-ton. For specification serial numbers shown in parentheses, see AR 615-26.
3	Total commissioned		2		
4	Staff sergeant, including		1	1	
5	Medical (673)		(1)	(1)	
6	Corporal, including		1		
7	Medical (673)		(1)		
8	Technician, grade 4 } including		1	1	
9	Technician, grade 5 } including		2		
10	Private, first class } including		1		
11	Private } including		2		
12	Technician, medical (409)	5	(1)		
13	Technician, medical (409)		([b] 1)		
14	Technician, surgical (861)	4	(1)	(1)	
15	Technician, surgical (861)	5	([c] 1)		
16	Technician, surgical (861)		([b] 1)		
17	Basic (521)		(1)		
18	Total enlisted		8	2	
19	Aggregate		10	2	
20	O Truck, ¼-ton		1		
21	O Truck, ¾-ton, weapons carrier		2		

Figure 14B Continued. T/O & E 9-65 Medical Detachment, Ordnance Maint. Bn, Armed Div., 15 Sept. 1943.

equipment issues was successfully used; namely, equipment was issued by the battalion shop office as directed in allocation by the division ordnance office. Records of issues were maintained in the division ordnance office. Both procedures show that issuing agencies must be with the maintenance battalion in order to supervise technical inspection and issue of equipment.

The battalion is usually directly under the control of *the executive officer* (major). He is in charge of all administration of the battalion thereby freeing the division ordnance officer. The executive officer through his adjutant receives, transmits, and issues orders concerning the battalion. He plans and supervises movements of the companies of the battalion. Battalion schools on maintenance and supply are supervised by this officer. He also approves battalion defense plans and defense plans of companies in the battalion, supervises and inspects military training, and the battalion SOP is his responsibility. The message center under the battalion adjutant, who is also the assistant executive officer, screens all incoming and outgoing communications. Through the personnel section, the necessary personnel records are maintained and the necessary reports rendered. All this comes under the executive officer.

The *Division Spare Parts Officer* (major) with an assistant supply officer (1st lieutenant) are responsible for the employment of the division supply section of headquarters company, in securing and transmitting to units of the division all spare parts and supplies. The major makes the initial procurement and does most of base depot liaison. The lieutenant physically runs the section. The supply major determines supply policies for the battalion and maintenance companies; supervises and inspects supply sections of the letter companies; either transmits, consolidates, or initiates requisitions for supplies and spare parts, and follows up these requisitions at the depots when necessary. The supply section of headquarters company is the base of supplies for the three letter companies.

	1	2	3	4	5	6	7	8	9	10	11	12	13
			Battalion headquarters		Headquarters company								
					Company headquarters								
1	Unit	Technician grade	Division ordnance officer's section	Headquarters section	Headquarters section	Maintenance section	Administrative, mess and supply section	Supply section	Service and salvage section	Inspection section	Total headquarters company	Total headquarters and headquarters company	Enlisted cadre
2	Lieutenant colonel		[a][e]1									1	
3	Major		[b][e]1	[d][e]3								4	
4	Captain		[e]1	[f]3	1						1	5	
5	First lieutenant			[g]5		[h]1		1			2	7	
6	Second lieutenant								1	1	2	2	
7	Total commissioned		3	11	1	1		1	1	1	5	19	
8	Warrant officer			[i]1				[i]1	[j]1		2	3	
9	Master sergeant, including		1	2						1	1	4	4
10	Chief clerk (052)		(1)									(1)	(1)
11	Master mechanic (342)									(1)	(1)	(1)	(1)
12	Motor (813)			(1)								(1)	(1)
13	Sergeant major (584)			(1)								(1)	(1)
14	First sergeant (585)						1				1	1	1
15	Technical sergeant, including		1	4				2	1	4	7	12	10
16	Ammunition (505)		(1)									(1)	(1)
17	Armorer (511)									(1)	(1)	(1)	(1)
18	Communication chief (542)			(1)								(1)	(1)
19	Foreman, automobile shop (337)									(1)	(1)	(1)	(1)
20	Foreman, machine shop (086)								(1)		(1)	(1)	(1)
21	Mechanic, artillery (913)									(1)	(1)	(1)	(1)
22	Operations and intelligence (814)			(1)								(1)	(1)
23	Personnel (816)			(1)								(1)	(1)
24	Repairman, instrument (922)									(1)	(1)	(1)	(1)
25	Supply (821)			(1)				(2)			(2)	(3)	(1)
26	Staff sergeant, including		1	1		1	2	3		6	12	14	10
27	Armorer (511)									(1)	(1)	(1)	(1)
28	Clerk, requisition (821)							(1)			(1)	(1)	(1)
29	Clerk, stock (324)							(1)			(1)	(1)	(1)
30	Clerk, stock record (323)							(1)			(1)	(1)	(1)
31	Mechanic, artillery (913)									(([k]1)2)	(2)	(2)	(1)
32	Mechanic, tank chassis (905)									([l]1)	(1)	(1)	
33	Mechanic, tank engine (909)									(1)	(1)	(1)	(1)
34	Mess (824)						(1)				(1)	(1)	(1)
35	Motor (813)					(1)					(1)	(1)	(1)
36	Repairman, instrument (922)									(1)	(1)	(1)	(1)
37	Statistical (212)		(1)									(1)	
38	Supply (821)						(1)				(1)	(1)	(1)
39	Supply, assistant (821)			(1)								(1)	
40	Sergeant, including		1	1						1	1	3	1
41	Ammunition, assistant (505)		(1)									(1)	
42	Armorer (511)									([k]1)	(1)	(1)	
43	Message center chief (674)			(1)								(1)	(1)
44	Corporal, including		1				1				1	2	1
45	Clerk, company (405)						(1)				(1)	(1)	(1)
46	Clerk, file (355)			(1)								(1)	
47	Technician, grade 3 (including)											1	1
48	Technician, grade 4 (including)											26	10
49	Technician, grade 5 (including)		6	15	3	6	19	42	15	1	86	36	4
50	Private, first class (including)											16	
51	Private (including)											24	
52	Armorer-artificer (511)	5				(1)					(1)	(1)	
53	Blacksmith (024)	5							(1)		(1)	(1)	
54	Clerk, code (806)	5		(1)								(1)	
55	Clerk, general (055)	4	(1)	(1)								(2)	(1)
56	Clerk, general (055)	5	(1)	([h]1)								(2)	
57	Clerk, general (055)		(([l]1)([m]1)[o]2)							([h]1)	(1)	(3)	
58	Clerk, parts (348)	4						(6)			(6)	(6)	(1)
59	Clerk, parts (348)	5						([t]6)			(6)	(6)	
60	Clerk, parts (348)							([t]12)			(12)	(12)	
61	Clerk, personnel (368)	4		(1)								(1)	(1)
62	Clerk, stock (324)	4						(3)			(3)	(3)	(1)
63	Clerk, stock (324)	5						(([t]2)3)			(3)	(3)	
64	Clerk, stock (324)							([t]6)			(6)	(6)	
65	Clerk, stock record (323)	4						(1)			(1)	(1)	
66	Clerk, stock record (323)	5						(1)			(1)	(1)	
67	Clerk, stock record (323)							(3)			(3)	(3)	
68	Clerk, typist (405)	5	(1)	([m]1)								(2)	(1)
69	Clerk, typist (405)		([k]1)					(1)			(1)	(2)	
70	Clerk, work order (457)	4							(1)		(1)	(1)	
71	Cook (060)	4					([n]1)(2)				(2)	(2)	(2)
72	Cook (060)	5					(2)				(2)	(2)	(2)
73	Cook's helper (521)						(1)				(1)	(1)	
74	Driver, half-track (734)	5		([o]1)								(1)	
75	Driver, truck, light (345)	5		([p]2)	([q]1)		([r]1)				(2)	(2)	
76	Driver, truck, light (345)											(2)	
77	Leather and canvas worker (609)	5							(1)		(1)	(1)	
78	Machinist (114)	3							(1)		(1)	(1)	(1)
79	Machinist (114)	4							(2)		(2)	(2)	(1)
80	Machinist (114)	5							([t]2)		(2)	(2)	
81	Machinist (114)								([t]1)		(1)	(1)	
82	Mechanic, automobile (014)	4				(2)					(2)	(2)	(1)
83	Mechanic, automobile (014)	5				([h]1)([m]1)([o]2)					(2)	(2)	
84	Messenger (675)	5		([h]1)								(1)	
85	Messenger (675)			([h]1)								(1)	

14 Remarks

†Insert number of battalion.

Staff

[a] Division ordnance officer.
[b] Division ordnance supply officer.
[d] 1 executive; 1 division spare parts officer; 1 shop officer.
[e] Division munitions officer.
[f] 1 S-2 and S-3; 1 S-4; 1 motor officer.
[g] 1 S-1 and adjutant; 1 communication officer; 3 liaison officers.
[a] Armed with carbine, cal. .30, unless otherwise indicated.
[h] Company motor officer.
[i] Supply, general.
[j] Munitions, armament machinist.
[k] Drives truck, ¼-ton.
[l] Drives truck, 2½-ton.
[m] Drives truck, ¾-ton.
[n] For officers' mess.
[o] Mounted on truck, 2½ ton.
[p] Armed with pistol, automatic, cal. .45.
[q] Mounted on half-track.
[r] 1 mounted on truck, 2½-ton; 1 mounted on truck, heavy wrecker.
[s] Armed with gun, submachine, cal. .45.
[t] Carried in truck, 2½-ton.
[u] Carried in half-track.
[v] 1 carried in truck, 2½-ton; 1 carried in truck, heavy wrecker.
[w] Carries second echelon tool set No. 1.
Driver(s), kitchen truck(s), also cook's helper.
For specification serial numbers shown in parentheses, see AR615-26.

Figure 14C. T/O & E 9-66 Headquarters and Headquarters Company Ordnance Maintenance Battalion, Armored Division, 15 Sept. 1943.

The spare parts major sees that records of stocks and expenditures and reports are kept up to date. It is through him all technical publications are ordered and delivered. He determines and recommends to the division ordnance officer such priorities, stock levels, or new depot locations as he deems advisable. A first lieutenant assistant is necessary because of the widely dispersed, varied nature of supply work.

No matter what type of supply system you are forced to use (corps, army, or base) it will be slow if you don't have a continuous follow up and liaison with the issuing agencies with which you are doing business. This is the job of the division spare parts major, with possibly the help of the lieutenant-colonel on occasion. Many officers in rear supply installations don't realize the armored division has such an enormous amount of materiel and what wear and tear this materiel is subjected to. When your requisitions are cut down, don't gripe. Liaison and follow up will show the depot the why and wherefore.

As said before, the salvage section of headquarters company works in close harmony with the division spare parts platoon. The major sets the priorities on salvageable items, controls cannibalization, and collects, stores, and reissues such parts. Also, he evacuates the totally salvageable items or assemblies.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
		Unit	Technician grade	Battalion headquarters		Headquarters company							Total headquarters and headquarters company	Enlisted cadre	Remarks
						Company headquarters									
				Division ordnance officer's section	Headquarters section	Headquarters section	Maintenance section	Administrative, mess and supply section	Supply section	Service and salvage section	Inspection section	Total headquarters company			
		Private—Continued.													
86		Operator, radio (776)	4		(4)	(2)						(2)	(2)	(1)	
87		Operator, radio (776)	5										(4)		
88		Operator, wrecker (529)	5							(*2)		(2)	(2)		
89		Repairman, radio (648)	4				(1)					(1)	(1)		
90		Stenographer (213)	5		(1)								(1)	(1)	
91		Toolmaker (241)	4							(1 *1)		(1)	(1)		
92		Welder, combination (256)	4							(2)		(2)	(2)	(1)	
93		Welder, combination (256)	5							(1 *1)		(1)	(1)		
94		Basic (521)						(13)				(13)	(13)		
95		Total enlisted		11	23	3	7	23	37	16	13	100	143	42	
96		Aggregate		14	35	4	8	23	39	18	14	116	* 165	42	
97	O	Carbine, cal. .30		9	25	3	6	22	23	11	10	75	109		
98	O	Carrier, personnel, half-track, M3A1,/armament.			1								1		
99	O	Gun, machine, cal. .30, light, flexible			*1				*6	*2	*1	9	10		
100	O	Gun, machine, HB, cal. .50, flexible			*1			*1	*7	*2		10	11		
101	O	Gun, submachine, cal. .45		3	7	1	2	1	26	7	4	41	51		
102	O	Launcher, rocket, AT, 2.36-inch		*1	*1				*7	*2		9	11		
103	O	Pistol, automatic, cal. .45		2	3								5		
104	O	Trailer, 1-ton		1	1			1	26		1	28	30		
105	O	Truck, ¼-ton		1	3		1				3	4	8		
106	O	Truck, ¾-ton, command		1	1	1						1	3		
107	O	Truck, ¾-ton, weapons carrier					*1					1	1		
108	O	Truck, 2½-ton, cargo, including		1	2			1	26		1	28	31		
109		Fuel and lubricant							(4)			(4)	(4)		
110		Kitchen						(1)				(1)	(1)		
111		Personnel and equipment		(1)	(2)						(1)	(1)	(4)		
112		Rations							(1)			(1)	(1)		
113		Spare parts							(20)			(20)	(20)		
114		Water							(1)			(1)	(1)		
115	O	Truck, 2½-ton, machine shop (Load A)								1		1	1		
116	O	Truck, 2½-ton, machine shop (Load C)								1		1	1		
117	O	Truck, 2½-ton, machine shop (Load D)								1		1	1		
118	O	Truck, 2½-ton, machine shop (Load F)								1		1	1		
119	O	Truck, 2½-ton, welding								1		1	1		
120	O	Truck, heavy wrecker								2		2	2		

Figure 14C Continued. T/O & E 9-66 Headquarters and Headquarters Company Ordnance, Maintenance Battalion, Armored Division, 15 Sept. 1943.

The *Battalion Shop Officer* (major) is the coordinator of all the battalion shops. He may inspect and allocate incoming work using the inspection section of headquarters company to determine routing and priorities where necessary. This inspection section of headquarters company when not employed on an inspection of the division, can be used to inspect the work in the letter companies, organic equipment of headquarters company, or to check or/and install modifications on newly issued equipment under the supervision of the battalion shop officer. He keeps a constant check on the status of work in the battalion shops to see that it is up to the standard necessary. He is in immediate contact with needs, status, and capabilities of the company shops. The necessary work status records and required reports are the battalion shop officer's responsibility. The inspection system of all companies must be standardized and efficient. This is the responsibility of the battalion shop officer. He is interested in the number of deadlined vehicles undergoing repair in the battalion shops. He wants to know why each vehicle or gun is deadlined, for how long, and disposition (whether it is going to be repaired, evacuated or salvaged). The dream of the shop officer is to be able to clean all deadlined vehicles out of the shops. The daily deadline and status of work report from the companies go to the battalion shop officer who consolidates them for the division ordnance officer. One of the big phases of a battalion shop officer's job is in modifications. He must be up to date and have first hand knowledge of all FSMWO's, and other modifications. With the inspection section, he determines what modifications are necessary on the newly issued equipment as well as equipment on hand in the division. In this sense, he must be the latest word in technical information. The battalion shop officer is the technical advisor to the division ordnance officer.

The battalion shop officer sees that all new equipment issued to the division is inspected properly before the division ordnance supply major issues it to the using units. Also he is in charge of all technical inspections of various units of the division, and thereby can help anticipate maintenance needs of the division before those problems reach the maintenance battalion shops.

The battalion shop officer frequently makes recommendations to the executive officer or lieutenant-colonel on the location of new shop sites. If the major keeps track of all contact parties and maintenance detachments, he can know when, where, and whom to contact to get a job done. The shop officer usually acts without going through the executive officer but he should keep the executive and the lieutenant-colonel informed of conditions.

There is a possibility (and there have been examples of this) that the battalion motor officer (captain) and his master sergeant will be used to aid the battalion shop officer in the battalion shops and in allocating headquarter company's motor vehicle third echelon work.

The *Battalion S-4* (captain) transmits, consolidates or initiates requisitions for strictly battalion supplies. He consolidates requests from company supply and motor officers and forwards all requisitions to the division spare parts office, to the division ordnance supply office, to division quartermaster, or to other appropriate issuing agencies. He then issues all items coming into the maintenance battalion. The post exchange in the field is normally a function of this officer. Daily ration reports from the companies are consolidated here. The battalion S-4 office is the requisitioning and issuing agency for all quartermaster supplies of the maintenance battalion.

The *Captain who is S2-S3* is directly in charge of the battalion intelligence, plans, and training. He keeps the tactical situation map, initiates and supervises plans for all movements, and training activities, and keeps the operations maps. Under the executive officer, he plans battalion operations.

The *Reconnaissance and Communication Officer* works with the S2-S3. He organizes the message center at battalion headquarters and trains signal personnel. He is the billeting officer and leads the advance party in the selection and preparation of new bivouac areas when so directed by the executive officer. He is responsible for seeing that the battalion is guided into the new area safely, and that proper communications, road guides, signs, and liaison are set up.

The *Battalion Motor Officer* (captain), as said before, may assist the battalion shop officer. Primarily, his function is operation, maintenance, and control of all battalion vehicles and the motor vehicle records. The battalion motor officer is responsible for the organic transportation of the battalion and also the loading plan for this transportation. If any company needs extra trucks or loading space the company CO calls on the battalion motor officer for it.

The *three liaison lieutenants* are more important than their ranks show. Their job is to keep contact with the units of the division. In the field they spend most of their time at the respective combat or reserve command headquarters. It is believed from experience that these liaison officers work best for the battalion shop officer. They spend about half of their time with their combat command headquarters and half their time with the battalion shop officer. Their job is to find out what is needed in their combat commands. Look for work. Anticipate maintenance needs. They call back to maintenance battalions headquarters for repair crews and equipment when jobs come up. They are expected to be able to judge what tools and parts are needed for certain jobs. It has been found best if these liaison officers each have a technical man with them. Many technical questions can be answered on the spot. These officers also keep the maintenance battalion headquarters informed on the tactical situation.

This T/O (Sept 1943) has done away with a *dental officer*. However there are still several armored divisions with one *medical officer* and one dental officer. One division has one medical officer and one medical administration officer and no dentist. The medical detachment is always with battalion headquarters and common practice is to put a detachment of 2 to 5 men in the letter companies when on tactical missions with their combat commands and separated from the battalion.

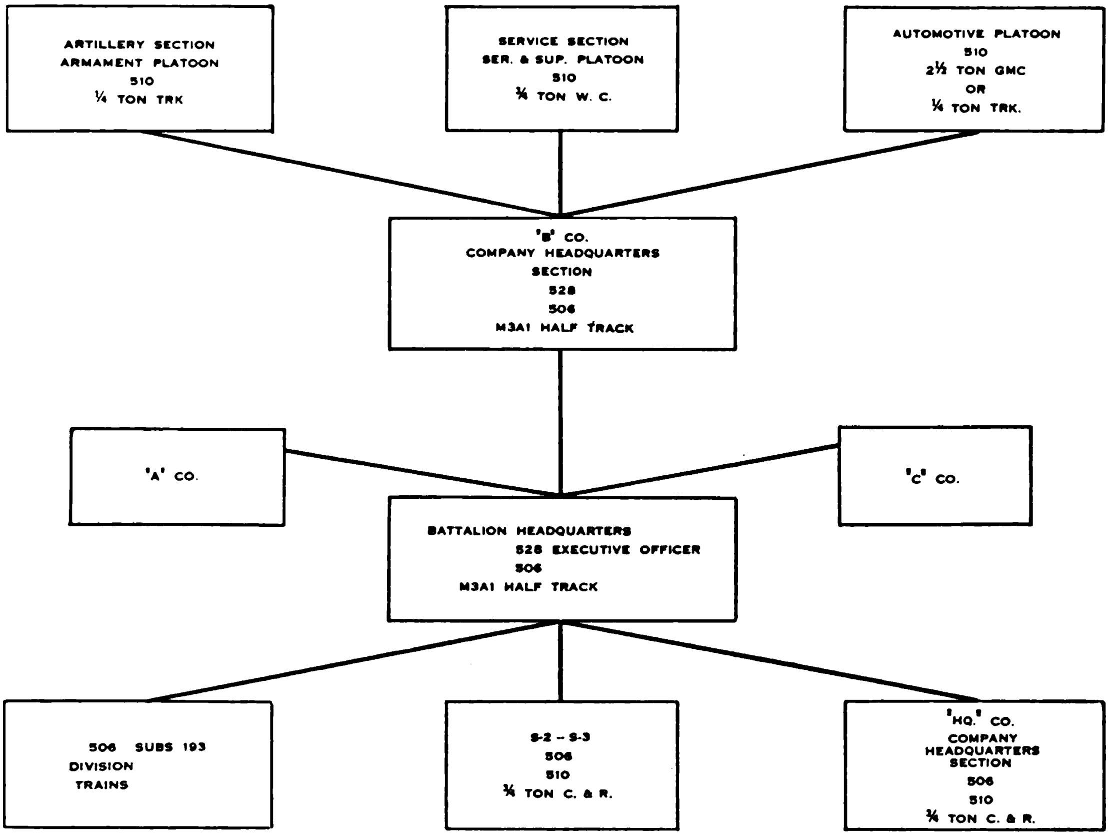


Figure 15. Radio Net, Ordnance Maintenance Battalion, Armored Division.

Communication. The means of communication within the maintenance battalion are visual signals, radio, and mounted messengers. Occasionally wire communication will be available. Time rather than space governs the choice between the use of mounted messengers and radio. Mounted messengers are preferred where distances are short, as this assists in clearing the air for vital long-distance traffic.

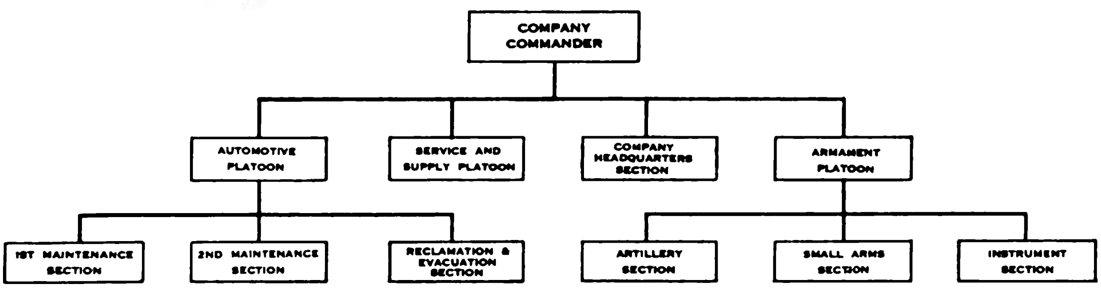


Figure 16A. Organization of the Maintenance Company in an Ordnance Maintenance Battalion of the Armored Division.

The battalion radio net includes the battalion commander, the executive, the commanding officer of headquarters company, and commanding officers of the maintenance companies and of maintenance platoons of the maintenance companies. The net is coordinated with the division and trains command nets by the reconnaissance and the communications officer of the battalion.

Normally it could be assumed that either the executive officer or the S3 could be in the battalion headquarters half-track. Usually on any movement, the executive officer will ride there and the S2-S3 as shown in Radio Net Chart, figure 15.

The 506 is the more powerful longer range radio and is used to tie the battalions or companies in on the division administrative net. This set is a substitute for the SCR 193. The 510 radios are used for the company nets and the 528 for battalion net.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
			Company headquarters			Service and supply platoon		Automotive platoon			Armament platoon					
1	Unit	Technician grade	Headquarters section	Maintenance section	Administrative, mess and supply section	Service section	Supply section	Platoon headquarters	2 maintenance sections (each)	Reclamation and evacuation section	Artillery section	Small arms section	Instrument section	Total	Enlisted cadre	Remarks
2	Captain	...	1											1	...	
3	First lieutenant			• 1			1	1			1			1	...	
4	Second lieutenant							1				1		2	...	
5	Total commissioned	...	1	1	...		1	2			1	1		7	...	
6	Warrant officer					• 1								1	...	
7	Master sergeant, including	...	1											1	1	
8	Master mechanic (342)	...	(1)											(1)	(1)	
9	First sergeant (585)				1									1	1	
10	Technical sergeant, including						1	1	1	1	1		1	7	7	
11	Chief artillery mechanic (913)										(1)			(1)	(1)	
12	Chief instrument repairman (922)												(1)	(1)	(1)	
13	Foreman, automobile shop (237)							(d • 1)	(1)	(1)				(4)	(4)	
14	Supply (821)						(1)							(1)	(1)	
15	Staff sergeant, including			1	2	1			1	1	1	1		9	7	
16	Chief armorer (511)											(1)		(1)	(1)	
17	Chief artillery mechanic, assistant (913)										(1)			(1)	(1)	
18	Foreman, automobile shop, assistant (237)								(1)					(2)	...	
19	Foreman, machine shop (086)	...			...	(1)								(1)	(1)	
20	Inspector, motor (413)									(1)				(1)	(1)	
21	Mess (821)				(1)									(1)	(1)	
22	Motor (813)			(1)										(1)	(1)	
23	Supply (821)				(1)									(1)	(1)	
24	Sergeant, including						1	1				1		3	2	
25	Chief Armorer, assistant (511)											(1)		(1)	...	
26	Clerk, stock record, (323)						(1)							(1)	(1)	
27	Decontaminating (809)							(1)						(1)	(1)	
28	Corporal, including				1									1		
29	Clerk, company (405)				(1)									(1)	(1)	
30	Technician, grade 3													11	7	
31	Technician, grade 4													42	8	
32	Technician, grade 5 (30–34 including)	...	5	3	24	10	9	34	16	18	15	9	10	64	2	
33	Private, first class													18	...	
34	Private													34	...	
35	Armorer (511)	4								(2)		(2)	...	(4)	(1)	
36	Armorer (511)	5										(4)		(4)		
37	Armorer (511)											((d • 1) (• • 1) 3)		(3)		
38	Blacksmith (024)	5				(1)								(1)		
39	Carpenter (050)	5				(1)								(1)		
40	Clerk, parts (348)	4					(1)							(1)	(1)	
41	Clerk, parts (348)	5					(• • 1)							(1)		
42	Clerk, parts (349)						(• • 2)							(2)		
43	Clerk, stock (324)	4					(• • 1)							(1)		
44	Clerk, stock (324)	5					(• • 1)							(1)		
45	Clerk, stock (324)						(• • 1)							(1)		
46	Clerk, stock record (323)	...					(1)							(1)	...	
47	Clerk, typist (405)						(1)							(1)		
48	Clerk, work order (457)	4				(1)								(1)	(1)	
49	Cook (060)	4			(2)									(2)	(2)	
50	Cook (060)	5			(2)									(2)	(2)	
51	Cook's helper (521)				(2)									(2)	...	
52	Driver, half-track (734)	5	(• 1)											(1)	...	
53	Driver, truck, light (345)	5			(• 1)									(1)	...	
54	Electrician (078)	5				(f • 1)								(1)	...	
55	Electrician, storage battery (215)	5						(• • 1)						(1)	...	
56	Electrician, tank and automobile (912)	3						(1)						(1)	(1)	
57	Electrician, tank and automobile (912)	4						(• • 1)						(1)	...	
58	Inspector, motor (413)	3								(1)				(1)	...	
59	Inspector, motor (413)	4								(1)				(1)	(1)	
60	Leather and canvas worker (609)	5				(1)								(1)	...	
61	Machinist (114)	4				(1)								(1)	...	
62	Machinist (114)	5				(• • 1)								(1)	...	
63	Machinist (114)					(1)								(1)	...	
64	Mechanic, artillery (913)	3									(2)			(2)	(1)	
65	Mechanic, artillery (913)	4								(2)	(2)			(4)	...	
66	Mechanic, artillery (913)	5									(1)			(7)	...	
67	Mechanic, artillery (913)										((d • 1) (• • 2) 4)			(4)	...	
68	Mechanic, automobile (014)	4		(1)										(1)	...	
69	Mechanic, automobile (014)	5		((f • 1) 2)										(2)	...	

Remarks (column 16):
† Insert letter of company.
‡ Insert number of battalion.
a Company motor officer and executive.
b Munitions, armament, machinist.
c Armed with carbine, cal. 30 unless otherwise indicated.
d Drives truck ¼-ton.
e Drives truck 2½-ton.
f Drives truck ¾-ton.
g Drives truck trailer, 40-ton.
h Drives truck 4-ton.
i Mounted on half-track.
j Mounted on trucks, 2½-ton (heavier.
k Carried in trucks, 2½-ton.
l Carries 2d echelon tool set No. 1.
m Carries apparatus, decontaminating.
n Armed with gun, submachine, cal. .45.
Driver(s) kitchen truck(s), also cook's helper.
For specification serial numbers shown in parentheses, see AR 615-

Figure 16B. T/O & E 9-67 Maintenance Company, Ordnance Maintenance Battalion, Armored Division, 15 Sept. 1943.

The *captain in command of the headquarters* company personnel (headquarters company commandant) is responsible for the administration, mess, and supply of the headquarters and headquarters company. It is his duty to see that the battalion staff is able to function efficiently; orderlies, tentage details, battalion officers mess, post exchange, and transportation are a few of these necessary details.

The service and salvage section and inspection section of headquarters company are both under direct supervision of lieutenants. While company officers of headquarters company, their work is largely for the battalion. As described be-

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
			Company headquarters			Service and supply platoon		Automotive platoon			Armament platoon					
	Unit	Technician grade	Headquarters section	Maintenance section	Administrative, mess and supply section	Service section	Supply section	Platoon headquarters	2 maintenance sections (each)	Reclamation and evacuation section	Artillery section	Small arms section	Instrument section	Total	Enlisted cadre	Remarks
70	Mechanic, chassis, automobile and half-track (906)	3						(1)						(1)		
71	Mechanic, chassis, automobile and half-track (906)	4						(1)						(1)		
72	Mechanic, chassis, tank (908)	3						(1)						(1)	(1)	
73	Mechanic, chassis, tank (908)	4						(1)						(1)		
74	Mechanic, engine, automobile and half-track (905)	3						(1)						(1)		
75	Mechanic, engine, automobile and half-track (905)	4						(1)						(1)		
76	Mechanic, engine, tank (909)	3						(1)						(1)	(1)	
77	Mechanic, engine, tank (909)	4						(1)						(1)		
78	Mechanic, fuel induction (926)	3						(1)						(1)	(1)	
79	Mechanic, fuel induction (926)	4						(1)						(1)		
80	Mechanic, general, automobile and half-track (965)	4						(1)	(2)					(5)		
81	Mechanic, general, automobile and half-track (965)	5						((a2)10)	(2)	(2)				(16)		
82	Mechanic, general, automobile and half-track (965)							(a1)	((a1)4)					(9)		
83	Mechanic, general, tank (966)	4							(2)					(4)		
84	Mechanic, general, tank (966)	5							(2)	((a3)4)				(8)		
85	Mechanic, general, tank (966)								((a1)4)					(8)		
86	Mechanic, turret (907)	3						(1)						(1)	(1)	
87	Mechanic, turret (907)	4						(1)						(1)		
88	Messenger (675)		((d1)2)											(2)		
89	Operator, decontaminating equipment (809)	5						(b1)						(1)		
90	Operator, radio (776)	4	(1)											(1)	(1)	
91	Operator, radio (776)	5	(1)											(1)		
92	Operator, wrecker (529)	5						(a1)		(a2)				(3)		
93	Repairman, automobile body (040)	4						(1)						(1)		
94	Repairman, automobile body (040)	5						(1)						(1)		
95	Repairman, instrument (922)	3											(1)	(1)	(1)	
96	Repairman, instrument (922)	4								(2)			(1)	(3)		
97	Repairman, instrument (922)	5											(5)	(5)		
98	Repairman, instrument (922)												(e1)	(1)		
99	Repairman, radiator (172)	4						(1)						(1)		
100	Repairman, radiator (172)	5						(1)						(1)		
101	Watchmaker (381)	4											(d1)	(1)		
102	Welder, combination (256)	4				(1)		(1)		(1)				(3)	(1)	
103	Welder, combination (256)	5				(c1)				(c1)				(2)		
104	Basic (521)				(17)									(17)		
105	Total enlisted		6	4	28	11	11	36	18	20	17	11	11	191	36	
106	Aggregate		7	5	28	12	12	38	18	20	18	12	11	*199	36	
107	O Carbine, cal. .30		5	4	27	9	6	30	16	14	15	10	9	161		
108	O Carrier, personnel, half-track, M3A1, w/o armament		1											1		
109	O Gun, machine, cal. .30, light, flexible		j1				j1	j2		j2				6		
110	O Gun, machine, HB, cal. .50, flexible					j1	i1	i1	j1	i4				9		
111	O Gun, submachine, cal. .45		2	1	1	3	6	8	2	6	3	2	2	38		
112	O Launcher, rocket, AT, 2.36-inch					k1	k2	k2		k2	k1			8		
113	O Trailer, 1-ton				1		6	1	1	1	1			12		
114	O Truck, ¼-ton		1					1			1	1	1	5		
115	O Truck, ¾-ton, weapons carrier			l1		1		1	1					5		
116	O Truck, 2½-ton, artillery repair										1			1		
117	O Truck, 2½-ton, automotive repair (Load A)							1						1		
118	O Truck, 2½-ton, automotive repair (Load B)							1						1		
119	O Truck, 2½-ton, cargo, including				1		6	1	1	1	1			12		
120	Kitchen				(1)									(1)		
121	Personnel and equipment							(1)	(1)	(1)	(1)			(5)		
122	Spare parts						(6)							(6)		
123	O Truck, 2½-ton, electric repair							1						1		
124	O Truck, 2½-ton, instrument repair												1	1		
125	O Truck, 2½-ton, machine shop (Load A)					1								1		
126	O Truck, 2½-ton, small arms repair											1		1		
127	O Truck, 2½-ton, welding					1								1		
128	O Truck, 4-ton, cargo							m1						1		
129	O Truck, heavy wrecker							1		2				3		
130	O Truck, trailer, 40-ton, tank recovery									3				3		

Figure 16B Continued. T/O & E 9-67 Maintenance Company, Ordnance Maintenance Battalion, Armored Division, 15 Sept. 1943.

fore, the inspection section works largely for the battalion shop officer. The machine shop and the salvage section also may work in connection with division spare parts platoon.

In the letter companies, A, B, and C, of the maintenance battalion the *company commander* (captain) is responsible for the training, administration, and discipline of his company. His duties embrace every activity of his command. His second-in-command (1st lieutenant) is also the company motor officer. The preparation of training schedules is a major administrative duty of the executive officer. The company commander usually rotates the duty of mess officer among his lieutenants to familiarize the junior officers with this phase of administration. The company commander signs for all property issued to his company. He details a company supply officer but he is still the responsible officer. All corrections, admonitions, reprimands and punishments should be made by the company commander. Company officers are delegated duties as shown on figure 16a.

The master mechanic, a master sergeant, is one of the most important noncommissioned officers in the company. The captain is usually the shop officer of the company shops. His master mechanic is his right hand man. Of course, the various lieutenants control their sections but the master mechanic coordinates shop work. He must work very closely with the first sergeant on company details, fatigue, guard, etc. Here, as in headquarters company, there is close cooperation between the reclamation and salvage section and the spare parts supply section.

LIGHT MAINTENANCE COMPANY

Mission. The mission of the light maintenance company is to procure and issue all ordnance materiel for the division, except ammunition and to perform 3rd echelon maintenance for ordnance equipment within the division. It also instructs and supervises in all 1st and 2nd echelon functions.

Capabilities. Capabilities are governed by the experience and qualification of each officer and enlisted man to fulfill his assigned task. Tools and special equipment can count for a company's capabilities if men are available to use them properly. A company is equipped to perform maintenance on small arms, artillery weapons, and general purpose vehicles.

The *Small Arms Section* should be able to do most of the division maintenance on all small arms. The reason is that as all infantry replacements come forward with weapons, weapons picked up from casualties are returned to ordnance companies for inspection and reissue. This procedure builds up a stock which enables the supply section to evacuate to the depot small arms which are in operating condition.

The *Artillery Section* is the section whose functions are governed by tools and equipment available to do the job. Minor repairs are made by this section, but most of the major jobs are evacuated to a higher echelon.

The *Automotive Section* is the largest of all sections in the company. This section handles all maintenance of general purpose vehicles as well as the recovery of all ordnance materiel. This section's capabilities are governed by the personnel's qualifications, and the time and tools available for the assigned task. The automotive section should be able to do 80 per cent of the division maintenance on general purpose vehicles.

The *Supply Section* is capable of procuring and issuing all major items and component parts used by the division. It also can carry a five-day supply of spare parts and a pool of vehicles, guns, and other major items. The amount of each item in the pool is governed by the mortality of the item.

Duties of Officers and Key Enlisted Men. *Company Commander* duties are the same as any company commander as far as administrative and training details are concerned. He will have to coordinate the work of his officers and their respective platoons. The C.O. is assisted by a W.O., who does most of the administrative work. The W.O. has several duties in the company; they are (1) company supply and mess officer, (2) administrative officer, (3) special service officer. He is assisted by the 1st sgt., supply sgt., mess sgt., and the company clerks.

Artillery Officer commands the artillery platoon in the company. The artillery platoon has the small arms section incorporated in it. This officer is responsible for maintenance on all artillery and small arms. It is advised that he take an active part in the procurement of major items and spare parts for artillery and small arms. He is assisted by a technical sergeant and a staff sergeant.

