



THE



ORDNANCE

SERGEANT

VOL. 4

AUGUST 1942

NO. 2



RESTRICTED

Published by the Ordnance School in the interest of Ordnance Sergeants

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Cover picture arranged and posed by the Fire Control Section of The Ordnance School. Photo by Photographic Section of The Ordnance School.

HIGHLIGHTS

This issue represents an effort to present a reasonably complete general picture of Fire Control. The Fire Control Section of The Ordnance School has endeavored to touch on everything worth the telling in the line of Fire Control, bearing in mind the fact that available space required general rather than detailed discussions.

Among the regular monthly features, although it is always difficult to select the most important article, because of widely differing viewpoints and interests, the outstanding article of this issue is probably that of the Automotive Section, "Recent Developments in Fuels and Lubricants". Lt. Severinghaus gives us an article here which is up to date and which explains changes vital to the maintenance of all Ordnance materiel.

Notice that the regular Fire Control article, "Inspecting and Repairing Generators for Issue", includes the latest information on lubrication as included in the changes described by Lt. Severinghaus.

These changes in lubricants will be discussed further in the next issue with an article titled, "Lubrication of Artillery Weapons".

Those of you who are interested in paper work should not overlook two articles in this issue. Under the Administration heading Staff Sergeant Schor tells us all about "Furloughs, Delays Enroute, and Passes". Of special interest to Depot and Supply men is Technical Sergeant Hathaway's article which makes bills of lading seem simple, "The Preparation of a Bill of Lading".

Of interest to every reader is the article intended primarily for machinists, "The Early Tool Builders", the first of two articles on this subject by Lieutenant Ogden.

Address all communications to: THE ORDNANCE SERGEANT, The Ordnance School, Ordnance Training Center, Aberdeen Proving Ground, Maryland.

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Editorial

"Give 'Em Hell
for Us"

Among the days America must remember is May 5, 1942. Not a day of victory or triumph or pleasure, but a day of defeat.

The fall of Corregidor marked the climax of the greatest military disaster in American history. Never before were so many American lives lost as at Corregidor and during the Bataan affair which preceded Corregidor. For the first time in American history American troops were definitely driven off of American soil, or were shot down to fall in their own blood.

It fell to a young army radio man to describe the final hour of Corregidor's agony. He tapped out a series of broken messages on May 5 while the rock fortress in Manila Bay was being shelled by siege guns and pounded from the air, and while the Japanese landing forces were beating down the last of the defenders.

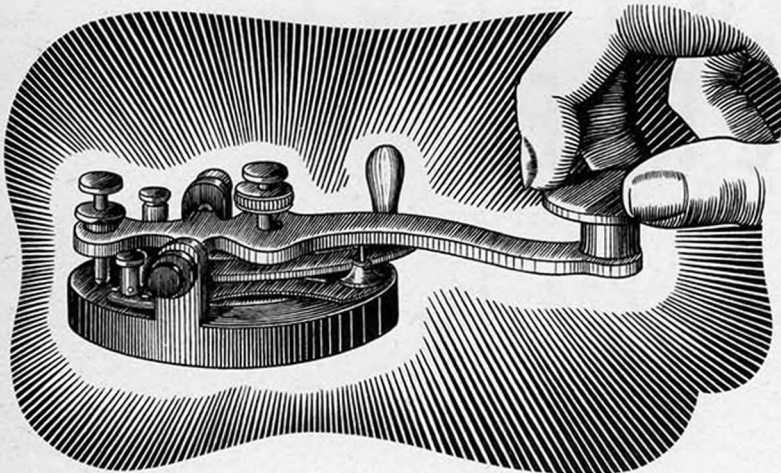
The young man who sent Corregidor's last message to the outside world had little literary talent, perhaps, but nevertheless his account is literature. The fire and noise and terror and hopelessness of the last minutes of the long, heroic, and unavailing defense burned their way into his story.

GIVE 'EM HELL FOR US.

Thus in its last moment Corregidor's message to the great new army springing up at home to "give 'em hell for us". The Corregidor garrison knew that the manhood of America would be coming to take up the fight. The endless divisions would come, too late to save Corregidor, but not too late to take it back, and not too late for the final victory. The men of Corregidor who knew the bitter taste of defeat had faith at the last in that.

The words of an obscure soldier on a blasted rock 8,000 miles from home dedicates this nation to its task. We're going back to Bataan!

---Adapted from an Editorial in the BALTIMORE SUN.



THE LAST MESSAGE FROM CORREGIDOR

"They are not near yet. We are waiting for God only knows what They are throwing men and shells at us and we may not be able to stand it. They have been shelling us faster than you can count . . ."

A pause, then this:

"We've got about 55 minutes and I feel sick at my stomach. They (his comrades) are around now smashing rifles. They bring in the wounded every minute. We will be waiting for you guys to help. This is the only thing, I guess, that can be done"

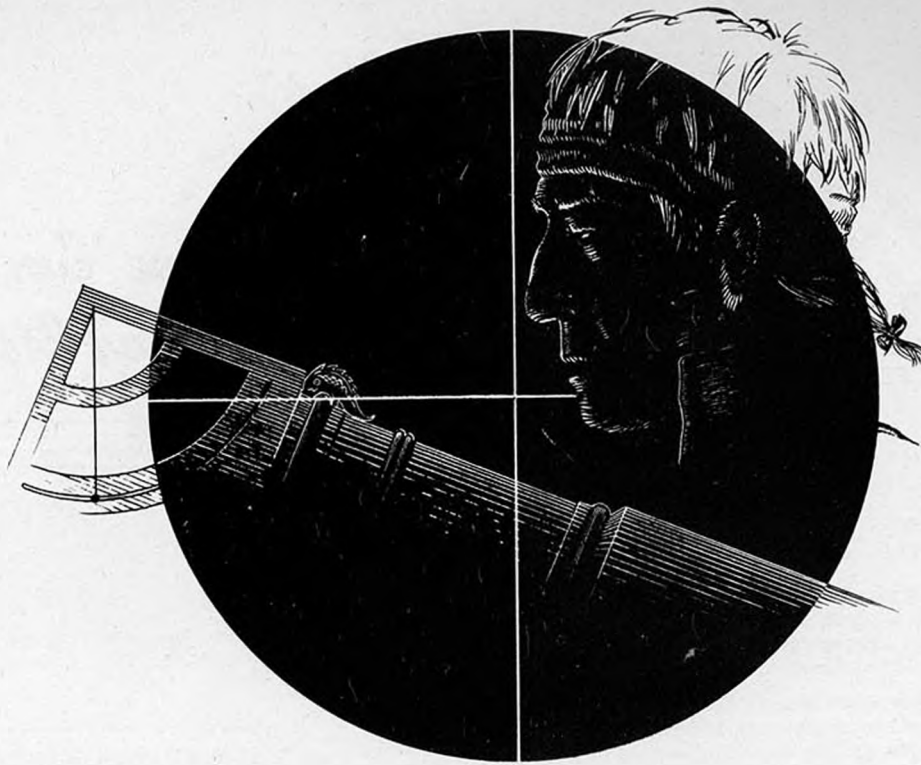
Another pause:

"Gen. Wainwright is a right guy and we are willing to go on for him, but shells were dropping all night, faster than hell. Damage terrific. Too much to take. They have got us all around and from skies. Men here all feeling bad, because of terrific nervous strain of siege. Corregidor used to be a nice place, but it's haunted now."

A few minutes later:

"Just made broadcast to Manila to arrange meeting for surrender. I can't say much. Can't think at all. I can hardly think . . . The jig is up. Everyone is bawling like a baby. They are piling dead and wounded in our tunnel. Arm's weak from pounding key; long hours, no rest, short rations, tired.

"I know now how a mouse feels, caught in a trap waiting for some one to come along and finish it . . . Message. My love to Pa, Joe, Sue, all my family, and friends. Hope they'll be there when I come home. Tell Joe (a brother in the Coast Artillery) to give 'em hell for us. God bless you and keep you."



HISTORY *and*
DEVELOPMENT
OF
FIRE CONTROL
MATERIEL

by J. F. KENNELLY, 2nd. Lt., Ord. Dept.

THE INTRODUCTION OF METAL SHOT . . . RESULTED IN THE INVENTION OF THE FIRST ITEM OF ARTILLERY SIGHTING EQUIPMENT

Introduction

The development of fire control instruments and sighting equipment has been comparatively recent, chronologically speaking, when contrasted with the antiquity of artillery weapons. A moment's contemplation will render the reasons for this apparent.

For more than three hundred years (from 1240 to 1550) the only projectiles used with ancient cannon were stones, and the maximum range of these improvised projectiles seldom exceeded three hundred yards. Even at this time, however, the importance of (1) elevation in relation to range, and (2) powder charge and weight of projectile in relation to range, were understood in a vague sort of way, and some attempt to apply the knowledge was attempted.

Guns were mounded at the muzzle end with dirt and rock, and later with wedges, for varying elevations. Some uniformity of procedure was attempted in the selection of projectiles of the same weight for same powder charges. However, weapons were so cumbersome, and knowledge so limited, that the results achieved were always exceedingly erratic.

The situation was further complicated by the fact that artillery was held in very low esteem. No army of ancient times had an artillery arm. Cannon were rented and civilian cannoners hired for short periods of time. Since this was only comparable to a spare time occupation the efficiency of gunners was usually proportionate to the wages involved.

For siege work these weapons had a certain mild effectiveness for breaching walls, and occasionally as a defense against sea-borne invaders. Against personnel their effect was psychological only, in most instances, until familiarity erased even this doubtful effect. Artillery of the thirteenth and fourteenth century was so clumsy, and muzzle velocities so low, that a nimble, keen-eyed soldier could usually dodge or evade most of the stone projectiles.

Sighting equipment for weapons of this type was obviously unnecessary. Fire control was a term yet unborn by several hundred years.

To aim artillery of the type under discussion, gunners merely pointed the weapon at the target (usually a wall or ship at a few hundred yards), raised the muzzle to an extent determined by experience, by mounding or ballasting with rock or dirt, ignited the charge, and then scurried for cover in the event the gun exploded (which was a not uncommon occurrence).

Medieval Developments

The introduction of metal shot succeeded in increasing the range of cannon tremendously and resulted in the invention of the first item of artillery sighting equipment. This was the "Gunner's Quadrant", a modified version of which is in common use even today. Its invention is claimed by Niccolo Tartaglia (1506 - 1559), an Italian mathematician, and the author of one of the first textbooks on gunnery to be written. ("Nuova Scienza", Venice, 1537)

This quadrant was used for laying guns and mortars in elevation. The original gunner's quadrant consisted of two arms forming a 90 degree angle, with a weighed plumb line suspended from the vertex of the angle. One arm was usually inserted in the bore of the gun, or, in the case of mortars, laid across the muzzle end. Readings to an accuracy of two degrees were possible. The gunner's quadrant existed in substantially this same form until 1843, when the spirit level quadrant was introduced by the Prussian artillery.

Despite the invention of the gunner's quadrant, range was still considered a function of variations in powder charge until nearly 1850. Yet it must be noted that the constantly increasing range of artillery accelerated the study of exterior ballistics long before the actual application of this science to practical gunnery was attempted.

"Angle of site" as distinguished from "elevation" or "range" was known in 1521. Settings of "quadrant elevation", or, an algebraically added site and range reading, were set by wedges and screws as early as 1631. Later, by several hundred years, the worm and wormwheel was tried, and discarded for this same use as impractical, due to the weight of artillery weapons.

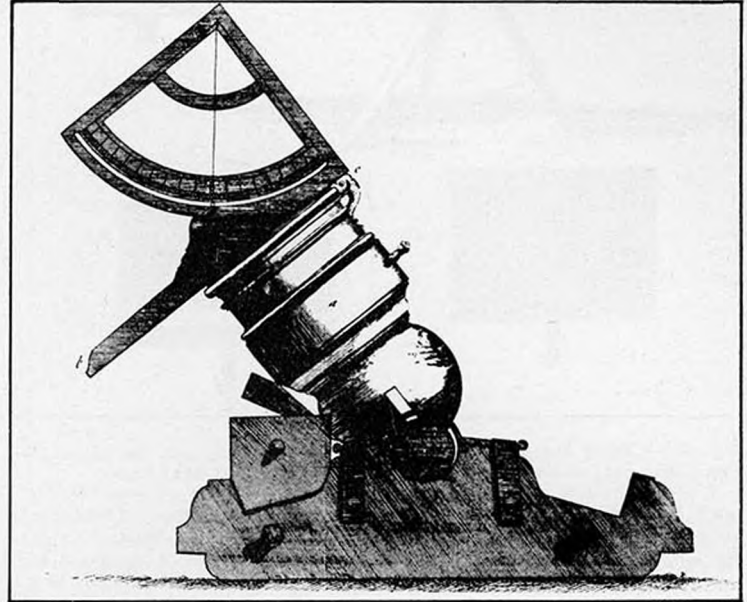


Fig. 1. -- Early Gun Laying - Illustrating the use of the gunner's quadrant of 1760 with a mortar of the same period.