Automotive Officer commands the automotive platoon which has the recovery section in it. He is assisted by two officers, one being designated as recovery

	1	2	3	4	5	6	7	8	9	10	11
						Armament platoon					
1	Unit	Technician grade	Division ordnance officer's section	Company headquarters	Supply platoon	Artillery section	Small arms section	Automotive platoon	Total company	Enlisted cadre	Remarks
2	Lieutenant colonel		[a][b] 1						1		† Insert number of company. [a] Division ordnance officer. [b] Officer, enlisted men and recovery vehicles are provided to evacuate disabled vehicles and armament which cannot be moved in the normal manner. [c] Armed with carbine, cal. .30 unless otherwise indicated. [d] Supply. General (unit supply and administrative officer). [e] Also drives truck. [f] Also acts as orderly. [g] Also acts as parts clerks. [h] Carry third echelon tool set No. 1. [i] Drivers of these trucks to be armed with gun, submachine, cal. .45. [j] Armed with pistol, automatic, cal. .45. [k] Armed with rifle, cal .30, M1903. [l] Armed with gun, submachine, cal. .45. *Assignment:* Organic with infantry division; a mobile unit. *Function:* To perform such 3d echelon maintenance on small arms, artillery matériel, and automotive vehicles as situation permits. Also performs function of ordnance supply, except ammunition, for the division. *Capacity:* 30 percent to 60 percent of 3d echelon maintenance for the division. For specification serial numbers shown in parentheses, see AR 615-26.
3	Major		[b] 1						1		
4	Captain		1	1					2		
5	First lieutenant				1	1		1	3		
6	Second lieutenant							([b] 1) 2	2		
7	Total commissioned		3	1	1	1		3	9		
8	Warrant officer			[d] 1					1		
9	Master sergeant, including		1						1	1	
10	Chief clerk (052)		(1)						(1)	(1)	
11	First sergeant (585)			1					1	1	
12	Technical sergeant, including		1		1	1		1	4	4	
13	Chief mechanic (337)							(1)	(1)	(1)	
14	Clerk, statistical (212)		(1)						(1)	(1)	
15	Mechanic, artillery (913)					(1)			(1)	(1)	
16	Supply (821)				(1)				(1)	(1)	
17	Staff sergeant, including			3	1	1	1	2	8	1	
18	Armorer (511)						(1)		(1)		
19	Crew chief (189)							(1)	(1)		
20	Foreman, auto repair shop (237)							(1)	(1)		
21	Mechanic, artillery (913)					(1)			(1)		
22	Mess (824)			(1)					(1)	(1)	
23	Motor (813)			(1)					(1)		
24	Supply (821)			(1)	(1)				(2)		
25	Sergeant, including				2			4	6		
26	Clerks, parts (348)				(2)				(2)		
27	Crew chief (189)							(4)	(4)		
28	Corporal, including			2					2	1	
29	Clerk, company (405)			(1)					(1)	(1)	
30	Dispatcher (410)			(1)					(1)		
31	Technician, grade 3 } including								6	4	
32	Technician, grade 4 } including								23	4	
33	Technician, grade 5 } including		9	21	20	11	4	80	44	1	
34	Private, first class } including								15		
35	Private } including								27		
36	Armorer (511)	4					(1)		(1)	(1)	
37	Armorer (511)	5					(([e] 1) 2)		(2)		
38	Armorer (511)						([e][f] 1)		(1)		
39	Blacksmith (024)	5						([e] 2)	(2)		
40	Carpenter, general (050)	5		(1)					(1)		
41	Clerk, general, (055)	4	(1)						(1)		
42	Clerk, general, (055)	5	([e] 2)						(2)		
43	Clerk, general, (055)		(3)						(3)		
44	Clerk, parts (348)	4			(2)				(2)		
45	Clerk, parts (348)	5			(2)				(2)		
46	Clerk, parts (348)				(4)				(4)		
47	Clerk, stock (324)	4			(1)				(1)		
48	Clerk, stock (324)				(1)				(1)		
49	Clerk, typist (405)	5			(1)				(1)		
50	Clerk, typist (405)				(1)				(1)		
51	Cook (060)	4		(2)					(2)	(1)	
52	Cook (060)	5		(1)					(1)	(1)	
53	Cook's helper (521)			(1)					(1)		
54	Driver, truck, heavy (245)	5						([e] 3)	(3)		
55	Driver, truck, light (345)	5	([f][e] 1)	([e] 1)	(([e] 2) ([f] 6)				(5)		
56	Driver, truck, light (345)		(([e] 2) 3)	(([f] 1) 2)	([e] 8)				(8)		
57	Electrician, automotive (912)	3						(1)	(1)	(1)	
58	Electrician, automotive (912)	4						(1)	(1)		
59	Electrician, automotive (912)	5						([h] 1)	(1)		
60	Electrician, automotive (912)							([e][f] 1)	(1)		
61	Electrician, storage battery (215)	5						(1)	(1)		
62	Inspector, motor (413)	4						(2)	(2)		
63	Machinist (114)	5				([f] 1)			(1)		
64	Mechanic, artillery (913)	3				(1)			(1)	(1)	
65	Mechanic, artillery (913)	4				(2)			(2)		
66	Mechanic, artillery (913)	5				(([e][f] 1) 3)			(3)		
67	Mechanic, artillery (913)					([e][e] 2)			(2)		
68	Mechanic, automobile (014)	3						(2)	(2)	(1)	
69	Mechanic, automobile (014)	4						(4)	(4)		
70	Mechanic, automobile (014)	5						(([h] 6) ([e] 3) 10)	(10)		
71	Mechanic, automobile (014)							(([e] 4) ([f] 2) 6)	(6)		
72	Mechanic, carburetor (926)	3						(1)	(1)	(1)	
73	Mechanic, carburetor (926)	4						(1)	(1)		
74	Mechanic, carburetor (926)	5						(1)	(1)		
75	Mechanic, carburetor (926)							(1)	(1)		
76	Mechanic, tank engine (909)	4						(1)	(1)	(1)	
77	Mechanic, tank engine (909)	5						(1)	(1)		
78	Painter (144)	5		(1)					(1)		
79	Repairman, automobile body (040)	4						(1)	(1)		
80	Repairman, automobile body (040)	5						(1)	(1)		

Figure 17a. T/O & E 9-8 Ordnance Light Maintenance Co., Inf. Div., 17 Nov. 1944.

officer. This platoon has a big job; and if it is done well, the officers and men will be kept busy. The automotive officer is responsible for all maintenance on general purpose vehicles and supervision of 1st and 2nd echelon maintenance in the division.

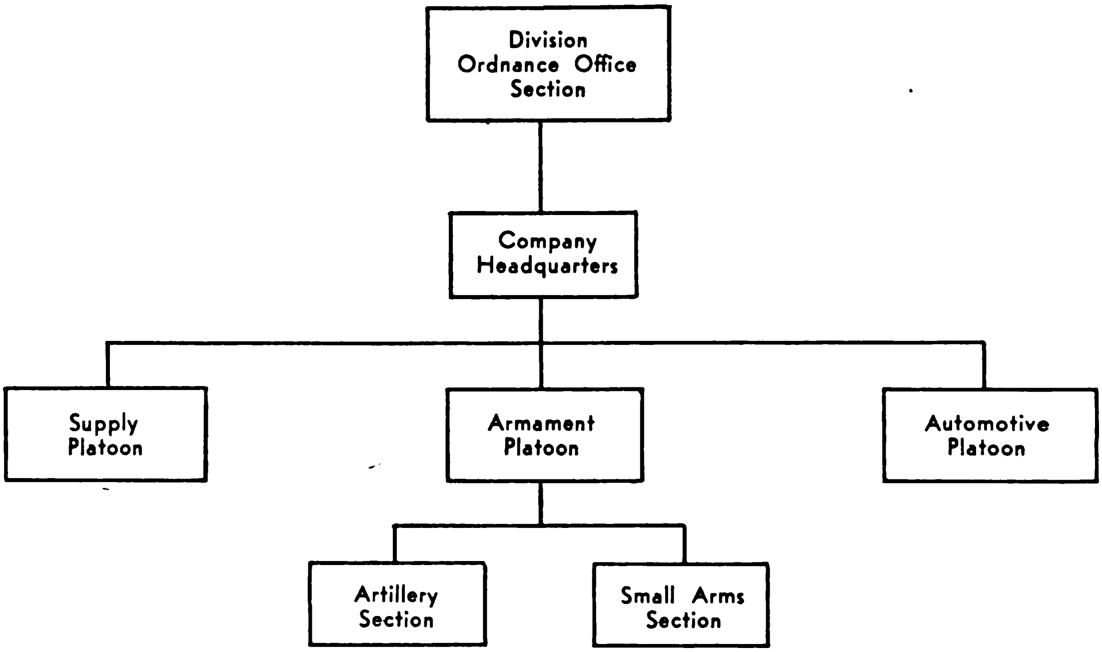


Figure 17b. Organization of a Light Maintenance Company.

Supply Officer commands the supply platoon. The platoon is responsible for the procurement, storage, and issue of all ordnance materiel and spare parts, except ammunition. This platoon issues supplies to all units of the division, which includes the maintenance platoons of the light maintenance company.

MEDIUM MAINTENANCE COMPANY

Mission. There are more medium maintenance companies organized than any other ordnance units. The company is organized and equipped to perform 3rd echelon maintenance of small arms, artillery, fire control equipment, general purpose vehicles, infantry division combat vehicles, and, when specially trained, tank destroyer equipment. It also performs resupply, evacuation, salvage, and inspection functions for the units it supports. This company is completely mobile and all necessary machine and hand tools are carried in shop trucks. Its mobility and diversified ability makes it suitable to follow combat elements closely and provide them with needed ordnance general supplies and maintenance.

Capabilities. The medium maintenance company is capable of performing all the 3rd echelon maintenance for an infantry division that cannot be handled by the divisional ordnance light maintenance company. The MM Co is capable of turning out 1,500 to 2,000 completed work orders in any month. Approximately 50 per cent of these work orders will be on automotive equipment and the remainder will be on armament equipment.

While working in the Italian Theater one MM Co turned out 500 work orders in a month. These work orders covered the replacement of accessories; the necessary welding, brazing, and forging of fenders, bodies, and frames; and the manufacture of necessary jigs, fixtures, and tools to perform the repairs. This same company turned out 800 work orders a month on armament materiel. These work orders covered replacement of disabled parts; adjustment of malfunctioning equipment; the manufacture of needed jigs, fixtures, and tools; and the necessary welding, brazing, and forging on small arms, artillery, and instrument materiel.

A MM Co will normally carry a basic load of supplies. With this basic load, it is able to provide needed ordnance supplies for the company and assist the divisional ordnance company in providing ordnance general supplies for the units supported. If additional supplies are needed, they are obtained by requisition from the nearest ordnance general supply depot.

Assignment. Every infantry division requires a MM Co. to support it. MM Co's are assigned to army and corps (see chapter 1, Vol. I) to provide 3rd echelon repairs. In addition to these routine duties, MM Co's are assigned to certain theaters or departments, such as Panama, Hawaii, and certain islands in the South and Southwest Pacific. Here they are required to perform all echelons of maintenance on all kinds and types of ordnance materiel, operate ordnance general supply establishments, and handle ammunition supply. When called upon to perform additional work, such as 4th echelon repair, the necessary equipment will be given the company.

Duties of Officers. The *Commanding Officer* of a MM Co. has the primary duty of supervising the operation and administration of the company. It will be necessary for him to provide vertical and horizontal liaison with troops supported, ordnance companies, and higher echelons of command.

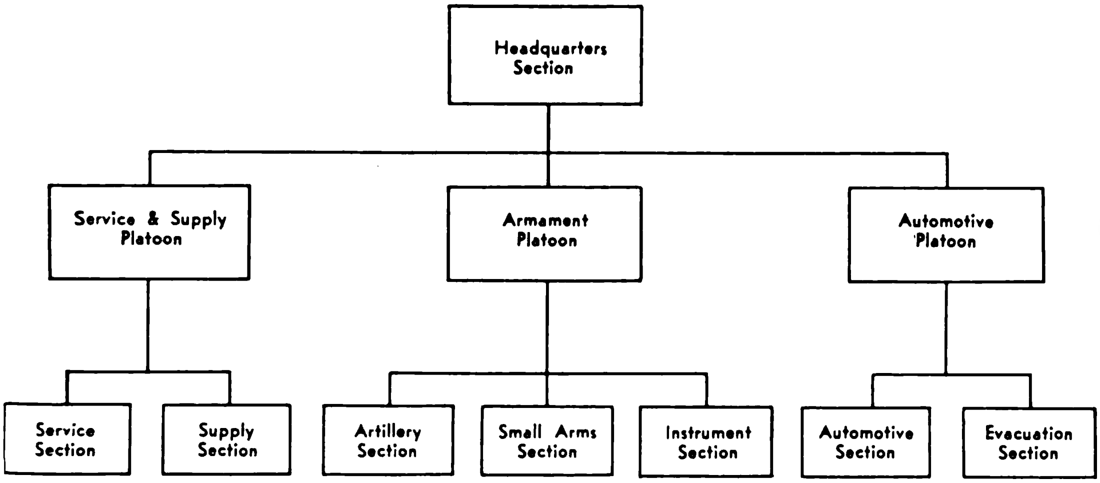


Figure 18a. Organization of a Medium Maintenance Company.

The *Shop Officer* will normally be the senior lieutenant in the company. He will have the primary duty of supervising the operation of the shop. An additional duty will be officer in charge of the automotive platoon. Since most work in the shop will be on automotive materiel, this choice of automotive officer as shop officer is natural.

The *Recovery Officer* will be in charge of the recovery section. He will supervise all recovery and evacuation work done by the company. In addition he will be assistant to the automotive officer. As such, he will aid and assist the automotive officer in his work in the automotive section, allowing this officer to spend the majority of his time in performing his primary duty as shop officer.

The *Artillery Officer* will be a lieutenant in the company. He will be in charge of the armament platoon and, as such, will supervise the operation of the artillery, small arms, and instrument repair sections of the shop.

The *Supply Officer* will be a lieutenant of the company. He will supervise the operation of the supply section and be responsible that an adequate supply of ordnance general supplies are on hand for issue to the shop and the using units.

The *Administrative Officer* will be a lieutenant of the company. He will be responsible for the supervision of the company mess, company supply, and all administrative details of the company. In addition he will be assistant to the C.O., which will allow the C.O. to spend his time performing his primary duty.

Duties of NCO's. A great deal of supervisory work in a MM Co. is done by the NCO's of the company. Naturally the best enlisted men in the company are chosen for these jobs. The *1st Sergeant* of the company handles all the minor details of administration. The *Mess Sergeant* is responsible for the mess, and the

	1	2	3	4	5	6	7
					Service and supply platoon		Armament platoon
1	Unit	Specification serial No.	Technician grade	Company headquarters	Service section	Supply section	Artillery section
2	Captain, including			1			
3	Company commander	4801		(1)			
4	First lieutenant, including				1		1
5	Artillery maintenance and repair	4808					(1)
6	Automotive maintenance and repair	4805					
7	Maintenance service	4813			(1)		
8	Second lieutenant, including			1			
9	Evacuation	4620					
10	Mess, supply and transportation	4113		(1)			
11	Total commissioned			2	1		1
12	Warrant officer, including					1	
13	Supply and administrative	4411				(1)	
14	Master sergeant, including			1			
15	Master mechanic	342		(1)			
16	First sergeant	585		1			
17	Technical sergeant, including					1	1
18	Foremen, auto repair shop	337					
19	Mechanic, artillery	913					(1)
20	Repairman, instrument	922					
21	Repairman, small arms	903					
22	Rigger	189					
23	Supply	821				(1)	
24	Staff sergeant, including			3	1		1
25	Foreman, auto repair shop	337					
26	Machinist	114			(1)		
27	Mechanic, artillery	913					(1)
28	Mess	824		(1)			
29	Motor	813		(1)			
30	Repairman, instrument	922					
31	Supply	821		(1)			
32	Sergeant, including					1	
33	Clerk, parts	348				(1)	
34	Mechanic, auto and half track	965					
35	Repairman, small arms	903					
36	Corporal, including			1			
37	Clerk, company	405		(1)			
38	Technician, grade 3						
39	Technician, grade 4						
40	Technician, grade 5 } including			21	12	11	12
41	Private, first class						
42	Private						
43	Blacksmith	024	5				
44	Carpenter	050	5		(1)		
45	Clerk, parts	348	4			(1)	
46	Clerk, parts	348	5			((a 1) 2)	
47	Clerk, parts	348				(b 4)	
48	Clerk, stock record	323	4			(b 1)	
49	Clerk, stock record	323	5			(c 1)	
50	Clerk, typist	405				(c 1)	
51	Cook	060	4	(2)			
52	Cook	060	5	(1)			
53	Cook's helper	521		(b 1)			
54	Driver, truck, light	345	5	(1)			
55	Driver, truck, light	345				(1)	
56	Electrician, automotive	912	3				
57	Electrician, automotive	912	4				

8	9	10	11	12	13
Armament platoon—Cont.		Automotive platoon			
Small arms section	Instrument section	Automotive section	Evacuation section	Total company	Enlisted cadre
				1	
				(1)	
		1		3	
				(1)	
				(1)	
		(1)		(1)	
				1	
			1	(1)	
			(1)	(1)	
		1	1	6	
				1	
				(1)	
				1	1
				(1)	
				1	1
1	1	1	1	6	6
		(1)		(1)	(1)
				(1)	(1)
	(1)			(1)	(1)
(1)				(1)	(1)
			(1)	(1)	(1)
				(1)	(1)
	1	2		8	2
		(2)		(2)	
				(1)	
				(1)	
				(1)	(1)
				(1)	(1)
	(1)			(1)	
				(1)	(1)
1			2	4	
				(1)	
			(2)	(2)	
(1)				(1)	
				1	1
				(1)	(1)
				19	7
				33	5
9	9	61	6	65	1
				5	
				19	
		(1)		(1)	
				(1)	
				(1)	(1)
				(2)	
				(4)	
				(1)	(1)
				(1)	
				(1)	
				(2)	(2)
				(1)	(1)
				(1)	
				(1)	
				(1)	
		(1)		(1)	(1)
		(1)		(1)	

14

Remarks

† Insert number of company.
[a] Drives truck, ¼-ton.
[b] Drives truck, 2½-ton.
[c] Armed with carbine, cal. .30, unless otherwise indicated.
[d] Drives truck, ¼-ton.
[e] Armed with pistol, automatic, cal. .45.
[f] Armed with rifle, cal. .30, M1903. (When in Cavalry Division, armed with Rifle, U. S. cal. .30 M1).
[g] Armed with gun, submachine, cal. .45.

When this organization is assigned to a cavalry division the following additional personnel and equipment is authorized:

Cavalry division ordnance officer's section

Lieutenant colonel, including.		1
Staff	4512	([e] 1)
Major, including		1
Ammunition and supply.	4514	([e] 1)
Captain, including		1
Staff	4512	(1)
Total commissioned.		3
Master sergeant, including.		1
Chief clerk	502	(1)
Technical sergeant, including.		1
Clerk, statistical	212	(1)
Staff sergeant, including		1
Ammunition	805	(1)
Sergeant, including		1
Ammunition	505	(1)
Corporal, including		1
Clerk, file	406	(1)
Technician, grade 4, including.		2
Clerk, typist	405	(2)
Technician, grade 5, including.		2
		2
Clerk, ammunition	505	(([e] 1)2)
Private, first class, including.		4
Clerk, general	405	(([e] 1)2)
Driver, truck, light	345	(([e] 1)([a] 1)2)
Private, including		3
Clerk, general	405	(([b e]1)([e] 1)2)
Basic	521	(1)
Total enlisted		16
Aggregate		[e] 19

58		Electrician, automotive	912	5							(([d]1)2)		(3)	
59		Electrician, general	078	5		(1)							(1)	
60		Inspector, motor	413	4							(2)		(2)	
61		Leather and canvas worker	609	5		(1)							(1)	
62		Leather and canvas worker	609			(1)							(1)	
63		Machinist	114	3		(1)							(1)	
64		Machinist	114	4		(1)							(1)	
65		Machinist	114	5		([b]1)3)							(3)	
66		Mechanic, artillery	913	3				(3)					(3)	(1)
67		Mechanic, artillery	913	4				(3)					(3)	
68		Mechanic, artillery	913	5				([a]1)([b]1)([d]1)([c]2)6)					(6)	
69		Mechanic, carburetor	926	3							(1)		(1)	(1)
70		Mechanic, carburetor	926	4							(1)		(1)	
71		Mechanic, carburetor	926	5							(2)		(2)	
72		Mechanic, general, automotive and half-track	965	3							(8)		(8)	(1)
73		Mechanic, general, automotive and half-track	965	4							(8)	(1)	(9)	(1)
74		Mechanic, general, automotive and half-track	965	5							([b]5)([c]11)20)	([d]1)	(21)	
75		Mechanic, general, tank	966	3							(1)		(1)	(1)
76		Mechanic, general, tank	966	4							(1)		(1)	
77		Mechanic, general, tank	966	5							(([a]1)2)		(2)	
78		Mechanic, motorcycle	138	5							(1)		(1)	
79		Mechanic, tractor chassis	319	3							(1)		(1)	
80		Mechanic, tractor chassis	319	4							(1)		(1)	
81		Mechanic, tractor chassis	319	5							(2)		(2)	
82		Messenger	675		([d]1)								(1)	
83		Operator, wrecker	529	5								(2)	(2)	
84		Painter	144	5							(1)		(1)	
85		Repairman, auto body	040	4							(1)		(1)	
86		Repairman, auto body	040	5							(1)		(1)	
87		Repairman, instrument	922	3						(1)			(1)	(1)
88		Repairman, instrument	922	4						(2)			(2)	
89		Repairman, instrument	922	5						(([b]1)([c]2)5)			(5)	
90		Repairman, radiator	172	4							(1)		(1)	
91		Repairman, radiator	172	5							(1)		(1)	
92		Repairman, small arms	903	4					(4)				(4)	
93		Repairman, small arms	903	5					(([b]2) ([a]1) ([c]1) 5)				(5)	
94		Watchmaker	381	4						(1)			(1)	
95		Welder, general	256	3		(1)						([c]1)	(2)	(1)
96		Welder, general	256	4		(1)							(1)	
97		Welder, general	256	5		([b]1)						([c]1)	(2)	
98		Basic	521		(([c]5)15)								(15)	
99		Total enlisted			27	13	13	14	11	11	64	9	162	25
100		Aggregate			29	14	14	15	11	11	65	10	•169	25
101	O	Carbine, cal. .30			23	13	11	11	9	9	52	7	135	
102	O	Gun, machine, HB, cal. .50, flexible					2				1		3	
103	O	Gun, submachine, cal. .45			1		1	2	1		2	1	8	
104	O	Launcher, rocket, 2.36-inch			1		1	1			1	1	5	
105	O	Rifle, cal. .30, M1903 or M1			5	1	2	2	1	2	11	2	26	
106	O	Trailer, 1-ton			1	2	6	1	2	1	4		17	
107	O	Truck, ¼-ton			1			1			1	1	4	
108	O	Truck, ¾-ton, weapons carrier					1	1	1		1		4	
109	O	Truck, 2½-ton, cargo			1	1	6	1			4		13	
110	O	Truck, 2½-ton, electrical repair									1		1	
111	O	Truck, 2½-ton, instrument repair								1			1	
112	O	Truck, 2½-ton, machine shop (Load A)				1							1	
113	O	Truck, 2½-ton, small arms repair							2				2	
114	O	Truck, 4-ton, wrecker										1	1	
115	O	Truck, heavy wrecker										1	1	

Cavalry division ordnance officer's section—continued.

O	Carbine, cal. .30		11
O	Gun, machine, HB, cal. .50, flexible.		3
O	Gun, submachine, cal. .45.		2
O	Launcher, rocket, 2.36".		1
O	Pistol, automatic, cal. .45.		2
O	Rifle, cal. .30, M1		4
O	Trailer, 1-ton		1
O	Truck, ¼-ton		1
O	Truck, ¾-ton		1
O	Truck, 2½-ton cargo		1

Normal assignment.—Army (or Independent Corps). Organically assigned to a cavalry division.

Function.—Third echelon maintenance on weapons, instruments and a limited number of vehicles.

Normal capacity.—1 per infantry division and with other units as required.

For specification serial number shown in column 2 for enlisted men, see AR 615-26; for officers and warrant officers, see TM 12-406 and 12-407.

Figure 18b. T/O & E 9-7 Ordnance Medium Maintenance Co., 30 Sept. 1944.

Supply Sergeant for supplies for the men of the company and all supplies other than ordnance general supplies. These men are in the headquarters section and their duties are the same as they are in any company in the Army.

The *Shop Foreman* is normally the master sergeant in the company. He is assistant to the shop officer and has direct supervision over men in the shop. In the absence of the shop officer, this man will be in charge of the shop. He should be a man with automotive and armament experience and ability. In addition, he must be capable of accepting responsibility. A good shop foreman is the first step towards having an efficient shop.

Each section has a *section foreman*. These men should be capable of supervising the EM under them and normally should be the best repairmen in the various sections. Section leaders should be capable of improvising jigs, fixtures, and tools to facilitate repairs in their sections. The section foremen will normally be technical sergeants.

In the supply section, a *Chief Clerk*, a technical sergeant, is the right-hand man of the supply officer. This NCO should have a complete knowledge of supply procedure, be familiar with SNL's, have a complete knowledge of storage and packaging, and be capable of supervising the men of the section.

Operational Examples. Frequently MM Co.'s are required to do work in addition to that normally assigned them. A MM Co was operating in the Caribbean Defense Command. This company in addition to its regular duties, was required to operate a 4th echelon shop and a branch depot of the ordnance section of a general depot, as well as handle ammunition storage in a number of ammunition magazines. The strength of this company never rose above 4 officers, 1 warrant officer, and 135 enlisted men.

A ship was entering a harbor at one of our ports of debarkation. Unfortunately it never docked but was sunk in the bay. Several 90mm guns were on this ship, but they were rescued from their watery grave by the Navy. A contact party was sent out from the MM Co in the vicinity to return these guns to the shop for repairs. This party consisted of 2 officers and 15 enlisted men. Included in the men were welders, artillery repairmen, instrument repairmen, and laborers. The equipment in this party included one heavy wrecker (10 ton), two 2½-ton 6x6's with winch, and all necessary hand tools. The guns were landed at 2100 one day at the naval dock with the contact party on hand. Immediately the crates were removed; retaining cables and tie rods were cut with torches; the guns placed behind prime movers; and in one hour, or by 2200, the guns were on their way to the shop for repairs. The efficiency and skill of this party together with their ingenuity performed the work in record time.

A bit of trouble developed within a field artillery battalion. This concerned the Ordnance Department because the half-tracks used as prime movers and personnel carriers by the battalion were blowing head gaskets regularly every several hundred miles. An inspection was ordered to determine the cause. This chore fell to the MM Co servicing the battalion. An inspection team was sent out that included an officer, a NCO, a civilian expert, and 8 EM. These men inspected all the half-tracks in the battalion and suggested that the head should be machined down 1/100th of an inch as a possible remedy. This was done on a test vehicle and it operated satisfactorily for some 600 miles with no indication of gasket blowing. After this test, all heads were changed and trouble ceased to exist.

One MM Co servicing several AAA battalions in one theater had the maintenance of the first British 40mm guns, predictors, and motor generators turned over to the U. S. Army. Since very few parts were shipped with this materiel, problems within the company started immediately upon receipt of these guns and equipment. These problems were solved by allowing the men in the company to make the necessary jigs, fixtures, and tools required for repairs. By using the parts supplied, making additional ones needed, and cannibalizing damaged units when absolutely necessary, the company kept 90 per cent of the guns and equipment operating for 18 months until they were replaced by 40mm guns of American manufacture. As the guns had been used by the British before being turned over to us, it can be realized how successful was the job done by this company.

A MM Co was operating on an island. The supply section of this company was expanded to supply all combat units in the vicinity. This required the company to build three warehouses, 50′ x 100′; to use two already in existence, 50′ x 150′; and to assign additional men to this work. Eventually the company was stocked with 50,000 items of ordnance general supply and serviced a large number of units. The total personnel of this company did not exceed 135 men at any time. While this was going on, the company was expected to, and did continue to, perform its normal maintenance duties in a more than satisfactory manner.

In the Pacific theater, a MM Co had the mission of supporting combat units located on a number of small islands in a theater. The islands were numerous and quite a distance apart. Transportation was available but it was hard to get because of the small amount available. This meant that the ordnance company had to provide maintenance and supplies for these units under very adverse conditions. Since the combat units were detachments of infantry and the islands were small, the major problem was supply and maintenance of small arms. To overcome this problem, men from various detachments were brought into the ordnance shops and given a complete training course in maintenance of all types of small arms. These men were trained until they were as proficient as regular ordnance repairmen. Then they were supplied with tools and a stock of spare parts and returned to their units with instructions to repair all possible materiel in their units. Needless to say, the repair work required by these outfits dropped almost to nothing and the ordnance company could chalk up another problem solved.

The MM Co is organized, equipped, and trained to perform 3rd echelon repair close behind combat units. The ability of these companies has been tried in battle and proved excellent. Due to its all-around ability, mobility, and tendency to successfully accomplish all missions assigned to it, the MM Co will be given jobs beyond the normal duties of the company. Experience has proved the ability of this company to produce excellent results under very adverse conditions.

MEDIUM AUTOMOTIVE MAINTENANCE COMPANY

Introduction. When the square divisions were in existence, the task of performing 3rd echelon automotive maintenance was assigned to Quartermaster battalions (LM), each battalion being made up of four light maintenance companies. When the triangular divisions came into existence, the battalions were redesignated as Quartermaster medium maintenance battalions, but soon afterwards were transferred to the Ordnance Department, where they became known as Ordnance Battalions, (MM) (Q). The companies of these battalions, known as 'letter' companies and as Ordnance Companies, (MM) (Q), operated with a strength of 7 officers and 195 enlisted men throughout some of the campaigns of World War II. These companies have now been streamlined into Ordnance Medium Automotive Maintenance Companies, better known as 'MAM' companies. They operate with a strength of 4 officers and 112 enlisted men, and have less transportation. This type of company is still in the experimental stage; but with a few minor changes in the organic equipment, the company may far exceed the expectations of flexibility and mobility.

Mission. The mission of this company is:

To receive overflow of work from the lower echelons and make 3rd echelon repair on vehicles and small arms.

To make technical inspections and supply lower echelons with technical advice.

To supply its shop with 3rd echelon parts and tools, and to supply the using troops with 1st and 2nd echelon parts and tools.

To perform recovery and evacuation.

To supply 3rd echelon maintenance on amphibious vehicles of all types in support of an amphibian operation.

Capabilities. The MAM is equipped to provide 3rd echelon maintenance for approximately 1,200 motor vehicles under normal conditions. The small arms section is capable under normal conditions of maintaining the equivalent of one third the small arms of an infantry division. If the occasion arises, the flexibility of the entire company makes it possible for it to be increased with personnel and equipment to handle 4th echelon maintenance, and it can be separated into supporting platoons with little decrease in output.

Assignment. This type of company is normally assigned to army or separate corps, although it can be found in the communications zone operating in conjunction with a base shop. When assigned to the communications zone, it retains the same degree of mobility that it has in the combat zone.

Duties of Personnel. The *Company Commander* of the MAM company has the ultimate responsibility for all phases of the operations of the company. He is responsible for its administration and the tactical and technical efficiency in its operations and training. He can and does delegate some of these responsibilities to his subordinates by making them directly responsible to him.

The *Maintenance Officers,* one per shop platoon, direct and supervise maintenance, repair, and inspection of all types of automotive equipment and general purpose vehicles. They supervise the operation of the automotive repair shop, examine incoming equipment and determine the exact nature of the repair needed, supervise inspection of all equipment, and supervise instruction. They can be and usually are held responsible for administration, tactical and technical training, supply, and security.

The *Supply Officer* supervises the receipt, inspections, storage, and distribution of equipment. He is thoroughly familiar with the technical aspect of automotive equipment and has good knowledge of related parts. He may be delegated to carry the same responsibilities as the automotive officer.

One of the junior officers of the company will be placed in charge of the headquarters and company supply section. He will function as the *Mess Officer, Personnel Officer, and Transportation Officer*, and will be directly responsible to the company commander.

The duties of the *First Sergeant, Mess Sergeant*, company *Supply Sergeant* and *Motor Sergeant* are related to a great extent to those duties of the same type noncommissioned officers in other units.

The *Master Sergeant,* better known as the master mechanic, is directly responsible to the shop officer (one of the maintenance officers) for the operation of an efficient shop. Each platoon sergeant is directly responsible to the master mechanic for the operation of his respective platoon.

Headquarters Section. The routine responsibilities and operations of this section are identical to those of any other company headquarters. The section is composed of an orderly room, a mess, an organic supply section, and a motor pool for company transportation. The primary duties to be performed by the personnel of this section have been covered in other sections of this manual. Information concerning complete detailed operations of a company headquarters can be found in TM 12-250, "Administration."

Small Arms Section. When the revision of the medium automotive maintenance company was introduced, an additional section was provided, which, up until then, was foreign to an automotive maintenance company. This section was introduced to provide maintenance for small arms.

Due to the fact that a MAM company is located almost entirely in the army service areas, it can readily be understood that the company would be charged with providing small arms maintenance and service for all organizations in the army service area. It is to be understood, though, that these companies are also found in the corps area in direct support of corps and division troops. Where the company is located in the army service area and there is a call for extra maintenance in small arms for front line troops, this section could and would receive the overflow. It is, however, a common practice to attach the small arms section to a light maintenance company or a medium maintenance company in the forward area. From an operational standpoint this section is independent from the rest of the company; therefore, it can easily and readily be separated from the parent unit. This independence is brought about by placing all spare parts and tools relative to small arms in the small arms section. All spare parts and supply functions can be handled by the section with no connection whatsoever with the supply section. All maintenance requests or work order requests, of course, go through the shop office, following the same procedure for work requests on the other sections of the shop.

Supply Section. The supply section (not to be confused with the organic supply section in company headquarters) is the core of the company upon which all other sections of the company depend. One of the primary functions of this section is to supply the other sections with automotive spare parts. At the same time there must be maintained an uninterrupted flow of 1st and 2nd echelon tools and parts to the using units. This flow can be maintained by issue from stock, exchange, requisition on higher echelons, or by any method prescribed by higher headquarters. There must also be constantly maintained a maximum level of spare parts and equipment to provide maintenance and service for using units for periods of time set down by army headquarters or other higher headquarters. These stock levels are usually based on a 15-day period, but are always regulated in accordance with current or forthcoming operations.

In the event the company is maintaining a pool of major items for purposes of direct exchange with the using units, the supply section is charged with the operation of this pool. This will prove to be quite a task as there is a considerable turnover of major items in the field; therefore, the section must set up a flexible system of operation which must, at the same time, be of an automatic nature. Mere procurement, storage, and issue of spare major items is not the whole job; this materiel must be properly inspected, authorized tools and accessories for each major item provided, and the complete serviceability of each item assured at all times. To discharge the latter responsibilities, the supply section must of course have the fullest cooperation of the various maintenance sections.

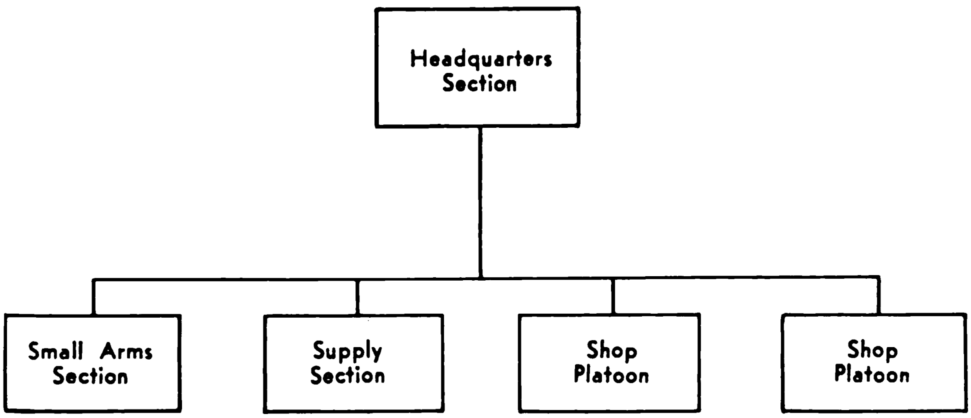


Figure 19a. Organization of a Medium Automotive Maintenance Company.

The supply section must, as in all other units of supply, maintain a complete set of records, so as to preserve a maximum stock level and in order to maintain an uninterrupted flow of supply from the depots to the using arm.

Shop Platoons. *General Functions.* The MAM company also contains two identical automotive maintenance or repair platoons, which can, if necessary, be merged into one large platoon. This is not always advisable nor frequently practiced, as it has been found that better operations are experienced by causing a competitive spirit through the use of two platoons. Also, it is usually of great importance that a company of this type have two separate operating repair units, as the occasion will arise time and time again in the field when a portion of the company will be attached to another similar organization which has been overloaded with work. From past experience in the field it has been found that usually an automotive platoon reinforced with spare parts and special tools has been a functional part of all amphibious invasions. The platoons in those operations can and usually do operate primarily for a short period of time as shore maintenance units, repairing amphibious vehicles of all types and any and all vehicles of organizations located in that area. The success of an operation will depend largely upon the efficiency and speed with which this unit will work; therefore, it is of the utmost importance that successful practices and techniques be applied to highly trained men and class 'A' equipment to fulfill that portion of ordnance service.

Under favorable conditions and routine operations each shop platoon is equipped to provide 3rd echelon maintenance for approximately 600 vehicles. This, of course, has been found to be a round figure as an entire company will invariably be providing maintenance for vehicles, ranging from 1,600 to 2,000 in number. For this reason when training personnel for and in this type of company, it is classed as a 'must' that the training be carried on under adverse conditions and exceeding the prescribed maintenance capacity, with specialists learning as much as possible about jobs other than their primary duties.

1	Unit	2 Specification serial No.	3 Technician grade	4 Headquarters section	5 Small arms section	6 Supply section	7 2 shop platoons (each)	8 Total company	9 Enlisted cadre
2	Captain, including			1				1	
3	Company commander	4805		(1)				(1)	
4	First lieutenant, including						1	2	
5	Platoon commander	4805					(1)	(2)	
6	Second lieutenant, including					1		1	
7	Supply, automotive	4440				[c] (1)		(1)	
8	Total commissioned			1		1	1	4	
9	Master sergeant, including			1				1	1
10	Master mechanic	342		(1)				(1)	(1)
11	First sergeant	585		1				1	1
12	Technical sergeant, including				1	1	1	4	4
13	Foreman, automotive repair shop	337					(1)	(2)	(2)
14	Repairman, small arms	903			(1)			(1)	(1)
15	Supply	821				(1)		(1)	(1)
16	Staff sergeant, including			3		1	1	6	6
17	Foreman, automotive repair shop assistant	337					(1)	(2)	(2)
18	Mess	824		(1)				(1)	(1)
19	Motor	812		(1)				(1)	(1)
20	Supply	821		(1)		(1)		(2)	(2)
21	Corporal, including			1					1
22	Clerk, company	405		([a] 1)				(1)	(1)
23	Technician, grade 3							14	(1)
24	Technician, grade 4							25	(1)
25	Technician, grade 5 including			11	7	11	35	40	(1)
26	Private, first class							7	
27	Private							13	
28	Blacksmith	024	4				(1)	(1)	
29	Blacksmith	024	5					(1)	
30	Bugler and messenger	803		([b] 1)				(1)	
31	Clerk, parts	348	4			(2)		(2)	
32	Clerk, parts	348	5			([e] 2)		(2)	
33	Clerk, parts	348				(([d] 4) 5)		(5)	
34	Clerk, typist	405				(1)		(1)	
35	Cook	060	4	(1)				(1)	(1)
36	Cook	060	5	(1)				(1)	(1)
37	Cook's helper	521		(1)				(1)	
38	Driver, truck, light	345	5	([e] 1)		([e] 1)	(([f] 1) ([e] 1) 2)	(2)	
39	Driver, truck, light	345						(4)	
40	Electrician, track and wheel vehicle	912	4				(1)	(1)	
41	Electrician, track and wheel vehicle	912	5					(1)	
42	Inspector, motor	413	3				(•• 1)	(2)	
43	Leather and canvas worker	609	5				(1)	(1)	
44	Leather and canvas worker	609						(1)	
45	Mechanic, carburetor	926	3				(1)	(1)	
46	Mechanic, carburetor	926	4					(1)	
47	Mechanic, wheel vehicle, automotive	965	3					(10)	(1)
48	Mechanic, wheel vehicle, automotive	965	4				(([f] 3, [g] 2) 22)	(11)	
49	Mechanic, wheel vehicle, automotive	965	5					(25)	
50	Painter, automobile	144	5				(1)	(1)	
51	Painter, automobile	144						(1)	
52	Repairman, automobile body	201	4				(1)	(1)	
53	Repairman, automobile body	201	5					(1)	
54	Repairman, radiator	172	4				(1)	(1)	
55	Repairman, radiator	172	5					(1)	
56	Repairman, small arms	903	4		(4)			(4)	
57	Repairman, small arms	903	5		(([d] 1) [g] 3)			(3)	
58	Welder, general	256	3					(1)	
59	Welder, general	256	4				(2)	(2)	
60	Welder, general	256	5					(1)	
61	Basic	521		(([f] 3) 6)				(6)	
62	Total enlisted			17	8	13	37	112	16
63	Aggregate			18	8	14	38	• 116	16
64	O Carbine, cal. .30			13	5	7	30	85	
65	O Gun, machine, HB, flexible, cal. .30					2	1	4	
66	O Gun, submachine, cal. .45			1		1	2	6	
67	O Launcher, rocket, 2.36-inch			1		2	1	5	
68	O Rifle, cal. .30, M1903			4	3	6	6	25	
69	O Trailer, 1-ton			1	1	6	3	14	
70	O Truck, ¼-ton						1	2	
71	O Truck, ¾-ton, weapons carrier			1		1	1	4	
72	O Truck, 2½-ton, cargo			1		6	3	13	
73	O Truck, 2½-ton, small arms repair				1			1	
74	O Truck, 4-ton, wrecker						1	2	

10 Remarks

† Insert number of company.
[a] Also classification specialist (275).
[b] Drives truck, ¾-ton.
[c] Armed with carbine, cal. .45, M1 unless otherwise indicated.
[d] Drives truck, 2½-ton.
[e] Drives truck, ¾-ton.
[f] 1 drives wrecker, 2 drive trucks, 2½-ton.
[g] Armed with rifle, cal. .30, M1903.
[h] Armed with gun, submachine, cal. .45.

Normal Assignment: Army (or independent corps).

Normal Function: 3d echelon maintenance for army (or independent corps.

Capacity: Capable of providing 3d echelon maintenance for approximately 1,200 motor vehicles under favorable conditions. Small arms section is capable, under normal conditions, of maintaining the equivalent of ½ the small arms of an infantry division.

For specification serial numbers for enlisted men shown in column 2, see AR 615-26; for officers see TM 12-400 and 12-407.

Figure 19b. T/O & E 9-27 Medium Automotive Maintenance Co., 19 May 1944.

Sections. (1) Contact Sections. The T/O does not allow for definite contact sections with the company, but that does not eliminate the fact that contact sections or contact parties are still necessary and essential to efficient operations. These contact parties can be of any size ranging from two or three men to an entire platoon. The number of parties will be governed by the number of units being serviced by the company, and each party should be composed of men who are specifically trained for the particular task. The individuals should be men who are experienced trouble shooters, experienced parts men, specialized mechanics and inspectors, and excellent instructors, for these men are delegated for liaison between ordnance and the using arm. A few of the normal duties of any contact party are inspections of equipment; replacement and repair of equipment; depending on the size of the party, delivering filled requisitions; returning completed jobs; giving instruction in 1st and 2nd echelon maintenance; and most anything that may arise. As regards size of parties, there should never be more than two or three men to a party when making roving contacts.

(2) Welding and Body Repair Section. This section is equipped with both oxyacetylene sets and electric arc welding sets; therefore, it can successfully fulfill any normal task requiring welding. As body repair requires a considerable amount of welding and heating, it is recommended that these sections be combined into one section. There will occur in the field very frequently a need for a greater number of welders, body repairmen, and blacksmiths than are allotted in the T/O; therefore, it is highly recommended that each of these men know the other jobs within this section. It is further recommended that men in other sections, such as leather and canvas workers and radiator repairmen, be trained for this department. It has been found that a greater number of men are needed in this section particularly during an invasion or when the company is charged with the maintenance of DUKW's (GMC, 2½-ton, 6x6, Amph.), and it can readily be seen that there would be a greater need for a welder than, for instance, a canvas worker during these operations.

(3) Radiator Repair Section. In a great number of cases, as recommended, this section will either be located near or will be a part of the welding and body repair section. It has been found that this section will usually be pressed with work; so, in addition to repair sets for this section, one radiator repair set is found in the body repair section. Each radiator repairman, as suggested for the welding and body repair section, should have at least two apprenticed radiator repairmen borrowed from other sections trained to assist or to continue the work if by chance the necessary to do so arises. Radiator repairmen will also have a definite knowledge of routine operations in the welding and body repair section.

(4) Carburetion and Ignition Section. This section is composed of the automotive electricians and carburetor mechanics of the company as the electrical and carburetion systems are related, to a great extent, in the functioning of a vehicle. The section does ignition and carburetion repairs on all assemblies of that nature in wheel and track vehicles. It has been found a good policy for the section to have available at all times certain serviceable standard assemblies for direct exchange in order to reduce loss of operations in the using arms. The exchanges are merely completed on a job order or work order initiated at the shop office; the job order being immediately completed with the exchange.

(5) Paint Section. This section is also located in coordination with the welding and body repair section, as the majority of its work results from work accomplished in that section. The normal duties of this section are to touch up newly welded jobs, make complete paint jobs, paint organizational markings on equipment, and do any other painting jobs that may arise.

There very seldom arises in the field the necessity for a complete paint job on a vehicle. Even though the painters are normally occupied with work, it is recommended that these men be trained as carpenters to handle at least all the simple work that will arise in the shop.

Salvage. This is not classified as an organic department of the company, but it is absolutely necessary that an organization of this type contain a salvage section, even if it is composed of only three or four men. This is a very important section, as a great number of campaigns have been successful, mainly due to the extensive salvage program in effect. Parts obtained from salvage are thoroughly inspected, and if found in good condition, placed in the company stock, issued, or directly used in repair of equipment of using units. All salvage not in usable condition is routed to special salvage units for renovation. All possible care should be exercised in the preservation of repairable salvage being evacuated, to insure that the repairable condition will still exist at the end of the trip. The salvage section should be composed of men from the shop platoon, but should be a sub-division of, or coordinated with, the supply section.

THE ORDNANCE MAINTENANCE COMPANY, ANTIAIRCRAFT

The mission of the Ordnance Maintenance Company, Antiaircraft (T/O & E 9-217), is normally to provide third echelon maintenance, including inspection and repair of the ordnance of antiaircraft units; and occasionally, when necessary, to fabricate or manufacture required items not available through normal supply channels. It is assigned to army within an appropriately located ordnance battalion in the ratio of one company to five antiaircraft battalions. In addition, such companies may be attached as necessary to the headquarters of large antiaircraft installations.

As this type of maintenance company is assigned within an ordnance battalion, it may often be called upon to do work other than antiaircraft maintenance. This is especially true of automotive jobs, for even the repair of tanks may be assigned to it when the other companies of the battalion are already overworked.

Detachments from other services, such as the Signal Corps (to maintain radar equipment), may be attached to the company as required.

Field shop administration, operation, supply, location, contact parties, inspections, and headquarters, as pertaining to this specific type of maintenance company, follow in the general manner previously discussed at the beginning of this chapter.

The only divergences from common practice in the use of contact parties are in antiaircraft units which are very widely dispersed and mobile task forces containing antiaircraft units in which cases contact parties may be temporarily attached to the units served. The supply section will furnish to these contact parties the necessary additional technical parts and supplies from its own stock, which it will replenish by requisition on the appropriate army depot or heavy maintenance company. The headquarters, service, and supply sections will be located as directed by the commander of the headquarters to which assigned, as conveniently as possible to all the units served. Therefore communication facilities must be provided so that the contact parties can get the supplies and service required. All service and supplies will go forward to the units as necessary—the services in their own technical vehicles.

In many cases there will be isolated antiaircraft installations on islands, at advance air bases, or in similar locations. Detachments composed of elements from the technical platoons, service section, and supply section will be furnished. The headquarters section will be located at or near the antiaircraft area or zone commander to provide the necessary liaison and to coordinate the maintenance.

Organization of Company. The company itself is divided into seven components as follows:

Headquarters Section (2-Officers, 25-EM)
Section Section (1-O, 25-EM)
Supply Section (1-WO, 8-EM)
Artillery Section (1-O, 24-EM)
Small Arms Section (10-EM)
Instrument & Fire Control Platoon (1-O, 45-EM)
Automotive Platoon (1-O, 30-EM)

In general practise the service and supply sections are combined into the service and supply platoon. The artillery and small arms sections are usually combined administratively into an armament platoon.

When taking up the remaining five components in turn, we find that the *Headquarters Section* has the responsibilities and accomplishes the same ends as are listed in the general discussion on headquarters (see above). However, greater emphasis than ever must be placed on complete and continual liaison, because of the wide geographical dispersion of the units served and because occasionally the company itself may be split up into detachments with the headquarters at some central location.

The *Service and Supply Platoon* takes care of field shop administration, furnishes or acquires needed maintenance supplies, keeps the necessary shop and supply records, and performs the necessary service tasks for the technical platoons, as discussed above.

The number of personnel assigned to each of the following technical platoons shows its relative importance. Specialized technical training and a high degree of maintenance skill is more likely to be encountered in this type of maintenance company than in almost any other. This is due to the complexity of antiaircraft weapons and their fire control equipment. Without some previous training a man finds it quite difficult to pick-up required knowledge from working with skilled mechanics in the field. Classes must be held continually so that all men may reach the highest degree of skill. Many men will be found who have knowledge of only one weapon or only one fire control device. It is imperative that this condition be corrected as soon and as much as possible. Every man must have as fully a rounded knowledge as he is capable of.

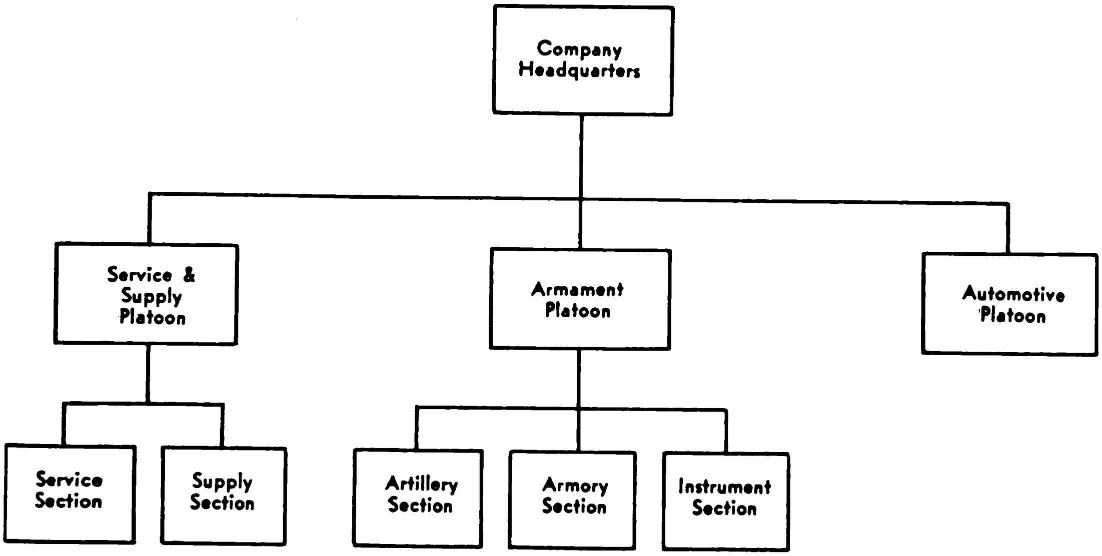


Figure 20a. Ordnance Maintenance Co., AA.

The armament platoon contains both artillery and small arms specialists. Emphasis is placed on antiaircraft equipment, that is, the small arms men will be especially conversant with such weapons as the watercooled cal .50 Browning machine gun. The small arms section may often be called upon to inspect the weapons of non-antiaircraft units. The artillery section may infrequently have to work on field artillery. However, the great majority of the artillery section's jobs will be on the 40mm Bofors gun. The ratio of battalions using this weapon to those using the 90mm is approximately four to one. The 120mm gun will be encountered but seldom. Men attached to mobile task forces will do most of their work on the multiple gun motor carriages M15A1, M16, and M17. It is best for all artillery mechanics to have a working knowledge of the oil-gears on the 40mm Bofors. Almost all maintenance will be done on the guns in their firing position. Cramped working quarters must be expected.

The instrument and fire control platoon is the largest division of the company. Most of its personnel is trained in the maintenance of off-carriage fire control equipment, oil gears, rammers and fuze setters, and generator units. Only a few men are qualified in the maintenance of height finders and instruments alone. This is the busiest portion of the company, as a great many adjustments must be made on every inspection and on every visit by a contact party to keep the fire control equipment functioning properly. The work of this platoon, also, must when possible be accomplished at the gun position. The importance of preserving the camouflage of the unit to be serviced cannot be overemphasized. A breach of camouflage discipline at a gun position can make an enemy quickly and permanently.

Every man in this section should ideally be capable of maintaining any type of fire control equipment. Actually such a situation will never exist. The best that can be hoped for is to expect of a man knowledge of at least two separate and distinct items of equipment.

	1	2	3	4	5
1	Unit	Specification serial No.	Technician grade	Company headquarters	Service section
2	Captain, including			1	
3	Company commander	4801		(1)	
4	First lieutenant, including				
5	Artillery maintenance and repair	4808			
6	Automotive maintenance and repair	4805			
7	Fire control instrument repair	4806			
8	Second lieutenant, including			1	1
9	Mess supply and transportation	4113		(1)	
10	Ordnance maintenance service	4813			(1)
11	Total commissioned			2	1
12	Warrant Officer, including				
13	Supply, general	4000			
14	Master sergeant, including				1
15	Master mechanic	342			(1)
16	First sergeant	585		1	
17	Technical sergeant, including				1
18	Foreman, automotive repair shop	337			
19	Machinist	114			(1)
20	Mechanic, artillery, antiaircraft	915			
21	Repairman, instrument, fire control	922			
22	Repairman, small arms	903			
23	Staff sergeant, including			3	1
24	Machinist	114			(1)
25	Mechanic, artillery, antiaircraft	915			
26	Mess	824		(1)	
27	Motor	813		(1)	
28	Repairman, instrument, fire control	922			
29	Supply	821		(1)	
30	Corporal, including			1	
31	Clerk, company	405		(a 1)	

6 Supply section	7 Artillery section	8 Small arms section	9 Instrument and fire control platoon	10 Automotive platoon	11 Total company	12 Enlisted cadre
					1	
					(1)	
	1		1	1	3	
	(1)				(1)	
				(1)	(1)	
			(1)		(1)	
					2	
					(1)	
					(1)	
	1		1	1	6	
1					1	
(1)					(1)	
					1	1
					(1)	(1)
					1	1
	1	1	1	1	5	5
				(1)	(1)	(1)
					(1)	(1)
	(1)				(1)	(1)
			(1)		(1)	(1)
		(1)			(1)	(1)
	1		2		7	4
					(1)	
	(1)				(1)	
					(1)	(1)
					(1)	(1)
			(2)		(2)	(1)
					(1)	(1)
					1	1
					(1)	(1)

13
Remarks

†Insert number of company.

[a] Also classification specialist (275).

[b] Drives truck, 2½-ton.

[c] Armed with carbine, cal. .30, unless otherwise indicated.

[d] Drives truck, ¼-ton.

[e] Drives truck, ¾-ton.

[f] Armed with rifle, cal. .30, M1903.

[g] Armed with submachine gun, cal. .45.

Normal assignment: Army (or independent corps).

Normal function: 3d echelon maintenance for antiaircraft artillery battalions.

Capacity: Capable of providing 3d echelon maintenance for 5 antiaircraft battalions. (Gun and/or automatic weapon.)

For specification serial numbers shown in column 2, for enlisted

32	Technician, grade 3 } including										20	10	men, see AR 615-26; for officers and warrant officers, see TM 12-406 and 12-407.
33	Technician, grade 4										39	2	
34	Technician, grade 5			20	11	8	22	9	42	29	55	1	
35	Private, first-class										7		
36	Private										20		
37	Carpenter	050			([r] 1)						(1)		
38	Clerk, parts	348	4			(1)					(1)		
39	Clerk, parts	348	5			([b] 1)					(1)		
40	Clerk, parts	348				(([b] 1)[r] 2)					(2)		
41	Clerk, stock record	323				(([de]1)2)					(2)		
42	Clerk, typist	405	5			([r] 1)					(1)		
43	Cook	060	4	(2)							(2)	(2)	
44	Cook	060	5	(1)							(1)	(1)	
45	Cook's helper	521		(1)							(1)		
46	Driver, truck, light	345	5	(1)		(1)					(2)		
47	Driver, truck, light	345					([e] 1)				(1)		
48	Electrician, automotive	912	3							(1)	(1)	(1)	
49	Electrician, automotive	912	4							(1)	(1)		
50	Electrician, general	078	5		([b] 1)						(1)		
51	Machinist	114	3		(1)						(1)	(1)	
52	Machinist	114	4		([b] 1)						(1)		
53	Machinist	114	5		(2)						(2)		
54	Mechanic, artillery, antiaircraft	915	3				(5)				(5)	(1)	
55	Mechanic, artillery, antiaircraft	915	4				(([r] 3)6)				(6)		
56	Mechanic, artillery, antiaircraft	915	5				(([br]1; [r]1) 10)				(10)		
57	Mechanic, automotive	965	3							(5)	(5)	(1)	
58	Mechanic, automotive	965	4							(6)	(6)		
59	Mechanic, automotive	965	5							(([b]1; [e]1; [r]7) 10)	(10)		
60	Mechanic, carburetor	926	4							([b] 1)	(1)		
61	Mechanic, carburetor	926	5							([b] 1)	(1)		
62	Messenger (bugler)	803		([d] [e] 1)							(1)		
63	Operator, wrecker	529	5							(1)	(1)		
64	Painter	144	5		(1)						(1)		
65	Repairman, automotive body	040	4							([b] 1)	(1)		
66	Repairman, control system, heavy artillery, antiaircraft	919	3						(1)		(1)	(1)	
67	Repairman, control system, heavy artillery, antiaircraft	919	4						(1)		(1)		
68	Repairman, control system, heavy artillery, antiaircraft	919	5						(1)		(1)		
69	Repairman, director, heavy artillery, antiaircraft, electrical	899	3						(1)		(1)	(1)	
70	Repairman, director, heavy artillery, antiaircraft, electrical	899	4						(1)		(1)		
71	Repairman, director, heavy artillery, antiaircraft, electrical	899	5						(1)		(1)		
72	Repairman, director, heavy artillery, antiaircraft, mechanical	917	4						(1)		(1)		
73	Repairman, director, heavy artillery, antiaircraft, mechanical	917	5						([b] 1)		(1)		
74	Repairman, director, light artillery, antiaircraft	918	3						([r] 1)		(1)		

Figure 20b. T/O & E 9-217 Ordnance Maintenance Company, AA, 28 March 1944.

	1	2	3	4	5	6	7	8	9	10	11	12	13
	Unit	Specification serial No.	Technician grade	Company headquarters	Service section	Supply section	Artillery section	Small arms section	Instrument and fire control platoon	Automotive platoon	Total company	Enlisted cadre	Remarks
	Private—Continued.												
75	Repairman, director, light artillery, antiaircraft	918	4						(([a] 2)3)		(3)		
76	Repairman, director, light artillery, antiaircraft	918	5						(([b] 1)7)		(7)		
77	Repairman, director, light artillery, antiaircraft	918							(3)		(3)		
78	Repairman, electric motor	304	4						(1)		(1)		
79	Repairman, generator units and cable	506	3						(1)		(1)	(1)	
80	Repairman, generator units and cable	506	4						(1)		(1)		
81	Repairman, generator units and cable	506	5						([a] 2)		(2)		
82	Repairman, height finder	921	3						(1)		(1)	(1)	
83	Repairman, height finder	921	4						(1)		(1)		
84	Repairman, height finder	921	5						([a] 1)		(1)		
85	Repairman, instrument, fire control	922	3						(1)		(1)	(1)	
86	Repairman, instrument, fire control	922	4						(3)		(3)		
87	Repairman, instrument, fire control	922	5						(([••] 1)5)		(5)		
88	Repairman, instrument, fire control	922							([a] 2)		(2)		
89	Repairman, radiator	172	4							([a] 1)	(1)		
90	Repairman, small arms	903	4					(5)			(5)		
91	Repairman, small arms	903	5					(([b]1; [••]1; [a] 3)4)			(4)		
92	Watchmaker	381	4						([a] 1)		(1)		
93	Welder, general	256	3		([a] 2)						(2)	(1)	
94	Welder, general	256	4							([••] 1)	(1)		
95	Welder, general	256	5		(([b] 1)2)						(2)		
96	Basic	521		(([a] 5)14)							(14)		
97	Total enlisted			25	14	8	24	10	45	30	156	25	
98	Aggregate			27	15	9	25	10	46	31	[•] 163	25	
99	O Carbine, cal. .30			21	12	5	19	6	36	21	120		
100	O Gun, machine, HB, cal. .50, flexible			1		1	1		1	1	5		
101	O Gun, submachine, cal. .45			1		1	1	1	1	2	7		
102	O Launcher, rocket, 2.36"			1		1	1		1	1	5		
103	O Rifle, cal. .30			5	3	3	5	3	9	8	36		
104	O Trailer, 1-ton			1	3	3	1	1	2	4	15		
105	O Truck, ¼-ton			1		1					2		
106	O Truck, ¾-ton, weapons carrier						1	1	1	2	5		
107	O Truck, 2½-ton, cargo			1	1	3	1			4	10		
108	O Truck, 2½-ton, electrical repair				1						1		
109	O Truck, 2½-ton, instrument repair								2		2		
110	O Truck, 2½-ton, machine shop (load A)				1						1		
111	O Truck, 2½-ton, small arms repair							1			1		
112	O Truck, heavy wrecker									1	1		

Figure 20b Continued. T/O & E 9-217 Ordnance Maintenance Company, AA, 28 March 1944.

The maintenance of fire control equipment is a job of continual adjustments. Inspection and contact parties will seldom find a unit that is in perfect working order. The treatment to which the items are subjected in transit and in setting up precludes such a possibility. Therefore, the necessity for contact parties to visit frequently all units served is obvious.

A knowledge of antiaircraft artillery maintenance will hasten and render easier the work of the members of this platoon. Such knowledge can be acquired quickly and easily in the field.

It is usually considered that the items to be maintained by the automotive platoon are limited to the organic automotive vehicles of the maintenance company itself, plus those of the units serviced. However, mechanics from this section aid the fire control men in the maintenance of generator units. This platoon is also assigned work, ranging from repair of jeeps to tanks, by the battalion to which the company is assigned. Any and every type of job must be accepted and accomplished in so far as material and personnel permit. Aside from these facts the mission of the automotive platoon does not differ from that of a similar platoon in any other ordnance maintenance company.

HEAVY MAINTENANCE COMPANY, FIELD ARMY*

Mission. This Company is equipped to perform 4th echelon maintenance for weapons, instruments, and a limited number of vehicles. The company is semi-mobile but can easily follow the combat elements and provide the essential ordnance general service and maintenance.

The ordnance heavy maintenance company is capable of performing the above functions for approximately four infantry divisions or five antiaircraft groups or five field artillery groups. Although this company is normally under Army command, it is attached in many instances to corps troops. This company is so equipped that the manufacture of tools, jigs, fixtures, etc., is easily accomplished.

The location of an ordnance heavy maintenance company (F.A.), usually depends on G-4's allotting a designated area with ample space for the setting up of a field shop.

If the area is in open country, many things must be taken into consideration in laying out a field shop. Most important are the road nets that govern all traffic entering either the artillery or automotive sections. With self-propelled guns, tractors, howitzers, and vehicles moving in and out of the area, it is quite obvious that adequate road and turning space is essential. All these large types of ordnance materiel must also be assembled and disassembled.

If the area is in a congested city or town, the same may be said pertaining to the space that is required. The utilization of all garages, machine shops, and large buildings will add to the efficiency of all operations carried out in such an area. Security and protection against air raids will depend on the use of civilian air raid shelters rather than dispersion and camouflage.

Capabilities. The *Supply Section* of a heavy maintenance company must maintain the stock level at all times. It will be concerned with the handling of heavy materiel and the supplying of large amounts of fast-moving parts. The flow of supply usually terminates in the heavy maintenance company's own shop area. The main reason for this is that such items as engine assemblies, 155mm tubes, and tank tracks are only a small part of the heavy equipment that it would be necessary to move to complete repairs. There is enough time wasted in the shop area, moving and placing the above items, without carrying them all over the countryside to the various units.

The heavy maintenance company draws all items pertaining to ordnance supplies from either a depot, salvage yard, or finished vehicle pool. These sources of supply are located in the vicinity. The ordance officer may authorize the interchanging of major items from vehicles and equipment in a pool to vehicles and equipment in a shop area of a heavy maintenance company.

Aside from the automotive and artillery sections being the main outlets of supply, the service section must always be equipped to handle any work that any of the other sections have to depend on. Welding sets must be kept in excellent condition and welding rods in large quantities must be on hand at all times.

*See end of chapter for the T/O & E of this organization.

Since instrument and small arms parts are both standard and conventional in nature, the supply section is little concerned with them other than having their stock level maintained and providing the necessary parts in any emergency that might arise.

Company supply itself is a normal function. Directives from higher headquarters will be the only outside influence that will have any bearing on its usually normal routine.

This section should normally be at a centralized point where it will be equidistant from the other sections and accessible to all in the bivouac area. It must have extensive space with outlets to each section for the moving of parts and materiel.

The *Instrument Section* must be adjacent to an open and preferably a level area. These conditions must exist if fire control instruments are going to be repaired and the sighting of such materiel accomplished. Tent flys may be employed to provide needed cover from dust, sand, and any foreign particles that would impair such operations.

The *Service Section* has to be between the automotive and artillery sections because the bulk of its work is with those sections. An added reason for locating the service section in this position is because the tools and equipment used are entirely too cumbersome and awkward to move any distance. The time element is important and any time-saving principles evolved in the beginning will further the efficiency of the field shop as the volume of work expands.

The *Automotive Section* must be next to the service section because it is dependent upon the tools, equipment, and type of work that that section is capable of accomplishing. The bodies and chassis of all vehicles require a great amount of welding, drilling, and pressing that only the service section can do. It is also well to remember that when things are rushed to such an extent that a manpower shortage exists, many of the artillery mechanics are quite capable of relieving the automotive platoon in the simple dismantling of vehicles. This will allow the automotive mechanics to work on jobs that are more technical in nature.

The *Artillery Section,* like the automotive section, will normally be situated next to the service section. Many guns and howitzers with bent or twisted trails and carriages demand the use of heavy tools and welding units. When both sections are separated by a great distance, working together becomes very difficult, time is lost, work piles up, and the general efficiency of the organization ceases to prevail.

The *Armory Section* may be in any position that is relatively handy to the quarters of the men. Unlike the other sections it is practically independent in that its type of work is by its nature more self-sufficient. The main reason is that parts and supplies used are standardized and very few modifications pertaining to small arms arise.

The *Shop Office* should always be located at the entrance of the shop area facing the main roads. All personnel entering the shop area will proceed to the shop office and obtain any pertinent information they may desire. All shop administration originates here and the various records and work order files must be kept orderly and in good condition at all times. If this policy is adhered to, it will save both the company and the using units any unnecessary confusion.

Recovery and Evacuation. The task of recovering and evacuating both allied and enemy equipment is most important to both the using arm and the Ordnance Department. The normal steps taken to recover this equipment are initiated by an evacuation company. Their principal mission is to return ordnance materiel that has been partially or completely destroyed in battle to a main collecting point. This collecting point is usually located in the rear of a division area. Here, a detachment of men from a MM Co is assigned the job of repairing the materiel to a limited extent. This operation is necessary in many cases if the materiel is going to be moved any distance in order to be fully repaired and reconditioned. At this point, the heavy maintenance companies enters the picture. They are responsible for the movement of the materiel from the collecting point to their own shop area. Here they have the tools, equipment, and facilities necessary for the repairing and salvaging of vehicles, self-propelled guns, and artillery pieces. Two 10-ton heavy wreckers are employed in the moving of such materiel from the collecting point to the heavy maintenance company's shop area. Upon arrival at the Heavy Maintenance Company's area, every effort is made to segregate the materiel and allot it to the various sections. Personnel are immediately assigned specific tasks to complete the repairs and salvage operations that are necessary to get the above mentioned materiel on the finish line. When the vehicles, self-propelled guns, and artillery pieces are completed, they are evacuated to separate pools designated by the type or class of materiel. At these pools they are lined up and maintained until they are reissued to the using units. The heavy maintenance company is the only company that will handle such materiel under normal conditions. These companies sometimes work in conjunction with heavy maintenance companies (Tk) which are responsible for the servicing and repairing of all tanks that have been evacuated from the forward collecting point in the divisional area.

Contact parties have two missions. The first is to complete all spot maintenance work in the bivouac area of the using units and to determine just what must be returned to the heavy maintenance company for a higher echelon of maintenance. The second, and just as important, is the advising and suggesting of better methods to diminish the amount of maintenance work that would ordinarily be expected in the future. In many instances a detachment of men is sent out to a designated area that is possibly fifty to one hundred miles from the parent organization. This detachment of men in turn is broken down into small contact parties and sent out to contact units in the immediate vicinity. Routine liaison between the detachment and the parent organization is necessary three or four times a week. Keeping each other informed of the progress made and any change of policy is absolutely essential for such a contact unit to be successful in completing its designated mission. One other important reason for keeping in touch with each other is the demand for parts and supplies needed to replenish any used in the work of the contact parties with the using units.

Inspections. There are three types of inspections that a heavy maintenance company will have to supervise at one time or another. They are formal, informal, and spot inspections. The latter is the most common and in most cases the most informative. It rectifies the negligence that the using arm is unknowingly ignoring. For our own self-preservation it is deemed advisable to send out qualified officers and enlisted men with both technical and administrative knowledge. This will enable them to inform the personnel of the using arm of existing regulations and requirements that we insist be complied with. In a spot check inspection we find out the discrepancies that exist on all items of ordnance materiel, and we are able to convey our findings to responsible officers who may immediately rectify the overall situation. The heavy maintenance company will always be concerned with the reparation and maintenance of heavy equipment that other ordnance companies normally have nothing to do with.

Duties of Officers. The *commanding officer* of a heavy maintenance company has the primary duty of supervising the operation and administration of the company.

The *shop officer* will normally be the senior lieutenant in the company. He will be wholly concerned with the operation of the shop. He will also be the automotive officer and command that platoon.

The *recovery officer* will have the recovery section in addition to being the assistant automotive officer. His being familiar with automotive work will enable the automotive officer to have more time in which to supervise shop operations.

The *artillery officer* will be a lieutenant in the company. He will have the armament platoon and supervise all work in that section. In many instances he will be concerned with instruments that are pertinent to the weapons themselves.

The *supply officer* will be a lieutenant of the company. He will be responsible for supplying the company and all units serviced with ordnance general supplies.

One 2nd Lieutenant will be the *administrative officer* of the company. He will be responsible for the men's welfare and see that all administrative details are promptly dealt with. He will be of valuable assistance to the C.O. in that he may take care of the many problems within the company and supervise shop operations.

Duties of NCO's. The shop foreman is normally a master sergeant. In the absence of the shop officer the shop foreman will be in charge. He must have a good knowledge of both armament and automotive work because most of the work is within those sections. Technical sergeants are in charge of the artillery, automotive, and supply sections and are designated as section foremen. However, the small arms, instrument, and service sections have either staff sergeant or technician third grade ratings. These men are the backbone of any organization and their knowledge is of untold value to all personnel within the company.

Operations. Typical operations of the ordnance heavy maintenance company (FA), may include work in the communications zone or in the combat zone. Both are equally important. In the communications zone this unit has the aspect of a provisional setup in that all units moving ahead are inspected and serviced so that they will be ready for anything. In the combat zone salvaging, major item replacement and all types of 4th echelon maintenance are the main types of work that will be encountered. Recovery and evacuation will be an important function if the company is within the corps area.

Conclusion. The ordnance heavy maintenance company (F.A.) is organized, trained, and equipped to perform any 4th echelon maintenance anywhere in the field. Although it is semimobile, it may move all organizational equipment at one time should the necessity present itself. Although its capacity for work is limited, this company is an integral part of the Ordnance Department and is responsible for the replenishing of ordnance materiel that has been partially damaged in combat.

HEAVY MAINTENANCE COMPANY (TANK)

Mission. The mission of the Ordnance Heavy Maintenance Company (Tank) is specifically fourth echelon maintenance of armored units. The company is capable of performing this fourth echelon maintenance for one armored division or its equivalent in armored equipment and armament. It will also perform fourth echelon maintenance on other vehicles and will inspect vehicles at point of delivery.

The HM Co (Tk) is organized along functional lines with a company headquarters, service and supply platoon (service section, supply section), armament platoon (artillery section, armory section, and instrument section), and a tank repair platoon (repair section and evacuation section). The tank repair platoon operates as the hub of the maintenance shop with the armament platoon and service and supply platoon in support.

This company, in addition to giving fourth echelon maintenance service to all types of armored equipment is capable, with its large service section (1 W.O. and 21 E.M.), of manufacturing parts and tools that are not available through normal supply channels. The following shop trucks are organic to the section for this work:

One ea. Truck, Machine Shop, load 'A'
One ea. Truck, Machine Shop, load 'C'
One ea. Truck, Machine Shop, load 'D'
One ea. Truck, Machine Shop, load 'F'
One ea. Truck, Welding

The spare parts and other accessories handled by the heavy maintenance company (Tk) are primarily those required by tanks and other combat vehicles (including their armament). The company will stock parts for its own fourth echelon work as well as parts to be issued to the using units.

The HM Co (Tk) will normally be assigned to ordnance battalions under Army control and will be found in the corps and/or army service areas. The basis for computing the number of HM Co's (Tk) required for any field army is as follows:

One HM Co (Tk) per Armored Division
0.3 HM Co (Tk) per Tank Bn (Sep)
0.3 HM Co (Tk) per TD Bn (SP)
0.2 HM Co (Tk) per Cav Regt (Mecz)
0.1 HM Co (Tk) per FA Bn (Hv)

During an advance of an army the companies will 'leapfrog' forward with the rear-most company moving forward to the new area first, and the balance of the companies following as the advance continues with impetus from the rear at all times. The company is not completely mobile and is dependent on additional transportation to accomplish its movement.

Duties of Officers. The *Commanding Officer* of a HM Co. (Tk) has the primary mission of supervising the company operations and administration. He will also find himself with an additional responsibility, that of being a liaison officer. It is the CO who must act as liaison officer between his company and supported and supporting units as well as other adjacent ordnance units.

The *Supply Officer* will be a first lieutenant. He will command the service and supply platoon of the company. He will exercise direct supervision of the supply section of his platoon, and he will be responsible for the provision of ordnance general supplies to the company shop and to using units. The service section has a W. O. (munitions, armament machinist) in command of the section. He must be a qualified man with a thorough knowledge of the intricate workings of lathes and other machines to be found in the machine shop trucks which comprise the bulk of the equipment organic to his section.

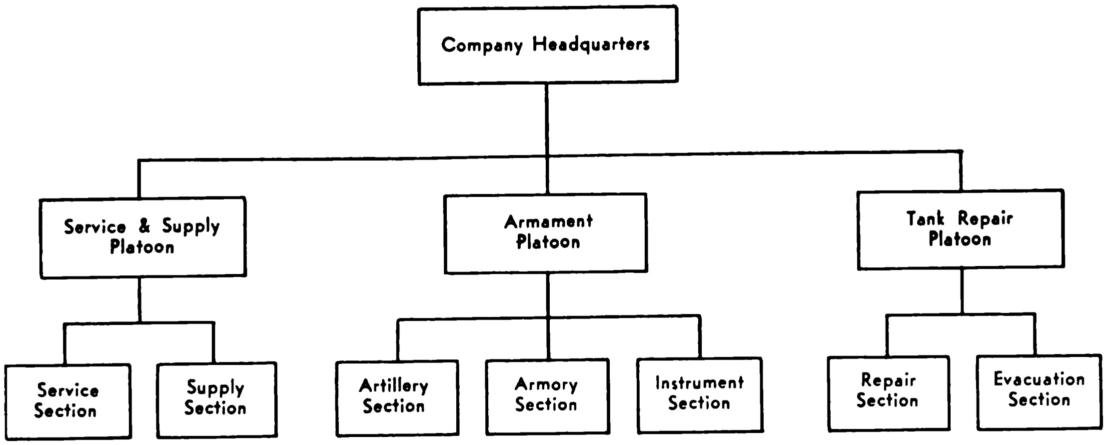


Figure 21a. Organization of a Heavy Maintenance Co., Tank.

A first lieutenant commands the tank repair platoon and also acts as repair officer in charge of the repair section of the platoon. A second lieutenant assigned to the repair section acts as his assistant. This is the only section of the company that has two officers in its organization.

The *Recovery and Evacuation Officer* will be a second lieutenant in charge of the evacuation section of the tank repair platoon. He will supervise all recovery and evacuation work done by the company.

A first lieutenant commands the armament platoon and also acts as artillery officer. In his capacity of platoon leader he will also supervise the operations of the armory section and instrument section. Two second lieutenants are assigned to the armament platoon, one to supervise the activities of the armory section and one the instrument section.

The senior first lieutenant will usually be designated as *Company Shop Officer* and as such he will be responsible for the general administration and functioning of all of the company shops.

Duties of NCO's. A very high percentage of the burden of supervision of the work of the various component parts of the company falls on the NCO's. Each section of the various platoons will have a minimum of one qualified NCO of the first three grades to act as section chief.

In company headquarters we find a first sergeant who handles all of the minor details of administration. Three staff sergeants (mess, motor, and unit supply) are in the company headquarters with duties the same as would be found in any other type of company.

The HM Co (Tk) will have a master sergeant (master mechanic) in the service section; he will normally act as shop foreman for the company shops. He is the

	1	2	3	4	5
1	Unit	Technician grade	Company headquarters	Service and supply platoon: Service section	Service and supply platoon: Supply section
2	Captain		1		
3	First lieutenant				1
4	Second lieutenant				
5	Total commissioned		1		1
6	Warrant officer			[a] 1	
7	Master sergeant, including			1	
8	Master mechanic (342)			(1)	
9	First sergeant (585)		1		
10	Technical sergeant, including				1
11	Chief mechanic, artillery (913)				
12	Chief repairman, instrument (922)				
13	Chief supply (821)				(1)
14	Foreman, auto repair shop (337)				
15	Staff sergeant, including		3	1	1
16	Assistant chief mechanic, artillery (913)				
17	Assistant chief supply (821)				(1)
18	Chief armorer (511)				
19	Chief rigger (189)				
20	Machinist (114)			(1)	
21	Mess (824)		(1)		
22	Motor (813)		(1)		
23	Motor inspector (413)				
24	Unit supply (821)		(1)		
25	Sergeant, including				
26	Assistant chief armorer (511)				
27	Corporal, including		1		
28	Clerk, company (405)		(1)		

6	7	8	9	10	11	12
Armament platoon			Tank repair platoon		Total company	Enlisted cadre
Artillery section	Armory section	Instrument section	Repair section	Evacuation section		
					1	
1			1		3	
	1	1	1	1	4	
1	1	1	2	1	8	
					1	
					1	1
					(1)	(1)
					1	1
1		1	1		4	4
(1)					(1)	(1)
		(1)			(1)	(1)
					(1)	(1)
			(1)		(1)	(1)
1	1		2	1	10	5
(1)					(1)	
					(1)	
	(1)				(1)	(1)
				(1)	(1)	(1)
					(1)	
					(1)	(1)
					(1)	(1)
			(2)		(2)	
					(1)	(1)
	1				1	
	(1)				(1)	
					1	1
					(1)	(1)

13

Remarks

†Insert number of company.

[a] Munitions, armament machinist.

[b] Drive(s) Ordnance Technical vehicle(s).

[c] Armed with carbine, cal. .30, unless otherwise indicated.

[d] Drives truck, ¾-ton.

[e] Drives truck, ¼-ton.

[f] Drives truck, 2½-ton.

[g] These trucks form a pool for the use of all sections. The vehicles may be driven by members of the company other than those designated as drivers in service section.

[r] Armed with rifle, cal. .30, M1903.

[s] Armed with gun, submachine, cal. .45.

Normal Assignment: To Ordnance Battalions under Army command.

Function: Fourth echelon maintenance for all types of armored equipment with emphasis on tanks.

Capacity: Capable of performing above function for one armored division or its equivalent in equipment.

The serial number symbol shown in parentheses is an inseparable part

29	Technician, grade 3 including										13	8	of the specialist designation. See AR 615-26.
30	Technician, grade 4 including										40	13	
31	Technician, grade 5 including		26	19	14	20	18	12	61	13	71	3	
32	Private, first class including										21		
33	Private including										38		
34	Armorer (511)	4					(6)				(6)	(3)	
35	Armorer (511)	5					(6)				(6)		
36	Armorer (511)						(([b]1) ([r]4)6)				(6)		
37	Blacksmith (024)	5		([da]1)							(1)	(1)	
38	Carpenter, construction			(1)							(1)		
39	Clerk, general (055)	5	([ea]1)								(1)		
40	Clerk, parts (348)	4			(1)						(1)	(1)	
41	Clerk, parts (348)	5			(1)						(1)		
42	Clerk, parts (348)				(2)						(2)		
43	Clerk, stock (324)	4			(1)						(1)	(1)	
44	Clerk, stock (324)	5			(1)						(1)		
45	Clerk, stock (324)				(2)						(2)		
46	Cook (060)	4	(2)								(2)	(1)	
47	Cook (060)	5	(2)								(2)	(1)	
48	Cook's helper (521)		(2)								(2)		
49	Driver, heavy truck (245)	5			([r]2)						(2)		
50	Driver, light truck (345)		([r]1)								(1)		
51	Electrician, general (078)	5		(([da]1)2)							(2)		
52	Electrician, track and wheel vehicle (912	4							(1)		(1)	(1)	
53	Electrician, track and wheel vehicle (912)	5							([br]1) (2)		(2)		
54	Electrician, track and wheel vehicle (912)								(1)		(1)		
55	Leather and canvas worker (609)	5	([ed]1)								(1)		
56	Machinist (114)	3		(1)							(1)	(1)	
57	Machinist (114)	4		(1)							(1)		
58	Machinist (114)	5		(([r]1)[b]2)							(2)		
59	Machinist (114)			([rb]2)							(2)		
60	Mechanic, artillery (913)	3				(3)					(3)	(1)	
61	Mechanic, artillery (913)	4				(5)					(5)	(1)	
62	Mechanic, artillery (913)	5				(([br]1)7)					(7)		
63	Mechanic, artillery (913)					(([r]4)5)					(5)		
64	Mechanic, automobile (014)	3							(4)		(4)	(1)	
65	Mechanic, automobile (014)	4							(6)	(1)	(7)		
66	Mechanic, automobile (014)	5							(([br]2)5)	([ee]1)	(6)		
67	Mechanic, automobile (014)								(3)	(3)	(6)		
68	Mechanic, carburetor (414)	5							([fr]1)		(1)		
69	Mechanic, chassis, track vehicle (908)	4							(1)		(1)	(1)	
70	Mechanic, chassis, track vehicle (908)	5							(3)		(3)		
71	Mechanic, chassis, track vehicle (908)								([r] 2)		(2)		
72	Mechanic, chassis, wheel vehicle (906)	3							(1)		(1)	(1)	
73	Mechanic, chassis, wheel vehicle (906)	5							(1)		(1)		

Figure 21b. T/O & E 9-37 Ordnance Heavy Maintenance Co. (Tank), 3 July 1943.