In 1742 an Englishman named Robins presented an extensive analysis of wind resistance on the trajectory of a projectile. This resulted in an exhaustive study of the factors affecting trajectories by outstanding mathematicians of the period and considerable knowledge was unearthed by the theorists but never applied by the military.

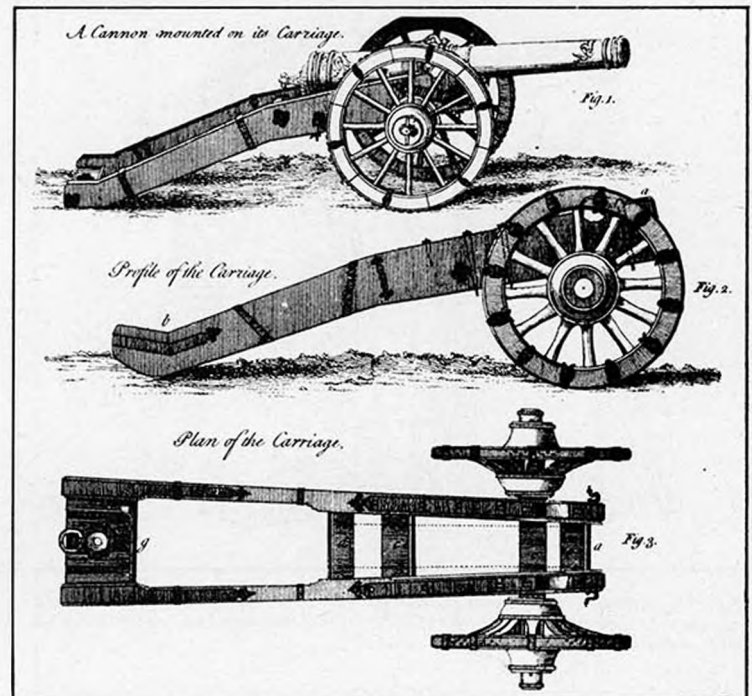


Fig. 2. -- Medieval Cannon, 1760.

Jean Baptiste de Gribeval (1715-1789), Inspector General of the French Army, was probably responsible for more reforms in the use of artillery than any other one man in history. One of these many reforms was the introduction of "tangent scales". The idea was not new, but the application was, as far as artillery was concerned.

These supplanted the opened, notched sights which were then being used for laying in direction. Tangent scales, with minor modifica-

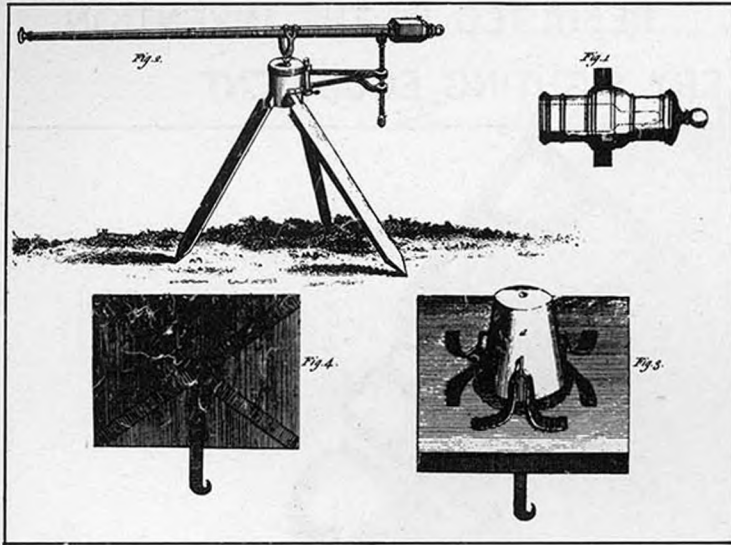


Fig. 3. -- Early Eighteenth Century - Not only cannon, but the Mitrailleuse, bomb pot, and mortar were also in common use at this time.

tions, remained in use with artillery, till the development of telescopic sights late in the 19th century. They supplemented the telescopic sighting equipment of most weapons, with practically all armies, from this time till the start of the first World War.

Nineteenth Century

The introduction of rifled artillery necessitated an allowance for drift, and tangent sights were soon provided with adjustable drift scales.

In various forms, mechanical sighting equipment governed gunnery until late in the nineteenth century. Since a sound mathematical basis for

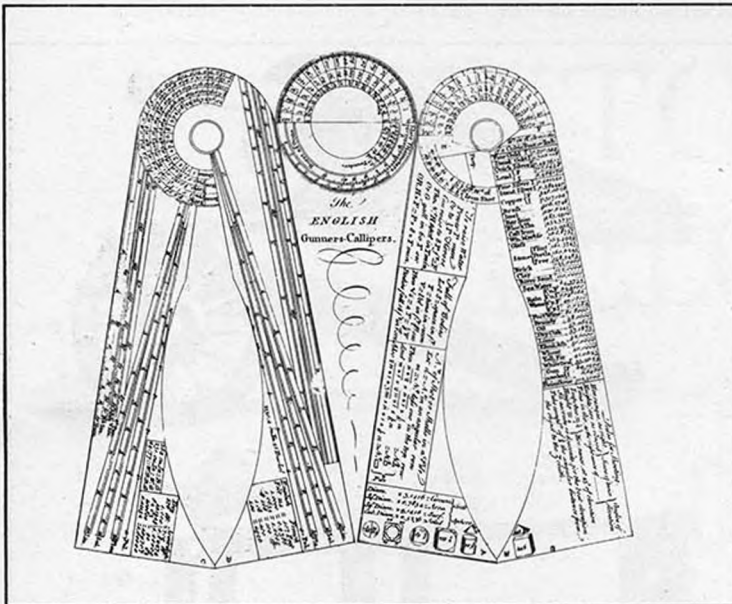


Fig. 4. -- Gunner's Calipers - Dating back to 1743, this ingenious looking contrivance was used by artilleryists for practically everything except swabbing the bore.

modern gunnery and instruments had been established as far back as 1742, this is difficult of comprehension, and can only be attributed to the lag in the development of applied optics and a disinclination of the military mind to adopt anything departing radically from accepted standards.

The only development of appreciable significance in the construction of mechanical sighting equipment to occur prior to 1880 was a tangent scale with a weighted pendulum which automatically corrected the line of sight for cant of trunnions. This was the forerunner of the modern azimuth compensating mechanism.

A brief survey of the fire control and sighting field as it existed in

the middle of the nineteenth century will show the conditions existing immediately prior to the development of more modern, telescopic instruments. It should be kept in mind that the difficulty of producing optical

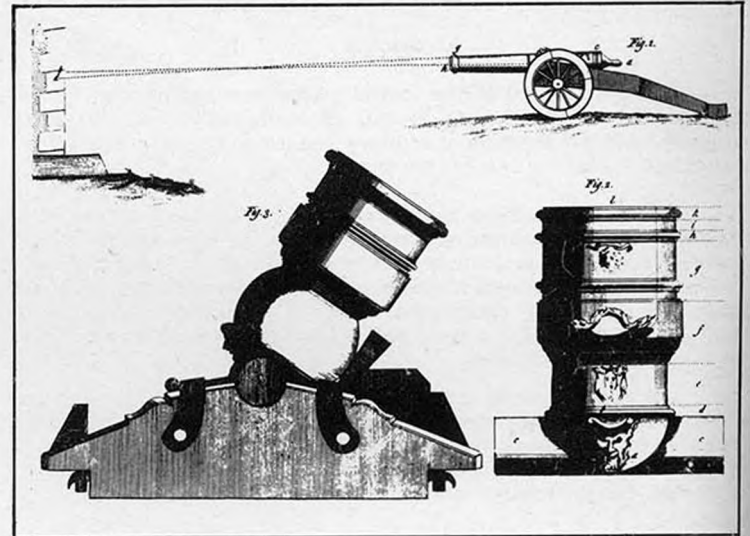


Fig. 5. -- Early Eighteenth Century - (Top) Medieval bore sighting? (Bottom) The mortars of this period were cumbersome affairs some noted for their ornamentation than accuracy.

glass of good quality, in quantity, was hampering the advance of applied optics at this time. Astronomical optics was not being handicapped in this respect, since astronomical instruments were utilizing mirrored surfaces in preference to lenses.

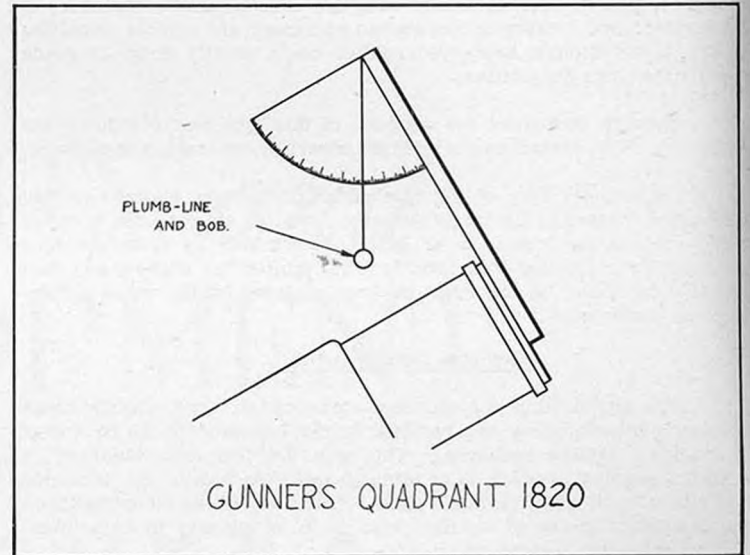


Fig. 6.

Elevation screws and nuts were in common use for obtaining elevation. Dispart and tangent sights comprised the rest of the "on carriage" fire control equipment. Basically, this was the general picture.

The U. S. Military Academy textbook on Ordnance and Gunnery for 1862, lists only five items used for the pointing of cannon. These were:

(1) A gunner's level for determining the highest level of breech and muzzle when the carriage wheels rested on uneven ground. This instrument included a spirit level.

(2) A tangent scale. - This was a brass plate, lower edge cut to the base ring of the piece, and the upper edge formed into offsets corresponding to differences in elevation of a quarter of a degree. It was used in pointing by placing the curved edge on the base ring, with the radius of the offset corresponding with the highest point of the ring, and sighting over the center of the offset and the highest point of the swell of the muzzle.

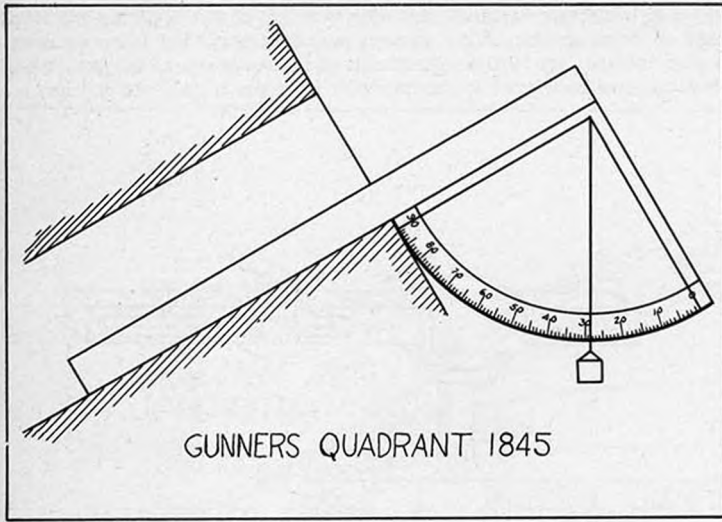


Fig. 7.

(3) The breech sight. - This was a more accurate form of the tangent scale. It was graduated to eighths of a degree and utilized a thumbscrew adjustment for greater precision.

(4) The pendulum hausse. - This was used for pointing field pieces and for obviating the error caused by uneven ground.

(5) A gunner's quadrant still utilizing a plumb line in preference to a spirit level. In this respect the American Army was far behind other major nations of the period.

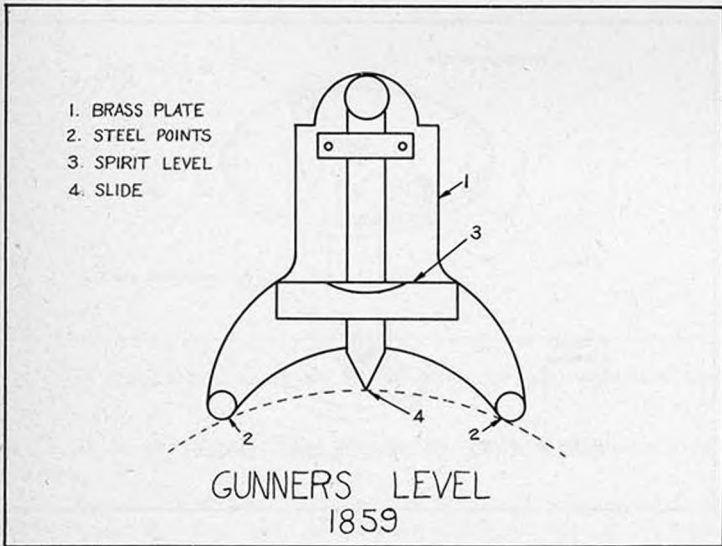


Fig. 8.