	1	2	3	4	5	6	7	8	9	10	11	12	13
				Service and supply platoon		Armament platoon			Tank repair				
	Unit	Technician grade	Company headquarters	Service section	Supply section	Artillery section	Armory section	Instrument section	Repair section	Evacuation section	Total company	Enlisted cadre	Remarks
74	Mechanic, engine, track vehicle (diesel) (910)	4							(1)		(1)	(1)	
75	Mechanic, engine, track vehicle (diesel) (910)	5							(2)		(2)		
76	Mechanic, engine, track vehicle (diesel) (910)								([r] 1)		(1)		
77	Mechanic, engine, track vehicle (gasoline) (909)	3							(1)		(1)	(1)	
78	Mechanic, engine, track vehicle (gasoline) (909)	4							(1)		(1)		
79	Mechanic, engine, track vehicle (gasoline) (909)	5							(2)		(2)		
80	Mechanic, engine, track vehicle (gasoline) (909)								([r] 1)		(1)		
81	Mechanic, engine, wheel vehicle (905)	3							(1)		(1)	(1)	
82	Mechanic, engine, wheel vehicle (905)	4							(1)		(1)		
83	Mechanic, engine, wheel vehicle (905)	5							(1)		(1)		
84	Mechanic, fuel induction (926)	4							(1)		(1)	(1)	
85	Mechanic, fuel induction (926)	5							(2)		(2)		
86	Mechanic, fuel induction (926)								([r] 1)		(1)		
87	Mechanic, turret (907)	3							(1)		(1)	(1)	
88	Mechanic, turret (907)	4							(2)		(2)		
89	Mechanic, turret (907)	5							(2)		(2)		
90	Mechanic, turret (907)								([r] 3)		(3)		
91	Metal worker (201)	5		(1)							(1)		
92	Painter, automobile (143)	5		(1)							(1)		
93	Receiving or shipping checker (186)	4			(1)						(1)		
94	Receiving or shipping checker (186)	5			(1)						(1)		
95	Receiving or shipping checker (186)				([r] 2)						(2)		
96	Repairman, instrument (922)	3						(1)			(1)	(1)	
97	Repairman, instrument (922)	4						(3)			(3)		
98	Repairman, instrument (922)	5						(5)			(5)		
99	Repairman, instrument (922)							([b r] 1)			(1)		

100		Repairman, radiator (172)	5							(2)		(2)	
101		Rigger (189)	5								(2)	(2)	
102		Rigger (189)									(2)	(2)	
103		Toolroom keeper (242)	5		(1)							(1)	
104		Watchmaker (381)	4						([r] 1)			(1)	
105		Watchmaker (381)	5						([r] 1)			(1)	
106		Welder, general (256)	4							(1)		(1)	(1)
107		Welder, general (256)	5							(1)		(1)	
108		Welder, armor-plate (923)	4		(2)					(1)		(3)	(1)
109		Welder, armor-plate (923)	5		(([b] [r]1)3)					(1)		(4)	
110		Wrecker operator (529)	5								([r] 4)	(4)	(1)
111		Basic (521)		(([r] 5)18)								(18)	
112		Total enlisted		31	21	16	22	20	13	64	14	201	36
113		Aggregate		32	22	17	23	21	14	66	15	[a] 210	36
114	O	Carbine, cal. .30		25	15	13	18	17	11	54	10	163	
115	O	Gun, machine, cal. .50, HB, flexible		1		2					2	5	
116	O	Gun, submachine, cal. .45		1	3						1	5	
117	O	Launcher, rocket, AT		1	1		1			1	1	5	
118	O	Rifle, cal. .30, M1903		6	4	4	5	4	3	12	4	42	
119	O	Semi-trailer, 6-ton, combined animal and cargo.				2						2	
120	O	Semi-trailer, 6-ton, van				4						4	
121	O	Trailer, 1-ton, 2-wheel, cargo		1						1		2	
122	O	Trailer, ¼-ton, 2-wheel, cargo								1		1	
123	O	Truck, ¼-ton		1							1	2	
124	O	Truck, ¾-ton, weapons carrier, w/winch.			[g] 3							3	
125	O	Truck, 2½-ton, cargo		1								1	
126	O	Truck, 2½-ton, cargo, w/winch								1		1	
127	O	Truck, artillery repair					1					1	
128	O	Truck, automotive repair, load "A"								1		1	
129	O	Truck, automotive repair, load "B"								1		1	
130	O	Truck, electrical repair								1		1	
131	O	Truck, instrument repair							1			1	
132	O	Truck, machine shop, load "A"			1							1	
133	O	Truck, machine shop, load "C"			1							1	
134	O	Truck, machine shop, load "D"			1							1	
135	O	Truck, machine shop, load "F"			1							1	
136	O	Truck, small arms repair						1				1	
137	O	Truck, welding			1							1	
138	O	Truck-tractor, 4–5-ton				2						2	
139	O	Truck, heavy wrecker									2	2	
140	O	Truck, trailer, 40-ton, tank transporter.									2	2	

Figure 21b Continued. T/O & E 9-37 Ordnance Heavy Maintenance Co. (Tank), 3 July 1943.

shop officer's chief assistant and will take charge of the shop in the absence of an officer. He must be a man who has been trained in both armament and tank repair.

Each repair section will have a technical or staff sergeant as section chief. They will be the assistants to the officer in charge of their sections. They should be capable of taking over the complete supervision of their section at any time when the section officer is not present. The section chief should be the best qualified repairmen in his section.

The section chief of the supply section is a technical sergeant. He must be able to completely supervise his section, and have a thorough knowledge of supply procedures, SNL's, warehousing, and packaging procedures.

Location of Bivouac Area. The heavy equipment organic to this type company plus the additional heavy equipment evacuated to it from armored units requires the bivouac area to be adjacent to hard surfaced roads. Existing shop buildings and empty buildings in towns will usually be utilized by the company because of the semi-permanent operations of the company shop. The type of vehicles and equipment that will be taken into the shop (tanks, tank recovery vehicles, self-propelled tank destroyers, and artillery pieces) makes it mandatory to have this point in mind when selecting buildings.

When establishing a field shop or a shop in permanent buildings, the tank shop (tank repair platoon) should be assigned the area best suited to accommodate tanks and self-propelled guns. The artillery section will usually receive its work from the tank shop, consequently it should be located as close to the tank shop as possible.

The service and supply platoon must depend on 'shuttling' in order to complete the transportation of its stock when the company moves forward. Two semitrailers 6-ton, animal and cargo, and four semitrailers, 6 ton, van, are the organic vehicles available for this movement. Bins are usually built in the vans for the transportation and storage of small parts. Large unit assemblies will be stored and transported in the animal and cargo trailers. Two 4-5 ton truck-tractors are supplied for the shuttling transportation of these semitrailers. The semitrailers provided do not allow enough storage capacity for the spare parts normally carried by the company; therefore, a small storage depot must be established within the supply section. This small depot will make it necessary to have personnel familiar with the proper methods of storing ordnance materiel, if necessary, in the open. Salvage canvas may be used as a means of protection against the elements if open storage is required. Permanent buildings should be used whenever their use is feasible.

The normal flow of spare parts and assemblies will be from the supporting ordnance depot to the Heavy Maintenance Company (Tk). A secondary source of materiel is cannibalization of salvaged vehicles. When a vehicle is cannibalized the parts will be cleaned and tagged in the shop and then turned over to the supply section to be put into stock. Fast moving parts will remain in the section while others will be sent to the supporting ordnance depot.

The work of the service section of the service and supply platoon has previously been covered above. The remaining sections have the necessary skilled mechanics, armorers, electricians, machinists, metal workers, instrument repairmen, welders, riggers, etc., and the equipment, including a total of eleven repair trucks and two 40-ton tank transporters, to perform the necessary evacuation and fourth echelon work of their sections.

A detailed breakdown of personnel and equipment for this type organization will be found in T/O & E 9-37. The HM Co (Tk) is organized, equipped, and capable of performing fourth echelon maintenance work in support of one armored division or similar armored units with the equivalent in armament and equipment. In addition to this function it can perform a certain amount of supply to the using units. It will normally be found in the corps or army service area. Its equipment and the trained men available enable this company to perform fourth echelon maintenance work, not only on armored equipment, but also on just about every other type of ordnance equipment, and it is to be expected that the company in the field will be found working on almost all of the varied types of equipment designed, developed, supplied, and maintained by the Ordnance Department of the U. S. Army.

HEAVY AUTOMOTIVE MAINTENANCE COMPANY

This company performs specialized automotive maintenance and repair for wheeled vehicles. It can handle repairs on truck-laying combat vehicles only in an emergency, and does *no* artillery, fire control, or instrument work. Essentially it is a mobile automotive garage such as may be found in any large American city.

The HAM company can perform 4th echelon maintenance on approximately 2500 vehicles. This makes it an ideal unit with which to support automotive maintenance in MM companies and to back up MAM companies. When the company is in permament shops, well-supplied with replacement units, and working with seasoned using troops, it can handle more than 2500 vehicles, but this basis is normally used in calculating ordnance troop requirements.

Therefore, one HAM company can efficiently handle unassisted the wheeled automotive 4th echelon for two infantry divisions, or it can carry the overflow from MM and MAM companies for an army. The company is normally assigned to army or an independent corps, and may be located for shop operations in the service area of either. It can operate as base maintenance for small forces for which larger units are unsuitable.

In addition to all 4th echelon, the HAM unit can do limited 5th echelon with its organic tool and equipment authorizations. An adequate machine shop and a great number of skills make this possible. In emergencies, this company could perform all 5th echelon rebuilding if reinforced with such items as additional lathes, crankshaft grinders, and additional 60-ton presses.

In addition to its maintenance and repair mission, the HAM company can repair small arms. The HAM company can be expected to be able to perform field echelons of repair on organizational field ranges.

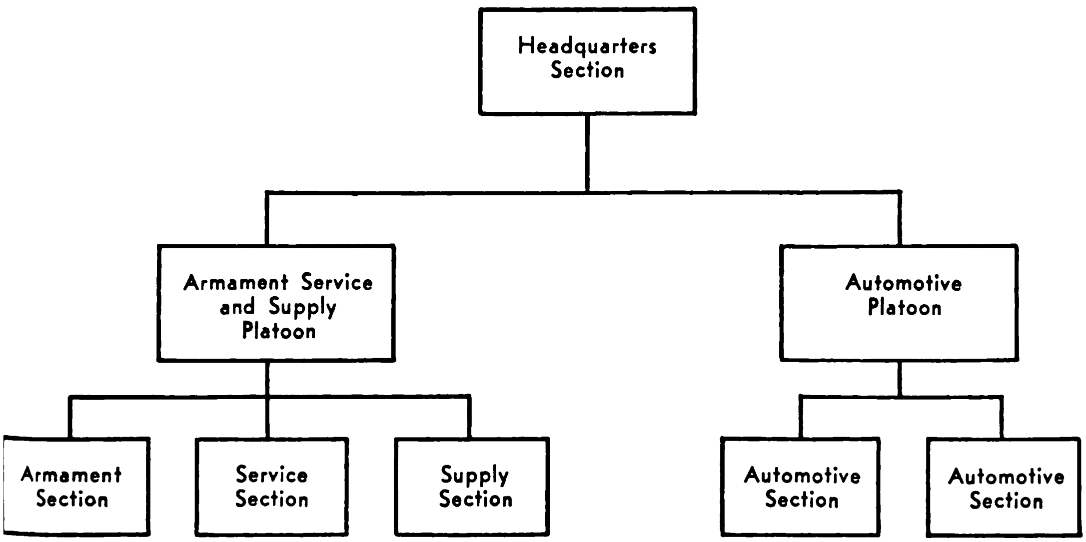


Figure 22a. Organization of a Heavy Automotive Maintenance Co.

The company carries a stock of 1st through 4th echelon parts necessary for its own operation, and either a full or proportionate supply for lower echelons. Driver tools and equipment may be drawn at a HAM company. The unit will issue 2nd echelon parts such as headlamps, horns, fan belts, rotors, sparkplugs, and mirrors. MM and MAM companies may draw carburetors, starting motors, propellor shafts, universal joints, and similar parts and subassemblies. HM (Tank) units can draw wheeled vehicle engines, transmissions, transfer cases, and related major assemblies if required. Normally, the stockage of the HAM company is 15 days; it never exceeds 30 days. It is not a major source of supply unless it is placed on an independent mission; this is especially true as the unit is usually a member of an ordnance battalion (T/O 9-76) which contains a depot company.

Employment and operations are best shown by several examples. During train-

	1	2	3	4	5	6	7	8	9	10	11	12
					Armament, service and supply platoon				Automotive platoon			
1	Unit	Specification serial No.	Technician grade	Headquarters section	Armament section	Service section	Supply section	Total platoon	2 automotive sections (each)	Total company	Enlisted cadre	Remarks
2	Captain, including			1						1		†Insert number of company. ª Also classification specialist (275). ᵇ Drives truck, ¼-ton. ᶜ Armed with carbine, cal. .30, unless otherwise indicated. ᵈ Drives truck, 2½-ton. ʳ Armed with rifle, cal. .30, M1903. ˢ Armed with gun, submachine, cal. .45. *Normal Assignment*: Army or independent corps. *Function*: Performs specialized 4th echelon maintenance and repair for wheel vehicles. *Capacity*: Capable of providing maintenance for approximately 2,500 wheel vehicles. For specification serial numbers shown in column 2, for enlisted men see AR 615-26; for officers and warrant officers see TM 12-406 and 12-407.
3	Company commander	4805		(1)						(1)		
4	First lieutenant, including			1			1	1	1	4		
5	Maintenance and repair, automotive.	4805							(1)	(2)		
6	Shop	4805		(1)						(1)		
7	Supply, general	4000					(1)	(1)		(1)		
8	Second lieutenant, including			1						1		
9	Mess, supply and transportation	4113		(1)						(1)		
10	Total commissioned			3			1	1	1	6		
11	Warrant officer, including					1		1		1		
12	Maintenance service	4813				(1)		(1)		(1)		
13	Master sergeant, including			1						1	1	
14	Master mechanic	342		(1)						(1)	(1)	
15	First sergeant	585		1						1	1	
16	Technical sergeant, including				1		1	2	1	4	4	
17	Foreman, automobile repair shop	337							(1)	(2)	(2)	
18	Repairman, small arms	903			(1)			(1)		(1)	(1)	
19	Supply	821					(1)	(1)		(1)	(1)	
20	Staff sergeant, including			3		1	1	2	1	7	3	
21	Foreman, automobile repair shop assistant.	337							(1)	(2)		
22	Machinist	114				(1)		(1)		(1)		
23	Mess	824		(1)						(1)	(1)	
24	Motor	813		(1)						(1)	(1)	
25	Supply	821		(1)			(1)	(1)		(2)	(1)	
26	Sergeant, including						1	1	2	5		
27	Clerk, parts	348					(1)	(1)		(1)		
28	Rigger	189							(2)	(4)		
29	Corporal, including			1						1	1	
30	Clerk company	405		(ª 1)						(1)	(1)	

31	Technician, grade 3									27	6
32	Technician, grade 4									45	5
33	Technician, grade 5 — including	---	---	19	8	13	14	35	61	77	2
34	Private, first class									9	---
35	Private									18	---
36	Blacksmith	024	4			(1)		(1)		(1)	---
37	Blacksmith	024	5	---	---	(1)	---	(1)	---	(1)	---
38	Bugler and messenger	803	---	([b] 1)	---	---	---	---	---	(1)	---
39	Carpenter, general	050	5	---	---	(1)	---	(1)	---	(1)	---
40	Clerk, parts	348	4	---	---	---	(2)	(2)	---	(2)	(1)
41	Clerk, parts	348	5	---	---	---	(1)	(1)	---	(1)	---
42	Clerk, parts	348	---	---	---	---	(([b] 1) 3)	(3)	---	(3)	---
43	Clerk, parts armament	848	5	---	(1)	---	---	(1)	---	(1)	---
44	Clerk, parts armament	848	---	---	(1)	---	---	(1)	---	(1)	---
45	Clerk, stock record	835	4	---	---	---	(1)	(1)	---	(1)	---
46	Clerk, stock record	835	5	---	---	---	(1)	(1)	---	(1)	---
47	Clerk, stock record	835	---	---	---	---	([r] 1)	(1)	---	(1)	---
48	Clerk, typist	405	5	(1)	---	---	---	---	---	(1)	---
49	Clerk, typist	405	---	---	---	---	([r] 3)	(3)	---	(3)	---
50	Cook	060	4	(2)	---	---	---	---	---	(2)	(2)
51	Cook	060	5	(2)	---	---	---	---	---	(2)	(2)
52	Cook's helper	521	---	(2)	---	---	---	---	---	(2)	---
53	Driver, truck, heavy	245	5	---	---	---	([r] 2)	(2)	---	(2)	---
54	Driver, truck, light	345	5	([r] 1)	---	---	---	---	([e] 1)	(1)	---
55	Driver, truck, light	345	---							(2)	---
56	Electrician, track and wheel vehicle	912	3							(1)	(1)
57	Electrician, track and wheel vehicle	912	4	---	---	(1)	---	(1)	(3)	(3)	---
58	Electrician, track and wheel vehicle	912	5							(3)	---
59	Inspector, motor	413	3	---	---	---	---	---	(2)	(4)	---
60	Machinist	114	3	---	---	(1)	---	(1)	---	(1)	(1)
61	Machinist	114	4	---	---	(2)	---	(2)	---	(2)	---
62	Machinist	114	5	---	---	([d][r] 1)	---	(1)	---	(1)	---
63	Mechanic, automotive, wheel vehicle.	965	3							(16)	(2)
64	Mechanic, automotive, wheel vehicle.	965	4	---	---	---	---	---	(([d][r] 4; [r]7) 40)	(20)	(2)
65	Mechanic, automotive, wheel vehicle.	965	5							(44)	---
66	Mechanic, carburetor	926	3							(1)	(1)
67	Mechanic, carburetor	926	4	---	---	---	---	---	(2)	(1)	---
68	Mechanic, carburetor	926	5							(2)	---
69	Mechanic, chassis, track vehicle	908	3							(1)	---
70	Mechanic, chassis, track vehicle	908	4	---	---	---	---	---	(1)	(1)	---
71	Mechanic, engine, track vehicle (diesel).	910	3							(1)	---
72	Mechanic, engine, track vehicle (diesel).	910	4	---	---	---	---	---	(1)	(1)	---
73	Mechanic, engine, track, vehicle (gasoline).	909	3							(1)	---
74	Mechanic, engine, track, vehicle (gasoline).	909	4	---	---	---	---	---	(1)	(1)	---
75	Mechanic, storage battery	912	5							(1)	---
76	Mechanic, storage battery	912	---	---	---	---	---	---	(1)	(1)	---

Figure 22b. T/O & E 9-197, 27 May 1944. Ordnance Heavy Auto Maintenance Company.

	1		2	3	4	5	6	7	8	9	10	11	12
	Unit		Specification serial No.	Technician grade	Headquarters section	Armament, service and supply platoon				Automotive platoon	Total company	Enlisted cadre	Remarks
						Armament section	Service section	Supply section	Total platoon	2 automotive sections (each)			
		Private—Continued.											
77		Operator, wrecker	529	5						(r 2)	(4)		
78		Painter, automobile	144	5			(d r 1)		(1)		(1)		
79		Painter, general	144				(1)		(1)		(1)		
80		Repairman, automobile body	201	4						(3)	(3)		
81		Repairman, automobile body	201	5							(3)		
82		Repairman, canvas cover	044	4							(1)		
83		Repairman, canvas cover	044	5						(2)	(1)		
84		Repairman, canvas cover	044								(2)		
85		Repairman, radiator	172	4						(1)	(1)		
86		Repairman, radiator	172	5							(1)		
87		Repairman, small arms	903	4		(3)			(3)		(3)		
88		Repairman, small arms	903	5		((d r1)(r1)3)			(3)		(3)		
89		Welder, general	256	3							(1)	(1)	
90		Welder, general	256	4			(r 3)		(3)	(1)	(2)		
91		Welder, general	256	5							(2)		
92		Basic	521		((r 5)10)						(10)		
93		Total enlisted			25	9	14	17	40	65	195	23	
94		Aggregate			28	9	15	18	42	66	ª 202	23	
95	O	Carbine, cal. .30			21	7	10	11	28	62	153		
96	O	Gun, machine, HB, cal. .50, flexible			1		1		1	1	4		
97	O	Gun, submachine, cal. .45			1			1	1	1	4		
98	O	Launcher, rocket, 2.36-inch			1	1		1	2	1	5		
99	O	Rifle, cal. .30			6	2	5	6	13	13	45		
100	O	Semitrailer, 6-ton, combination animal and cargo						5	5		5		
101	O	Trailer, 1-ton			1	1	2		3	4	12		
102	O	Trick, ¼-ton								1	2		
103	O	Truck, ¾-ton, weapons carrier			1			1	1		2		
104	O	Truck, 2½-ton, cargo			1		1		1	4	10		
105	O	Truck, 2½-ton, machine shop					1		1		1		
106	O	Truck, 2½-ton, small arms repair				1			1		1		
107	O	Truck, 4-ton, wrecker								1	2		
108	O	Truck, 4-5-ton, tractor						2	2		2		
109	O	Truck, wrecking, heavy								1	2		

Figure 22b Continued. T/O & E 9-197, 27 May 1944. Ordnance Heavy Auto Maintenance Co.

ing one HAM company was a member of a battalion containing a MM company, a HM (field army) company, a base depot company, and a MAM company. The HAM company did all heavy automotive work for the battalion in garrison and on maneuvers, backing up the MM and MAM company, and conducting all preventive maintenance spot-checks and using troop instruction for the command.

An example of a HAM company doing entirely 5th echelon work occurred on the Alaska Highway where the supply line was slow in delivery and scant in production. The company commander, with higher headquarters approval, secured all heavy machine shop equipment available for reinforcement of his unit. The unit dropped all vehicular job maintenance and turned out approximately 200 engine rebuilds, 100 transmissions, 100 transfer cases, and hundreds of smaller assembly rebuilds each month. Its production of job orders for a single month ran frequently over 1,000. It operated a crankshaft grinder, redesigned deisel fuel pumps, ran engine rebuild test stands, straightened frames (with home-made equipment), and fabricated over 250 parts and pieces per month. Further, it was its own construction firm, erecting supplemental shops and ware houses when they were needed when the unit's operations increased.

A HAM company in the South Pacific operated the so-called service command shops for 3rd and for 4th echelon maintenance, did base maintenance, operated a 3rd echelon depot, and maintained a vehicle replacement pool. On the other hand, a HAM company in the same theater operated as a self-contained 5th echelon shop in a base maintenance organization.

The following is quoted from the report of a HAM company in a combat zone to give an example of the production and operation of this unit: "We completed 2200 jobs the last quarter-year, with engine rebuilds now at 55 per month. We are servicing all the generators (light plants) on the island and are rebuilding lend-lease subassemblies for the (Allied) forces here. The shop, contrary to the T O and E, is operating in two sections. The first does all 4th and 5th echelon on 'allied trades' and the other does 3rd and 4th echelon on vehicles. Twenty-four hour wrecking service has been carried on without accident to our drivers or equipment. During the last three months, we have sent back 200 tons of scrap to the United States." While deviations from approved T/O & E's are against doctrine, this example shows the inherent flexibility of the HAM Company.

The above indicates that evacuation, reclamation, and salvage are definite jobs which can be performed by HAM companies, although not specifically required by the T/O & E. The wrecker service continues around the clock.

The company is organized into a headquarters section, an armament, service and supply platoon, and on automotive platoon, as shown in figure 22. The equipment of the company field shop is moved by the five 6-ton semitrailers provided. Parts are contained in 40 M-1940 spare parts tool cabinets. Since there are but two prime movers, the company is only semi-mobile in the sense that it must move at all times by echelon. There is never the practical possibility of borrowing additional movers to make the HAM company fully mobile in one trip.

The company is not a light one as it must carry the company tool and supply set listed in SNL N-197, 80 motor vehicle mechanics tool sets, and the following special sets:

10 electrical and carburetor mechanic sets;
2 battery experts' sets;
2 blacksmiths' sets No. 2;
6 body mechanics' sets;
4 machinists' sets;
2 painters' sets;
2 sheet metal and radiator mechanics' sets;
4 trimmers' sets;
1 vulcanizers' set;
5 welders' sets.

The company is reasonably well-armed for any enemy action that it might encounter, having in addition to rifles and carbines, 22 M-1 grenade launchers, four cal .50 heavy-barrel machine guns, and five bazookas.

The HAM company is a highly specialized automotive maintenance unit capable of sufficient flexibility to branch from its assigned mission when required. It is essential to the full picture of ordnance service of the using troops.

THE EVACUATION COMPANY

Evacuation Company. The Evacuation Company is the ordnance organization charged with the responsibility for the solution of the problem of evacuation. The arrangement given here of personnel and equipment within the organization should not be considered as limiting in any respect. It is offered merely as a guide, and it may be altered in the field by responsible commanders to fit any particular situation. Recovery, Evacuation and Field Rigging are covered in detail in chapter 6, Volume III.

Mission. The mission of the Ordnance Evacuation Company is as follows:

The transportation of disabled ordnance materiel from points along the axis of supply and evacuation and from collecting points to ordnance shops for repair.

In the case of a retirement by our troops, the evacuation of all ordance materiel from those areas which are likely to fall into the hands of the enemy.

Assisting in the movement of depots and maintenance shops whenever the time and/or equipment is available.

The transportation of materiel between maintenance echelons.

The transportation of serviceable items forward.

Assisting the quartermaster salvage troops after an advance in clearing areas of large items of salvage equipment which the quartermaster service is not equipped to handle.

When the company is operating as part of a maintenance battalion, it will be supplied through the supply office of the battalion in accordance with the procedures outlined by the battalion commander. When the company is on detached mission, it will normally draw its supplies from the echelon to which it is attached.

The company commander is responsible for the training of the company. He must continuously plan a course of action to be carried out in all foreseen circumstances and must supervise the training of personnel in the proper performance of their duties. This training must work toward the goal of automatic performance of duties so that they will be carried on even in times of great stress, and so that a high degree of coordination between individuals and units will weld the whole into an efficient working team.

In the combat zone the evacuation company will normally be under the control of the army ordnance officer. Evacuation companies will circulate throughout the combat zone performing their mission. They will also be active in the communications zone where they will be under the control of the communications zone ordnance officer. Other units will be assigned to the theater reserve to be assigned as needed. The organization of an evacuation company is shown in T/O 9-187, which is shown below.

All personnel of the evacuation company are armed. In general, officers, NCO's, and enlisted men operating directly in evacuation operations will carry carbines, and the rest of the enlisted men will carry the cal .30 rifle. Since it is expected that these companies will usually operate some distance behind the front lines, they carry only defensive weapons. Evacuating units will be armored against cal .30 fire and will carry a cal .50 machine gun for antiaircraft and ground protection.

Each heavy squad in the operating platoon is equipped with a 40-ton tank recovery unit (either the M-26 or the M-19). The light squad is equipped with the M1 heavy wrecker. T/E 9-187, shown below, lists the major items of equipment authorized the unit.

In order for the evacuation company to operate at peak efficiency and with a minimum loss of down time, the evacuation loads should be equally distributed between the various platoons. This will not always be possible, but should be constantly borne in mind as the ideal solution. This ideal will be particularly difficult to obtain when the company is operating over a wide area, as in the case of the evacuation company assigned to the field army or in cases where the situation is changing rapidly. The actual solution adopted will depend on the tactical situation. The preparation of plans to fit the particular situation is the responsibility of the company commander. He is also responsible for the execution of these plans when they are approved by higher headquarters. Two possible solutions to the problem are suggested below.

Centralized Company Control. In this situation, the entire company would operate from a central bivouac; the loads on the platoons would be equalized by the assignment of missions from company headquarters to the platoon with the lightest load. This method requires a high degree of direct supervision of the company. Company supply and messing problems are decreased. However, the average distance to be covered per mission will be high, and the number of missions to be handled in a given time will be small.

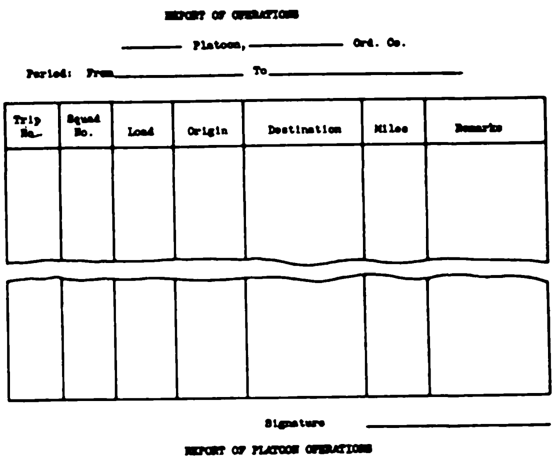
	1	2	3	4	5	6	7	8	9	10
				3 recovery platoons (each)						
1	Unit	Technician grade	Headquarters section	Platoon headquarters	6 heavy squads (each)	1 light squad	Total platoon	Total company	Enlisted cadre	Remarks
2	Captain		1					1		†Insert number of company. [a] Executive officer. [b] Property, mess and liaison officer. [c] One of these men will also act as orderly (695). [d] Will also drive tanks in recovery operations. [e] These guns are mounted 1 per 4 2½-ton trucks (or heavier) listed on this table. The serial number symbol shown in parentheses is an inseparable part of the specialist designation. A number below 500 refers to an occupational specialist whose qualification analysis is found in AR 615-26. A number above 500 refers to a military occupational specialist listed in Circular No. 14, War Department, 1942.
3	First lieutenant		[a] 1	1			1	4		
4	Second lieutenant		[b] 1					1		
5	Total commissioned		3	1			1	6		
6	First sergeant (585)		1					1	1	
7	Technical sergeant, including			1			1	3	3	
8	Platoon chief (014)			(1)			(1)	(3)	(3)	
9	Staff sergeant, including		3					3	2	
10	Mess (824)		(1)					(1)	(1)	
11	Motor (813)		(1)					(1)		
12	Supply (821)		(1)					(1)	(1)	
13	Sergeant, including			2	1	1	9	27	5	
14	Reconnaissance (744)			(2)			(2)	(6)	(2)	
15	Squad leader (653)				(1)	(1)	(7)	(21)	(3)	
16	Corporal, including		1					1	1	
17	Clerk, company (405)		(1)					(1)	(1)	
18	Technician, grade 4 } including							2	1	
19	Technician, grade 5 } including							42	6	
20	Private, first class } including		15	8	5	5	43	40	4	
21	Private } including							60		
22	Chauffeur (344)	5	(1)					(1)		
23	Chauffeur (344)		[c] (4)	(3)			(3)	(13)		
24	Chauffeur (245)	5			(1)		(6)	(18)	(2)	
25	Chauffeur (245)					(1)	(1)	(3)	(1)	
26	Cook (060)	4	(2)					(2)	(1)	
27	Cook (060)	5	(2)					(2)	(1)	
28	Cook's helper (521)		(3)					(3)		
29	Mechanic, tank (404)[d]	5			(1)	(1)	(7)	(21)	(3)	
30	Rigger (189)				(3)	(2)	(20)	(60)	(3)	
31	Welder, general (256)					(1)	(1)	(3)		
32	Basic (521)		(3)	(5)			(5)	(18)		
33	Total enlisted		20	11	6	6	53	179	23	
34	Aggregate		23	12	6	6	54	185	23	
35	O Carbine, cal. .30		17	10	4	4	38	131		
36	O Gun, machine, cal. .50, HB, flexible [e]		2	2			2	8		
37	O Gun, submachine, cal. .45		2	2		1	3	11		
38	O Launcher, rocket, antitank		2	1			1	5		
39	O Rifle, cal. .30		4		2	1	13	43		
40	O Trailer, 1-ton, 2-wheel, cargo		2					2		
41	O Truck, ¼-ton		1	2			2	7		
42	O Truck, ¾-ton, command and reconnaissance with winch		1					1		
43	O Truck, ¾-ton, weapon carrier, with winch					1	1	3		
44	O Truck, 2½-ton, cargo, with winch		3					3		
45	O Truck, wrecking, heavy					1	1	3		
46	O Truck, 40-ton, tank recovery				1		6	18		

Figure 23. T/O 187 Ordnance Evacuation Company, 2 Oct. 1942.

Dispersed Platoon Control. This solution allows the platoon to operate from a location convenient to its work. This will decrease the down time and increase the number of missions that can be handled. Also, liaison work will be facilitated by the close proximity to the collecting point, and movement of platoons will be facilitated. The disadvantages of this solution are that the supply and messing of the company becomes complicated; it is difficult for the company headquarters to maintain close control over the platoons, and this may result in wide variations in the load imposed on any one platoon. Within this solution, there are two methods of assigning the evacuation platoons. These are:

Assignment to Tactical Units. Platoons may be assigned to support definite tactical organizations. This arrangement allows the platoon and the tactical unit to get acquainted with each other: to learn each other's requirements, methods of operation, capabilities, and limitations thereby improving coordination and the quality of ordnance service rendered. However, the work required by a tactical unit will vary widely, resulting in poor equalization of the evacuation load. Also, the tactical unit may make a sudden movement of some length, requiring the platoon either to follow or make other arrangements. This necessitates close liaison between company headquarters and the platoons.

Assignment to Specific Areas. Platoons may be assigned definite areas instead of definite tactical units. Much of the discussion in the preceding paragraph will apply also in this case. However, the loads may be more easily equalized by adjusting the areas from time to time as the need arises, and platoons will not be required to follow tactical units.


REPORT OF OPERATIONS

______ Platoon, ______ Ord. Co.

Period: From ______ To ______

Trip No.	Squad No.	Load	Origin	Destination	Miles	Remarks

Signature ______

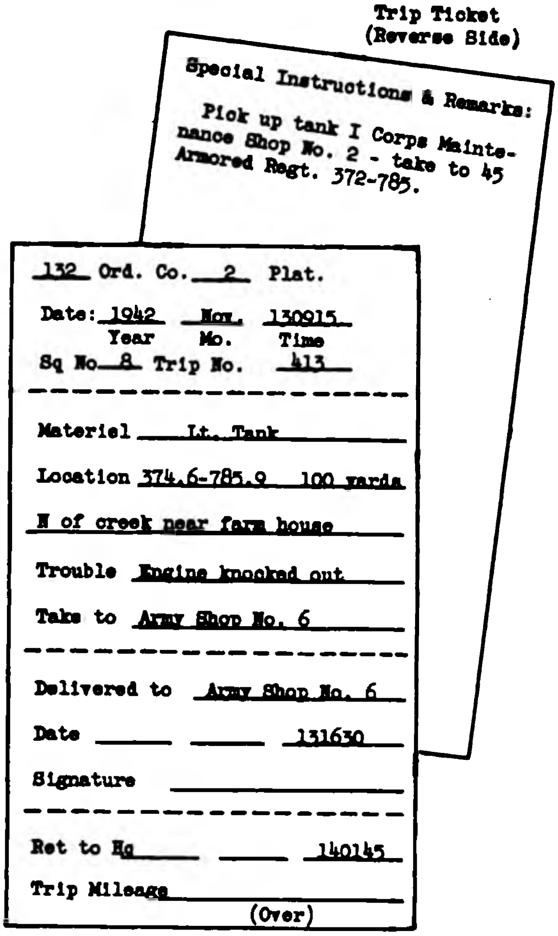
REPORT OF PLATOON OPERATIONS

Figure 23A. Report of Operations.

Reports. In order to facilitate the equalization of loads on the various platoons, company headquarters must keep a close check on the work performed by each. This check will also be necessary to enable the company to prepare reports required by the higher headquarters. When the company is operating as a unit, the check will be maintained by requiring all calls for missions to pass through company headquarters and by requiring all trip tickets to be turned in to the company headquarters. If the platoons are dispersed, their headquarters will be required to send a report to company headquarters at prescribed intervals, giving the details of the missions performed.

Trip Ticket. In order to enable the company commander to keep informed of the missions carried out by the various platoons, a record will be kept of all missions performed. A convenient form for this purpose is a trip ticket. This will be used as the authorization for a squad to perform a given mission and will be prepared in duplicate by the headquarters assigning the mission. It will give the item of materiel to be moved, its location, the apparent trouble with it, and the place to which it is to be moved. Space will also be provided for special instructions, such as new materiel to be carried forward. The trip ticket will contain spaces for the inclusion of the designation of the squad performing the task, time of departure, time of return, mileage covered, and remarks. When a squad is on a mission the duplicate of this ticket should be kept in an active file or posted on an operations board in platoon headquarters. Upon completion of the mission this duplicate may be destroyed. The information contained in the original is posted to a consolidated report, and the original trip ticket is disposed of as directed by the company commander.

The *Consolidated Report* is submitted to company headquarters at prescribed



Trip Ticket
(Reverse Side)

Special Instructions & Remarks:
Pick up tank I Corps Maintenance Shop No. 2 - take to 45 Armored Regt. 372-785.

132 Ord. Co. 2 Plat.

Date: 1942 Nov. 130915
Year Mo. Time

Sq No 8 Trip No. 413

Materiel Lt. Tank

Location 374.6-785.9 100 yards N of creek near farm house

Trouble Engine knocked out

Take to Army Shop No. 6

Delivered to Army Shop No. 6

Date ______ ______ 131630

Signature ______

Ret to Hq ______ ______ 140145

Trip Mileage ______

(Over)

Trip Ticket
(Obverse side)

Figure 24. Trip Ticket.

REPORT OF OPERATIONS, ______ Ord. Co.

Period: FROM ______________ To ______________

Platoon	1st	2nd	3rd	Totals
No. of trips				
Total Mileage				
Destination	No. of Trips	No. of Trips	No. of Trips	Total

REPORT OF COMPANY OPERATIONS

Figure 25. Report of Company Operations.

intervals. It shows in consolidated form the pertinent information contained in all trip tickets for missions performed during the reporting period. This form is prepared in duplicate by platoon headquarters, the original being transmitted to company headquarters at the end of the reporting period. The duplicate is retained by platoon headquarters and filed for their own information.

Company headquarters will use the consolidated reports received from the platoons to prepare a breakdown of the work preformed by the company as a whole. This will give the company commander a check on the equalization of the loads on the platoons and will assist him in reassignment of spheres of action for the platoons.

In order that the company commander may have proper knowledge of the situation and of impending operations, he must keep in close contact with the army ordnance officer. With information obtained from this source, he can dispose his platoons so as to give the maximum support where it is needed the most. In an active engagement the company commander must keep in close touch with his platoons and shift their zones of action as may be necessary to equalize the evacuation loads. Company headquarters should keep an operations map showing the salient features of the tactical situation and the location and area assignments of each platoon. An additional advantage of this map is its use in preparing overlays which may be used as movement orders for the reassignment of spheres of action for the platoons. Platoon headquarters will maintain a situation map showing the last reported position of each of their operating squads.

Company Headquarters. The company headquarters consists of one or more officers and the required number of enlisted men.

The vehicles assigned to company headquarters include the following:

Truck, ¼-ton, 4x4. This vehicle is used primarily for general messenger service.

Truck, ¾-ton, 4x4. This vehicle is usually assigned to the company commander for his use or to be used as he may direct.

Truck, 2½-ton, 6x6. One of these vehicles is used as the kitchen truck. It carries the range, icebox and kitchen utensils.

Other trucks of this type are used as company supply trucks. When the company moves, these trucks will carry office equipment and other company impedimenta.

Organization. The company headquarters carries out the general military administrative functions of the company. In order to facilitate the division of responsibility, this section is divided into the following subsections:

Administrative. This subsection is headed by the first sergeant. It is responsible for:

- The training and administration of the company.
- The maintenance of personnel records.
- The maintenance of the company council book.
- The preparation of training programs and schedules for the military and technical training of the company.
- The supervision of all training in the company.
- The maintenance of the correspondence files and the correspondence book, and the preparation of such records and reports as may be directed by the company commander.
- The preparation of all necessary plans covering the changes in the location of the company, and the maintenance of a situation map showing the locations of the various components of the company.
- The conduct of periodic scheduled or unscheduled inspections of all phases of the activities of the company.

Mess. This subsection is headed by the mess sergeant and is responsible for:

- Securing, transporting, preparing, and serving rations.
- The preparation of all menus whenever the variety of the ration will permit.

Supply. This subsection is headed by the supply sergeant and is responsible for:

- The maintenance of the stock record covering all company property.
- The maintenance of all records of individual equipment and of files of memorandum receipts of property held by members of the company.
- The maintenance of files of all vouchers to the stock record account.
- The preparation of requisitions of all items required by the company,

The preparation of all property forms—such as reports of survey; statements of charges; inventory and inspection reports; over, short and damaged reports; etc.—required in the property administration of the company.

Transportation. This section is headed by a motor sergeant. It is responsible for traffic control within the company.

Personnel. *Company Commander.* The company commander is responsible for all phases of the operations of the company. He should require the heads of all sections to keep him informed at all times of any changes in the status of matters pertaining to the operation of the company. He should establish the major policies and routine of procedure governing the operation of the company, but should delegate the responsibility for the performance of specific duties to the proper subordinates. Such subordinates should be held strictly responsible for the results. He is solely responsible for the administration of disciplinary action under the 104th Article of War, and he cannot delegate this authority. He is also responsible for planning for future requirements and inspecting the units of the company. He should actively participate in personnel administration. He should from time to time reassign officer and noncommissioned officer personnel in the company to different sections or duties. Such a practice will assist in preparing the company to meet emergencies. He should endeavor to insure continuity of policy within the company by the maintenance of policy books by each section.

Company Executive. In general, the senior lieutenant of the company will be designated as the company executive. In addition to his normally assigned duties, he will keep himself informed of matters affecting the entire company, and he will be prepared to act for the company commander in his absence.

Property, Mess, and Liaison Officer. Has the usual functions of such an officer.

First Sergeant. The first sergeant is the company commander's senior representative in matters pertaining to company administration. He is specifically responsible to the company commander for:

Maintenance of all records and reports pertaining to company administration.

Preparation of purely military training programs and schedules.

The enforcement of discipline.

The preparation and issuing of company orders as directed by the company commander.

The supervision of formations.

The preparation of routine correspondence.

Supply Sergeant. The supply sergeant is responsible to the supply officer for the security, proper storage, and administration of the company property. He should understand thoroughly all property regulations and must keep accurate and complete records and inventories.

Mess Sergeant. The mess sergeant is responsible to the mess officer for all matters pertaining to the administration, obtaining, preparing, and serving of the company mess and the care and maintenance of all mess property.

Motor Sergeant. The motor sergeant is responsible for the dispatching and maintenance of company vehicles.

Company Clerk. The company clerk is responsible to the first sergeant for the typing of all necessary files and records kept by that office.

The Evacuation Platoon

The evacuation platoon is organized with a platoon headquarters, headed by the platoon commander, who is assisted by eleven enlisted men, and six heavy squads and one light squad, each of which consists of an evacuation unit and its crew.

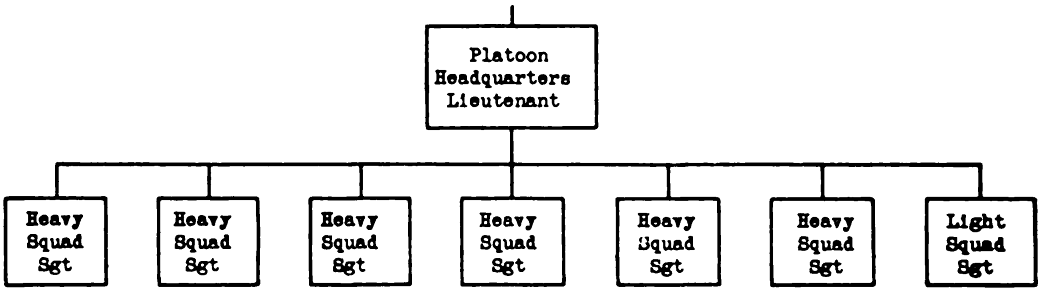
The major items of equipment assigned to the evacuation platoon are shown in the Table of Organization.

The general picture of the problem confronting the evacuation platoon is discussed at the beginning of this study. In this connection it should be clearly understood that the ultimate responsibility of the evacuation platoon falls on the company commander, to whom the platoon commander is in turn responsible.

Control of the units of the evacuation platoon will normally be effected through platoon headquarters. The platoon will be assigned a specific mission and will be given any general instructions necessary by company headquarters. Within the limitations imposed by these instructions, the full responsibility for the accomplishment of the mission falls on the platoon commander. Through platoon headquarters the platoon commander will control the dispatching of vehicles from the platoon area and the movements of these vehicles in the field.

In order to maintain the close control specified above, it is imperative that the platoon commander maintain close contact both with evacuation units in the field and with company headquarters.

Careful consideration should be given to recognition signals between ground and air forces. These signals will be prescribed by higher headquarters. All evacuation units in the field should be kept informed of any changes of such recognition signals and carefully instructed in their use. This is particularly important for such units, since their size and slow speed make them excellent targets for both aircraft and artillery. It may sometimes happen also that they will be transporting captured enemy equipment, in which case they might be mistaken for enemy units.



Sections of the company will have personnel assigned to them as required.

Figure 26. The Evacuation Platoon.

The control of the platoon is administered from the platoon office. This office maintains a situation map showing the location of the various evacuation squads, and will prepare reports required by company headquarters. The platoon office is also responsible for maintaining liaison with collecting points or the combat units supported. These functions are carried out by reconnaissance noncommissioned officers, who go forward to collecting points or other places where damaged materiel may be found and keep platoon headquarters informed as to routes to such places, as well as the number, types, and conditions of materiel to be evacuated. These liaison agents should cooperate closely with other ordnance representatives at collecting points. If possible, radio communication should be used. In the absence of directives, these agents should be prepared to make a cursory inspection of damaged materiel with a view to recommending the proper destination for evacuation.

The Recovery Squad

The heavy evacuation squad consists of an evacuation transporter unit with its crew. It is in command of a sergeant, and the crew consists of five additional men.

The primary function of an evacuation squad is to go forward to the location of damaged ordnance materiel, load it on the transporter vehicle, and carry it to a maintenance shop for repair.

Squads should keep in close contact with platoon headquarters, keeping it informed of their location and of any other pertinent data in which it may be interested. The squad will be trained in the use of, and prepared to use, the prescribed recognition signals between ground and air forces.

Heavy evacuation units normally will be protected by armor against fire from small arms. They will also be equipped with a cal .50 machine gun for protection against aircraft and enemy raids. In addition, each man will be equipped with a carbine.

The light squad is essentially the same as the above except that it is equipped with a heavy wrecker in place of the transporter unit referred to above.

The operations of the evacuation squad are of a highly specialized nature. Since they will operate fairly close to the front lines, where they may be subject to enemy attack, it is essential that they be welded into a smooth-working, highly efficient team in order that they may accomplish their mission in the most expeditious manner. The training of these squads should include the efficient use of camouflage and the proper use of individual cover. These men should also be well trained in detecting and neutralizing booby traps. A security plan should be worked out in detail, and the squad drilled in its execution, so that proper protection may be maintained at all times.

The sergeant in charge of the squad acts as its commander at all times. He acts as foreman during evacuation operations. He is responsible for the training and efficiency of his crew.

The driver operates the vehicle on the road and operates the winches during loading and unloading operations. He is responsible for the mechanical condition of the vehicle and the maintenance of the motor book. He also acts as gunner when the mechanic is otherwise employed.

The mechanic assists the driver in keeping the equipment in good mechanical condition. He also assists in loading and unloading, especially where mechanical ability is required. It may sometimes happen that a small amount of mechanical work on the damaged vehicle will make it easier to handle in loading operations. A few minutes spent in such preparations may save hours in loading time. The mechanic acts as gunner when the need arises and will man the cal .50 machine gun when required both on the march and during loading operations.

The riggers handle the ropes and cables under the direction of the squad leader and perform any other duties as he may direct. They should be capable of driving tanks and other automotive equipment so as to assist in loading operations where the automotive power of the damaged vehicle may be used. These men should be fully conversant with ropes, knots, and other rigging equipment, and should exercise great care not to injure the disabled or damaged materiel further in loading and unloading operations.

HEADQUARTERS AND HEADQUARTERS COMPANY, ORDNANCE BASE DEPOT

Organization. On 13 September 1944 a tentative T/O & E 9-620-1T was adopted by the War Department. The organization provided herein was essentially the ordnance top echelon in a base section set-up. Known as the headquarters and headquarters company, ordnance base depot, this organization consolidates command, technical operations, and administrative functions for ordnance service within the scope of a base under a single well-defined organization. The unit is headed by a colonel (who may be recommended for the rank of brigadier general if deemed appropriate by the theater commander), and in addition includes 28 other officers, three warrant officers, and 100 enlisted men. Functions of the various groups have not been determined thus far although officers experienced in base ordnance service will readily ascertain that there is little radical difference in duties which were formerly somewhat decentralized under base group set-ups, etc.

Operation. From inspection of T/O & E 9-620-1T it is seen that each major division has an administration branch in addition to the others. In a broad sense, it is considered that this branch will execute the overhead functions for the division as a whole, whereas the other branches will carry out the detailed mission. Further, from a study of the specialized nature of officers and enlisted personnel in these 'operating' branches, one is led to presume that the ordnance officer will require execution as well as control and supervision of many operational details by headquarters personnel. In this regard, and as is appropriate for the base section situation, certain branches of the various divisions may in part operate in the various ordnance installations of the base. For example, certain of the supply and maintenance personnel may perform their duties at the base depot or base shop.

The organization's designation of a base depot conforms to present staff policies which favor centralization of base activities. Specifically, it is contemplated that the supply, maintenance, and other activities for all the various services will operate at a single consolidated set-up wherever practicable. The combined operation is therefore designated a base general depot with ordnance service comprising a section thereof. This set-up, in addition to providing excellent control and super-

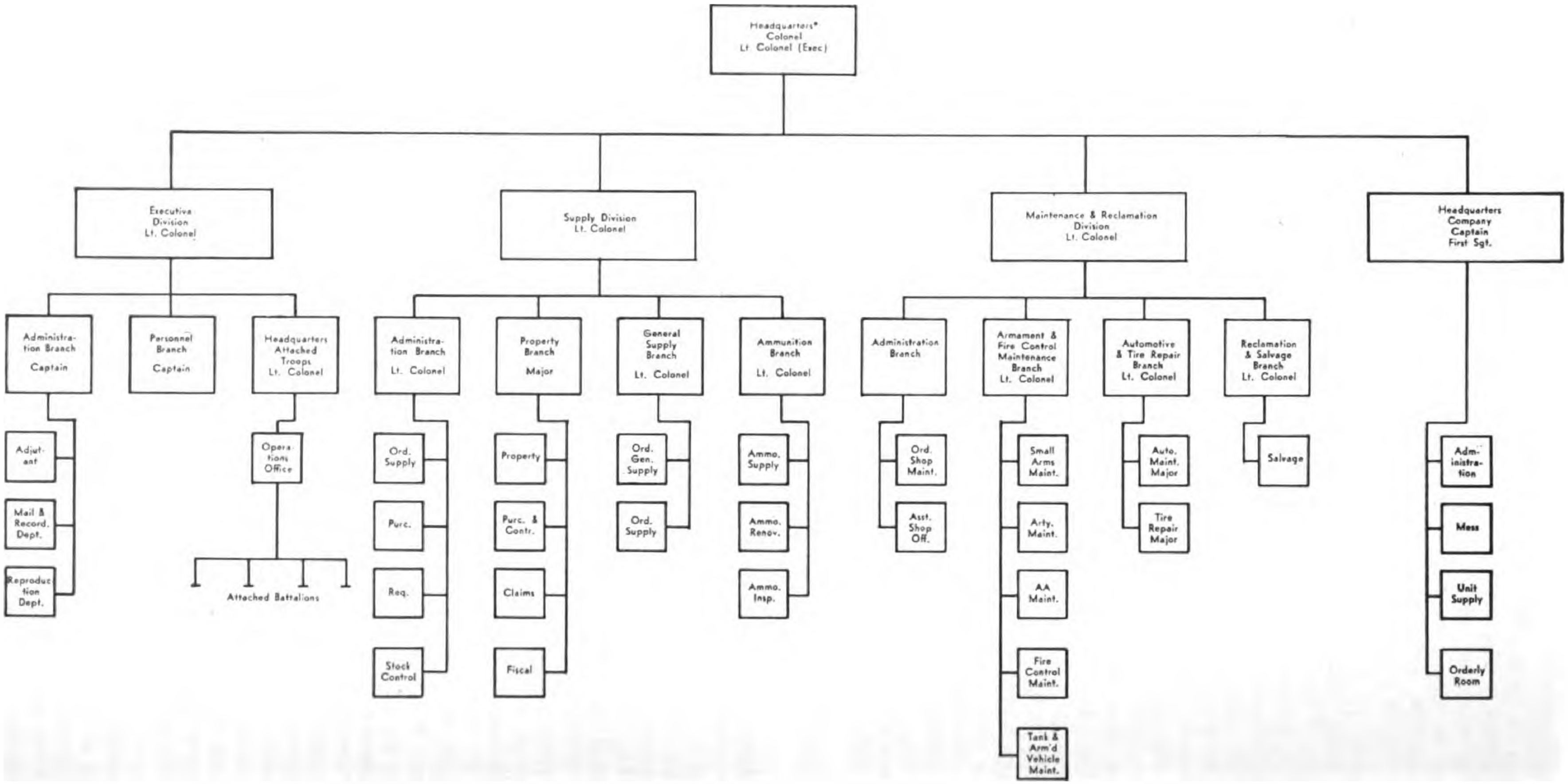


Figure 27. Organization of a Headquarters and Headquarters Company, Ordnance Base Depot.

vision of services of supply, enables numerous other advantages which include pooling common labor, rail, and motor transportation; overhead services such as utilities, maintenance, police, guard, warehousing, etc.; expediting of handling materiel shipments incoming and outgoing, etc. However, the consolidation of personnel replacements, port facilities, medical installations, allied military government, and similar overhead functions is not intended in the base general depot.

The headquarters and headquarters company, ordnance base depot, is not a mobile organization, nor is it capable of separate operation in the sense that supplementary facilities of the AG, JAG, FD, PM, and the allied services will be necessary in the field. This organization is directly under the communications zone ordnance echelon and will be considered by readers when studying Base Sections Operation in Staffs, Chapter 6, Volume I.

ORDNANCE SERVICE COMPOSITE ORGANIZATION

The Ordnance Service Composite Table of Organization and Equipment 9-500 was published 6 August 1943*. Within the T/O & E are found platoon, company, and battalion headquarters, mess, supply, and maintenance teams, recovery and bomb disposal units. Sections and teams in the proper number can be placed

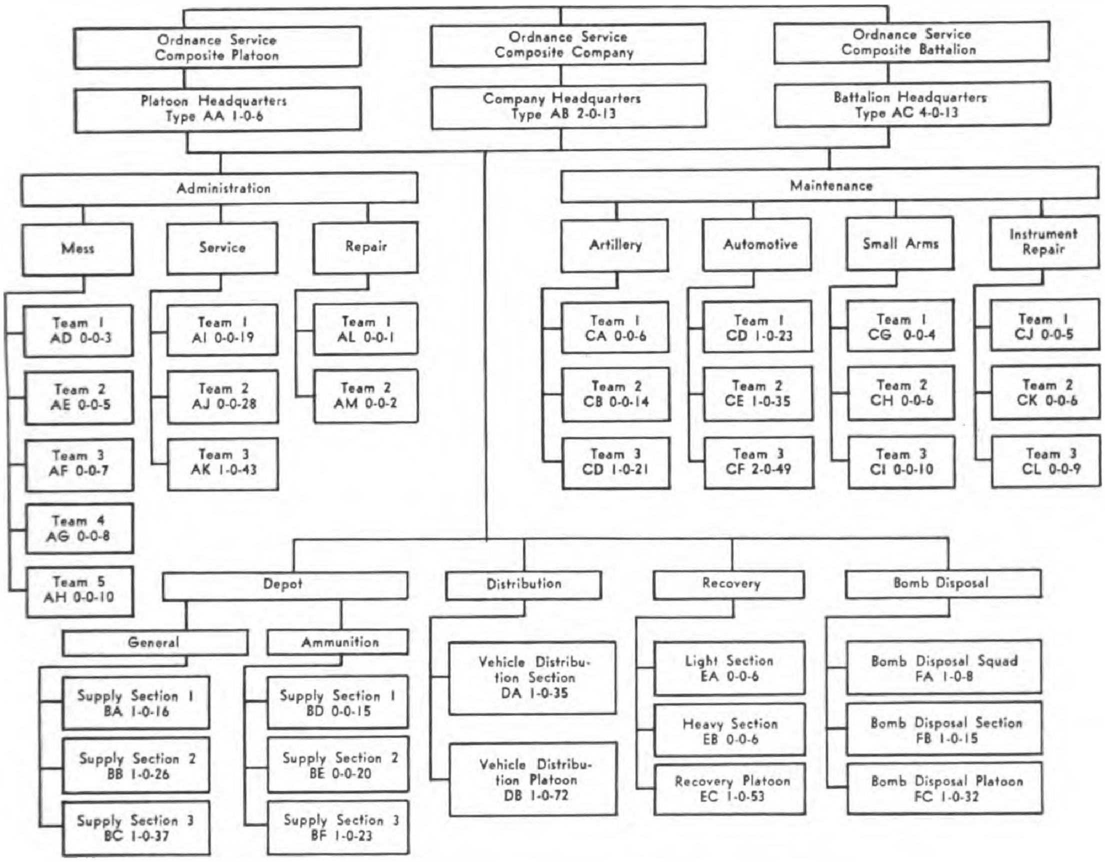


Figure 28. Ordnance Service Composite Organization.

under the command of an adequate composite headquarters to perform most types of ordnance service required in the field. The T/O & E serves as an authority for grouping ordnance personnel and equipment into standard elements. Flexibility of organization results because there are a large variety of elements from which to choose when forming a composite organization.

The possibilities of this type of organization are indicated in an example of

*Ordnance Service Organization, T/O & E 9-500 of 14 Oct 1944, supersedes the above mentioned T/O & E. No material was available on this particular organization at the time this text was written, however its organization and operations are very similar and for that reason the above article is retained.

happenings that might take place in the Southwest Pacific. The theater commander requires trained men to perform AA maintenance in a particular sector. An AA Maintenance Company is sent from the States. Because the Company is not mobile enough and because it is not organized to operate in several sections simultaneously, it can not find enough AA repair work to keep busy. As a result the company gradually changes its function and performs automotive maintenance, depot work, or whatever ordnance work it can find to do. The AA maintenance personnel and equipment have been misplaced. An Ordnance Service Composite Company might have been sent. It is a special company, handpicked for a particular situation. For example: a company headquarters, a supply team, a mess team, 6 instrument teams, and 4 AA maintenance teams could have been selected. These elements are all taken from T/O & E 9-500 and are chosen in such numbers as to perform effectively in an area where AA installations are widely separated. Each instrument and maintenance team can operate separately allowing the company to 'range out' so as to serve a large area and thereby find sufficient AA maintenance work to keep the company completely occupied with work for which it is equipped and trained.

The fictitious example outlined above shows one unit that may be formed from standard ordnance elements or teams to serve a particular purpose. There are many other needs, and in T/O & E 9-500 are found many other elements that may be combined in a like manner to suit the needs.

In a recent letter from the commander of a composite unit overseas the comment is made that this is a "very practical" set-up.

BALLISTIC AND TECHNICAL SERVICE TEAMS FOR FIELD OPERATIONS

Introduction. Up to the present, calibration of artillery in the field has been a lengthy and difficult process. The impracticability of setting up at the gun positions cumbersome apparatus usually employed for proving ground determination of velocities necessitated the removal of guns to rear areas or the ascertainment of range differences by observation of fire under combat conditions.

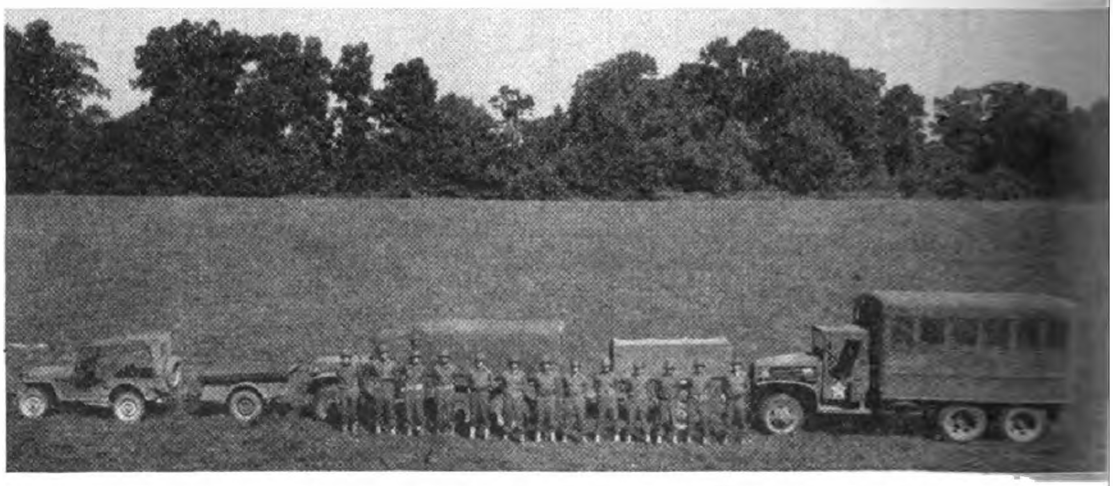


Figure 29. Ballistic Calibration Teams for Field Operation. Complete T6 Chronograph Team and Equipment.

It is now possible by the use of compact, portable T6 Chronograph equipment to determine gun velocities in theaters of operation with proving ground accuracy. While it is preferable to remove the weapons to a rest or advance base area, calibration may be done at combat positions. All the guns of a battery at the front can be relatively calibrated in from two to three hours, provided the calibration team can move freely about the gun positions. The same number of guns can be calibrated in a base area in about one hour.

This rapid and precise velocity calibration is performed by Ballistic and Technical Service Teams organized and trained by the Ordnance Department at the direction of the Chief of Ordnance upon request for such service from the artillery arms and commanding generals in the theaters of operation. These teams are available for duty in the various theaters. Their functions and method of obtaining velocity measurements are described in this section.

Purpose. Effective employment of artillery in the field depends not alone on the efficiency of gun crews, but also on a knowledge of the ballistic characteristics of the weapons. The difference in velocity, and consequently in range, between

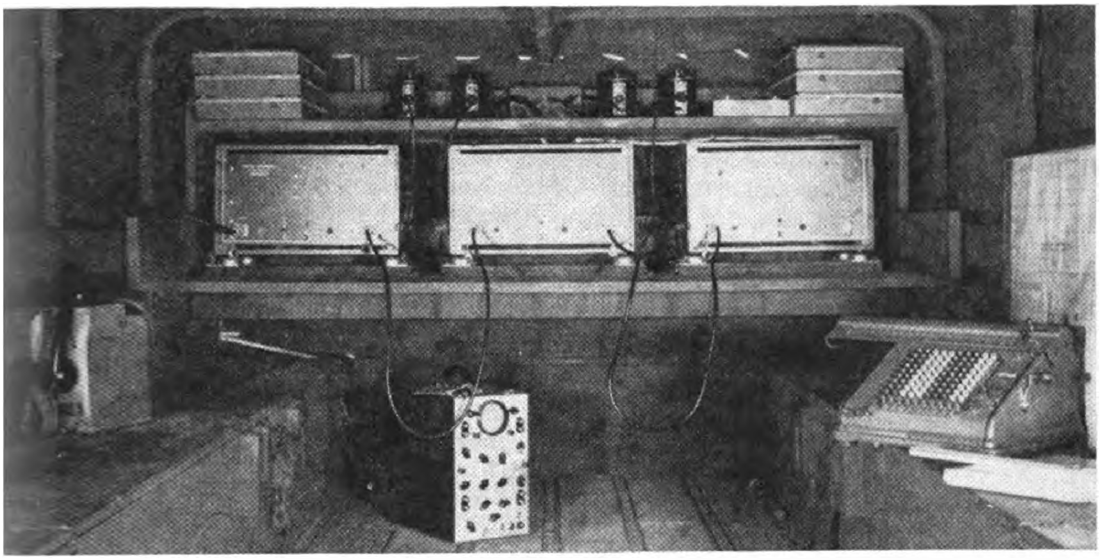


Figure 30. Interior of 1½-Ton 6 x 6 Truck With Chronograph Equipment in Operating Position.

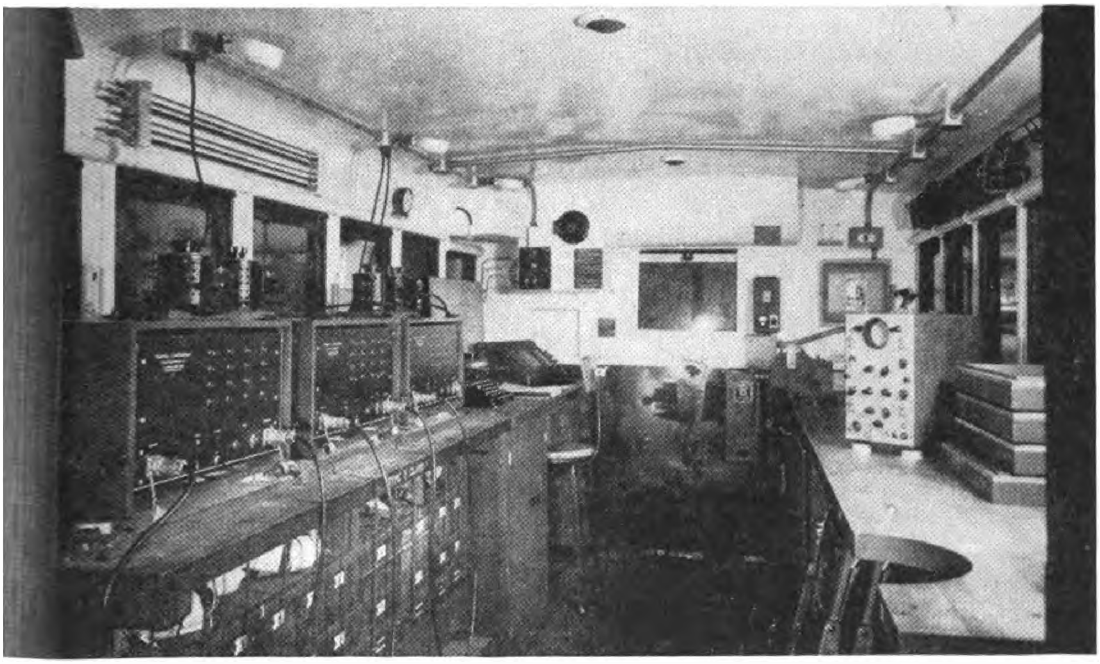


Figure 31. Interior of 2½-Ton Machine Shop Truck With Chronograph Equipment in Operating Position.

a gun as issued and the same gun after use must be known if fire is to be accurate. Firing tables give velocities and ranges for a new gun using standard ammunition. If factors making for differences exist, variations in velocities and ranges from those in the firing table must be compensated for if the center of impact is to be brought on the target promptly.

Failure to correct for velocity differences in guns may result in an unsuccessful artillery mission with possible casualties to friendly troops that might not have occurred if adjustment of fire had been accurate and rapid. When fire is inaccurate excessive ammunition is used, and resultant abnormal wear of gun tubes will hasten the necessity for their replacement. These consequences of velocity variation are avoidable. Grading and segregation of ammunition lots is the first and most important corrective measure; calibration of the weapons is the second.

In order to secure the maximum efficiency in combat fire, it is very desirable to have previously determined either the absolute or relative calibration of the larger weapons being employed within the respective artillery organizations. It should be noted, however, that calibration is merely a refinement in the improvement of artillery fire, except possibly in weapons like the 8-inch gun, and is apt to be far less important than differences between ammunition lots. Differences between guns, save for the single case of unobserved fire, are subject to control; but when ammunition lots are mixed the differences between lots make for contradictions in every salvo. Hence, ammunition lot integrity is the basis for application of any calibration data.

Guns are frequently blamed for inaccuracies actually caused by mixing of ammunition lots, and even by mixing of shell of different zone weights (without correction) in ready stacks at the guns. This neglect to grade and segregate ammunition sometimes results in alleged dispersion errors attributed to worn or 'oval' bores, which cause tubes to be wrongly condemned at a very early life.

Strict observance of ammunition lots is indispensable to controlled artillery fire. No amount of calibration will do much toward securing accuracy if grading and segregation of ammunition are neglected. Once proper sorting of ammunition is achieved, calibration will enable accurate and rapid control of fire to be maintained.

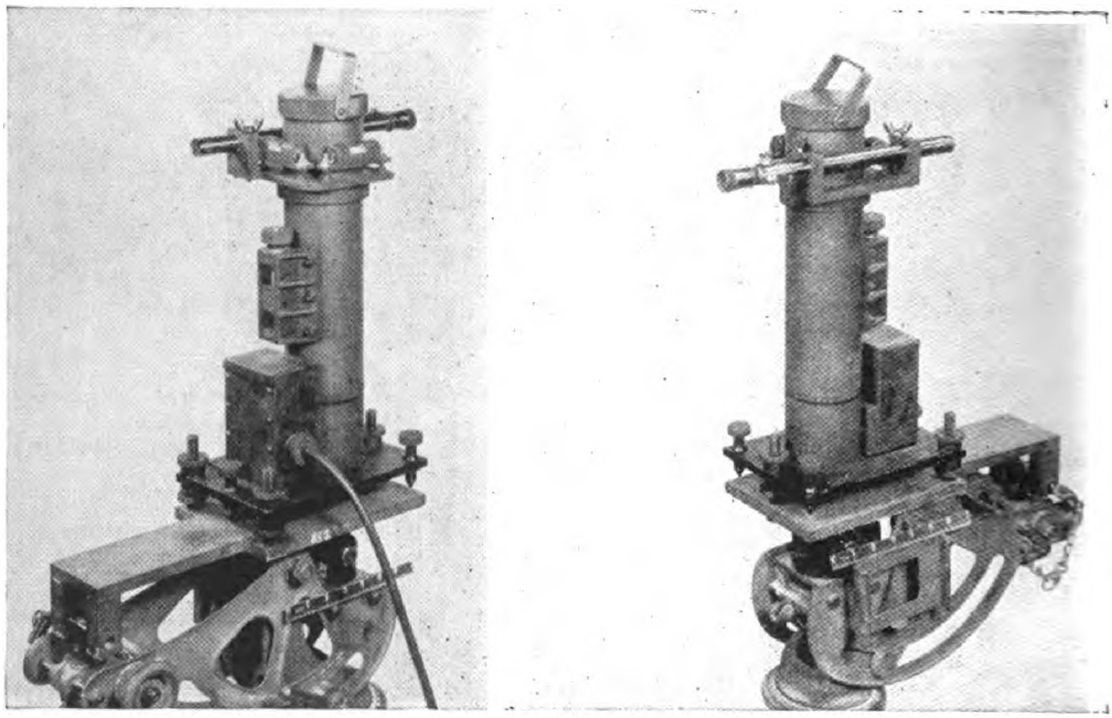


Figure 32. Right and Left Hand Views of "Sky-Screen" Showing Aligning Telescope, Focusing Knob Leveling Assembly and Mounting on the Machine Gun Mount.

Calibration. Calibration is of two kinds: absolute calibration, and relative calibration. Absolute calibration determines the velocity of a gun relative to the velocity of a standard gun fired with uniform standard ammunition under standard conditions. This form of calibration demands the retention of a secondary lot of ammunition of known velocity for each caliber. As a rule, absolute calibration will only be carried out for new or reissued weapons. A used 90mm gun will, for example, be calibrated and found to have a velocity of 2625 f/s. This gun will then be reissued as a 2625 f/s gun, and not as a standard 2700 f/s gun.

Relative calibration determines the differences in velocity between the weapons of a battery or a battalion. All guns shoot the same lot and weight zone of ammunition for velocity and are graded in relation to each other. The procedure contributes greatly to the accuracy of massed fire by permitting accurate ascertainment of elevation differences necessary to bring the centers of impact of the several weapons of a battery or battalion to the same point. Calibration formerly involved either removal of weapons from the front to a rear area, or a lengthy process of determining range variations by observation of fire under hazardous and difficult combat circumstances. While it is quicker and more convenient to remove guns to a rest or advance base area for calibration, it is now possible for ballistic and technical service teams to calibrate guns relatively at their combat positions through the use of recently developed chronograph equipment. Such calibration cannot be done as readily as calibration in rear areas. The most practicable way to calibrate the majority of weapons is to deliver them at a central point somewhat to the rear and do a swift and first class job there. Under such circumstances a gun can be calibrated within fifteen minutes.

Despite its disadvantages, calibration under combat conditions cannot be avoided entirely. For important weapons like the 8-inch gun, it might be worth while to bring up chronograph instruments at night, calibrate during the next day's fire, and remove the equipment the following night.

Figure 33. Placing Aiming Stakes Preliminary to Placing the "Sky-Screens."

The rapidity with which behind-the-line calibration can be done is best illustrated by the work of a ballistic and technical service team which calibrated the guns of the VI Corps Artillery in Italy in less than three and one-half days. A full battalion (12 guns) of 155mm guns, M1, were calibrated in a single day. Two batteries of artillery were calibrated in battle positions in one day while observing many precautions of camouflage, concealment, and avoidance of repeated travel across fields to instruments—in this instance, no enemy counter-battery fire was received during calibration.

It is important to know the types of guns that should be calibrated and the kind of calibration that should be used for specific weapons.

Repeated calibration of low velocity guns or howitzers is not vital because the weapons do not lose velocity rapidly even with relatively large numbers of rounds fired. For instance, the 105mm howitzer loses only 2 f/s velocity per 1,000 rounds of mixed zone ammunition fired. Since errors accumulate by the square law, the elimination of the calibration error would have an entirely negligible effect on the total error which includes metro error, map range errors, 'error-of-the-day,' and other factors. With low velocity weapons, correction from a wear curve, even though approximate, is sufficient.

High velocity weapons wear very rapidly; consequently, both antiaircraft and field artillery can make effective use of calibration data. An 8-inch gun will lose about 33 f/s velocity for every 100 rounds fired. Such a loss can cause a significant change in range and have an important effect on the hitting of point targets. The high velocity weapons should be calibrated at least relative to each other within the unit, and preferably should have absolute calibration. Proper calibration should be of particular advantage to the 8-inch, 155mm, and 4.5-inch guns.

Calibration of direct fire weapons is not essential, since a moderate drop in velocity results in only a slight drop at the target instead of a large change of range like that which may occur in the use of terrestrial fire. While velocity loss may be important with respect to armor penetration, information on velocity drop of direct fire weapons can be readily and quite reliably obtained from velocity-drop curves or tables.

The usefulness of a velocity measure is dependent upon the constancy of velocity of the weapon, the uniformity of ammunition from lot to lot, the ratio of the velocity error to other existing errors, and the efficiency with which the velocity information will be used.

Figure 34. Determining the Relative Heights of the "Sky-Screens," and Gun Muzzle by Means of an Engineer's Level.

Calibration Teams. Two types of calibration teams were created, each having a particular formation. The *Maintenance Calibration Team* is a fourth echelon group operating under semi-proving-ground conditions. It furnishes absolute calibration on new and overhauled guns that require calibration before issue or reissue by Ordnance.

The *Field Calibration Team* works with the third echelon to obtain relative calibration. In general, its duties will be to calibrate relatively the weapons of battalions. It will fire all the guns of a battalion with the same lot of ammunition. The resultant information will allow the battalion commander to know how all his guns shoot relative to each other. This will enable him to make appropriate corrections within the battalion and to effect an advantageous grouping of guns in the respective batteries.

If the gun books are properly posted, mean wear of the battalion's weapons can be calculated from the wear rates given in the firing tables and from data supplied by the Ballistic Research Laboratory. Although the wear rate is an average and not accurately applicable to any single gun, the average of 12 guns will not be far from correct. A comparison of this computed value with the mean calibration will give a measure of the difference between the relative calibration and an absolute calibration. This will enable the battalion commandeı to place a used gun issued by Ordnance in its appropriate place in the battalion. When a relative calibration is done on an entire battalion, that, in connection with wear curves, approximates an absolute calibration.

Figure 35. Measuring the Base Line.

A complete calibration team is composed of two officers and eleven enlisted men. The team is split into two units: a field calibration team consisting of an officer and eight enlisted men, and a maintenance calibration team with an officer and three enlisted men. The personnel of the teams are trained not only in the performance of their specialized duties, but also in ballistics, in sound ordnance practice, and in the principles of artillery. Their sole purpose is that of service to the artillery.

The Calibration Teams (figure 29) are self-sufficient operating units. They have their own power supply, instrument maintenance and repair facilities, and transportation. Equipment is carried in a truck, 1½-ton, 6 x 6, towing a 1-ton trailer containing an M5 motor-generator set, and in a truck, ¼-ton, 4 x 4, towing a ¼-ton cargo trailer. A 2½-ton 6 x 6 machine shop truck completes the automotive vehicles. The "Jeep" and the ¼-ton trailer, together with the 1½-ton 6 x 6 truck and generator trailer, pertain to the Field Calibration Team. The remaining vehicle is assigned to the Maintenance Team. Commonplace vehicles without distinctive features were selected to avoid attracting special attention from the enemy.

Equipment of Teams. The equipment of a field calibration team consists of the following:

5 'sky screens' pick-up, telephoto, with amplifiers
4 tripods, machine gun, for cal .30 machine gun, Model 1917
3 counters, chronograph
3 sets of five conductor cables, each consisting of one 500-ft. length and one 200-ft. length, plus a number of jumper cables of various lengths
4 stakes, aiming
1 machine, computing
2 thermometers, powder, M1
1 quadrant, gunner's, M1
1 level, Builders, WYE, with compass
2 tapes, steel, 300-ft. and 100-ft. lengths
1 bob, plumb
1 typewriter, portable
1 set, test, Signal Corps, 1 56 D
Miscellaneous tools and spare parts

The instruments used in obtaining velocities for calibration are 'sky screens' and chronographs. A 'sky screen' (figure 32) consists of a telescopic lens system and a photo-electric cell inclosed in a tube. The photo-electric cell detects the change in sky light that occurs when a projectile enters the atmospheric region intercepted by the telescope. This change in light is converted by the photo-electric cell into an electrical impulse which is amplified and used to trigger the chronograph.

The chronographs (figures 30 and 31) are of the counter-chronograph type. They measure the time interval between passage of the projectile over the first and second 'sky screens' in units of 1/100,000 second.