The naval academy textbook for 1875 shows that no startling improvements had resulted in any radical change in methods of aiming and pointing in the ensuing few years. Although this text contains an exhaustive treatise on gunnery, especially as treating the factors causing deviations, the applied gunnery remains similar in principle to that of twenty years before.

The navy, however, was using both the spirit level quadrant and the plumb line quadrant at this period (1875). Tangent sights were used to give the elevation above the horizontal plane of the deck. Pendulums, working in a graduated arc were used to indicate the heel or inclination of the ship's deck with reference to the horizontal. As the author himself admits, "-- little reliance was placed in these contrivances".

It is doubtful whether or not other armies and navies were far in advance of the American services at this time. Tangent sights were not even adopted in the British navy until as late as 1850, and the "Treatise on Service Ordnance", published for the English Army in 1909 indicates tangent and bore sights were used with breech loading weapons of all major calibers as late as 1908.

By 1880 the range of artillery was so great that some means for observation of distant targets and some sort of sighting equipment for indirect fire was urgently needed.

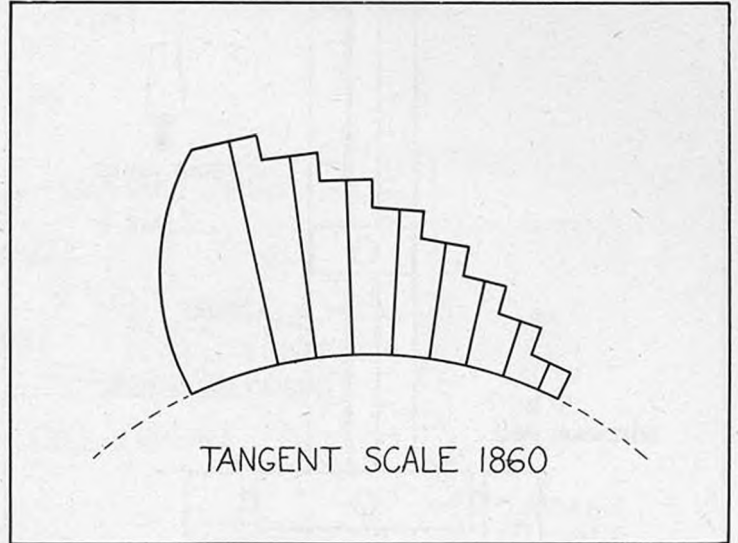


Fig. 9.

Major Porro, in the middle of the nineteenth century introduced the "Lunette a' Napoleon Troiseme", a military telescope with a prism erecting system, of ten power, which was less than two inches in length. In the light of present knowledge this instrument had several serious disadvantages. The attempt to achieve compactness had resulted in an instrument which was far too small for practical use. The power (ten) was much too high for an instrument designed to be used by holding in the hand. The length was too short to take maximum advantage of the optical possibilities for efficient functioning. Nevertheless, this occurrence

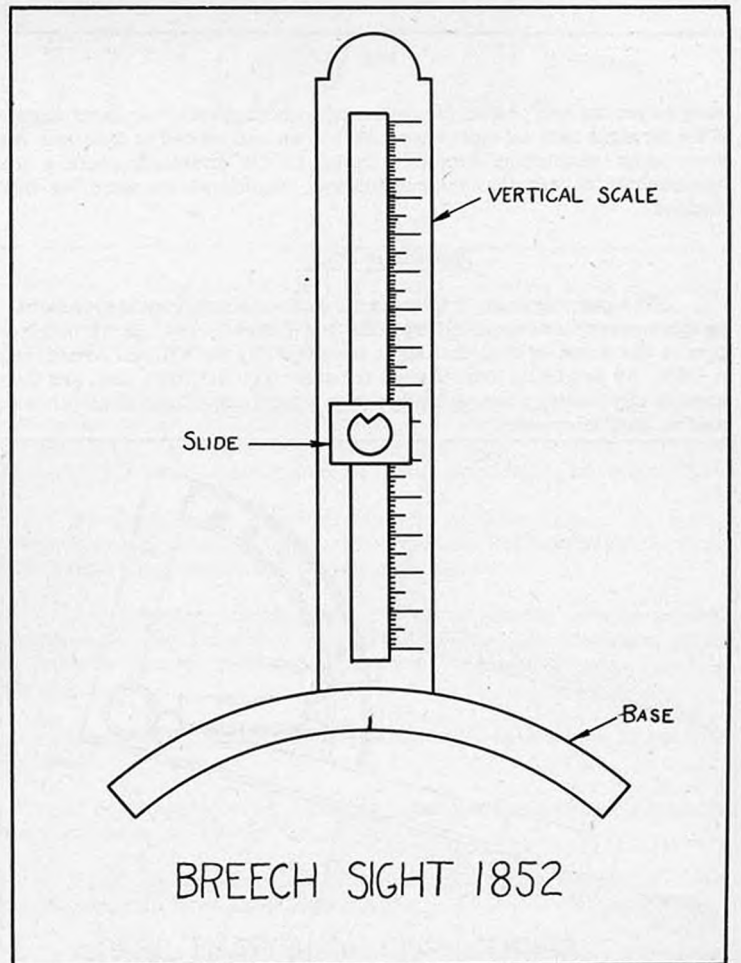


Fig. 10.

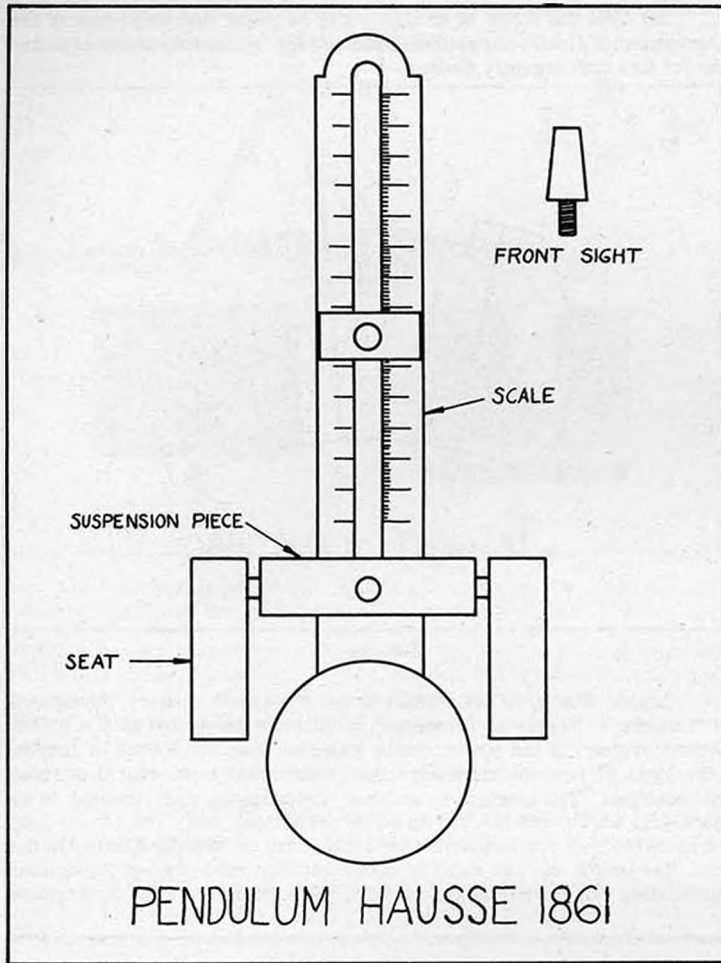


Fig. 11.

inaugurated the use of a telescope for observation, and other instruments of the straight tube telescope type were soon introduced to facilitate the observation of distant targets. Early in the twentieth century the stereoscopic observation instrument was adopted as standard for this purpose.

Panoramic Sights

The panoramic sight is today the most commonly employed sighting instrument used by artillery units for indirect fire. In its original form it was a non-optical dial sight, developed by Sir William Armstrong in 1855. As originally constructed the sight saw but little use, and then only for night firing where a lantern with a vertically illuminated slit was used as an aiming point.

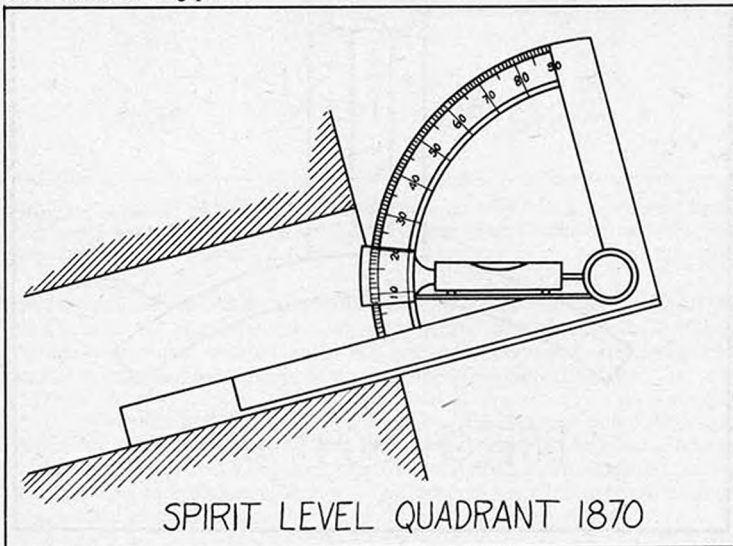


Fig. 12.

A telescope replaced the open portion of the sight as the next stage of development. This proved unsatisfactory and mirrors were adopted instead. By 1900 the panoramic sight, now known as the panoramic telescope, had developed to substantially the form it consists of today.

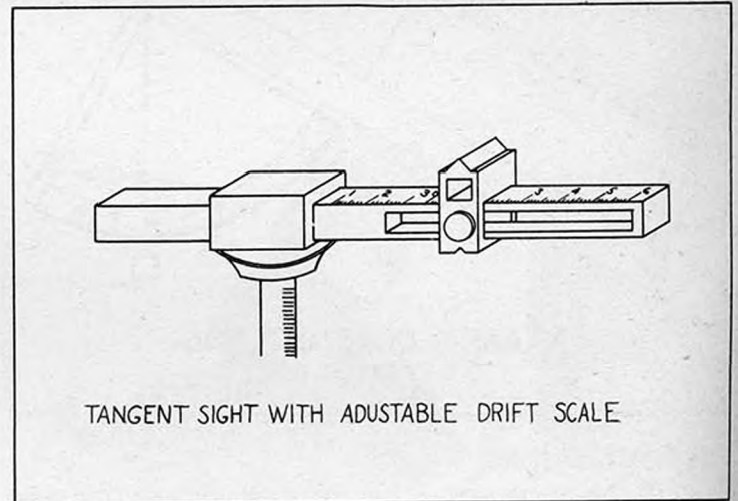


Fig. 13.

Improvements since 1900 have, for the most part, been refinements of mechanical operation, and the substitution of prisms for the reflecting surfaces formerly consisting of mirrors. In addition, there have been numerous changes in the method of mounting to conform with improvements in the design of artillery carriages. Cross wire reticles and graticules of spider webbing and wiring have given way to the modern, etched glass reticle.