In field calibration the field calibration team upon arrival at a gun position selects suitable parking sites for its vehicles. Due regard for distance from the guns careful camouflage, and concealment measures are observed. Locations for the two 'sky screens' are then determined by aligning aiming stakes with the

Figure 36. Measuring the Light Intensity at the "Sky-Screen" Amplifier.

muzzle of the gun whenever the weapon can be sufficiently depressed. If the gun is incapable of the required depression, the gun telescope may be used for aligning the stakes. The first 'sky screen' is placed approximately 100 feet in front of the

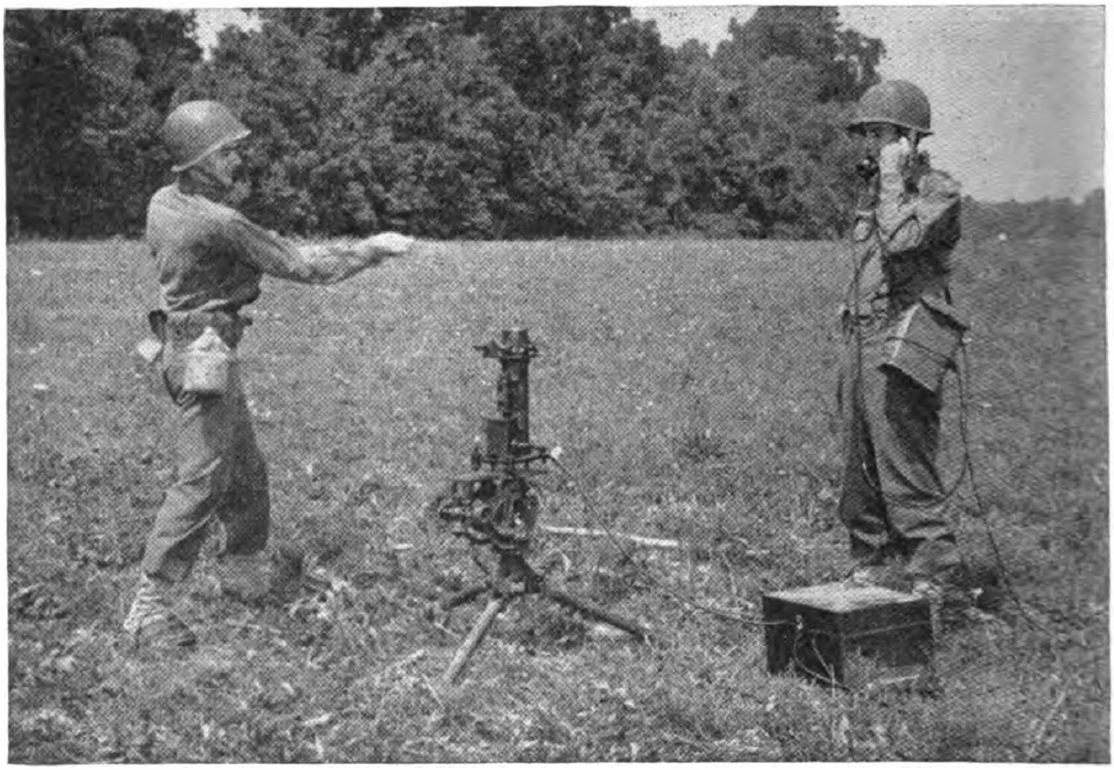


Figure 37. "The Whip Test." This Test Simulates Bullet Pulse and is Made Just Prior to Firing to Check the Proper Operation of the Equipment.

gun muzzle, depending on the terrain. The distance between the 'sky screens' may be from 100 to 200 feet.

The machine gun tripods which support the 'sky screens' are then placed at the positions indicated by the aiming stakes (figure 33), the 'sky screens' are fastened to the tripods, and the instruments are leveled. For high-angle fire a gunner's quadrant is employed to set the 'sky screens' so that they will intercept the trajectory at right angles.

After the 'sky screens' are leveled they are oriented by sighting on the gun muzzle. The distance between the 'sky screens' is then measured with great precision (figure 35), and the relative height between the gun muzzle and the two 'sky screens' is obtained by an engineer's level (figure 34). These measurements are essential for determination of an effective base line and the subsequent calculation of the trajectory intercept.

Following determination of the base line, the 'sky screens' are connected to the amplifiers and thence to the chronographs. The equipment is now ready for operation. Before firing is begun a final check of the connections and the functioning of the instruments is given by the 'whip test' (figure 37), which consists of flicking a rod or looped cable over the 'sky screen'. Passage of the rod or cable over the lens of the 'sky screen' interrupts some of the light entering the instrument in the same way that would be accomplished by the transit of a projectile. If this test is positive, firing may begin.

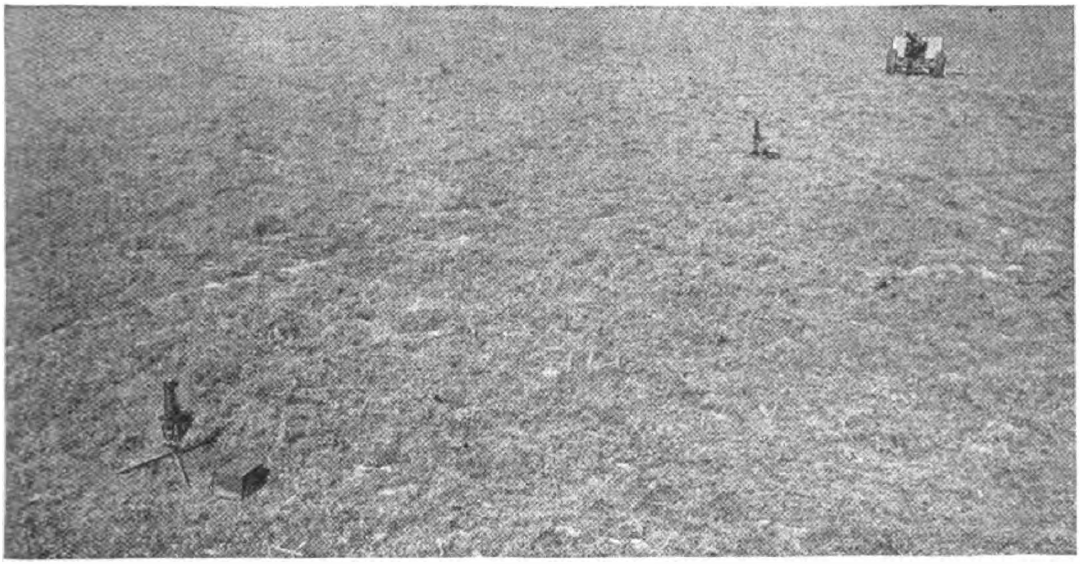


Figure 38. Arrangement of "Sky-Screens" and Gun Ready for Measurements in a Non-Camouflaged Position.

When a projectile is fired it intercepts the light over the first 'sky screen'. The difference in light value is transformed by the photo-electric cell into an electrical impulse which is amplified sufficiently to start the counter-chronograph. The chronograph continues counting in 1/100,000 seconds until the projectile passes over the second 'sky screen', causing the second electrical impulse which stops the counting. The time interval between the passage of the projectile over the two 'sky screens' is thus measured to the nearest 1/100,000 second.

From the data known about the geometry of the 'sky screen' set-up the distance along the trajectory between the two 'sky screens' can be computed. Dividing this distance by the computed time gives the instrumental velocity, which is the average velocity over the distance between the two 'sky screens'. By means of charts, this velocity may be corrected back to muzzle velocity.

Further, to assure accuracy of velocity computation one warming round and five record rounds are fired for each calibration. The average velocity of the record rounds is then taken as the actual velocity of the gun.

ORDNANCE BASE GROUP

The mission and functioning of an Ordnance Base Group, operating similarly to a regimental headquarters for the command and control of various ordnance battalions in the base section, is very similar to that previously discussed for an

	1	2	3	4	5	6	7	8	9	10	11
				Headquarters detachment							
1	Unit	Technician grade	Group headquarters	Detachment headquarters and administration section	Maintenance section	Operations section	Ammunition and supply section	Attached chaplain	Total group headquarters and headquarters detachment headquarters	Enlisted cadre	Remarks
2	Colonel		1						1		† Insert number of group. ᵃ Executive. ᵇ Operations supply and maintenance. ᶜ Adjutant. ᵈ Commander of detachment. ᵉ Assistant adjutant, assistant group supply. ᶠ Cadre herein indicated is intended for headquarters and headquarters detachment only. It does not include attached units such as Medical Corps, Engineers, Quartermaster, etc. ᵍ Also drives truck. This organization will furnish the necessary personnel for the administration of a base ordnance depot comprising 3 to 6 ordnance battalions or equivalent separate companies. The serial number symbol shown in parentheses is an inseparable part of the specialist designation. See AR 615-26.
3	Lieutenant colonel		ᵃ1						1		
4	Major		ᵇ3						3		
5	Captain		ᶜ1					1	2		
6	First lieutenant			ᵈ1					1		
7	Total commissioned		6	1				1	8		
8	Warrant officer			ᵉ1			ᵉ1		2		
9	Master sergeant, including			1		1	1		3	4	
10	Communications (542)									(1)	
11	Operations (814)					(1)			(1)	(1)	
12	Sergeant major (502)			(1)					(1)	(1)	
13	Supply (821)						(1)		(1)	(1)	
14	Technical sergeant, including			1		1			2		
15	Personnel (816)			(1)					(1)		
16	Intelligence (631)					(1)			(1)		
17	Staff sergeant, including			1					1		
18	Message center chief (674)										
19	Supply (821)			(ᶠ1)					(1)		
20	Sergeant, including				1	1			2		
21	Assistant operations (814)				(1)	(1)			(2)		
22	Technician, grade 4 } including								6	3	
23	Technician, grade 5 } including								5		
24	Private, first class } including			13	3	2	5		5		
25	Private } including								7		
26	Chaplain's assistant (534)	5		(1)					(1)		
27	Clerk, general (055)	4		(1)					(1)	(1)	
28	Clerk, general (055)				(1)		(1)		(2)		
29	Clerk, mail (056)	4		(1)					(1)	(1)	
30	Clerk, mail (056)	5		(1)					(1)		
31	Clerk-typist (405)	4		(2)			(1)		(3)	(1)	
32	Clerk-typist (405)	5		(2)			(1)		(3)		
33	Clerk-typist (405)			(2)	(1)	(1)	(1)		(5)		
34	Messenger (675)			(ᵍ1)			(1)		(2)		
35	Orderly (695)			(1)					(1)		
36	Stenographer (213)	4		(1)					(1)		
37	Basic (821)				(1)	(1)			(2)		
38	Total enlisted			16	4	5	6		31	7	
39	Aggregate		6	18	4	5	7	1	41	7	
40	O Carbine, cal. .30		1	15	3	4	6		29		
41	O Gun, machine, Browning, HB, cal. .50, flexible		1		1		1		3		
42	O Pistol, automatic, cal. .45		5						5		
43	O Rifle, cal. .30, M1903			3	1	1	1		6		
44	O Trailer, 1-ton, 2-wheel, cargo						1		1		
45	O Truck, ¼-ton						1		1		
46	O Truck, ¾-ton, command		1						1		
47	O Truck, 1½-ton, cargo				1				1		

Figure 39A. T/O & E 9-312 Headquarters and Headquarters Detachment, Ordnance Base Group. 8 June 1943.

Ordnance Group operating in the combat zone. Both of these outfits operate under T/O & E 9-12 dated 15 April 1944. The decision to activate or form an Ordnance Base Group will be made by competent authority (the theater commander) and will be based upon the number and type of ordnance battalions which are to operate in the base.

The base ordnance officer will assign each company, or lower command such as bomb disposal squads, to definite battalions, which in turn are assigned to specific groups. Where all ordnance troops of the base are organized in one group, the commanding officer of attached troops (reference to discussion of Headquarters and Headquarters Company, Ordnance Base Depot) is also the group commander. Where two or more groups are organized each will have its own commander under the commanding officer of attached troops. Since most bases are not currently organized under the new Ordnance Base Depot set-up, various adoptions of command are at present used in the field. The second in command at the Ordnance Section of Base Headquarters may be the group commander; the base ordnance officer may designate an officer of field grade as group commander, or, in relatively small-scale operations, the base ordnance officer may perform this function in addition to his other duties.

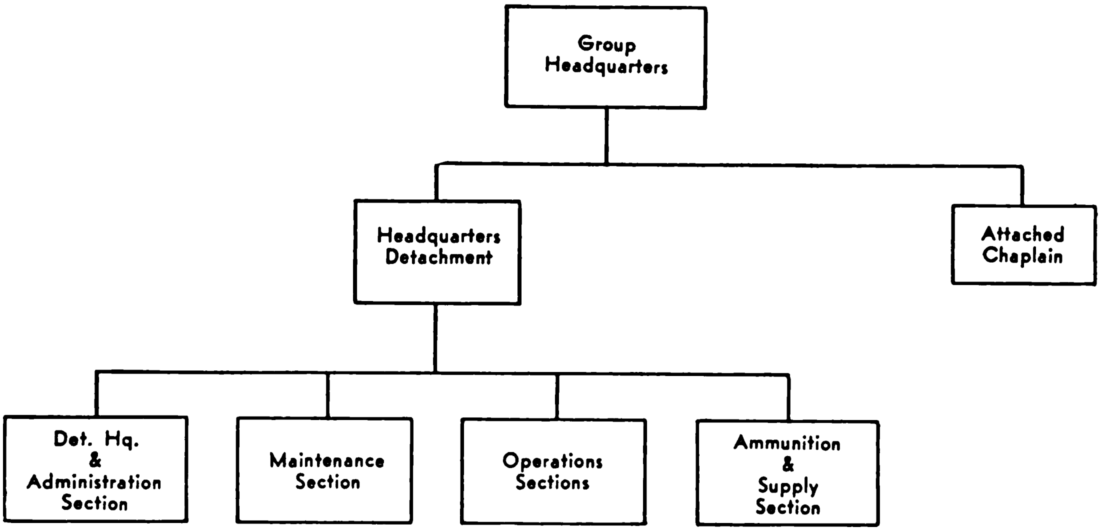


Figure 39B. Organization of a Headquarters and Headquarters Det. Ordnance Base Group.

Ordnance Base Group Headquarters may perform command and administrative control functions only; or, as designated by the base ordnance officer, technical control of the various assigned battalions may also be delegated to it. The operational policy in any case will be established in the standard operating procedure published by the base ordnance officer.

ORDNANCE BASE BATTALION

In the Ordnance Group organization it is usually found that certain units are assigned to the communications zone which will not be placed under either the Base Armament or Base Automotive Maintenance Battalions. The Ordnance Base Battalion, organized under the same table of organization (T/O & E 9-76) and basically operating in the same manner as the Ordnance Battalion, which has previously been discussed in this chapter, is designated as the headquarters for such units. The base battalion may comprise all 3rd echelon maintenance companies. It may be composed of 4th echelon maintenance companies, all depot companies, motor vehicles assembly and distributing companies, or some combination of these. Normally, however, ammunition companies will not be placed under the same battalion headquarters with maintenance and supply units.

The type and number of units assigned to a base battalion will depend, therefore, upon its location in the communications zone, the ordnance service problem, and finally the units to be assigned.

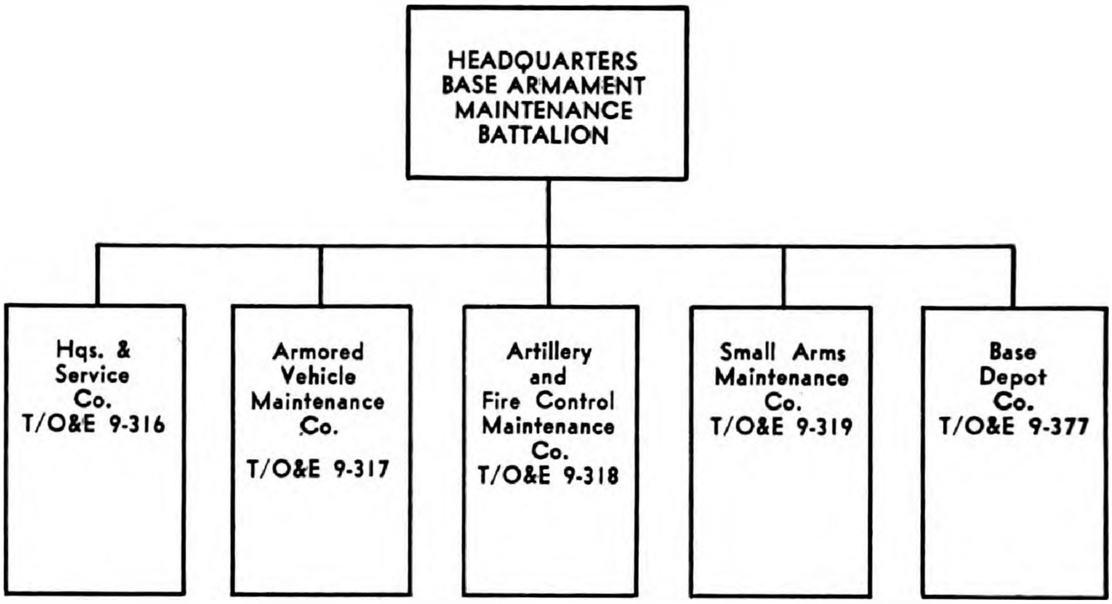


Figure 40a. Organization of a Base Ordnance Maintenance Battalion.

	1	2	2	3	5	6	7	8	9
1	Unit	Headquarters and service company (T/O 9-316)	Depot company (T/O 9-377)	Armored vehicle maintenance company (T/O 9-317)	Artillery and fire-control maintenance company (T/O 9-318)	Small arms maintenance company (T/O 9-319)	Total battalion	Enlisted cadre	Remarks
2	Lieutenant colonel	1					1		†Insert number of battalion. The component companies of this battalion cannot operate separately. This battalion must operate as a whole.
3	Major	1					1		
4	Captain	3	1	1	1	1	7		
5	First lieutenant	3	2	2	2	1	10		
6	Second lieutenant	1	3	3	2	1	10		
7	Total commissioned	9	6	6	5	3	29		
8	Warrant officer	2		1			3		
9	Master sergeant	2	2	1	1	1	7	7	
10	First sergeant	1	1	1	1	1	5	5	
11	Technical sergeant	3	7	8	3	1	22	14	
12	Staff sergeant	4	6	10	7	3	30	8	
13	Sergeant	1	8	1	1		11	1	
14	Corporal	1	1	1	1	1	5	5	
15	Technician, grade 3	2		21	13		36	23	
16	Technician, grade 4	18	18	58	32	18	139	28	
17	Technician, grade 5	33	19	80	54	27	213	14	
18	Private, first-class	15	21	27	17	11	91	} 3	
19	Private, including	24	28	42	24	17	135		
20	Basic	(10)	(8)	(15)	(7)	(6)	(46)		
21	Total enlisted	104	111	245	154	80	694	108	
22	Aggregate	115	117	252	159	83	726	108	
23	O Carbine, cal. .30	90	93	156	124	65	528		
24	O Gun, machine, cal. .50, HB, flexible	1	1	1	1	1	5		
25	O Pistol, automatic, cal. .45	2					2		
26	O Rifle, cal. .30, M1903	23	24	56	35	18	156		
27	O Truck, ¼-ton	1	1				2		
28	O Truck, ¾-ton, weapons carrier	5	1	1	1	1	9		
29	O Truck, 2½-ton, cargo		1				1		
30	O Truck, wrecking, heavy		1	1			2		

Figure 40b.

BASE ARMAMENT MAINTENANCE BATTALION

Mission. The mission of this unit is to supervise, maintain, and control 5th echelon armament maintenance work in the Armament Section of an Ordnance Base Shop. It is designed to serve a force of 200,000 to 300,000 troops.

The various maintenance and supply companies listed below may be assigned to the battalion according to the expected volume of work in the various repair groups. The battalion operates a complete armament repair section which may be either an integral part of the shop or may be located in a separate area dispersed for protection against enemy action.

The battalion is capable of performing the necessary maintenance equivalent to nine infantry divisions or one armored division. It is characteristically permanent in location and of large troop composition; it operates extensive shop facilities.

Component companies, as listed below, habitually function in a battalion setup as they are not organized or equipped to operate separately.

Organization. There are 20 officers, 3 w. o. and 694 enlisted men in this unit. The following types of organizations will normally be assigned to the battalion: T/O & E 9-315.

Headquarters and Service Company, T/O & E 9-316
Ordnance Base Armored Vehicle Maintenance Company, T/O & E 9-317
Ordnance Base Artillery and Fire Control Maintenance Company, T/O & E 9-318
Ordnance Small Arms and Maintenance Company, T/O & E 9-319
Ordnance Base Depot Company, T/O & E 9-377

BASE AUTOMOTIVE MAINTENANCE BATTALION

Mission. The mission of this unit is to supervise, maintain, and control 5th echelon automotive maintenance work in the Automotive Section of an Ordnance Base Shop. It is designed to serve a force equipped with from 25,000 to 40,000 motor transport vehicles.

The various maintenance and supply companies listed below may be assigned to the battalion according to the expected volume of work in the various repair groups. The maintenance companies listed must work together as a battalion since they are not organized or equipped for separate operation. In general, the battalion is immobile and of large troop composition; it will normally operate a wide range of the base shop facilities.

Under the shop organization, listed in a section following, the battalion head-

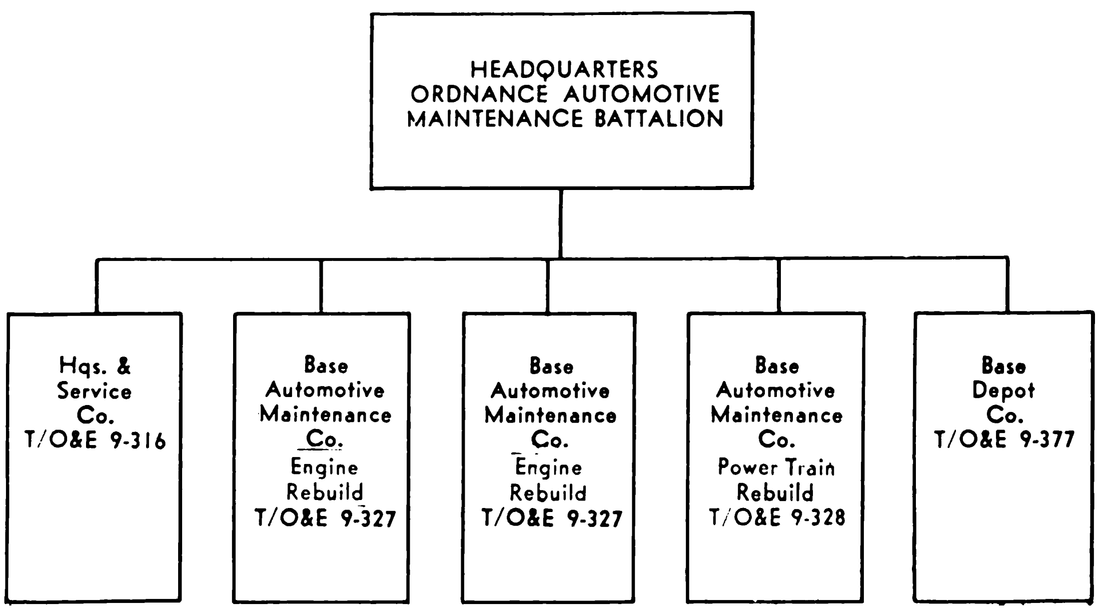


Figure 41a. Organization of a Base Automotive Maintenance Battalion.

quarters may operate for both technical and administrative control of assigned troops, or for administrative control only, according to policies established by the base ordnance officer.

1	1	2	3	4	5	6	7	8
1	Unit	Headquarters and service company (T/O 9-316)	Depot company (T/O 9-377)	2 engine rebuild companies (each) (T/O 9-327)	Power train rebuild company (T/O 9-328)	Total battalion	Enlisted cadre	Remarks
2	Lieutenant colonel	1	.....	.....	.....	1	.....	† Insert number of battalion. The component companies of this battalion cannot operate separately. This battalion must operate as a whole.
3	Major	1	.....	.....	.....	1	.....	
4	Captain	3	1	1	1	7	.....	
5	First lieutenant	3	2	2	2	11	.....	
6	Second lieutenant	1	3	3	1	11	.....	
7	Total commissioned	9	6	6	4	31	.....	
8	Warrant officer	2	.....	.....	.....	2	.....	
9	Master sergeant	2	2	1	1	7	7	
10	First sergeant (585)	1	1	1	1	5	5	
11	Technical sergeant	3	7	4	3	21	17	
12	Staff sergeant	4	6	4	3	21	4	
13	Sergeant	1	8	2	1	14	1	
14	Corporal	1	1	1	1	5	5	
15	Technician, grade 3	2	.....	15	6	38	21	
16	Technician, grade 4	18	18	36	18	126	28	
17	Technician, grade 5	33	19	53	30	188	13	
18	Private, first class	15	21	36	32	140	} 2	
19	Private, including	24	28	47	43	180		
20	Basic	(10)	(8)	(11)	(12)	(52)	.....	
21	Total enlisted	104	111	200	130	754	103	
22	Aggregate	115	117	206	143	787	103	
23	O Carbine, cal. .30	90	93	159	106	607	.....	
24	O Gun, machine, cal. .50, HB, flexible	1	1	1	1	5	.....	
25	O Pistol, automatic, cal. .45	2	.....	.....	.....	2	.....	
26	O Rifle, cal. .30, M1903	23	24	47	34	175	.....	
27	O Truck, ¼-ton	1	1	.....	.....	2	.....	
28	O Truck, ¾-ton, weapons carrier	5	1	1	1	9	.....	
29	O Truck, 2½-ton, cargo	.....	1	.....	.....	1	.....	
30	O Truck, wrecking, heavy	.....	1	.....	.....	1	.....	

Figure 41b. T/O & E 9-325 Ordnance Base Automotive Maintenance Battalion.

Organization. This organization has 31 officers, 2 warrant officers, and 750 enlisted men. Component companies of this battalion are:

Headquarters and Service Company, (T/O & E 9-316)

Two (2) Ordnance Base Automotive Maintenance Companies (Engine Rebuild), (T/O & E 9-327)

Ordnance Base Automotive Maintenance Company (Power Train Rebuild), (T/O & E 9-328)

Ordnance Base Depot Company, (T/O & E 9-377)

BASE ARMORED VEHICLE MAINTENANCE COMPANY

Mission. This unit is assigned at least one per Ordnance Base Armament Maintenance Battalion for the performance of 5th echelon maintenance on armored vehicles. The number of units assigned to battalion will be determined by the expected volume of armored vehicle maintenance work in the Base Shop. The unit is trained and qualified to perform major overhaul on all types of armored vehicles and serves a force of from 200,000 to 300,000 troops under average conditions.

Organization. The Base Armored Vehicle Maintenance Company does not operate separately but rather as a component organization of the Base Armament Maintenance Battalion.

Supply functions for technical operation are controlled and maintained by the supply sections, but the unit does not carry a basic load of spare parts. It is dependent upon the Base Depot Company for re-supply of replacement spare parts.

	1	2	3	4	5	6	7	8	9	10
1	Unit	Specification serial No.	Technician grade	Company headquarters	Service section	Supply section	Maintenance platoon	Total company	Enlisted cadre	Remarks
2	Captain	----	---	1	----	----	----	1	---	† Insert number of company and battalion. * Also drives truck. *Assignment.*—1 company per ordnance base armament maintenance battalion, T/O & E 9-315. *Function.*—Performs 5th echelon maintenance on all types of armored vehicles. *Capacity.*—The battalion of which this company is an integral part supports a ground combat force of 100,000 troops. Cooks authorized by this table are to be attached to headquarters and service company for the operation of a battalion mess. When an element is operating separately from the company headquarters, a proportionate number of basics, as determined by the unit commander, may be attached to the element. For specification serial numbers see TM 12-406, 12-407, and 12-427.
3	Company commander	4803	---	(1)	----	----	----	(1)	---	
4	First lieutenant	----	---	----	1	----	1	2	---	
5	Maintenance platoon commander	4803	---	----	----	----	(1)	(1)	---	
6	Service and supply	4813	---	----	(1)	----	----	(1)	---	
7	Second lieutenant	----	---	----	1	1	1	3	---	
8	Maintenance	4803	---	----	----	----	(1)	(1)	---	
9	Service and supply	4813	---	----	(1)	----	----	(1)	---	
10	Supply section	4000	---	----	----	(1)	----	(1)	---	
11	Total commissioned	----	---	1	2	1	2	6	---	
12	Warrant officer	----	---	----	----	----	1	1	---	
13	Assistant maintenance	4803	---	----	----	----	(1)	(1)	---	
14	Master sergeant	----	---	----	1	----	1	2	2	
15	Master mechanic	342	---	----	(1)	----	----	(1)	(1)	
16	Platoon chief	337	---	----	----	----	(1)	(1)	(1)	
17	First sergeant	585	---	1	----	----	----	1	1	
18	Technical sergeant	----	---	----	3	1	3	7	2	
19	Assistant platoon chief	337	---	----	----	----	(3)	(3)	---	
20	Motor inspector	413	---	----	(3)	----	----	(3)	(1)	
21	Section chief	821	---	----	----	(1)	----	(1)	(1)	
22	Staff sergeant	----	---	----	1	----	----	1	---	
23	Assistant section chief	114	---	----	(1)	----	----	(1)	---	
24	Sergeant	----	---	----	----	1	----	1	---	
25	Assistant section chief	821	---	----	----	(1)	----	(1)	---	
26	Corporal	----	---	1	----	----	----	1	1	
27	Clerk, company	405	---	(1)	----	----	----	(1)	(1)	
28	Technician, grade 3 } including							43	7	
29	Technician, grade 4 } including							62	7	
30	Technician, grade 5 } including	----	---	21	26	7	174	98	8	
31	Private, first class } including							7	} 1	
32	Private } including							18		
33	Automobile body repairman	201	4	----	(1)	----	(2)	(3)	(1)	
34	Automobile body repairman	201	5	----	(1)	----	(2)	(3)	---	
35	Clerk shop	457	5	----	----	----	(1)	(1)	---	
36	Clerk shop	457	---	----	(*1)	----	(2)	(3)	---	
37	Clerk typist	405	5	----	----	(1)	----	(1)	---	
38	Clerk typist	405	---	(*1)	----	----	----	(1)	---	
39	Cook	060	4	(2)	----	----	----	(2)	(1)	
40	Cook	060	5	(3)	----	----	----	(3)	(1)	
41	Cook's helper	590	---	(3)	----	----	----	(3)	---	
42	Electrician, automotive	912	4	----	(2)	----	(6)	(8)	(1)	
43	Electrician, automotive	912	5	----	----	----	(6)	(6)	---	
44	Leather and canvas worker	609	5	----	(1)	----	----	(1)	(1)	
45	Leather and canvas worker	609	---	----	(1)	----	----	(1)	---	
46	Machinist	114	3	----	(1)	----	----	(1)	(1)	
47	Machinist	114	4	----	(1)	----	----	(1)	---	
48	Machinist	114	5	----	(2)	----	----	(2)	---	
49	Mechanic, automotive	014	4	----	----	----	(4)	(4)	(1)	
50	Mechanic, automotive	014	5	----	----	----	(4)	(4)	---	
51	Mechanic, automotive, track vehicle.	966	3	----	----	----	(8)	(8)	(1)	
52	Mechanic, automotive, track vehicle.	966	4	----	----	----	(9)	(9)	---	
53	Mechanic, automotive, track vehicle.	966	5	----	----	----	(16)	(16)	---	
54	Mechanic, chassis, track vehicle	908	3	----	----	----	(10)	(10)	(1)	
55	Mechanic, chassis, track vehicle	908	4	----	----	----	(9)	(9)	---	
56	Mechanic, chassis, track vehicle	908	5	----	----	----	(19)	(19)	---	
57	Mechanic, engine, track vehicle	909	3	----	----	----	(13)	(13)	(1)	
58	Mechanic, engine, track vehicle	909	4	----	----	----	(12)	(12)	---	
59	Mechanic, engine, track vehicle	909	5	----	----	----	(25)	(25)	---	
60	Mechanic, fuel induction	926	3	----	----	----	(2)	(2)	(1)	
61	Mechanic, fuel induction	926	4	----	----	----	(2)	(2)	---	
62	Mechanic, fuel induction	926	5	----	----	----	(4)	(4)	---	
63	Mechanic, tractor	319	3	----	----	----	(2)	(2)	(1)	
64	Mechanic, tractor	319	4	----	----	----	(2)	(2)	---	
65	Mechanic, tractor	319	5	----	----	----	(4)	(4)	---	
66	Mechanic, turret and gyrostabilizer.	907	3	----	----	----	(2)	(2)	(1)	
67	Mechanic, turret and gyrostabilizer.	907	4	----	----	----	(2)	(2)	---	
68	Mechanic, turret and gyrostabilizer.	907	5	----	----	----	(4)	(4)	---	
69	Motor inspector	413	3	----	(4)	----	----	(4)	---	
70	Motor inspector	413	4	----	(5)	----	----	(5)	---	
71	Parts clerk, armament	848	4	----	----	(1)	----	(1)	(1)	
72	Parts clerk, armament	848	---	----	----	(1)	----	(1)	---	
73	Parts clerk, automotive	348	5	----	----	(1)	----	(1)	(1)	
74	Parts clerk, automotive	348	---	----	----	(1)	----	(1)	---	
75	Stock clerk	835	---	----	----	(2)	----	(2)	(1)	

	1	2	3	4	5	6	7	8	9	10
	Unit	Specification serial No.	Technician grade	Company headquarters	Service section	Supply section	Maintenance platoon	Total company	Enlisted cadre	Remarks
76	Tinsmith	201	4	----	(1)	----	----	(1)	(1)	
77	Tinsmith	201	5	----	(1)	----	----	(1)	---	
78	Toolroom keeper	242	5	----	(1)	----	----	(1)	---	
79	Welder, armor plate	923	3	----	(1)	----	----	(1)	---	
80	Welder, combination	256	4	----	(1)	----	----	(1)	(1)	
81	Welder, combination	256	5	----	(1)	----	----	(1)	---	
82	Wrecker operator	529	5	----	----	----	(1)	(1)	---	
83	Wrecker operator	529	---	----	----	----	(1)	(1)	---	
84	Basic	521	---	(12)	----	----	----	(12)	---	
85	Total enlisted	-----	---	23	31	9	178	241	24	
86	Aggregate	-----	---	24	33	10	181	248	24	
87	O Carbine, cal. .30	-----	---	24	33	10	181	248	---	
88	O Gun, machine, cal. .50 HB, flexible.	-----	---	1	----	----	----	1	---	
89	O Truck, ¼-ton, weapons carrier	-----	---	1	----	----	----	1	---	
90	O Truck, ¾-ton, weapons carrier	-----	---	1	----	----	----	1	---	
91	O Truck, 2½-ton, cargo, with winch.	-----	---	1	----	----	----	1	---	
92	O Truck, wrecking, heavy	-----	---	----	----	----	1	1	---	

Figure 42a. T/O & E 9-317 7 Sept. 1944. Ordnance Base Armored Vehicle Maint. Co.

A break-down of the various company sections and personnel is shown in the accompanying table of organization, T/O & E 9-317, Figure 42A.

BASE AUTOMOTIVE MAINTENANCE COMPANY (POWER TRAIN REBUILD)

Mission. This unit is assigned at least one per Ordnance Base Automotive Maintenance Battalion for the performance of 5th echelon maintenance of heavy units (power train). The unit is trained and qualified to perform major overhaul on all types of heavy units and consequently will receive work on both automotive and armored vehicle assemblies. Like other base maintenance outfits it is not adaptable to separate operation and, further, it is entirely dependent for supplies and operational equipment upon the Base Depot Company assigned to battalion.

Organization. The various company sections and personnel are shown in the accompanying table of organization, T/O & E 9-328, Figure 42B.

	1	2	3	4	5	6	7	8	9
1	Unit	Technician grade	Company headquarters	Service section	Supply section	Maintenance platoon	Total company	Enlisted cadre	Remarks
2	Captain	----	1	----	----	----	1	----	† Insert number of company. ‡ Insert number of battalion. Cooks shown on this table to be attached to headquarters and service company to operate a combined battalion mess. 1 company per ordnance base automotive maintenance battalion. Company is designed to function as part of the battalion.
3	First lieutenant	----	----	1	----	1	2	----	
4	Second lieutenant	----	----	----	1	----	1	----	
5	Total commissioned	----	1	1	1	1	4	----	
6	Master sergeant, including	----	----	1	----	----	1	1	
7	Master mechanic (342)	----	----	(1)	----	----	(1)	(1)	
8	First sergeant (585)	----	1	----	----	----	1	1	
9	Technical sergeant, including	----	1	----	1	1	3	3	
10	Platoon chief (837)	----	----	----	----	(1)	(1)	(1)	
11	Section chief (821)	----	----	----	(1)	----	(1)	(1)	
12	Shop foreman (337)	----	(1)	----	----	----	(1)	(1)	
13	Staff sergeant, including	----	1	----	----	2	3	----	
14	Assistant platoon chief (906)	----	----	----	----	(2)	(2)	----	
15	Assistant shop foreman (906)	----	(1)	----	----	----	(1)	----	

1	1	2	3	4	5	6	7	8	9
1	Unit	Technician grade	Company headquarters	Service section	Supply section	Maintenance platoon	Total company	Enlisted cadre	Remarks
16	Sergeant, including	----	----	1	----	----	1	----	
17	Assistant section chief (114)	----	----	(1)	----	----	(1)	----	
18	Corporal, including	----	1	----	----	----	1	1	
19	Clerk, company (405)	----	(1)	----	----	----	(1)	(1)	
20	Technician, grade 3						6	3	
21	Technician, grade 4						18	5	
22	Technician, grade 5 including	----	8	27	11	83	30	1	
23	Private, first class						32	----	
24	Private						43	----	
25	Automotive mechanic (014)	3	----	----	----	(2)	(2)	(1)	
26	Automotive mechanic (014)	4	----	----	----	(4)	(4)	----	
27	Automotive mechanic (014)	5	----	----	----	(5)	(5)	----	
28	Automotive mechanic (014)	----	----	----	----	(4)	(4)	----	
29	Carpenter, packer (203)	----	----	(2)	----	----	(2)	----	
30	Clerk, general (055)	4	(1)	----	----	----	(1)	----	
31	Clerk, parts (348)	4	----	----	(2)	----	(2)	(1)	
32	Clerk, parts (348)	5	----	----	(2)	----	(2)	----	
33	Clerk, parts (348)	----	----	----	(4)	----	(4)	----	
34	Clerk, shop (457)	5	----	(1)	----	(1)	(2)	----	
35	Clerk, typist (405)	1	(1)	----	(2)	----	(3)	----	
36	Cook (060)	4	(1)	----	----	----	(1)	(1)	
37	Cook (060)	5	(2)	----	----	----	(2)	(1)	
38	Cook's helper (521)	----	(2)	----	----	----	(2)	----	
39	Mechanic, automotive, chassis (906)	3	----	----	----	(3)	(3)	(2)	
40	Mechanic, automotive, chassis (906)	4	----	----	----	(5)	(5)	----	
41	Mechanic, automotive, chassis (906)	5	----	----	----	(8)	(8)	----	
42	Mechanic, automotive, chassis (906)	----	----	----	----	(6)	(6)	----	
43	Mechanic's helper (521)	----	----	----	----	(33)	(33)	----	
44	Machinist (114)	4	----	----	----	(1)	(1)	(1)	
45	Machinist (114)	5	----	----	----	(2)	(2)	----	
46	Machinist (114)	----	----	----	----	(1)	(1)	----	
47	Metal worker (201)	5	----	(1)	----	----	(1)	----	*Function:* Performs 5th echelon maintenance, by complete rebuilding of power train assemblies for reissue by 3d and 4th echelon shops. For specification serial numbers shown in parentheses, see AR 615-26.
48	Metal worker (201)	----	----	(1)	----	----	(1)	----	
49	Painter, automotive (143)	5	----	(1)	----	----	(1)	----	
50	Painter, automotive (143)	----	----	(1)	----	----	(1)	----	
51	Radiator repairman (172)	4	----	(2)	----	----	(2)	(1)	
52	Radiator repairman (172)	5	----	(2)	----	----	(2)	----	
53	Rigger (189)	5	----	(1)	----	----	(1)	----	
54	Rigger (189)	----	----	(1)	----	----	(1)	----	
55	Storage battery electrician (215)	5	----	(1)	----	----	(1)	----	
56	Storage battery electrician (215)	----	----	(5)	----	----	(5)	----	
57	Toolmaker (241)	3	----	(1)	----	----	(1)	----	
58	Toolmaker (241)	4	----	(1)	----	----	(1)	----	
59	Toolroom keeper (242)	5	----	(2)	----	----	(2)	----	
60	Welder, combination (256)	4	----	(1)	----	----	(1)	(1)	
61	Welder, combination (256)	5	----	(1)	----	----	(1)	----	
62	Basic (521)	----	(1)	(2)	(1)	(8)	(12)	----	
63	Total enlisted	----	12	29	12	86	139	15	
64	Aggregate	----	13	30	13	87	143	15	
65	O Carbine, cal. .30	----	11	23	10	65	109	----	
66	O Gun, machine, cal. .50, H. B. flexible	----	1	----	----	----	1	----	
67	O Rifle, cal. .30, M1903	----	2	7	3	22	34	----	
68	O Truck, ¾-ton, weapons carrier	----	1	----	----	----	1	----	

Figure 42b. **T/O & E 9-328 28 Oct. 1943. Base Automotive Maint. Co.**

BASE AUTOMOTIVE MAINTENANCE COMPANY (ENGINE REBUILD)

Mission. Two of these companies are usually assigned per ordnance base automotive battalion. They perform fifth echelon maintenance in rebuilding standard engines and assemblies such as generators, pumps, etc. One company usually operates the production line and the other is organized on a job maintenance basis. The former company rebuilds approximately fifty in-line engines a day and the latter about ten. The companies use heavy specialized tools of the base shop and, therefore, cannot operate independently.

Organization. The various company sections and the personnel are shown in the accompanying table of organization, T/O & E 9-327, Figure 42C.

	1	2	3	4	5	6	7	8	9	10
	Unit	Technician grade	Company head-quarters	Service section	Supply section	Engine rebuild platoon	Sub-assembly re-build platoon	Total company	Enlisted cadre	Remarks
2	Captain		1					1		†Insert number of company and of battalion. *Assignment.*—2 companies per ordnance base automotive maintenance battalion. *Function.*—Performs 5th echelon maintenance by rebuilding standard engines, and subassemblies such as generators and pumps. 1 company usually operates the production line, the other company usually assigned to job lots. [a] Maintenance officer to assist in engine rebuild or assembly rebuild platoon. [b] Also drives truck. Cooks shown on this table to be attached to headquarters and service company to operate a combined mess. For specification serial numbers shown in parentheses, see AR 615-26.
3	First lieutenant					1	1	2		
4	Second lieutenant		[a]1	1	1			3		
5	Total commissioned		2	1	1	1	1	6		
6	Master sergeant, including			1				1	1	
7	Master mechanic (342)			(1)				(1)	(1)	
8	First sergeant (585)		1					1	1	
9	Technical sergeant, including		1		1	1	1	4	4	
10	Motor inspector (337)		(1)					(1)	(1)	
11	Platoon chief (337)					(1)	(1)	(2)	(2)	
12	Section chief (821)				(1)			(1)	(1)	
13	Staff sergeant, including		1			2	1	4		
14	Assistant motor inspector (413)		(1)					(1)		
15	Assistant platoon chief (413)					(2)	(1)	(3)		
16	Sergeant, including			1	1			2		
17	Assistant section chief (114, 821)			(1)	(1)			(2)		
18	Corporal, including		1					1	1	
19	Clerk, company (405)		(1)					(1)	(1)	
20	Technician, grade 3							15	8	
21	Technician, grade 4							36	5	
22	Technician, grade 5 including		10	10	11	83	73	53	4	
23	Private, first class							36	1	
24	Private							47		
25	Automotive mechanic (014)	3				(4)	(5)	(9)	(3)	
26	Automotive mechanic (014)	4				(8)	(9)	(17)	(3)	
27	Automotive mechanic (014)	5				(12)	(13)	(25)		
28	Automotive mechanic (014)					(8)	(9)	(17)		
29	Carpenter, packer (203)	4				(1)		(1)		
30	Carpenter, packer (203)	5				(1)		(1)		
31	Carpenter, packer (203)					(2)		(2)		
32	Clerk, automobile parts (348)	4			(2)	(1)	(1)	(4)	(1)	
33	Clerk, automobile parts (348)	5			(2)	(2)		(4)		
34	Clerk, automobile parts (348)				(4)			(4)		
35	Clerk, general (055)	4	(1)					(1)		
36	Clerk, shop (457)	5		(1)				(1)	(1)	
37	Clerk, shop (457)					(1)	(1)	(2)		
38	Clerk, typist (405)		(1)		(2)			(3)	(1)	
39	Cook (060)	4	(2)					(2)	(1)	
40	Cook (060)	5	(2)					(2)	(1)	
41	Cook's helper (521)		(3)					(3)		
42	Engine specialist (412)	3				(1)	(1)	(2)	(1)	
43	Engine specialist (412)	4				(1)	(2)	(3)		
44	Engine specialist (412)	5				(1)	(4)	(5)		
45	Engine specialist (412)					(1)	(2)	(3)		
46	Mechanic, carburetor (414)	3					(1)	(1)	(1)	
47	Mechanic, carburetor (414)	4					(2)	(2)		
48	Mechanic, carburetor (414)	5					(3)	(3)		
49	Mechanic, carburetor (414)						(3)	(3)		
50	Mechanic, ignition (012)	3					(1)	(1)	(1)	
51	Mechanic, ignition (012)	4					(2)	(2)		
52	Mechanic, ignition (012)	5					(3)	(3)		
53	Mechanic, ignition (012)						(3)	(3)		
54	Mechanic, motorcycle (138)	4		(1)				(1)		
55	Mechanic, motorcycle (138)	5		(2)				(2)		
56	Mechanic, motorcycle (138)			(1)				(1)		
57	Mechanic's helper (521)					(29)	(1)	(30)		
58	Motor inspector (413)	3				(1)		(1)	(1)	
59	Motor inspector (413)	4				(2)		(2)		
60	Motor inspector (413)	5				(3)		(3)		
61	Sheet metal worker (201)	5					(2)	(2)	(1)	
62	Sheet metal worker (201)						(1)	(1)		
63	Toolmaker (241)	3		(1)				(1)	(1)	
64	Toolmaker (241)	4		(1)				(1)		
65	Toolroom keeper (242)	5		(2)				(2)	(1)	
66	Basic (521)		([b]1)	(1)	(1)	(4)	(4)	(11)		
67	Total enlisted		14	12	13	86	75	200	25	
68	Aggregate		16	13	14	87	76	206	25	
69	O Carbine, cal. .30		14	10	11	66	58	159		
70	O Gun, machine, cal. .50, HB, flexible		1					1		
71	O Rifle, cal. .30, M1903		2	3	3	21	18	47		
72	O Truck, ¾-ton, weapons carrier		1					1		

Figure 42c. Ordnance Base Automotive Maint. Co. (Engine Rebuild) Organization.

BASE SMALL ARMS MAINTENANCE COMPANY

Mission. This unit is normally assigned one per Base Armament Maintenance Battalion for the performance of 5th echelon repair of small arms. Personnel are organized and trained to perform major overhaul on all small arms including hand and shoulder weapons, machine guns, mortars, and their respective mounts. This unit is not capable of mobility or separate operation and is entirely dependent upon the assigned Base Depot Company for the supply of replacement spare parts.

Organization. The various company sections and authorized personnel are shown in the accompanying table of organization, T/O & E 9-319, Figure 42D.

	1	2	3	4	5	6	7	8	9
1	Unit	Specification serial No.	Technician grade	Company headquarters	Supply section	Small arms repair section	Total company	Enlisted cadre	Remarks
2	Captain			1			1		† Insert number of company. ‡ Insert number of battalion. *Assignment.*—1 company per ordnance base armament maintenance battalion, T/O 9-315. *Function.*—Performs 5th echelon maintenance on small arms. *Capacity.*—The battalion of which this company is an integral part supports a ground combat force of 100,000 troops. Cooks authorized by this table are to be attached to headquarters and service company for the operation of a battalion mess. When an element is operating separately from the company headquarters, a proportionate number of basics, as determined by the unit commander, may be attached to the element. For specification serial numbers, see TM 12-406, 12-407, and 12-427.
3	Company commander	4807		(1)			(1)		
4	First lieutenant					1	1		
5	Small arms repair section	4807				(1)	(1)		
6	Second lieutenant						1		
7	Supply section	4000			(1)		(1)		
8	Total commissioned			1	1	1	3		
9	Master sergeant					1	1	1	
10	Master mechanic	342				(1)	(1)	(1)	
11	First sergeant	585		1			1	1	
12	Technical sergeant					1	1	1	
13	Section chief	903				(1)	(1)	(1)	
14	Staff sergeant				1	1	2	1	
15	Assistant section chief	821			(1)		(1)		
16	Assistant section chief	903				(1)	(1)	(1)	
17	Corporal			1			1	1	
18	Clerk, company	405		(1)			(1)	(1)	
19	Technician, grade 3 } including						12	2	
20	Technician, grade 4 } including						15	4	
21	Technician, grade 5 } including			9	3	54	30	2	
22	Private, first class } including						3		
23	Private } including						6		
24	Clerk, parts, armament	848			(2)		(2)		
25	Clerk, shop	457	5			(1)	(1)		
26	Clerk, stock	835	4		(1)		(1)		
27	Cook	060	4	(1)			(1)	(1)	
28	Cook	060	5	(1)			(1)	(1)	
29	Cook's helper	590		(1)			(1)		
30	Leather and canvas worker	609	5			(1)	(1)	(1)	
31	Leather and canvas worker	609				(1)	(1)		
32	Machine gun mechanic	903	3			(6)	(6)		
33	Machine gun mechanic	903	4			(6)	(6)	(2)	
34	Machine gun mechanic	903	5			(12)	(12)		
35	Machinist	114	4			(1)	(1)	(1)	
36	Machinist	114	5			(1)	(1)		
37	Small arms weapons mechanic	903	3			(6)	(6)	(2)	
38	Small arms weapons mechanic	903	4			(6)	(6)		
39	Small arms weapons mechanic	903	5			(12)	(12)		
40	Toolroom keeper	242	5			(1)	(1)		
41	Truck driver, light	345	5	(1)			(1)		
42	Truck driver, light	345		(1)			(1)		
43	Basic	521		(4)			(4)		
44	Total enlisted			11	4	57	72	13	
45	Aggregate			12	5	58	75	13	
46	O Carbine, caliber .30			12	5	58	75		
47	O Gun, machine, cal. .50, HB, flexible			1			1		
48	O Truck, ¼-ton			1			1		
49	O Truck, ¾-ton, weapons carrier			1			1		

Figure 42d. T/O & E 9-319. Sept. 7, 1944. Ordnance Base Small Arms Maintenance Company.

	1	2	3	4	5	6	7	8	9	10
1	Unit	Specification serial No.	Technician grade	Company headquarters	Service section	Supply section	Artillery platoon	Fire control platoon	Total company	Enlisted cadre
2	Captain			1					1	
3	Company commander	4801		(1)					(1)	
4	First lieutenant						1	1	2	
5	Artillery section	4808					(1)		(1)	
6	Fire control section	4806						(1)	(1)	
7	Second lieutenant				1	1			2	
8	Service and supply	4813			(1)				(1)	
9	Supply section	4000				(1)			(1)	
10	Total commissioned			1	1	1	1	1	5	
11	Master sergeant						1	1	2	1
12	Foreman	914					(1)		(1)	(1)
13	Foreman	922						(1)	(1)	
14	First sergeant	585		1					1	1
15	Technical sergeant				1	1	2	2	6	2
16	Master mechanic	342			(1)				(1)	(1)
17	Section chief	821				(1)			(1)	
18	Section chief	914					(1)		(1)	
19	Section chief	915					(1)		(1)	(1)
20	Section chief	919						(1)	(1)	
21	Section chief	922						(1)	(1)	
22	Sergeant					1			1	1
23	Assistant section chief	821				(1)			(1)	(1)
24	Corporal			1					1	1
25	Clerk, company	405		(1)					(1)	(1)
26	Technician, grade 3								27	11
27	Technician, grade 4								30	4
28	Technician, grade 5 including			13	12	5	50	56	66	2
29	Private, first class								3	
30	Private								10	
31	Artillery mechanic, heavy	914	3				(2)		(2)	(1)
32	Artillery mechanic, heavy	914	4				(2)		(2)	
33	Artillery mechanic, heavy	914	5				(4)		(4)	
34	Artillery mechanic, heavy antiaircraft	915	3				(2)		(2)	(1)
35	Artillery mechanic, heavy antiaircraft	915	4				(2)		(2)	
36	Artillery mechanic, heavy antiaircraft	915	5				(4)		(4)	
37	Artillery mechanic, light	913	3				(6)		(6)	(1)
38	Artillery mechanic, light	913	4				(6)		(6)	
39	Artillery mechanic, light	913	5				(12)		(12)	
40	Artillery mechanic, light antiaircraft	978	3				(2)		(2)	(1)
41	Artillery mechanic, light antiaircraft	978	4				(2)		(2)	
42	Artillery mechanic, light antiaircraft	978	5				(4)		(4)	
43	Clerk, parts	848	4			(1)			(1)	(1)
44	Clerk, parts	848	5			(1)			(1)	
45	Clerk, parts	848				(2)			(2)	
46	Clerk, shop	457	5		(ᵃ1)		(1)	(1)	(3)	
47	Clerk, typist	405				(1)			(1)	
48	Control system, repairman, heavy antiaircraft	919	3					(2)	(2)	(1)
49	Control system, repairman, heavy antiaircraft	919	4					(2)	(2)	
50	Control system, repairman, heavy antiaircraft	919	5					(4)	(4)	
51	Cook	060	4	(2)					(2)	(1)
52	Cook	060	5	(1)					(1)	(1)
53	Cook's helper	521		(2)					(2)	
54	Director repairman, heavy antiaircraft, electrical	899	3					(1)	(1)	
55	Director repairman, heavy antiaircraft, electrical	899	4					(1)	(1)	
56	Director repairman, heavy antiaircraft, electrical	899	5					(3)	(3)	
57	Director repairman, heavy antiaircraft, mechanical	917	3					(1)	(1)	(1)
58	Director repairman, heavy antiaircraft, mechanical	917	4					(1)	(1)	
59	Director repairman, heavy antiaircraft, mechanical	917	5					(2)	(2)	

11 — Remarks

†Insert number of company.

‡Insert number of battalion.

ᵃ Also drives truck.

ᵇ Includes 1 graduate of the coated optics training course.

Assignment.—1 company per ordnance base armament maintenance battalion, T/O & E 9-315.

Function.—Performs 5th echelon maintenance on artillery, optical and fire control instruments.

Capacity.—The battalion of which this company is an integral part supports a ground combat force of 100,000 troops.

Cooks authorized by this table are to be attached to headquarters and service company for the operation of a battalion mess.

When an element is operating separately from the company headquarters, a proportionate number of basics, as determined by the unit commander, may be attached to the element.

For specification serial numbers see TM 12-406, 12-407, and 12-427.

Figure 42e. T/O & E 9-315, 7 Sept. 1944. Ord. Base Artillery and Fire Control Maint. Co.

BASE ARTILLERY AND FIRE CONTROL MAINTENANCE COMPANY

Mission. This unit is normally assigned one per Base Armament Maintenance Battalion for the performance of 5th echelon repair of artillery and fire control materiel. Personnel are organized and trained to perform major overhaul on all types of artillery and fire control equipment. This unit is not capable of mobility or separate operation and is entirely dependent upon the assigned Base Depot Company for the supply of replacement spare parts.

Organization. The various company sections and authorized personnel are shown in the accompanying table of organization, T/O & E 9-318, Figure 42E.

	1	2	3	4	5	6	7	8	9	10	11
	Unit	Specification serial No.	Technician grade	Company headquarters	Service section	Supply section	Artillery Platoon	Fire control platoon	Total company	Enlisted cadre	Remarks
60	Electric motor repairman	304	4	---	(1)	---	----	----	(1)	---	
61	Electric motor repairman	304	5	---	(1)	---	----	----	(1)	---	
62	Fire control repairman, light antiaircraft	918	3	---	----	---	----	(3)	(3)	(1)	
63	Fire control repairman, light antiaircraft	918	4	---	----	---	----	(2)	(2)	---	
64	Fire control repairman, light antiaircraft	918	5	---	----	---	----	(5)	(5)	---	
65	Generator repairman	505	4	---	----	---	----	(1)	(1)	---	
66	Generator repairman	506	5	---	----	---	----	(1)	(1)	---	
67	Height finder repairman	921	3	---	----	---	----	(1)	(1)	(1)	
68	Height finder repairman	921	4	---	----	---	----	(1)	(1)	---	
69	Height finder repairman	921	5	---	----	---	----	(3)	(3)	---	
70	Instrument repairman, fire control	922	3	---	----	---	----	(4)	(4)	(1)	
71	Instrument repairman, fire control	922	4	---	----	---	----	(b3)	(3)	---	
72	Instrument repairman, fire control	922	5	---	----	---	----	(b8)	(8)	---	
73	Leather and canvas worker	609	5	---	(1)	---	----	----	(1)	(1)	
74	Leather and canvas worker	609	---	---	(1)	---	----	----	(1)	---	
75	Machinist	114	3	---	(1)	---	----	----	(1)	(1)	
76	Machinist	114	4	---	(1)	---	----	----	(1)	---	
77	Machinist	114	5	---	(1)	---	----	----	(1)	---	
78	Toolroom keeper	242	5	---	(1)	---	(1)	(1)	(3)	---	
79	Truck driver, light	345	5	(1)	----	---	----	----	(1)	---	
80	Watch repairman	381	3	---	----	---	----	(1)	(1)	(1)	
81	Watch repairman	381	4	---	----	---	----	(1)	(1)	(1)	
82	Watch repairman	381	5	---	----	---	----	(3)	(3)	---	
83	Welder, combination	256	3	---	(1)	---	----	----	(1)	---	
84	Welder, combination	256	4	---	(1)	---	----	----	(1)	(1)	
85	Welder, combination	256	5	---	(1)	---	----	----	(1)	---	
86	Basic	521	---	(7)	----	---	----	----	(7)	---	
87	Total enlisted	-----	---	15	13	7	53	59	147	23	
88	Aggregate	-----	---	16	14	8	54	60	152	23	
89	O Carbine, caliber .30	-----	---	16	14	8	54	60	152	---	
90	O Gun, machine, caliber .50, HB, flexible	-----	---	1	----	---	----	----	1	---	
91	O Truck, ¼-ton	-----	---	1	----	---	----	----	1	---	
92	O Truck, ¾-ton, weapons carrier	-----	---	1	----	---	----	----	1	---	
93	O Truck, 2½-ton, cargo, with winch	-----	---	1	----	---	----	----	1	---	

Figure 42c.

TIRE REPAIR OPERATION

The Army's overseas tire repair plants are not large buildings, but there is plenty of activity going on inside them—24 hours a day! And, considering the fact that the Ordnance Tire Repair Companies serve as the hub of all tire maintenance and supply overseas to the extent that they are either directly or indirectly responsible for the success of these functions. it is interesting to note that up until a couple of years ago these plants would have been considered rather extravagant and unnecessary outfits, operating as they now do. For the time was when anything but relatively minor tire and tube repairs weren't worth the time and trouble they took. It was easier, and cheaper in the long run, to get a new tire.

The general impression many people have that synthetic rubber has solved our whole problem is far from accurate. That is why the present operation of Ordnance Tire Repair Companies is playing a star part in the theaters of war.

An Ordnance Tire Repair Company is a self-sufficient unit made up of about 146 enlisted men and 5 officers. Many of the men assigned to these companies

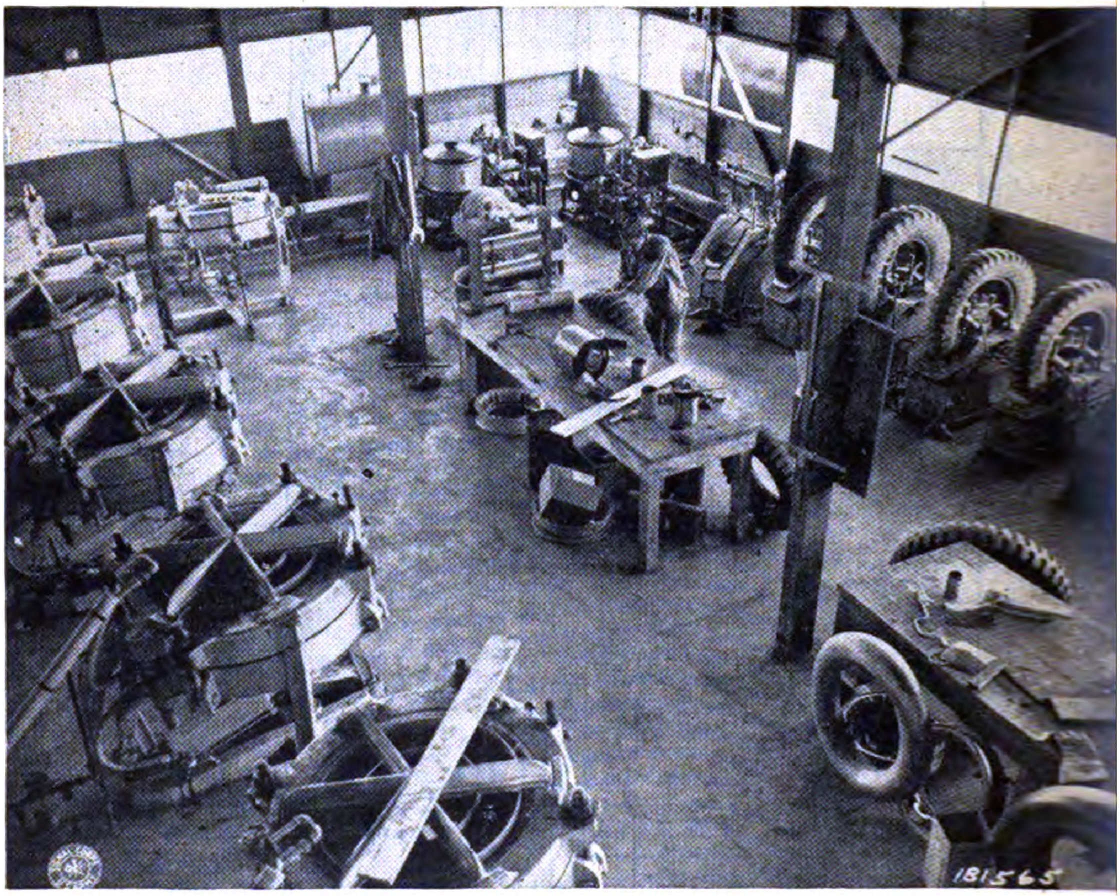


Figure 43a. Tire Repair Shop.

were 'tire men' in private industry before the war, and, of course, in addition to this background of experience, they all receive specialized training in one or other of the five schools set up by the Army to teach principles and practices of tire recapping and tire and tube repair and maintenance. Enlisted men get two months of training—officers double that.

The plants themselves are set up in two sections, each consisting of a building about 32 by 100 feet, and each having the same kind and amount of equipment. Thus, destruction of, or damage to, one building would not completely incapacitate the company. Work in the shops is departmentalized and put through on a production line basis in typical American style. One Ordnance Tire Repair Company can handle about 250 recaps and 350 sectional repairs in a 24-hour day.

In addition to molds, matrices, and all the other equipment normally required for recapping and repairing, equipment includes a Vita-cap chamber for the repair of odd-size tires. Those interested in the more detailed phases of tire repair will find a full listing of the set-up of equipment and materials in SNL N-347, and a description of tire and tube processing methods will be found in TM 9-1868, "Tire Repair and Retreads."

Existing regulations state that a tire repair company will perform repairs of tires, tubes, and flaps "to the fullest extent of its facilities." That these facilities are remarkably complete is attested to by the fact that the only tires which now come back to the States from overseas theaters where tire repair companies are located are those which have passed the point of usefulness for anything but scrap or non-military service. You can imagine what this means in terms of precious time saved and equally precious shipping facilities freed for other important supplies.

The operation of an Ordnance Tire Repair Company in relation to the units it serves is fairly simple. Unserviceable tires and tubes which are removed from the vehicle and which cannot be repaired by the organizational repair equipment are sent to the Ordnance Tire Repair Plant. A credit memorandum is issued at this time so that a new or used tire may be obtained without delay from the issuing depot as a replacement for the unserviceable tire turned in. Used or reconditioned tires are always issued for exchange in preference to new ones. All tires repaired by Ordnance Tire Repair Companies are sent to issue depots where they are placed in stock for re-issue. Thus, the Tire Repair Company serves as a clearing house for inspection, classification, and processing of all unserviceable and used tires, tubes, and flaps.

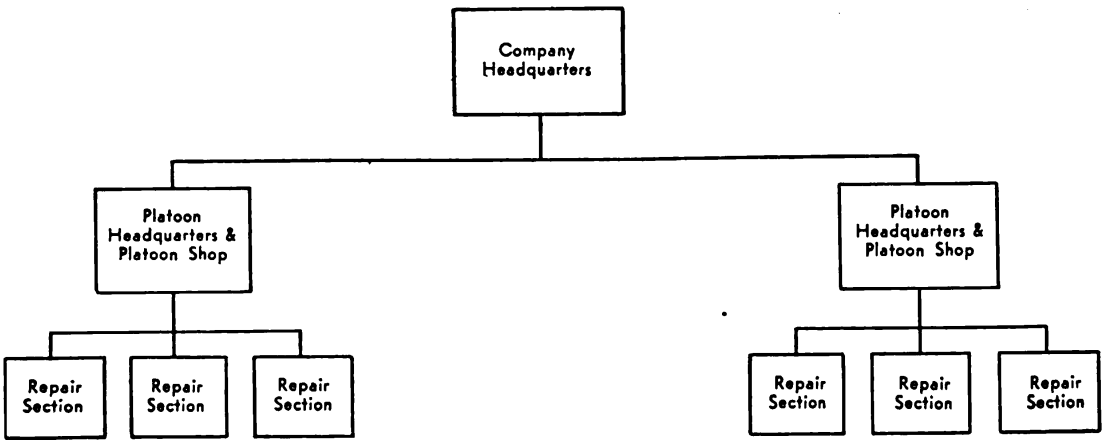


Figure 43b. Organization of a Tire Repair Company.

In addition to the performance of tire and tube repair, the Ordnance Tire Repair Company serves in another capacity which may well be considered equal in importance. This is the function of educating using organizations in the correct methods of tire maintenance and vehicle operation insofar as it affects tire wear. Obviously, since new tires are actually scarce, it is important that the ones we have receive the utmost in care and the only way this can be accomplished satisfactorily is to have men on the scene of action who are experts in operation and maintenance methods and procedures. And that is where the Tire Repair Companies come in.

First, they act as training points for field personnel. Selected personnel can quickly learn the important factors of operation and preventive maintenance when they are explained by men who have first hand knowledge of the subject. And the Tire Repair Companies' opportunities for getting this type of information across to the officers, noncommissioned officers, and enlisted men are naturally not limited to formal class-room instruction, since in the course of their activities they maintain direct contacts with the men in the field and in the shop.

Training activities even include personnel from Allied forces who receive thorough instruction in setting up and operating a repair platoon and thus are enabled to establish similar independent units of their own. This naturally relieves the burden on our own operators.

There is another angle to the training-set up which provides perhaps one of the most effective ways of assuring that maintenance is being performed to the utmost

	1	2	3	4	5	6	7	8	9	10
					2 platoons					
1	Unit	Specification serial No.	Technician grade	Company headquarters	Platoon headquarters and platoon shop	3 repair sections (each)	Total platoon	Total company	Enlisted cadre	Remarks
2	Captain, including	----	----	1	----	----	----	1	----	† Insert number of company. *Function:* Operates 2 complete tire rebuilding and vulcanizing shops in communications zone, less 1 vulcanizer (Vitacap No. 3). Performs retreading and sectional repairs on all sizes of tires. *Capacity:* Company consists of 2 platoons, 3 repair sections each; each section capable of operating 1 platoon set of shop equipment at maximum capacity, during 1 shift. Estimated capacity approximately 130 retreads per day and 350 sectional repairs per day. *Assignment:* As required in communications zone, usually on basis of 1 company capable of handling tires for 30,000 to 40,000 vehicles of mixed types under normal conditions. ᵃ When company is divided each sergeant assumes the dual function of supply and mess. One assigned to each platoon. Clerks assigned to platoon should be schooled in all branches of work handled by platoon, two to be available for each work shift. For specification serial numbers shown in column 2, for enlisted men, see AR 615-26; for officers, see TM12-406 and 12-407.
3	Tire maintenance and repair officer.	4818	----	(1)	----	----	----	(1)	----	
4	First lieutenant, including	----	----	----	1	----	1	2	----	
5	Platoon commander and supply officer.	4818	----	----	(1)	----	(1)	(2)	----	
6	Second lieutenant, including	----	----	----	1	----	1	2	----	
7	Shop and production officer.	4818	----	----	(1)	----	(1)	(2)	----	
8	Total commissioned	----	----	1	2	----	2	5	----	
9	First sergeant	585	----	1	----	----	----	1	1	
10	Technical sergeant, including	----	----	----	1	----	1	2	1	
11	Platoon chief	240	----	----	(1)	----	(1)	(2)	(1)	
12	Staff sergeant, including	----	----	2	----	1	3	8	3	
13	Mess	824	----	(ᵃ1)	----	----	----	(1)	(1)	
14	Shop foreman	240	----	----	----	(1)	(3)	(6)	(1)	
15	Supply	821	----	(ᵃ1)	----	----	----	(1)	(1)	
16	Corporal, including	----	----	1	----	----	----	1	1	
17	Clerk, company	405	----	(1)	----	----	----	(1)	(1)	
18	Technician, grade 3							12	2	
19	Technician, grade 4							28	4	
20	Technician, grade 5 } including	----	----	10	5	19	62	41	3	
21	Private, first class							20	----	
22	Private							33	----	
23	Clerk, stock	835	4	----	(1)	----	(1)	(2)	(1)	
24	Clerk, stock	835	5	----	(1)	----	(1)	(2)	(1)	
25	Clerk, stock	835	----	(1)	(1)	----	(1)	(3)	----	
26	Clerk typist	405	----	----	(1)	----	(1)	(2)	----	
27	Cook	060	4	(2)	----	----	----	(2)	(1)	
28	Cook	060	5	(1)	----	----	----	(1)	----	
29	Cook's helper	521	----	(2)	----	----	----	(2)	----	
30	Electrician, general	078	5	(1)	----	----	----	(1)	(1)	
31	Fireman, stationary boiler	084	5	----	----	(1)	(3)	(6)	(1)	
32	Tire inspector	240	3	----	----	(1)	(3)	(6)	----	
33	Tire rebuilder	240	3	----	----	(1)	(3)	(6)	(2)	
34	Tire rebuilder	240	4	----	----	(4)	(12)	(24)	(2)	
35	Tire rebuilder	240	5	----	----	(5)	(15)	(30)	----	
36	Tire rebuilder	240	----	----	----	(4)	(12)	(24)	----	
37	Truck driver, light	345	5	(1)	----	----	----	(1)	----	
38	Truck driver, light	345	----	(1)	(1)	----	(1)	(3)	----	
39	Tube repairman	240	----	----	----	(1)	(3)	(6)	----	
40	Basic	521	----	(1)	----	(2)	(6)	(13)	----	
41	Total enlisted	----	----	14	6	20	66	146	15	
42	Aggregate	----	----	15	8	20	68	151	15	
43	O Carbine, cal. .30	----	----	15	8	20	68	151	----	
44	O Gun, machine, cal. .50, HB, flexible	----	----	1	----	----	----	1	----	
45	O Truck, ¼-ton	----	----	1	----	----	----	1	----	
46	O Truck, ¾-ton, weapons carrier	----	----	----	1	----	1	2	----	
47	O Truck, 1½-ton, cargo	----	----	1	----	----	----	1	----	

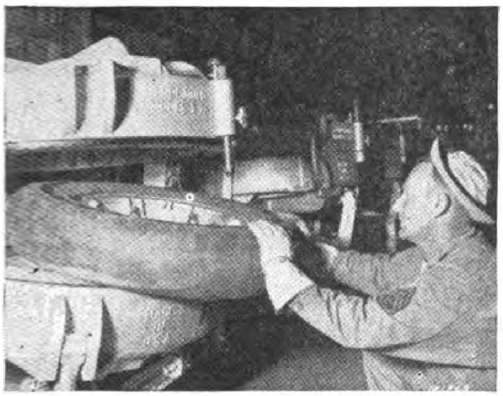
Figure 43b. Ordnance Tire Repair Company.

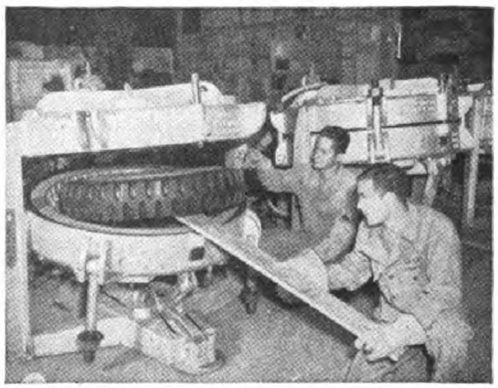
in all phases of operation. This is the establishment of tire inspection teams, which are trained by the Tire Repair Companies.

Through these teams, drivers can be instructed in all the vital points of tire and tube maintenance. Needless to say, it is important that they be constantly reminded of their responsibilities in this regard though it is always to be hoped that lack of maintenance is more a result of lack of knowledge on the subject than lack of concern on the part of the personnel involved.

To get an idea of just how badly needed these inspection teams are, take the case of the team which, making a test of a vehicle unit, found the following situation:

Applying Camelback to Buffed Tire.





Placing Tire in Mould. Removing Tire from Mould.
Figure 44. Re-Treading Operations in the Tire Repair Shop.

Many tires in the unit were still being used long after they should have been removed for repair or recapping. This is serious because of the fact that recapping requires only about one fourth of the amount of rubber used in a new tire. Furthermore, the shortage of material and manpower for the production of new tire carcasses is as serious as the rubber shortage itself. Therefore, it is vitally important that tires be turned in for repair and recapping before the carcasses are damaged.

Many of the tires in the unit were unevenly worn, which is an indication of mechanical maladjustment—as damaging to the vehicle as to the tire.

Many had valve caps missing and many more had valves incorrectly mounted. This negligence, inasmuch as it is so common, deserves special attention, since mud lodged in the valve actually prevents accurate use of the pressure gage, while valves that can't be reached obviously can't be used. And pressures must be kept right! Over fifty percent of the tires tested in this unit were under or over prescribed pressure!

Many had directional and non-directional tires on the same vehicle, others had tires mismatched, and still others had directional tires incorrectly mounted. All of these errors cause undue wear on tires and none of them are justified by the time or effort saved—it takes just as long to install a tire with the tread in one direction as it does in another.

Many had stones between the duals or lodged in the tires themselves. The difficulty this can cause should be apparent even to the uninitiated.

In general inspections it has been found that, foolish as it may sound, bottles and empty ration cans are actually responsible for a substantial proportion of serious damage to tires!

It is the correction of situations like these that the Tire Repair Companies and the inspection teams hope to be able to remedy, for there is no doubt that proper vehicle operation and preventive maintenance on tires and tubes can radically reduce replacement needs. An important source of information on the subject, incidentally, is TM 31-200, "Maintenance and Care of Pneumatic Tires and Rubber Treads." It is well illustrated and simply written—more like a magazine than the manuals most of us are familiar with—so all personnel who have anything to do with operation of vehicles and/or maintenance of tires should be thoroughly familiar with the manual and will find it easy reading.

As in any outfit which has a specific job to do, there are always times when the men in an Ordnance Tire Repair Plant find it necessary to use their ingenuity and cook up a special job for someone. So if you should wander into a Tire Repair Plant at any time you needn't be surprised to find them making hose connections, gaskets, gear shift lever knobs, or some of the 130-odd items of the sort that they turn out from scrap rubber. There's no manual that covers this situation—it's just the old American custom of doing the job that has to be done, and then a little more, sometimes just for the hell of it.

BASE SHOP OPERATION

In the base ordnance service will be found the 3rd and 4th echelon of maintenance set up in a manner similar to that for combat zone organization, except that normally a larger time to process jobs will be afforded base units. The recepient of materiel evacuated by the third and four echelon, both from tactical units in the combat zone (AGF) and local base units (SOS), is the base shop furnishing the so-called 5th echelon of maintenance. Although lower echelons of repair are necessarily performed by the base shop it is a maintenance principle for the shop to operate a large volume of 5th echelon work in the channel of evacuation, rather than a filling-station or garage service in direct support of using units.

Operational policies for the shop are established by the base ordnance officer through his maintenance officer. The base ordnance officer will designate a commanding officer of the shop (hereinafter referred to as the Shop Officer) who, in certain operations may also be the battalion or group commanding officer for the various units operating in the shop. The geography of the base section (island warfare, desert, continental, etc.); the tactical situation and manner of employment for Ordnance materiel generally, will determine the particular layout and troop composition of the shop. Combinations including any and all of the various ordnance organizations described below, and along the lines indicated in the accompanying shop plan, may be expected by officers newly arriving in overseas theaters. It should be borne in mind that the shop may operate as a separate ordnance base installation; it may be administratively and literally within an ordnance base depot (See preceding section discussing Headquarters and Headquarters Company, Ordnance Base Depot) or, again, it may be within the ordnance section of a base general depot. In any case, policies for the shop, and technical control thereof are exercised directly by the base ordnance officer.

Conservatively speaking a vast multitude of technical problems concerning ordnance materiel, its modification, alteration, improvisation and even research problems, are constantly arising within the theater. Action in such matters will be coordinated with tactical unit, communications zone, and theater ordnance officers by the base ordnance officer. The maintenance work involved is largely conducted in the base shop whose large variety of heavy fixed machinery, time available, reasonable working conditions, and assimilation of highly trained personnel make it ideal for the job. The base section ordnance officer will, through the shop officer, select officers and noncommissioned officers of the shop staff for liaison field trips to tactical units, as necessary, for coordinating technical problems which arise from time to time.

Technical operation for the various shop sections, and the organization and functions of a base depot company have been discussed in preceding sections of this chapter, and chapter 2, volume III respectively. These operations apply to related sections of the shop and hence will not be repeated.

One might say, as medium maintenance companies carry a large share of the ordnance service burden in the combat zone, so the base shop is the big operator for the base section.

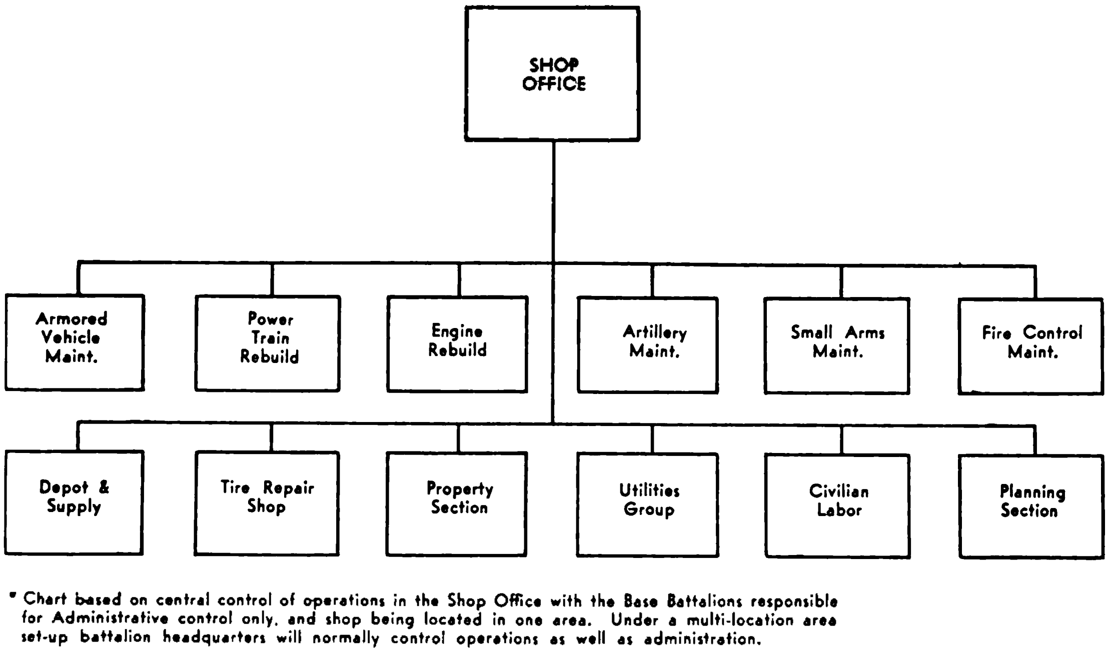
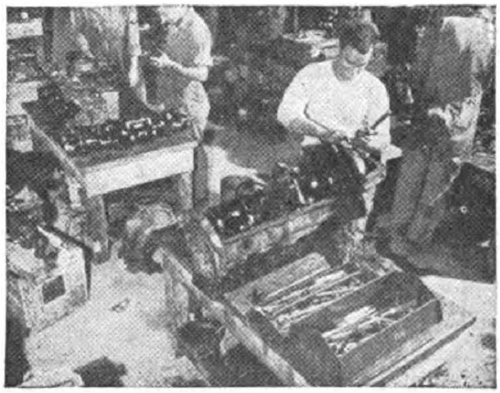


Figure 45. Organization of an Ordnance Base Shop.