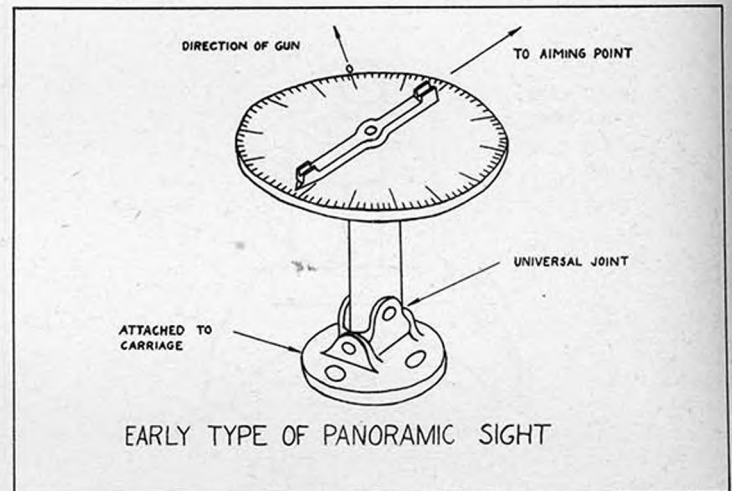
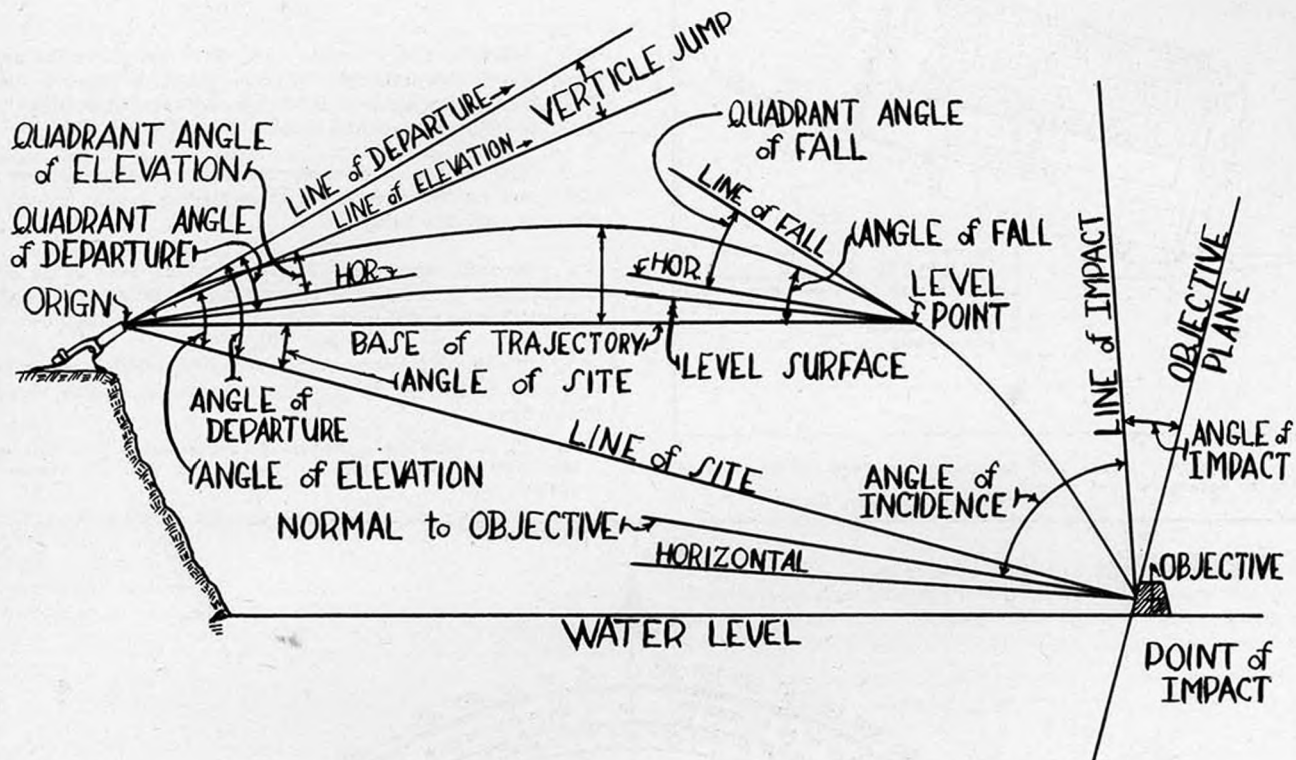


Fig. 14.

Telescopic Sights

The factors hindering the development of the telescopic sights were concisely stated by Lieut. E. L. Zalinski, of the 5th Artillery, U. S. Army, in 1882. These were, briefly:

- (1) Expense and delicacy of these items.
- (2) Errors in elevation due to varying refraction.
- (3) Necessary smallness of the graduations of arc for deflection and elevation.
- (4) Ease with which the line of collimation could be thrown out of adjustment with reference to the zero of graduation.
- (5) Difficulty of replacing the telescopic sight in exactly the same position on the gun and the danger of affecting adjustment while doing this.
- (6) Absence of adjustment when the gun trunnions were out of the horizontal.



ELEMENTS of TRAJECTORY in AIR

(7) Insufficient adjustment for deflection for long ranges and high winds.

(8) Danger of displacing the line of sight with reference to the mounting.

While some of these problems look ridiculous today it should be borne in mind that they were real and serious hindrances at the time. Through the ingenuity of Lieut. Zalinski, and officers of the American Ordnance Department, several telescopic sights were developed which far exceeded in efficiency anything in use by other nations at the time.

Artillery Fire Control, 1881

A most interesting picture of fire control as applied to seacoast artillery can be gathered from the various reports of practice firing conducted at Fortress Monroe in the 1880's. One, occurring in 1881, is of particular interest for two reasons. The telescopic sight was introduced and the necessity of accurate range finding instruments realized.

The firing to which the data below applied occurred in 1881. It was conducted with a 15" S.B., 8" converted rifle and a 100-pounder Parrott rifle.

The following sidelights on the methods of fire control and sighting of the time should be of general interest.

(1) Velocity of wind was obtained by use of an anemometer and electric bell.

(2) Direction of wind was obtained by use of a kite, the string of which was attached to a dial.

Fig. 15. -- Elements of Trajectory in Air - A better title might be, "Why fire control instruments are necessary!" These are only a few of the exterior ballistic factors entering into consideration when plotting the path of a projectile.

(3) Barometric, temperature, and humidity conditions were determined by the standard meteorological instruments of the period, and reduced in each case to the weight of a cubic foot of air; this gave three variables in a tangible form for direct comparison and application.

(4) Pointing was experimented with by three means: (a) by the Lorain telescopic sight, (b) by a newly developed Zalinski telescope sight from Frankford Arsenal, and (c) with open sights.

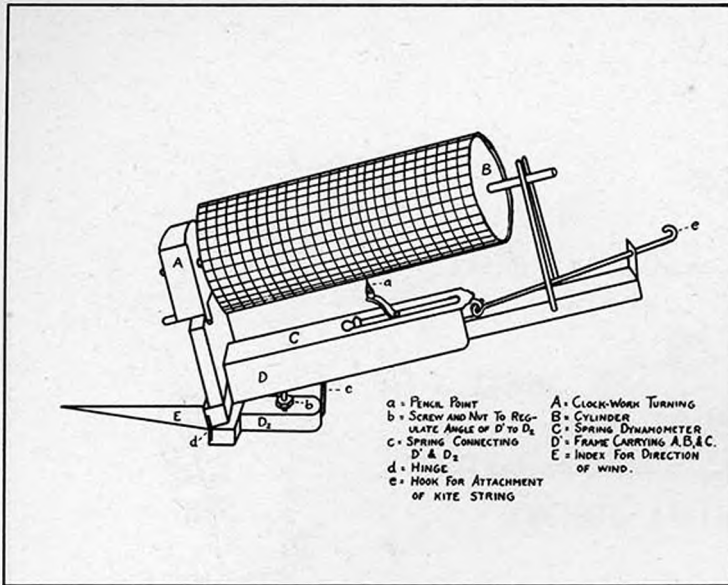
(5) Elevation was set in three ways, in keeping with the experimentation that was underway: (a) with the Lorain telescopic sight, (b) by the Zalinski trunnion elevating device, and (c) by a spirit level gunner's quadrant.

(6) Time of flight of the projectiles was determined by use of a stop watch.

(7) Deflections were obtained by means of theodolites and transits on a platform to the rear of the gun.

(8) Range was obtained by triangulation, using plane tables on the beaches some distance away from the gun.

The results of the firing conducted as illustrated above were most illuminating to the many military observers present. The overwhelming superiority of the telescopic sight over the open sight was amply demon-



a. PENCIL POINT
 b. SCREW AND NUT TO REG-
 ULATE ANGLE OF D TO D₂
 c. SPRING CONNECTING
 D' & D₂
 d. HINGE
 e. HOOK FOR ATTACHMENT
 OF KITE STRING

A. CLOCK-WORK TURNING
 B. CYLINDER
 C. SPRING DYNAMOMETER
 D. FRAME CARRYING A, B, & C.
 E. INDEX FOR DIRECTION
 OF WIND.

Fig. 16. -- Anemometer, 1881 - This instrument was used in conjunction with a kite to determine wind direction and velocity.

strated, and the need for accurate and more precise range finding methods emphasized by the results of the firing.

The next important development in the history of fire control has to do with range finders.

Range Finders

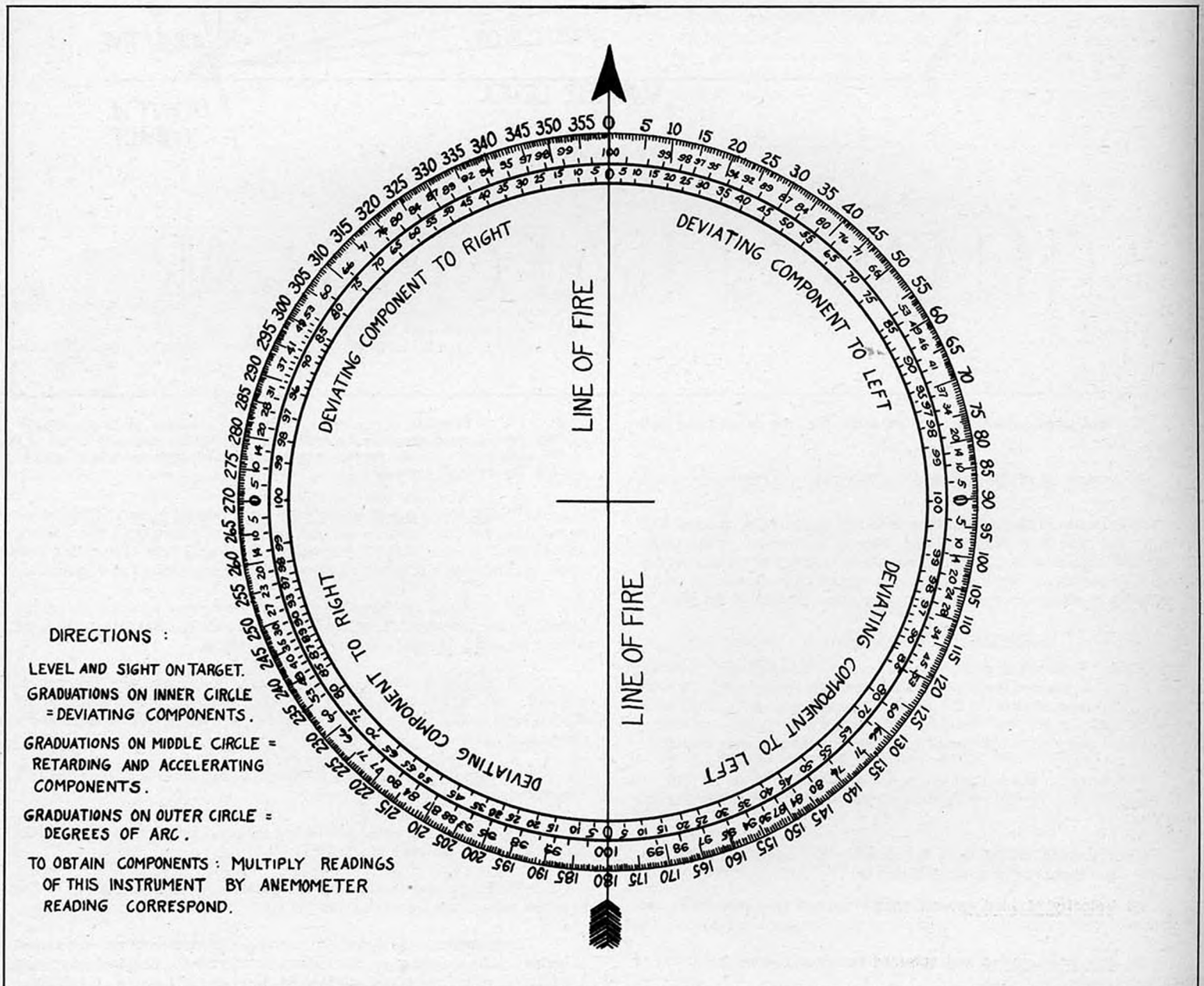
When artillery ranges exceeded 1000 yards the accuracy of the human eye in the estimation of range could no longer be depended upon. There was an urgent need for range finders and position finders which would be both accurate and capable of field use.

During the nineteenth century experiments were carried on with every conceivable type of range finding device, based on many principles not utilized today.

In 1881, telemeters or range finders were in the heyday of their development. Frantic experimentation was underway in every country in a search for an instrument that was adaptable to field use.

The types in use at this time and under experiment could be divided into three main classes: acoustic telemeters, stadials, and topographical telemeters.

Fig. 17. -- Nineteenth Century Plotting Rule - This rule dates back to the 2880's and was used in conjunction with an anemometer for fire control work.



Two types of acoustic telemeters (The Redier and LeBoulenge) were in sporadic use. These two instruments were developed in the 1870's by the French and Belgians respectively. The principle of the acoustic telemeter has been abandoned as the basis of a range finding instrument in the time since then, though it has been utilized in instruments of a different application and purpose.

Stadias determine distance by reference to the apparent height of an object, assuming the real height to be known. The principle instruments existing at the time in this class were the telescopic stadimeter conceived by Colonel Goulier, of the French Army, and the "Lunette Cornet", of a Piedmontese officer, Major Porro.

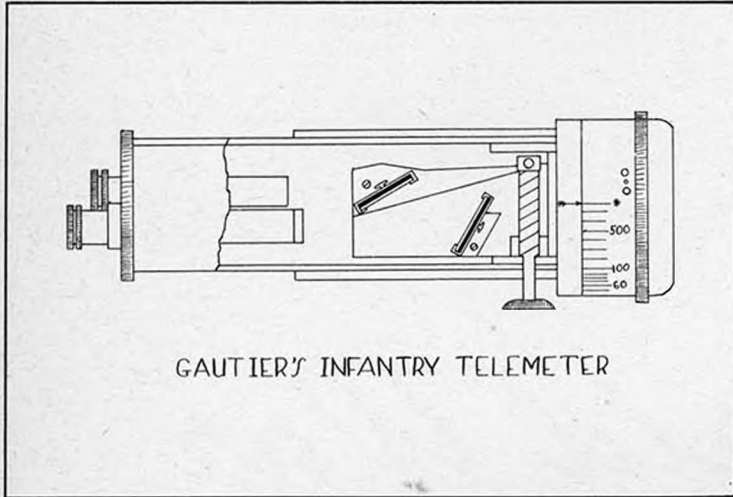


Fig. 18.

Topographical telemeters included a variety of two station range finding systems based on the triangulation principle of operation, and a few instruments tending toward the self-contained design.

Among the instruments in this group could be found several distinct types:

- (1) Those with fixed short bases, three types of which were in existence in the 1880's, all of American design.
- (2) Instruments of the theodolite type, the most notable being one invented by Major Nolan, R.A., U.S.
- (3) Range finders of the sextant type. The French Gautier telemeter was typical of the many instruments in this group and fairly accurate at short ranges only. This was its chief disadvantage.

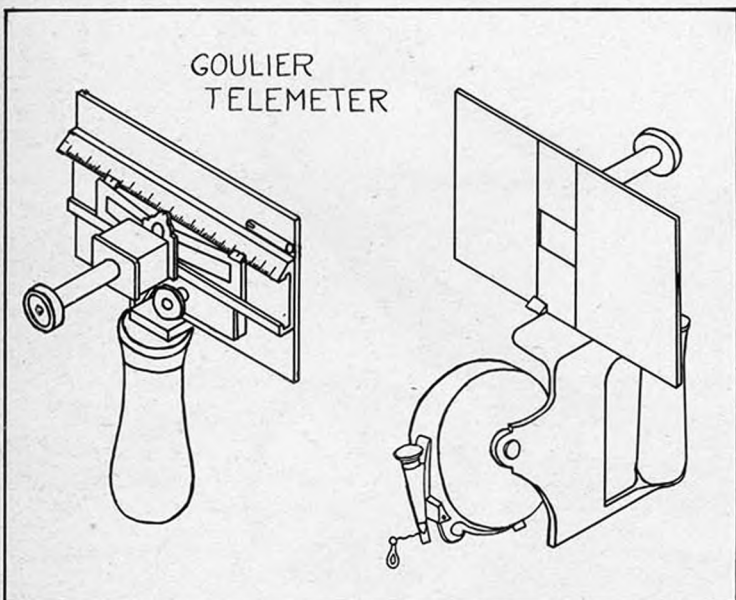


Fig. 19.

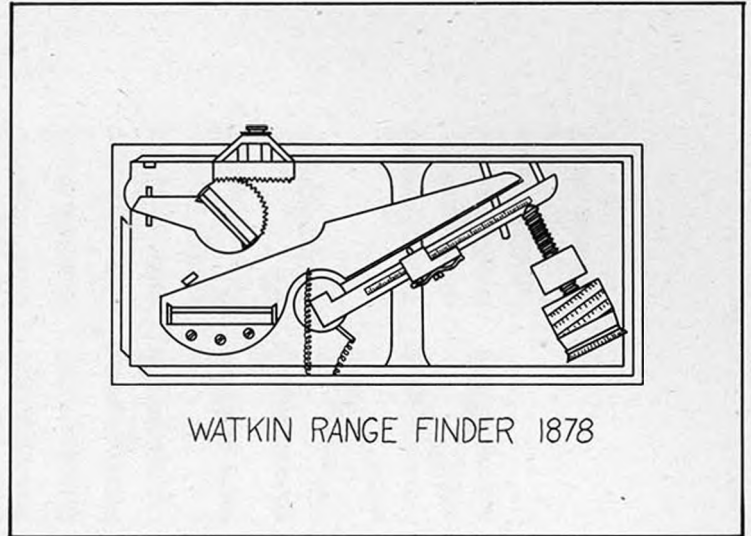


Fig. 20.

Other notable instruments of the period were the Watkin range finder, Weldon range finder, the Malta instrument, and the Bell Hydro-scope.

Position finders came into being about 1864. Major Watkin, of the American Army, conceived the Watkin Depression Position Finder in the 1880's. This instrument, excluding minor improvements in functioning, is almost identical with the similar instruments employed today.

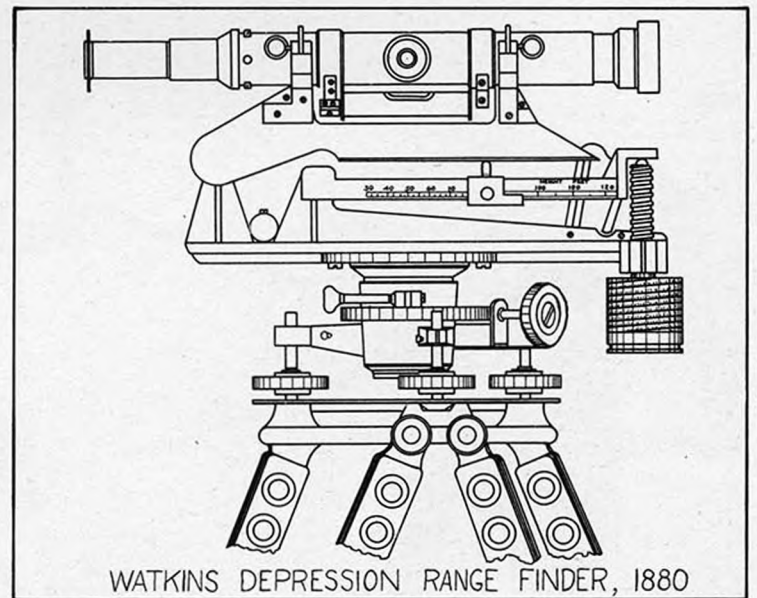


Fig. 21.

The biggest objections to all of these early range finding devices were (1) time required to complete measurement, (2) inherent errors of too great a magnitude for accurate gunnery, and (3) poor construction.

Eventually acoustic range finders and stadimetric instruments more or less faded from the scene as far as military use was concerned.

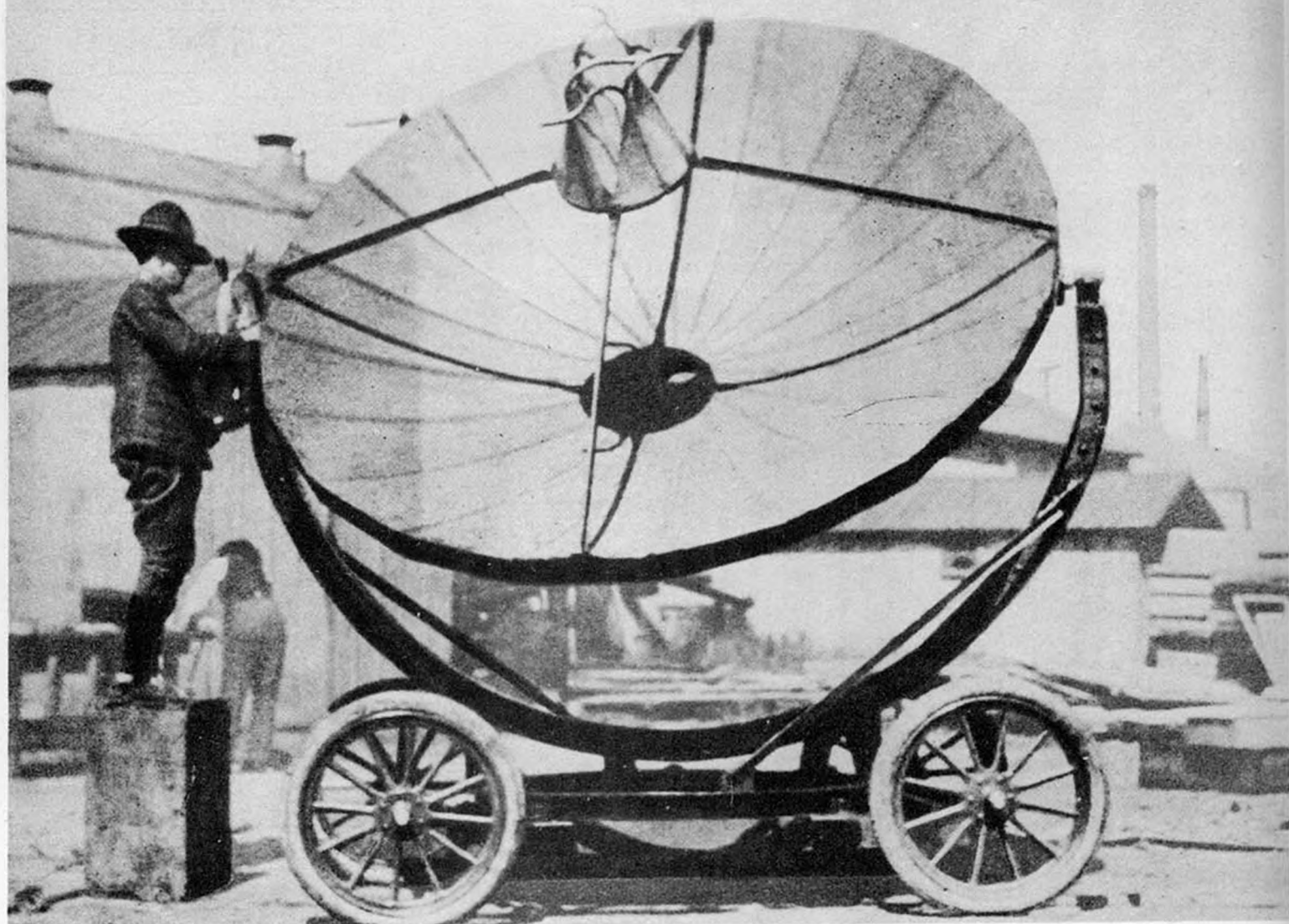
Self-contained, coincidence type range finders came into standard use at the opening of the twentieth century for field use. These instruments now exist in base lengths ranging from 70 centimeters to thirty-three feet. During the first world war the stereoscopic height finder and range finder were developed to meet the need for instruments which could track a rapidly moving aerial target. These instruments have been steadily improved since.

Of passing interest is a T-shaped stereoscopic range finder designed for submarine use by Zeiss. It consisted of a double vertical

(Continued on page 171)

FIRE CONTROL MATERIEL

*in the
First World War*



The Old Days of Firing Point Blank---Passed with the Civil War

(Extracted and condensed from the report of the Honorable Benedict Crowell, Assistant Secretary of War and Director of Munitions, 1917-1918) from "America's Munitions" - Government Printing Office, 1919.

At the threshold of the (First) War with Germany we were confronted with the problem of providing on a large scale those instruments of precision with which modern artillerists point their weapons. As mysterious to the average man as the sextant and other instruments which help the navigator to bring his ship unerringly to port over leagues of pathless water, or as those devices with which the surveyor strikes a level through a range of mountains, are the instruments which enable a gunner to drop a heavy projectile exactly on his target without seeing it at all.

The old days of sighting a cannon point blank at the visible enemy over the open sights on the barrel of the weapon passed with the Civil War. As the power of guns increased and their ranges lengthened, the artillerists began firing at objects actually below the horizon or hidden by intervening obstacles. These conditions necessarily brought in the method of mathematical aim which is known as indirect fire.

In the great war indirect firing was so perfected that within a few seconds after an observer had definitely located an enemy battery, that battery was deluged with an avalanche of high explosive shell and destroyed, even though the attacking gunners were several miles away and hills and forests intervened to obscure the target from view. With the aid of correlated maps in the possession of battery gunners and the aerial observer, a mere whisper of the wireless sufficed to turn a torrent of shell precisely upon the enemy position which had just been discovered. So accurate had indirect artillery fire become that a steel wall of missiles could be laid down a few yards ahead of a body of troops advancing on a broad front, and this wall could be kept moving steadily ahead of the soldiers at a walking pace with few accidents due to inaccurate control of the guns firing the barrage.

The chief difference between the old and new methods of artillery practice is the degree of precision attained. At the time of the Civil War the artillery was fired relatively blindly, reliance being placed upon the weight of the fire regardless of its accuracy and its effectiveness; but modern artillery has recognized the importance of the well placed shot and demands instruments that must be marvels of accuracy, since a slight error in aiming at modern ranges means a miss and the total loss of the shot.

Such uncanny accuracy is made possible by the use of those instruments of precision known as fire control apparatus. The gunner who is not equipped with proper fire control instruments and sighting equipment cannot aim correctly and is placed at a serious disadvantage in the presence of the enemy. These instruments must not only be accurate as a chronometer, but they must be sufficiently rugged to withstand the concussion of close artillery fire.