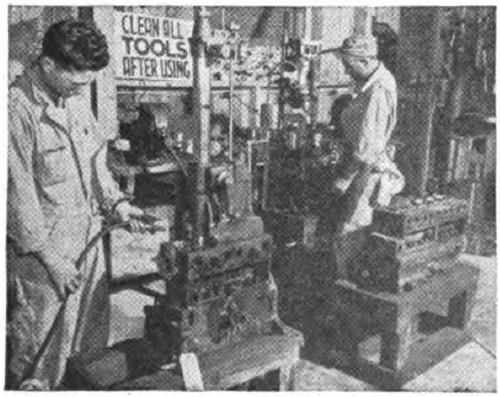
Organization. The shop office (or Headquarters) is the technical and administrative control point for the installation. Other sections of the shop are broken down into functional groups as shown in the organizational chart. Each section operates under the direction of a commissioned officer who, in turn, is directly responsible to the Shop Officer.

Layout. The illustrated lay-out is typical of base sections organized in areas where permanent type buildings are available. Under these conditions the site selected should be directly available to the rail and highway net and by all means should be capable of extensive expansion, if possible without necessitating new construction. The yard selected should involve such expansiveness that operations will not only have plenty of elbow-room for heavy handling gear (for example travelling gantry cranes, etc.) but also impairment of work will not result in the event shipping limitations necessitate temporary storage of salvage materiel. The buildings selected should preferably be of single high story heavy mill construction and provided with ample inter-area connecting wall openings and corridors. Certain civilian manufacturing and other plants such as mills and industrial schools frequently possess many prerequisities desirable for setting-up a base shop. The set-up in island warfare is largely one involving improvisation to local conditions. Buildings are not available and hence the various sections will be set up initially under canvas. Where operations are anticipated for extended periods tented areas should be fitted with weather-tight wood sidings and concrete floors. In some areas native buildings fabricated of hand woven thatch construction on wood frame have been successfully used for base shops. Such improvisations may serve to greatly increase (and therefore reduce output) the burden of shop personnel.

Whether the shop is situated in buildings or under canvas the general principles allied to industrial production should be followed. Sections with allied functions will occupy adjoining areas. Flow channels of work are kept to a minimum distance and avoid cross-over, cut-back or similar conflict with other operations in the work areas. The "weak-link" is insured against stopping production such that tools and replacement spares are so situated as to be available to production at the proper place when needed. The shop's traffic diagram is arranged to prevent cross-areas in processes as previously mentioned. Heavy unit work and storage areas are designated such as to provide easy handling and minimum movement distances. The personnel safety and fire hazards will also be incorporated in the shop lay-out. Finally, it is desirable to provide a separate clean and natural lighted area for the Fire Control repair section. Overseas, the refinement of temperature-control air-conditioned areas for this purpose will usually be foregone.



Engine Tear Down Inspection.



Cylinder Reboring and Honing. Engine Assembly.

Figure 46. Engine Overhaul Operations in a Base Shop.

Operation. In the general sense unserviceable materiel, skill and replacement spares meet in work areas to result in a conversion into serviceable ordnance materiel. Reception, inspection, classification, in transit storage and delivery to various shop sections are accomplished in the yard. Normally the yard is separated into reception, storage and delivery sections. Operations and records will be kept straightened out where such a functional separation is effected in the yard.

Military and civilian personnel, in approximately a 50-50 ratio, will furnish the skill and labor in base shops located in countries where local tradesmen are available. In island warfare frequently no skilled civilians will be on hand, in which case the allocation of troops to the shop must be correspondingly increased. Although the shop officer may in fact be the troop commander, he will normally establish the battalion headquarters, and the various unit's bivouac areas apart from the shop site.

The Base Ordnance officer will designate a level of supply for operating replacement spare parts to be maintained at the base shop. These supplies are requisitioned, controlled, received and issued by the base depot company assigned the base shop. The supply level will largely be determined by the shop work volume and stores capacity in the parts bins of the various operating sections and the depot company. In one overseas set-up a total supply level of ten days is used, wherein eight days are in depot storage and two days in the operating section's bins.

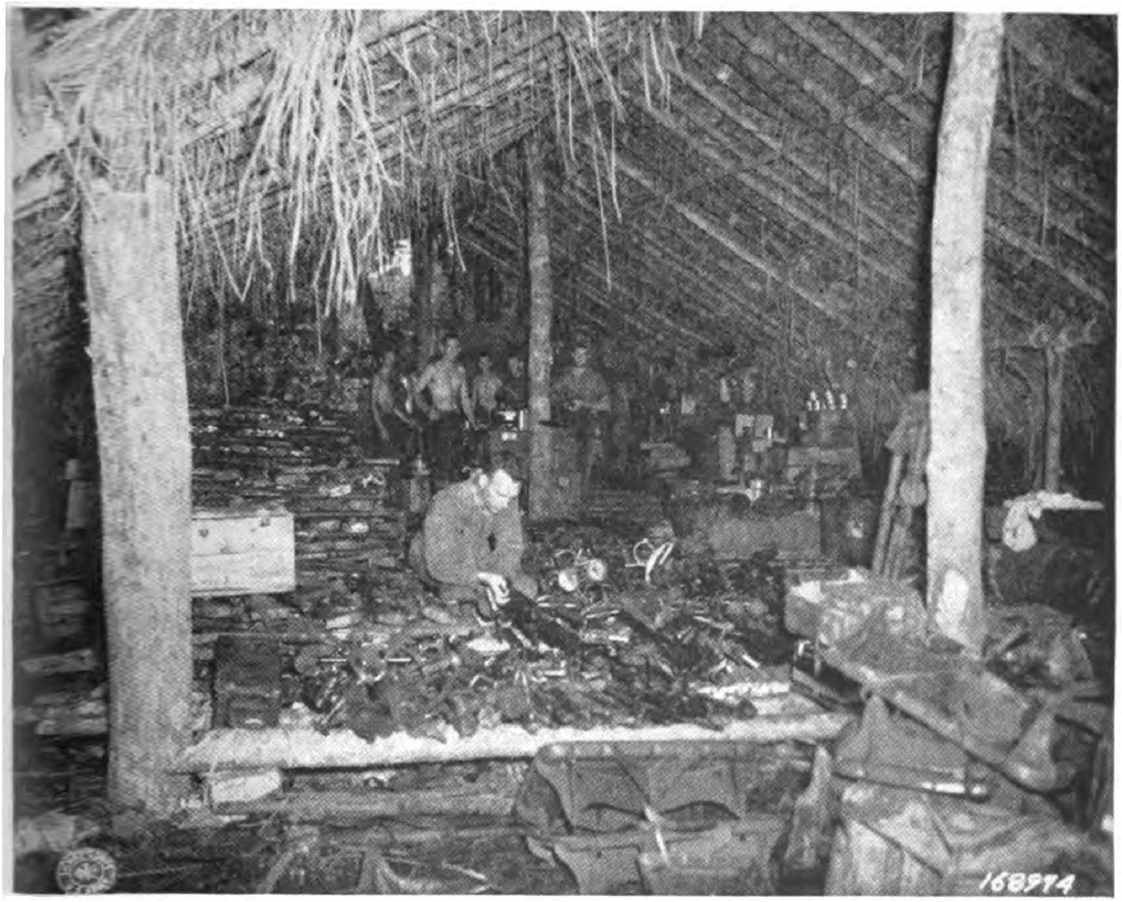


Figure 47. Small Arms Gun and Mount Repair, Showing Improvised Construction of Shop.

Under present arrangements a list of tools and operating equipment to be furnished base armament and automotive maintenance battalions is contained in SNL's N-315 and N-325 respectively. Supply planning is another matter which will be continuously effected. The Ordnance officers of the Zone of Interior and the Communications Zone will control supply planning according to prior agreements. In continuation of shop operations, the planning and stock control group of the general supply section in the base ordnance office may change base ordnance plans. Direct coordination of the base depot supply and shop officers may have an effect on supply planning with the actual ordering of parts in the base depot. Also the Shop Officer of the base shop will continually direct supply plans and procedures and may instigate certain changes and procedures as necessary. The latter method has many advantages but precludes suitable advance information regarding contemplated operations to the base shop officer. Advance arrangements between the Communications Zone ordnance officer and the Zone of Interior must be made for the initial issue of tools, equipment, and spare parts for the shop. Regardless of the arrangement adopted, the base ordnance officer is responsible for the timely and judicious re-ordering of supplies for the shop.

Shop property (tools, machinery and operational equipment) is as important to operations as personnel and supplies, and requires an equal measure of control and supervision. Upkeep maintenance may be performed by units operating in the various sections or by a utilities group organized for that purpose. Where a utilities group is organized it normally controls and operates all shop activities not directly concerned with repair work, for example, carpenter and box shop, paint shop, electrical, sanitation, and power plant. Hand and power tools, attachments, jigs and fixtures and items allied to tool maintenance or operation will be controlled through the use of chits by the shop tool crib. Day by day turn-back of tools to the crib is impractical and is avoided by making a daily check of all personnel leaving the shop. Soldiers and civilians will obtain a proper clearance from the tool crib before being permanently transferred or relieved from the shop. The shop officer will normally delegate responsibility to the shop property officer for the adequacy of tool spare parts. The shop property officer will give continuous personal attention to possible weak links in all operational equipment. For example, if the shop must operate with only one power generator, every item needed for hasty repairs, partial overhaul, and complete tear-down repair for that generator will be kept in readiness against a possible failure of the unit. Similarly he will endeavor to duplicate and triplicate spares of all critical or essential items of shop equipment as practicable. Grinding wheels and dresser sets are often important in this regard.

Basically the shop operation depends upon work volume by production methods. Therefore, since most item replacements concern major re-built parts it is seen the shortage of relatively few items will shut down an entire section or assembly line with disastrous results. Engine rebuild cannot assemble engines with a shortage of piston pins for example—indeed it may be quite impractical to perform even those operations prior to piston pin assembly. By the same token, much of the fixed heavy machinery is of a special nature and not the type commonly found in any other ordnance installation. It is here the shop property officer's study will serve to avert production stoppages.

Conclusion. The base shop is a big operation amply equipped and manned by a large group of officers and men. Its mission is 5th echelon maintenance although secondarily it is a supply agency in the sense that repaired major items, unit assemblies, and parts are a source of internal re-supply within the theater, such supplies being forwarded to the base depot.

General purpose vehicle shop repairs will comprise approximately fifty percent of the work load and perhaps more in operations involving either long lines of supply by overland truck transport or long periods of static activity among combat units. In like manner an intensive employment of armor, artillery, small arms or some combination of these will be correspondingly reflected by increases of size and activity for their respective maintenance sections of the shop.

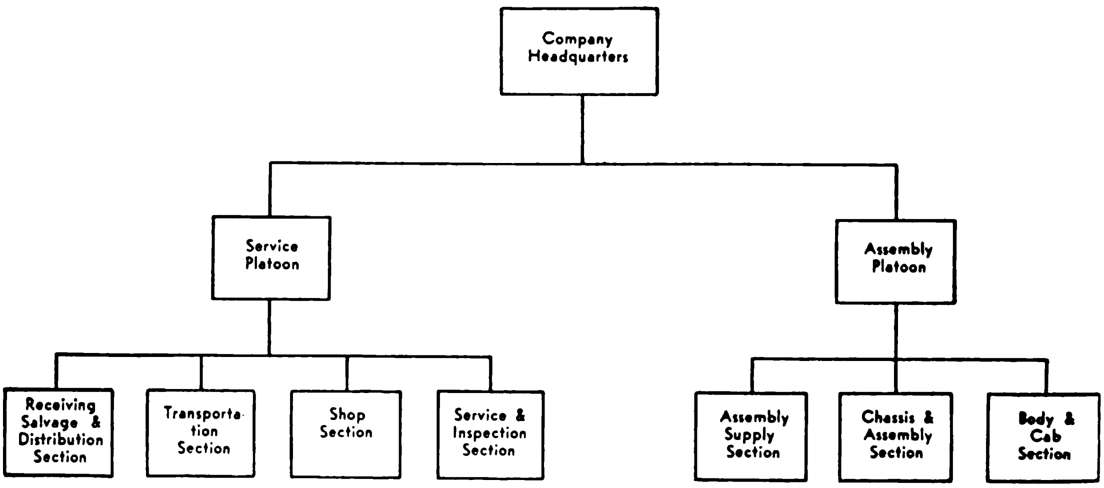


Figure 48a. Organization of a Motor Vehicle Assembly Company.

ORDNANCE MOTOR VEHICLE ASSEMBLY COMPANY

M.V.A. companies are assigned to theaters of operation as required, are usually placed in ordnance base battalions under a headquarters and headquarters detachment (T/O 9-76), and are located near a port of debarkation. Their job is to assemble and service for distribution all standard motor vehicles which are shipped in single or twin unit packs.

	1	2	3	4	5	6	7	8	9	10	11	12	13
					Service platoon				Assembly platoon				
1	Unit	Specification serial No.	Technician grade	Company headquarters	Receiving, salvage and distribution section	Transportation section	Shop section	Service and inspection section	Assembly supply section	Chassis and assembly section (2 each)	Body and cab section	Total company	Enlisted cadre
2	Captain, including			1								1	
3	Company commander	4443		(1)								(1)	
4	First lieutenant, including							1		1		3	
5	Supply section officer	4440						(1)				(1)	
6	Assembly line platoon commander	4443								(1)		(2)	
7	Second lieutenant, including			1							1	2	
8	Mess, supply, and transportation officer	4113		(1)								(1)	
9	Service section officer	4913									(1)	(1)	
10	Total commissioned			2				1		1	1	6	
11	Master sergeant, including						1					1	1
12	Chief mechanic	337					(1)					(1)	(1)
13	First sergeant	585		1								1	1
14	Technical sergeant, including						1	1		1	1	5	2
15	Foreman, mechanic	086					(1)					(1)	(1)
16	Section chief	413 965 086						(1)		(1)	(1)	(4)	(1)
17	Staff sergeant, including			2	1	1		1	1			6	1
18	Foreman, mechanic	086						(1)				(1)	
19	Mess	821		(1)								(1)	(1)
20	Motor	813				(1)						(1)	
21	Supply	821		(1)					(1)			(2)	
22	Section chief	821			(1)							(1)	
23	Sergeant, including				1					2		5	2
24	Foreman, mechanic	086								(2)		(4)	(1)
25	Receiving and shipping clerk	821			(1)							(1)	(1)
26	Corporal, including			1			1					2	1
27	Clerk, company	405		(1)								(1)	(1)
28	Foreman, mechanic	086					(1)					(1)	
29	Technician, grade 3											17	2
30	Technician, grade 4											29	7
31	Technician, grade 5 } including			9	13	35	11	11	11	27	14	66	5
32	Private, first class											16	
33	Private											30	
34	Automobile body repairman	040	5					(1)				(1)	
35	Automobile serviceman	014						(2)				(2)	
36	Bugler	803		(* 1)								(1)	
37	Carpenter, general	050	4		(1)							(1)	
38	Carpenter, general	050	5		(1)							(1)	
39	Carpenter, general	050			(2)							(2)	
40	Clerk, parts	348	4		(1)				(2)			(3)	(1)
41	Clerk, parts	348	5		(1)				(1)			(2)	(1)
42	Clerk, parts	348			(3)				(2)			(5)	
43	Clerk, stock record	835	5						(1)			(1)	(1)
44	Clerk, stock record	835							(1)			(1)	
45	Cook	060	4	(2)								(2)	(1)
46	Cook	060	5	(2)								(2)	(1)
47	Cook's helper	521		(2)								(2)	
48	Crane operator	063	4			(6)						(6)	(2)
49	Crane signalman	521				(5)						(5)	
50	Electrician, automotive	912	5				((* 1) 2)	(1)				(3)	(1)
51	Machinist	114	3				(1)					(1)	
52	Machinist	114	5				(2)					(2)	
53	Mechanic, automotive	965	3					(1)		(6)	(3)	(16)	(2)
54	Mechanic, automotive	965	4					(1)		(6)	(3)	(16)	(2)
55	Mechanic, automotive	965	5			(1)		(2)		((*1) 13)	(7)	(35)	
56	Mechanic, fuel induction	926	5					(1)				(1)	(1)
57	Radiator repairman	[illegible]	5				(1)					(1)	
58	Rigger	189	5			(2)						(2)	
59	Rigger	189				(4)						(4)	
60	Storage battery electrician	912	5				(1)					(1)	
61	Storage battery electrician	912					(1)					(1)	
62	Toolroom keeper	242	5						(1)			(1)	
63	Toolroom keeper	242							(1)			(1)	
64	Truck driver, light	345	5			(7)						(7)	
65	Truck driver, light	345		(1)		(5)						(6)	
66	Warehouseman	261			(2)							(2)	
67	Welder, acetylene	257	5				(1)					(1)	
68	Welder, combination	258	4				(1)					(1)	(1)
69	Wrecker operator	[illegible]	5			(4)						(4)	
70	Basic	521		(1)	(2)	(1)	(1)	(2)	(2)	(2)	(1)	(14)	
71	Total enlisted			13	15	36	14	13	12	30	15	178	22
72	Aggregate			15	15	36	14	14	12	31	16	184	22
73	E Crane, rubber tired, 12th Class, 14-18-ton, Lorain					3						3	
74	O Carbine, cal. .30			15	15	36	14	14	12	31	16	184	
75	O Gun, machine, Browning, cal. .50			1								1	
76	O Trailer, 1-ton, cargo					3						3	
77	O Trailer, cargo, 5-6 ton					5						5	
78	O Truck, ¼-ton			1								1	
79	O Truck, ¾-ton, weapons carrier			1								1	
80	O Truck, 2½-ton, cargo					12						12	
81	O Truck, 2½-ton, electrical repair						1					1	
82	O Truck, 2½-ton, machine shop, load A								1			1	
83	O Truck, heavy wrecker					2						2	

14 — Remarks

(Insert number of company.

Assignment—Employed in Communications zone, usually near a port of debarkation.

Function—Uncrate, assemble and service motor vehicles shipped overseas in single or twin unit packs. Also capable of performing 3d echelon automotive maintenance for wheeled vehicles for communications zone units.

Capacity—Can assemble approximately 25 vehicles per day in twin unit packs or 75 in single unit packs. Production can be increased by additional labor. Can perform 3d echelon automotive maintenance for approximately 1,200 to 1,500 wheeled vehicles.

Note—Motor vehicle distributing company, T/O & E 9-237 usually assigned to supplement this unit for clearance of assembled motor vehicles.

* Also drives truck.

For specification serial numbers for enlisted men, shown in column 2, see AR 615-26; for officers see TM 12-406 and 12-407.

Figure 48b. T/O & E 9-348 Ordnance Motor Vehicle Assembly Company (Portable).

Organization permits use of the group assembly system or the assembly line system. All general purpose vehicles, half-track, and heavy duty trucks are assembled, but, in addition, the company must be prepared to assemble almost any type vehicle used by the Armed Forces. On a beachhead or in rugged terrain where an assembly line is impossible because of lack of space, the spot or group method of assembly is used. More successful, however, is the assembly line system.

This system is generally used at a port of debarkation or when conditions and space permit. Assembly line production will double the output of a company and if augmented by civilian or other labor the output can be further increased.

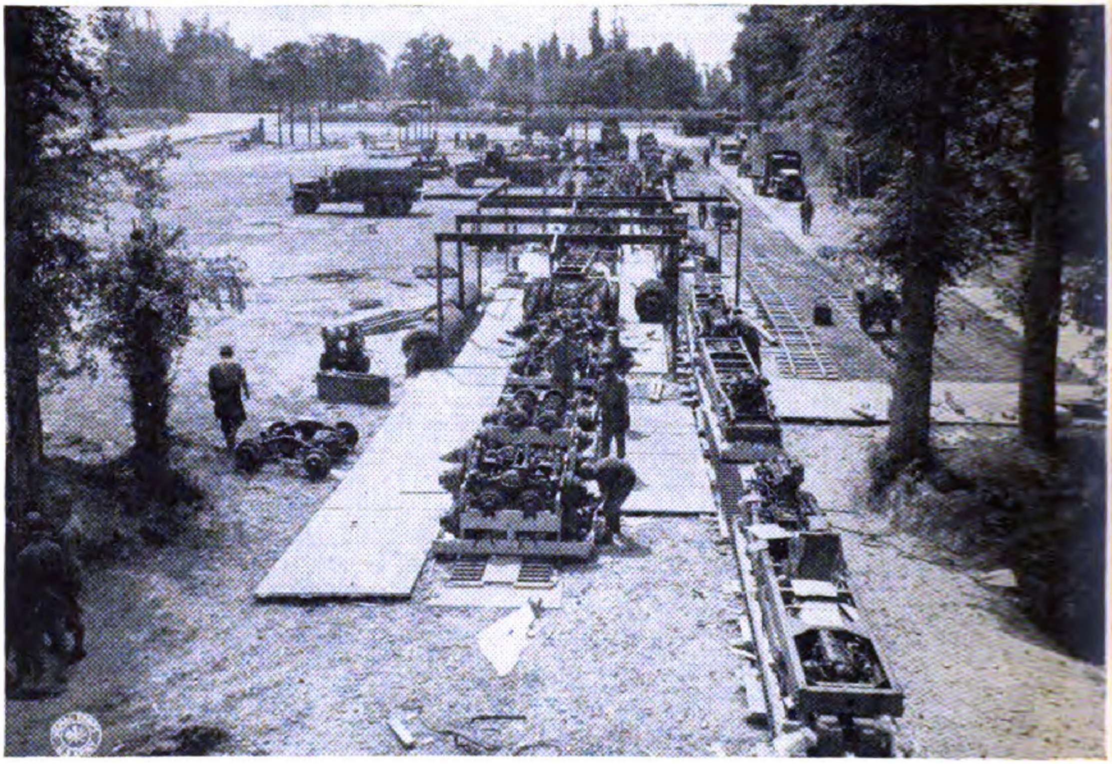


Figure 49. Truck Assembly by Production Methods.

Vehicles with missing parts are assembled and tagged indicating what is missing and placed on the deadline, or damaged parts are repaired and missing parts replaced.

Assembled vehicles are inspected and when ready for use are either turned over to a motor pool or a using organization at the port of debarkation.

ORDNANCE MOTOR VEHICLE DISTR. CO.

The Ordnance Motor Vehicle Distributing Company is assigned to the theater of operations as required. It usually operates in the communications zone and is placed in an ordnance base battalion under a headquarters and headquarters detachment (T/O 9-26). This company is organized into a company headquarters and two distributing platoons. With the T/O here the MVD Co can normally operate a motor pool of approximately 2000 vehicles. This includes new vehicles assembled by motor vehicle assembly companies and vehicles repaired by base automotive shops. Vehicles for the combat zone are drawn from the pools operated by these MVD Co's. As required by the situation, the MVD Co is used to assist in the forward movement of ordnance supplies and the evacuation of unserviceable materiel.

	1	2	3	4	5	6	7	8	9
				2 platoons (each)					
1	Unit	Technician grade	Company headquarters	Platoon headquarters	2 sections (each)	Total platoon	Total company	Enlisted cadre	Remarks
2	Captain	----	1	----	----	----	1	----	†Insert number of company. ᵃ Also drives truck. *Assignment.*—As required to communications zone depots. *Function.*—Distributes motor vehicles from communications zone depots to forward units and establishments. For specification serial numbers shown in parentheses, see AR 615-26.
3	First lieutenant	----	----	1	----	1	2	----	
4	Second lieutenant	----	1	----	----	----	1	----	
5	Total commissioned	----	2	1	----	1	4	----	
6	First sergeant (585)	----	1	----	----	----	1	1	
7	Technical sergeant, including	----	1	----	----	----	1	1	
8	Truckmaster (668)	----	(1)	----	----	----	(1)	(1)	
9	Staff sergeant, including	----	2	1	----	1	4	2	
10	Mess (824)	----	(1)	----	----	----	(1)	(1)	
11	Platoon chief (668)	----	----	(ᵃ1)	----	(1)	(2)	----	
12	Supply (821)	----	(1)	----	----	----	(1)	(1)	
13	Sergeant, including	----	----	----	1	2	4	----	
14	Section chief (668)	----	----	----	(1)	(2)	(4)	----	
15	Corporal, including	----	2	----	1	2	6	1	
16	Assistant section chief (668)	----	----	----	(1)	(2)	(4)	----	
17	Clerk, company (405)	----	(1)	----	----	----	(1)	(1)	
18	Dispatcher (410)	----	(1)	----	----	----	(1)	----	
19	Technician, grade 4						6	2	
20	Technician, grade 5 including	----	12	----	33	66	44	7	
21	Private, first class						44	7	
22	Private						50		
23	Clerk, file (355)	----	(1)	----	----	----	(1)	----	
24	Clerk, general (055)	5	(1)	----	----	----	(1)	(1)	
25	Clerk, general (055)	----	(1)	----	----	----	(1)	----	
26	Clerk-typist (405)	5	(1)	----	----	----	(1)	(1)	
27	Cook (060)	4	(1)	----	----	----	(1)	(1)	
28	Cook (060)	5	(2)	----	----	----	(2)	(1)	
29	Cook's helper (521)	----	(2)	----	----	----	(2)	----	
30	Mechanic, automotive (014)	4	(ᵃ1)	----	(ᵃ1)	(2)	(5)	(1)	
31	Mechanic, automotive (014)	5	----	----	(ᵃ1)	(2)	(4)	(1)	
32	Truck driver, heavy (245)	5	----	----	(3)	(6)	(12)	(1)	
33	Truck driver, heavy (245)	----	----	----	(3)	(6)	(12)	(1)	
34	Truck driver, light (345)	5	----	----	(6)	(12)	(24)	(2)	
35	Truck driver, light (345)	----	----	----	(18)	(36)	(72)	(6)	
36	Basic (521)	----	(2)	----	(1)	(2)	(6)	----	
37	Total enlisted	----	18	1	35	71	160	21	
38	Aggregate	----	20	2	35	72	164	21	
39	O Carbine, cal. .30	----	16	1	25	51	118	----	
40	O Gun, machine, cal. .50, HB, flexible	----	1	1	----	1	3	----	
41	O Gun, submachine, cal. .45	----	1	1	1	3	7	----	
42	O Launcher, rocket, AT	----	1	----	1	2	5	----	
43	O Rifl, cal. .30, M1903	----	3	----	9	18	39	----	
44	O Truck, ¼-ton	----	1	1	1	3	7	----	
45	O Truck, 2½-ton, cargo, w/winch	----	----	----	2	4	8	----	
46	O Truck, 2½-ton, wrecker	----	----	1	----	1	2	----	

Figure 50. T/O 9-328 Ordnance Motor Vehicle Distributing Company.

	1	2	3	4	5
	Unit	Technician grade	Company headquarters	Service and supply platoon: Service section	Service and supply platoon: Supply section
2	Captain		1		
3	First lieutenant				1
4	Second lieutenant				
5	Total commissioned		1		1
6	Warrant officer			[a] 1	
7	Master sergeant, including			1	
8	Master mechanic (342)			(1)	
9	First sergeant (585)		1		
10	Technical sergeant, including				1
11	Chief armorer (511)				
12	Chief mechanic, artillery (913)				
13	Chief repairman, instrument (922)				
14	Chief supply (821)				(1)
15	Foreman, auto repair shop (337)				
16	Staff sergeant, including		3	1	1
17	Assistant, mechanic, artillery (915)				
18	Assistant, motor inspector (413)				
19	Assistant, supply (821)				(1)
20	Machinist (114)			(1)	
21	Mess (824)		(1)		
22	Motor (813)		(1)		
23	Unit supply (821)		(1)		
24	Corporal, including		1		
25	Clerk, company (405)		(1)		
26	Technician, grade 3				
27	Technician, grade 4				
28	Technician, grade 5 including		26	29	11
29	Private, first class				
30	Private				
31	Armorer (511)	4			
32	Armorer (511)	5			
33	Armorer (511)				
34	Blacksmith (024)	5		(2)	
35	Carpenter, construction (050)	5		(1)	
36	Carpenter, construction (050)			(1)	
37	Clerk, stock (324)	4			(1)
38	Clerk, stock control (374)				(1)
39	Clerk, typist (405)	4	(1)		
40	Cook (060)	4	(2)		
41	Cook (060)	5	(2)		
42	Cook's helper (521)		(2)		
43	Driver, heavy truck (245)	5			(2)
44	Driver, light truck (345)	5	([a] 1)		([a] 3)
45	Driver, light truck (345)				

6	7	8	9	10	11
Armament platoon			Automotive platoon	Total company	Enlisted cadre
Artillery section	Armory section	Instrument section			
--------	--------	--------	--------	1	--------
1	--------	--------	1	3	--------
--------	1	--------	--------	1	--------
1	1	--------	1	5	--------
--------	--------	--------	--------	1	--------
--------	--------	--------	--------	1	1
--------	--------	--------	--------	(1)	(1)
--------	--------	--------	--------	1	1
1	1	1	1	5	5
--------	(1)	--------	--------	(1)	(1)
(1)	--------	--------	--------	(1)	(1)
--------	--------	(1)	--------	(1)	(1)
--------	--------	--------	--------	(1)	(1)
--------	--------	--------	(1)	(1)	(1)
1	--------	--------	1	7	3
(1)	--------	--------	--------	(1)	--------
--------	--------	--------	(1)	(1)	--------
--------	--------	--------	--------	(1)	--------
--------	--------	--------	--------	(1)	--------
--------	--------	--------	--------	(1)	(1)
--------	--------	--------	--------	(1)	(1)
--------	--------	--------	--------	(1)	(1)
--------	--------	--------	--------	1	1
--------	--------	--------	--------	(1)	(1)
				13	9
				40	9
44	14	13	40	66	4
				21	--------
				37	--------
--------	(5)	--------	--------	(5)	(2)
--------	(5)	--------	--------	(5)	(1)
--------	(([b]2)([r]3)4)	--------	--------	(4)	--------
--------	--------	--------	--------	(2)	(1)
--------	--------	--------	--------	(1)	--------
--------	--------	--------	--------	(1)	--------
--------	--------	--------	--------	(1)	(1)
--------	--------	--------	--------	(1)	--------
--------	--------	--------	--------	(1)	--------
--------	--------	--------	--------	(2)	(1)
--------	--------	--------	--------	(2)	(1)
--------	--------	--------	--------	(2)	--------
--------	--------	--------	--------	(2)	--------
--------	--------	--------	--------	(2)	--------
--------	--------	--------	--------	(2)	--------

12 — Remarks

†Insert number of company.

[a] Munitions armament machinist.

[b] Also drive(s) ordnance technical vehicle(s).

[c] Armed with carbine, cal. .30, unless otherwise indicated.

[d] Also drives ¼-ton truck.

[r] Armed with rifle, cal. .30 M1903.

[s] Armed with gun, submachine, cal. .45.

Normal assignment: To ordnance battalions under army command.

Function: Fourth echelon maintenance for weapons, instruments and a limited number of vehicles.

Capacity: Capable of performing above functions for approximately 4 infantry divisions, or 5 antiaircraft groups or 5 field artillery groups.

The serial number symbol shown in parentheses is an inseparable part of the specialist designation. See AR 615-26.

	1	2	3	4	5	6	7	8	9	10	11	12
	Unit	Technician grade	Company headquarters	Service and supply platoon: Service section	Service and supply platoon: Supply section	Armament platoon: Artillery section	Armament platoon: Armory section	Armament platoon: Instrument section	Automotive platoon	Total company	Enlisted cadre	Remarks
46	Electrician (078)	5		(2)						(2)		
47	Electrician, track and wheel vehicle (912)	4							([d a] 1)	(1)	(1)	
48	Electrician, track and wheel vehicle (912)	5							([a b] 1)	(1)		
49	Leather and canvas worker (609)	5		([a] 1)						(1)		
50	Leather and canvas worker (609)			(3)						(3)		
51	Machinist (114)	3		(1)						(1)	(1)	
52	Machinist (114)	4		(([b a] 2)3)						(3)		
53	Machinist (114)	5		([b a] 2)						(2)		
54	Machinist (114)			(3)						(3)		
55	Mechanic, artillery, antiaircraft (915)	3				(2)				(2)	(1)	
56	Mechanic, artillery, antiaircraft (915)	4				(4)				(4)		
57	Mechanic, artillery, antiaircraft (915)	5				(2)				(2)		
58	Mechanic, artillery, heavy (914)	3				(2)				(2)	(1)	
59	Mechanic, artillery, heavy (914)	4				(3)				(3)		
60	Mechanic, artillery, heavy (914)	5				([a b] 1)				(1)		
61	Mechanic, artillery, light (913)	3				(2)				(2)	(1)	
62	Mechanic, artillery, light (913)	4				(4)				(4)		
63	Mechanic, artillery, light (913)	5				(14)				(14)		
64	Mechanic, artillery light (913)					(([a] 9)10)				(10)		
65	Mechanic, automobile (014)	3							(2)	(2)	(1)	
66	Mechanic, automobile (014)	4							(4)	(4)		
67	Mechanic, automobile (014)	5							(6)	(6)		
68	Mechanic, automobile (014)								(([c] 2)6)	(6)		
69	Mechanic, chassis, track vehicle (908)	5							(1)	(1)	(1)	
70	Mechanic, chassis, track vehicle (908)								([a] 1)	(1)		
71	Mechanic, chassis, wheel vehicle (906)	3							(1)	(1)	(1)	
72	Mechanic, chassis, wheel vehicle (906)	4							(1)	(1)		
73	Mechanic, chassis, wheel vehicle (906)	5							(1)	(1)		
74	Mechanic, chassis, wheel vehicle (906)								([a] 1)	(1)		
75	Mechanic, engine, track vehicle (gasoline) (909)	5							(1)	(1)		
76	Mechanic, engine, track vehicle (gasoline) (909)								(1)	(1)		
77	Mechanic, engine wheel vehicle (905)	3							(1)	(1)	(1)	
78	Mechanic, engine wheel vehicle (905)	4							([a b] 1)	(1)		
79	Mechanic, engine wheel vehicle (905)	5							([a b] 1)	(1)		
80	Mechanic, engine wheel vehicle (905)								([a] 1)	(1)		
81	Mechanic, fuel induction (926)	4							(1)	(1)	(1)	
82	Mechanic, fuel induction (926)	5							(1)	(1)		
83	Mechanic, tractor (319)	3							(1)	(1)	(1)	
84	Mechanic, tractor (319)	4							(2)	(2)		
85	Mechanic, tractor (319)	5							(3)	(3)		
86	Messenger (675)		([d a] 1)							(1)		
87	Painter, general (144)	5		(1)						(1)		
88	Receiving or shipping checker (186)	5			(2)					(2)		
89	Receiving or shipping checker (186)				([a] 2)					(2)		
90	Repairman, control system, heavy antiaircraft (920)	4						(1)		(1)	(1)	

91		Repairman, control system, light antiaircraft (919)	5			
92		Repairman, director, heavy antiaircraft (917)	4			
93		Repairman, director, light antiaircraft (918)	5			
94		Repairman, height-finder (921)	5			
95		Repairman, instrument, fire control (922)	3			
96		Repairman, instrument, fire control (922)	4			
97		Repairman, instrument, fire control (922)	5			
98		Repairman, instrument, fire control (922)				
99		Repairman, instrument, electric (338)	5			
100		Toolroom keeper (242)	5		(1)	
101		Watchmaker (381)	4			
102		Welder, combination (256)	4		(3)	
103		Welder, combination (256)	5		(([b r]2)3)	
104		Wrecker operator (529)	5		(2)	
105		Basic (521)		(([r] 6)17)		
106		Total enlisted		31	31	13
107		Aggregate		32	32	14
108	O	Carbine, cal. .30		24	25	9
109	O	Gun, machine, cal. .50, HB, flexible		1	2	2
110	O	Gun, submachine, cal. .45		1		3
111	O	Launcher, rocket, AT		1	1	
112	O	Rifle, cal. .30, M1903		7	7	2
113	O	Semitrailer, combination animal and cargo				2
114	O	Semitrailer, 6-ton van				4
115	O	Trailer, 1-ton, 2-wheel, cargo		1		
116	O	Truck, ¼-ton		1		
117	O	Truck, ¾-ton, weapon carrier, w/winch				3
118	O	Truck, 2½-ton, cargo		1		
119	O	Truck, artillery repair				
120	O	Truck, automotive repair				
121	O	Truck, electrical repair				
122	O	Truck, instrument repair				
123	O	Truck, machine shop			4	
124	O	Truck, small arms repair				
125	O	Truck, welding			2	
126	O	Truck-tractor, 4-5-ton				2
127	O	Truck, 10-ton, heavy wrecker			2	

Figure. 51a. T O & E 9-9, Ordnance

		(1)		(1)	
		(1)		(1)	(1)
		(1)		(1)	
		(r 1)		(1)	
		(1)		(1)	(1)
		(1)		(1)	
		(1)		(1)	
		(2)		(2)	
		(r b 2)		(2)	
				(1)	
		(1)		(1)	
				(3)	(1)
				(3)	
				(2)	
				(17)	
46	15	14	42	192	33
47	16	14	43	• 198	33
37	13	11	34	153	
				5	
			1	5	
1	1		1	5	
10	3	3	8	40	
				2	
				4	
1				2	
			1	2	
				3	
				1	
1				1	
			2	2	
			1	1	
		2		2	
				4	
	2			2	
				2	
				2	
				2	

Heavy Maintenance Co., Field Army.

Line	Column						
	1	2	4	5	7	10	11	12
3	First lieutenant	----	1	----	--------	3	----	[a] Supply and clerical, Ordnance. For specification serial numbers shown in parentheses, see AR 615-26.
5	Total commissioned	----	1	----	1	5	----	
6	Warrant officer	----	----	[a] 1	--------	1	----	
31	Delete entire line	----	----	----	--------	----	----	
32	Delete entire line	----	----	----	--------	----	----	
33	Delete entire line	----	----	----	--------	----	----	
49	Leather and canvas worker (609)	5	(1)	----	--------	(1)	----	
52	Machinist (114)	4	([b] 3)	----	--------	(3)	----	
65	Mechanic, automotive and half-track (965).	3	----	----	--------	(2)	----	
66	Mechanic, automotive and half-track (965).	4	----	----	--------	(4)	----	
67	Mechanic, automotive and half-track (965).	5	----	----	--------	(6)	----	
68	Mechanic, automotive and half-track (965).	----	----	----	--------	(6)	----	
99¼	Repairman, small arms (903)	4	----	----	(5)	(5)	(2)	
99½	Repairman, small arms (903)	5	----	----	(5)	(5)	(1)	
99¾	Repairman, small arms (903)	----	----	----	(([b]2r3)4)	(4)	----	
118	O Truck, 2½-ton, cargo	----	5	----	--------	6	----	
123	O Truck, machine shop (load A)	----	1	----	--------	1	----	
123½	O Truck, machine shop (load B)	----	1	----	--------	1	----	
125	Delete entire line	----	----	----	--------	----	----	

Figure 51b. T/O & E 9-9, 3 July 1943, Ordnance Heavy Main. Co., Field Army.

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