Types of Equipment Used

Equipment classified under "Sights and Fire-Control Apparatus" comprises all devices to direct the fire of offensive weapons and to observe the fire of these weapons in order to place it on the target. Included in this list are instruments of a surveying nature which serve to locate the relative position of the target on the field of battle and to determine its range. For this purpose the artillery officer uses aiming circles, azimuth instruments, battery commander's telescopes, prismatic compasses, plotting boards and other instruments. Telescopes and field glasses equipped with measuring scales in them are also employed in making observations.

Instruments of a second group are attached directly to the gun to train it both horizontally and vertically in the directions given by the battery commander. These devices include sights of different types, elevation quadrants, clinometers and other instruments. The intricate panoramic sight which is used especially in firing at an unseen target is

one of the most important instruments of this group.

Still another group of instruments comprises devices such as range deflection boards, deviation boards, and wind indicators which, together with range tables and other tables, assist the battery commander to ascertain the path of the projectile under any condition of range, altitude, air pressure, temperature and other physical influences. When it is understood that the projectile fired by such a weapon as the German long range gun which bombarded Paris at a distance of 70 miles mounts so high into the air that it passes into the highly rarified layers of the air envelope surrounding the earth and thus into entirely different conditions of air pressure, it can be realized how abstruse these range calculations are and how many factors must be taken into account. Fire control equipment enables the artilleryman to make these computations quickly.

In addition to the above items many auxiliary devices are needed by the artillery, notable among these being the self-luminous aiming posts, and other arrangements which enable gunners to maintain accuracy at night. This whole elaborate set of instruments is supplied to the field and railway artillery - the big guns - and in part to trench-mortar batteries and even to machine guns, which in the latter months of the (first world) war was used in indirect firing.

Still another group of pointing instruments is used by antiaircraft guns against hostile aircraft to ascertain their altitude, speed and future location in order that projectiles fired by AA guns may hit these high and rapidly moving targets. Sights are also used on the airplanes themselves to aid the crew in the dropping of bombs and in gunfire against enemy planes and targets. One of these sights corrects automatically for the speed and direction of the airplane.

Fuze setters which enable the gunner to time the fuze in the shell so that the projectile, moving with enormous speed explodes at precisely the desired point, were required in large numbers.

The responsibility for the design, procurement, production, inspection and supply of the above equipment to the American Expeditionary forces was lodged in the Ordnance Department. The effectiveness of the artillery on the field of battle depended directly on the efficiency of the fire control equipment furnished by this Department.

Production

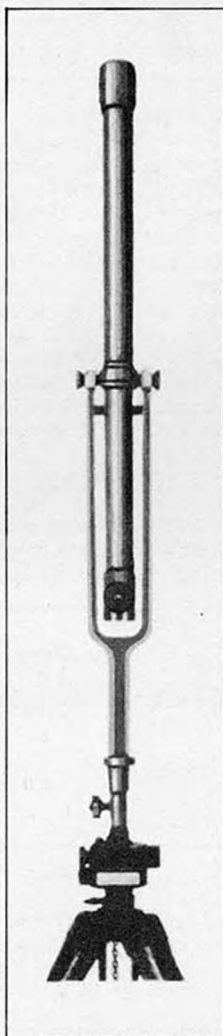
The optical industry in this country before the war was in the hands of a few firms; the workers were largely German, or of German origin; the kinds and designs of apparatus produced were essentially European in character; and the optical glass was procured entirely from abroad and chiefly from Germany.

It was easier and cheaper to order glass from abroad than to develop its manufacture in this country. Educational and research institutions obtained a large part of their optical equipment from Germany and duty free importation favored and encouraged this dependence on Germany for scientific apparatus.

With our entrance into the war European sources of supply were abruptly cut off and we were brought face to face with the problem of furnishing these items to the Army and Navy for use in the field. Prior to 1917 only three private manufacturers in the U. S. had built fire control apparatus in any quantity for the government. The only other source of supply in this country had been Frankford Arsenal.

Prior to 1917 the largest order for fire control equipment which our Army had ever placed in a single year amounted to \$1,202,000. The total orders for such instruments placed by the Ordnance Department alone during the 19 months of the war exceeded \$50,000,000.

To meet the situation, existing facilities had to be increased, new



Battery
Commander's
Periscope

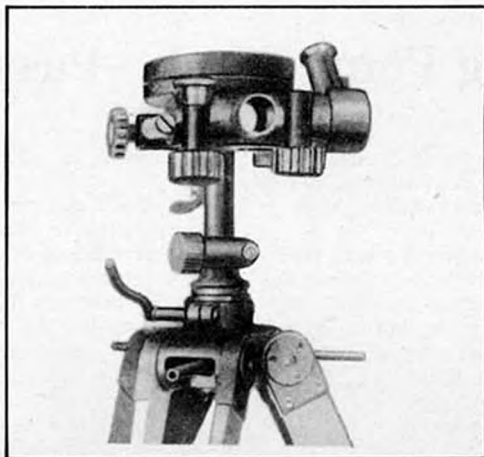
facilities developed, and other, allied, industries converted to the production of fire control equipment. Speed of production meant everything if our troops were to be equipped in such a manner as to meet the enemy on approximately equal terms.

Optical Glass

In April, 1917, the most serious problem in the situation was the manufacture of optical glass. Previously all optical glass used in America had been imported from abroad. The war stopped this source of supply abruptly and in 1915 experiments on the making of optical glass were under way at five different plants, including the Bureau of Standards.

By April, 1917, the situation had become acute; some optical glass of fair quality had been produced, but nowhere had its manufacture been placed on an assured basis. The processes were not adequately known. Without optical glass fire control instruments could not be produced; optical glass is a thing of high precision and in its manufacture accurate control is required throughout the factory processing. In this emergency the government appealed to the Geophysical Laboratory of the Carnegie Institute of Washington for assistance.

This laboratory had been engaged in the study of solutions, such as optical glass, at high temperatures, for many years and had a corps of scientists trained along the lines essential to the successful production of optical glass. A group of its scientists was placed at the Bausch and Lomb Optical Co., in April, 1917, and given virtual charge of the plant. By November the manufacturing processes at this plant had been

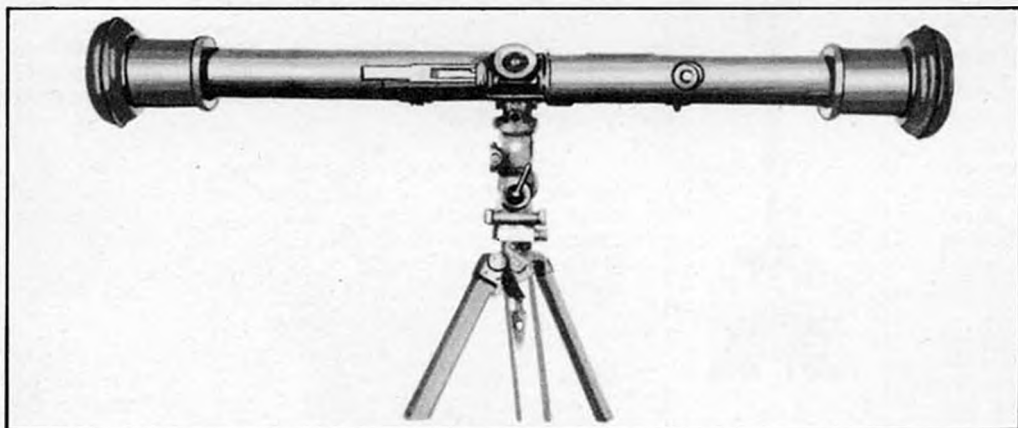


Aiming Circle

By February, 1918, the supply of optical glass was assured; but the manufacture of optical instruments was so seriously behind schedule that a military optical glass and instrument section was formed in the War Industries Board and took charge of the entire optical instrument industry of the country. Through the efforts of its chief, Mr. George E. Chatillon, of New York, the entire industry was coordinated. By September, 1918, the production of fire control instruments to meet the requirements of both the Army and Navy during 1919 was assured.

The Ordnance Job

To the accomplishment of this result the Ordnance Department contributed most effectively. The information and long experience



Range Finder

mastered, and large quantities of optical glass of excellent quality were being produced. In December, 1917, the work was extended and other companies were taken over in a similar manner.

An ordnance officer was in charge of the Rochester party from the Geophysical Laboratory, and was responsible for much of the pioneer development work done there. It was here that the methods of production were mastered and placed on a production basis.

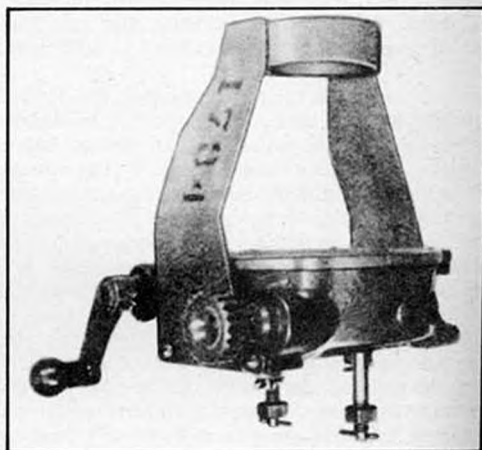
The Bureau of Standards aided in the development of a chemically and thermally resistant crucible in which to melt optical glass; also in the testing of the glass, and especially in the testing of optical instruments. The Geological Survey aided in locating sources of raw materials, such as sand, of adequate chemical purity.

of Frankford arsenal in this type of work was placed at the service of contractors; trained officers were stationed at different factories; and schools for operatives in precision optics were established at Frankford, at Rochester, and at Pasadena, Calif. The fire control program, in short, required all the available talent and resources of the country to carry it to a successful conclusion.

Production Difficulties

Because our Army had adopted a number of French guns for manufacture here, it became necessary to build sights for these weapons according to the French designs. This gave much trouble, not only because of the delay in securing samples and drawings, but because of the difficulty in producing articles from these French drawings by American methods.

The most intricate of these French sights was the Schneider quadrant sight. It was used with the French 155mm gun, the 155mm howitzer, and the 240mm howitzer. The structure was highly complicated, and extreme accuracy was required at every stage of production.

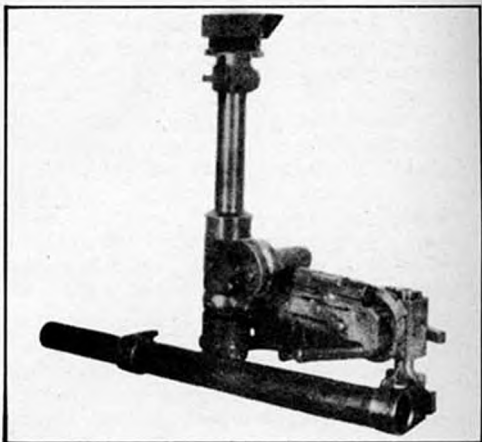


Bracket Fuze Setter
Model of 1916

The design of this sight was received from France early in 1918, yet it was the first of November, 10 days before the armistice, when the first of these sights was delivered. A total of 7000 sights had been ordered, which meant a year's work for 1000 men. On November 11 American factories had delivered 74 sights.

The amount of the labor involved in the Schneider quadrant sight is shown by the fact that while the raw material cost but \$25.00, the finished sight was worth about \$600.00. On November 11 the number of sights completed was short of requirements for installation on completed gun carriages by about 400 but the rate of progress which had been attained in production would have overtaken the output of gun carriages by January 1, 1919.

Another difficult task was the construction of telescopic sights for the French 37mm guns.



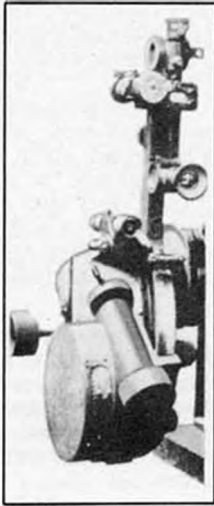
Sight for 75mm Field Gun

The same difficulty of adapting French plans was encountered. When the armistice was signed 884 guns had been produced but only 142 telescopic sights completed. Had the war lasted the shortage would have ceased to exist after January 1, 1919.

Periscopes from twenty inches to twenty feet in length were produced in quantity. These periscopes enabled the men in the trenches to

look over the top in comparative safety. The long periscopes were used in deep shelter trenches and bomb proofs. The production of the short base periscopes, battery commander's periscope, and the 3- and 6-meter periscope was progressing at such a rate that the need of the Army for 1919 would have been met on time.

The instruments manufactured are too numerous to enumerate at length. The manufacture of many types of instruments was undertaken. Among these the French sitogoniometer, a device which assists the battery commander in obtaining data for the correction of fire; quadrant sights; compasses; panoramic sights; azimuth instruments; plotting boards; telescopes; gunners quadrants; fuze setters; tripods, elevation quadrants; aiming circles; and innumerable others.

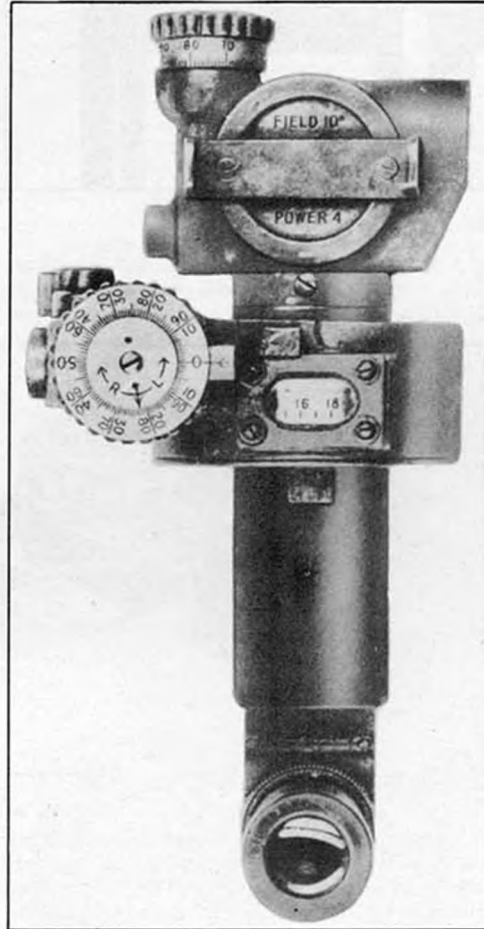


French Quadrant Sight
with American
Panoramic Sight

of our needs while our own industry was being developed.

Field Glasses

When the war began the Signal Corps had the duty of providing field glasses for all branches of the Army. The first estimate showed that these glasses would be needed by the tens of thousands, whereas the manufacturing facilities of the country had been turning them out by the hundreds.



Panoramic Sight

caused by final cooling and stirring. It must have a high transmission of light.

Existing factories expanded many times. The chief center of supply was Rochester, N.Y. where several optical companies were located. The output of one company, Bausch and Lomb, which had never manufactured more than 1800 pairs of field glasses in a year, was speeded up until in November, 1918, 3,500 pair a week were being produced, and 5,500 pair a week was the goal in sight. Many other companies were producing these observation instruments, also.

Out of a situation that seemed impossible at the outset, the Signal Corps built up an industry within a comparatively few months which provided all the field glasses that were necessary in the operations of the American Expeditionary Forces. Often, to keep the optical factories equipped with sufficient workmen, the Signal Corps obtained the furlough of drafted men with experience in this line so that they might go to work making field glasses.

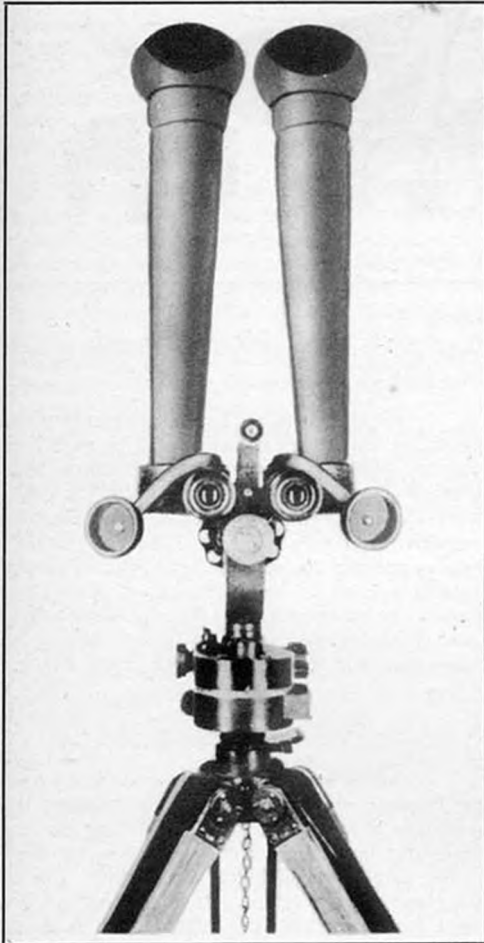
All organizations except artillery were supplied with a six-power glass having an angular field of view of 150 yards wide at 1000 yards. The glasses were of the prismatic type with individual focus for each eye. Each glass was provided with a leather carrying case and shoulder strap. On the top of the case a compass was mounted.

The artillery organizations were supplied with eight-power field glasses, all of which were purchased in France.

The total requirements of the American Expeditionary Forces for field glasses of the six-power type during the period of hostilities were approximately 100,000 pairs. The total shipments from America were approximately 106,000 pairs.

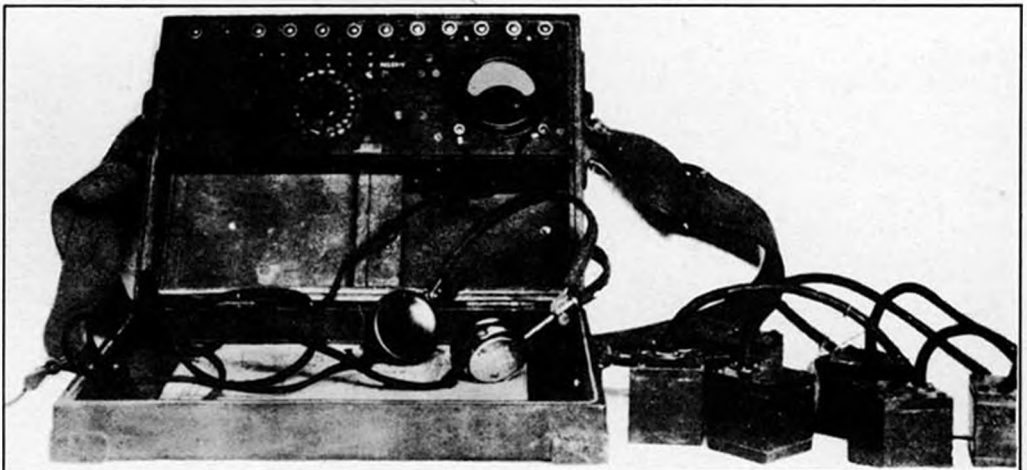
Listening Instruments

In childhood we were enthralled by tales of those magic persons whose keen hearing could detect even the whisper of growing grass. As camouflage developed, modern warfare yearned for such supernatural gifts of sense that troops might detect the unseen presence of the enemy. Accordingly, science, the fairly godmother of today's soldiers raised her wand, and lo, the Army was equipped with the wonderful ears of the fairy tale, uncanny no longer, but a concrete manufacturing proposition.

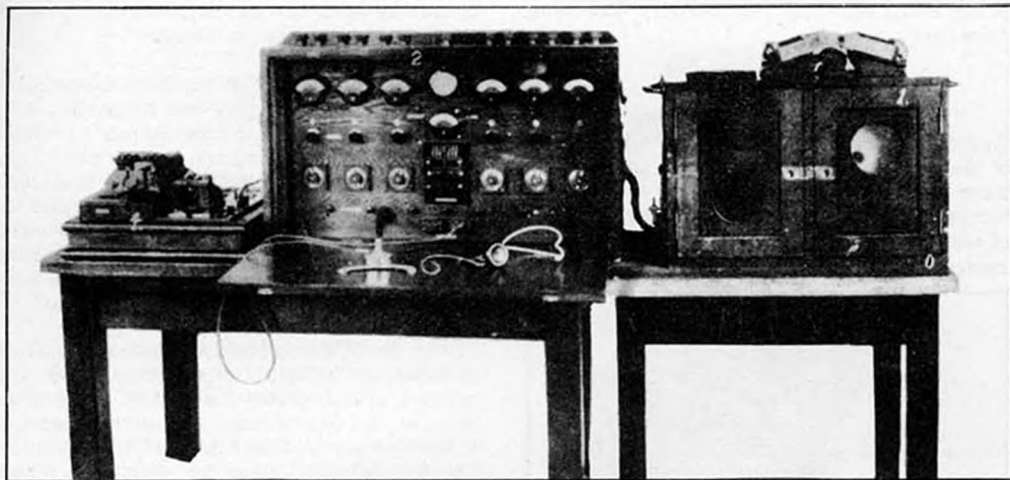


Battery Commander's
Telescope

At no time during the fighting did our artillery units have a sufficient supply of fire control instruments. This was due to the fact that we were not able to secure in Europe the amount of this equipment required to take care



Light Microphone Set



American T-M Surface Sound-Ranging Set

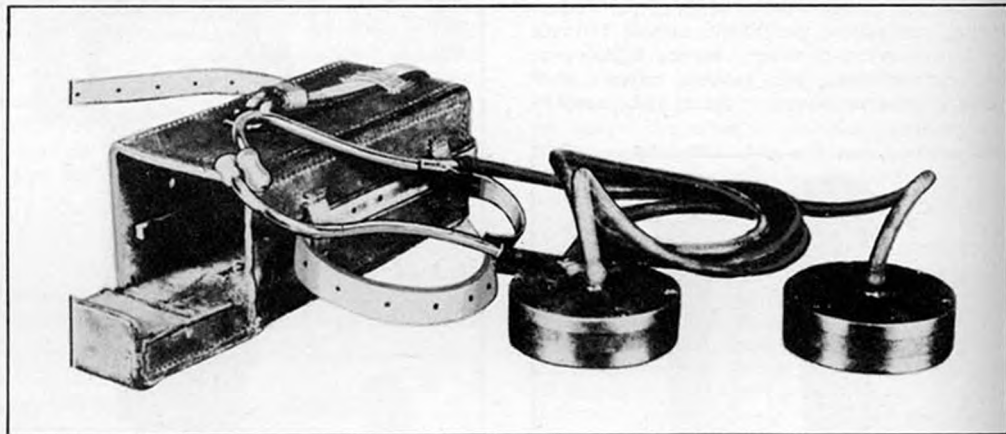
Camouflage had succeeded in baffling the camera and observation instruments to some extent and made necessary the development of instruments that could detect the enemy by sound. Since the unaided ear was not keen enough to supply the desired information, applied science came to the rescue with the various devices embraced in the general classification of sound-ranging equipment. The production of the equipment was under the direction of the Engineer Department of the Army.

In three classes of military work hearing was required refined to the razor edge. With keen enough ears, we could detect those subterranean operations of the enemy known as mining; we could detect the position of hostile artillery; and we could employ this sensitiveness of hearing on the darkest night to detect the approach of hostile aircraft.

The Geophone

One of these long distance ear drums invented by man was known as the "geophone". It was invented by the French, and was a simple mechanism. The device or drum which received the sound waves and magnified them consisted

of a small closed box with a confined air space. This box was weighted with a leaden disc to give it the required inertia. The geophone was



Geophone Sound-Ranging Set

placed upon the ground and the vibrations of the earth were communicated through the medium of the confined air space. The sounds then reached the listener's ears via a rubber tube

and an ordinary stethoscope horn. By means of this device the slightest vibrations of the ground are rendered audible.

The geophone was used to detect enemy mining operations. If the enemy were burrowing in the ground within 75 yards the geophone revealed the fact. In order to enable the listener to know from what direction the sounds came, two geophone boxes were provided, one connected with each ear. In this way the binaural sense indicated direction.

Geophones were used by both sides, and so effective did they prove to be, that they eliminated mining operations altogether. When an enemy mine was located by one of these devices a counter mine was started through at once, usually with disastrous results to the hostile forces.

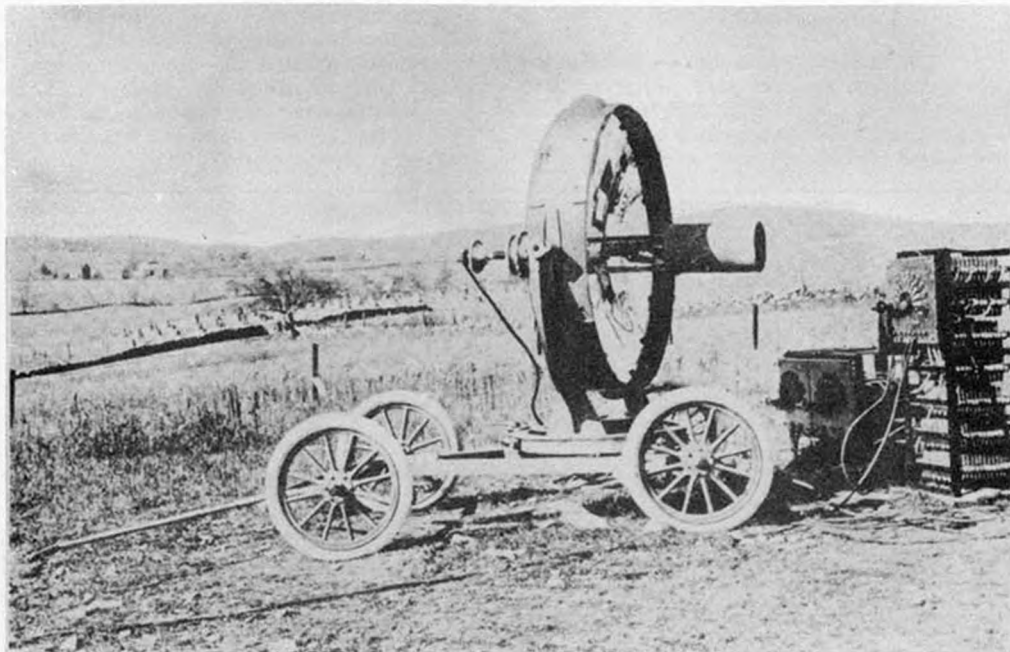
As our first step in the production of geophones we adopted the French device, but later developed an American instrument with nearly one third greater range. We produced the

improved model in sufficient quantities to meet all requirements.

We also developed an electromechanical geophone that could be connected by wire to a central listening station some distance back from an exposed location. The receiving boxes were hidden in No-Man's-Land. They were so sensitive that they not only recorded subterranean activity but at night would betray enemy raiding parties by the vibrations of their footsteps. The boxes could even pick up the conversation of enemy parties, even in low tones, the apparatus thus acting as the dictograph of war.

Sound Ranging Equipment

But by far the most important work done by listening instruments was in locating the positions of enemy gun batteries. This was one scientific instrument which the Germans were never able to produce for themselves. During the final months of the war more enemy guns were located by listening instruments than any other means. An American instrument, with the Army, spotted 117 German gun positions in a single day by surface sound ranging. This was the record high, but at all times our sound-detecting equipment had an uncanny accuracy. Up to the end of the fighting no way had been discovered to conceal the location of a gun from sound ranging instruments suitably placed and located.



60-inch Open Type Portable Searchlight

The instruments used for locating gun positions were of such a highly complicated and technical nature that no one but designers and mechanics skilled in the production of complex electrical equipment could build them at all. The recording instruments were of a sort so delicate that their use had never been considered outside of laboratories. Yet here they were required to operate successfully amid the din and concussion of heavy bombardment. All useless sounds and jars had to be filtered out so that only the sought-for vibrations arrived at the central listening station.

Studies of gunfire show that when a cannon fires an explosive shell of high velocity there are three distinct concussions. One of them is the sharp crack produced in the air when the shell, dragging a short vacuum trail behind it, passes over the head of the observer. As the air rushes into this vacuum and collides with itself it produces a crack that is similar to ordinary thunder. The second concussion is produced at the muzzle of the gun by the expanding gases that propel the shell. There is still a third, the break, or explosion. In order to locate a battery or gun only one of these concussions — the explosion at the muzzle of the gun — must be picked up by the microphone. The first and third shocks, and all other sounds, must be damped out and excluded.

A number of microphones would be placed in scattered positions, usually in a trench, and then connected with the central recording mechanism. When a microphone picked up a hostile gun position the disturbance was instantly transmitted through several miles of wire. An ingenious and complicated mechanism actuated an electromagnetic needle, which instantly recorded this disturbance on a tape of photographic paper, calibrated to show fifths of seconds in time. Each microphone on outpost duty was represented on this tape by a parallel line; and, as six microphones were usually used, the tape was striped with six lines. As the other microphones at the front picked up the concussion of the gun, their records were made on their respective lines; and the observers at the central station, by noting the differences in time between the reports of the various microphones and by making calculations based on the rate at which sound travels, could locate the gun that set up disturbances by means of ordinary triangulation. So accurately did this system work that the position was located to within 50 feet.

It is interesting to note that the practice of our Army was to secure in advance, by means of surface sound ranging, and other methods, the positions of all the enemy's guns that could be learned. Then, often after hours or even days, the fire began simultaneously upon all these gun positions just as our attack started.

Birth of the Sound Locator

The Engineering Department conducted extensive experiments in the development of aerial sound detectors, for use against hostile aircraft at night. One form developed consisted of a set of long horns with listening tubes attached to the small ends and leading to receivers on the observer's head set. These horns were mounted on a turntable which the observer could revolve, so that the horns could be turned in the general direction of the sound. Four horns were used in this mechanism — two to indicate the direction of the airplane in a horizontal circle (in azimuth) and the other pair to indicate the direction on the vertical arc (in elevation).

Under favorable conditions the sensitivity of this device was three times that of the unaided ear, and the plane could be located within an angle of 1°. The horn detector, however, was large and cumbersome and not satisfactory for a mobile unit.

For field sound ranging, the paraboloid sound reflector was developed. This hemispherical object, like a huge fountain basin in shape, was made of material similar to building board and shaped in parabolic lines. Such a sound collector echoed or reflected the sound from every point of its surface to a focal point where the listening instrument was located. They had a sensitivity three times that of the unaided ear and could locate sound within 3° of arc.

(Note: This type sound locator is shown on the title page of this article, page 108)

Flash Ranging Devices

Although valuable work in detecting gun positions was done by sound ranging, yet both sides located guns by watching their flashes. We improved the flash ranging sets of the allies. These were simple in principle. A number of

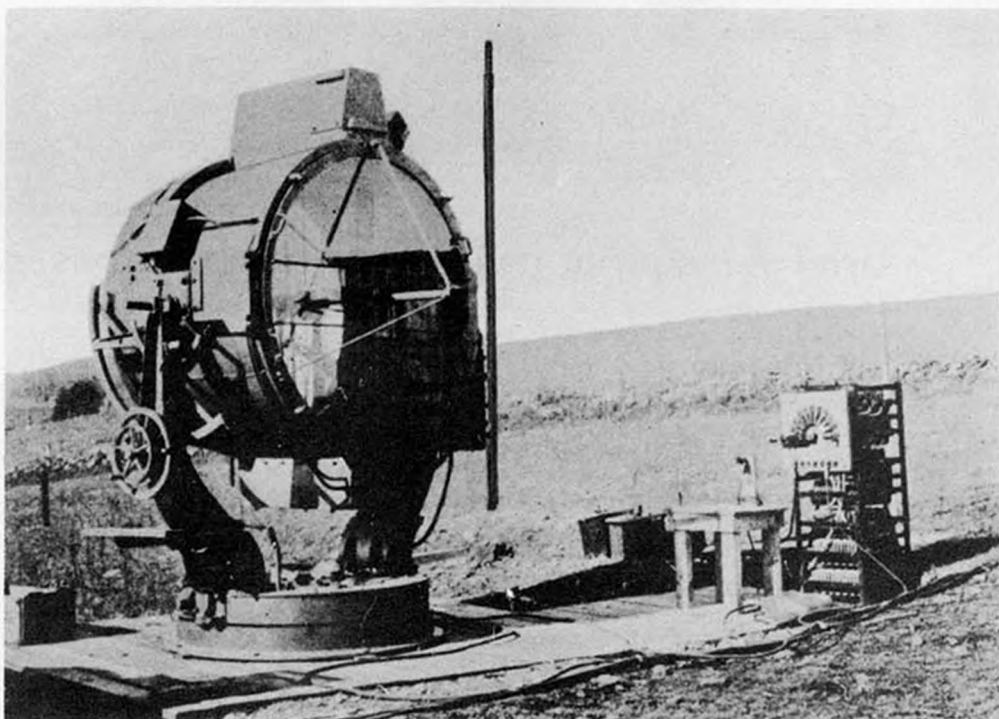
knew the observers at the front had probably caught the same flash.

When the fighting stopped our military scientists were developing a ground sound ranging apparatus which could be utilized to give troops advance warning of the approach of heavy artillery shells.

Preliminary experiments showed that at a distance of 4.1 miles this mechanism could record the firing of a gun some 19 seconds before the arrival of the shell. This elapsed time, under proper circumstances would enable troops properly warned to seek cover from the explosion of the projectile. This development was made possible by the far greater speed with which shock vibrations travel through a dense medium like the earth than through the usual sound conveying medium, the atmosphere.

Searchlights

The searchlight equipment of the Army prior to 1914 consisted chiefly of lights located at our coast defenses. In 1916 we began the development of mobile searchlight-and-power-



60-inch high-intensity Sea Coast type searchlight

observers at posts commanding good views were equipped with observation telescopes mounted on tripods to watch for flashes of enemy guns. Whenever two or more of them observed the same flash and reported its direction, the position of the gun could be determined by triangulation.

However, in operation, the system was not so simple, because of the fact that the observers reporting might not have observed the same flash. This difficulty was met by furnishing each operator an outpost switch set. As soon as he observed the flash he closed the switch and turned on a small electric light at headquarters station which might be miles away. Then, as soon as he could, he telephoned the direction of the flash observed. If the switchboard operators saw two or three lights flash simultaneously he

units for field army work, four horse-drawn equipments with 36-inch lights being ordered first, and later eight other sets with extensible towers and gasoline electric generators. In January, 1917, we ordered 50 high intensity lights to replace low intensity lamps at our seacoast fortifications. Later, twenty additional lights, of a 60-inch dimension were ordered.

After entry into the war anti-aircraft requirements accelerated needs. 360 high intensity searchlights, 693 high intensity arc mechanisms, and 1000 mirrors of standard design, were ordered.

Existing equipment was studied with a view to improvement. Eighteen different types of searchlights were tested, and either partially or wholly developed and put into production.

(Continued on page 172)

FRANKFORD ARSENAL

by

L. W. BOODY
Chief Clerk

AND

G. W. CAIN
Fire Control Design Section

Bridge Street Guard Building

Before the establishment of the arsenal there was located on the grounds now occupied by it a cantonment called Cantonment on Frankford Creek. The only obtainable record to bear out this statement is a list of Commissioned Officers stationed here from June, 1814.

The evolutions beginning the sham battle known as "Point-no-Point", which occurred June 22, 1808, took place on the ground where the arsenal is located, further showing that this particular tract was used for military purposes some years prior to the establishment of the arsenal.

The Frankford Arsenal was established under the general authority providing depots to be established in various parts of the country, as contained in Section 14 of the Act of Congress, February 8, 1815, viz:

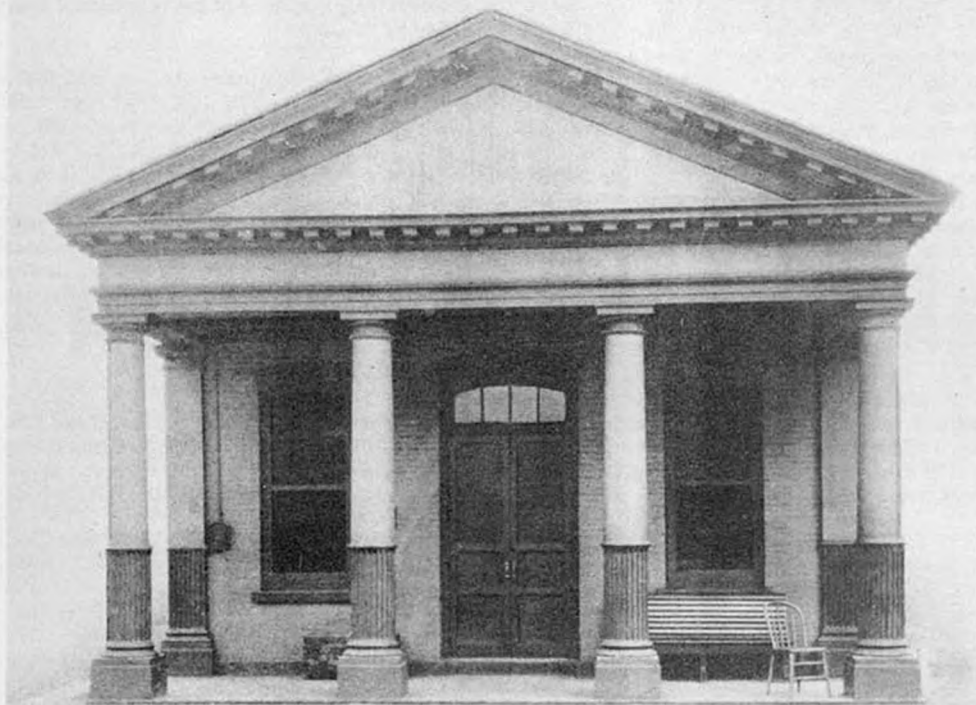
"That to insure system and uniformity in the different public armories, they are hereby placed under the direction of the Ordnance Department, and the Colonel of the Ordnance Department, under the direction of the Secretary of the Department of War, is hereby authorized to establish depots of arms, ammunition, and ordnance stores in such parts of the United States and in such number as may be deemed necessary"

Construction work at the Frankford Arsenal was begun in 1816, while a building, which is now a double set of officers' quarters and occupied by officers on the post, was constructed sometime before 1812. There is now in use as quarters a building completed by the Government in 1817, and one storehouse completed in 1817. President Madison presided at the laying of the cornerstone of this storehouse, and the affair was an event of considerable interest to the community.

The reasons as given by Lieut. Colonel Bomford, the then "Colonel of Ordnance", which originally led to the erection of Frankford Arsenal, were:

- "1. The superior facility and economy of water carriage:
- "2. The arrangement of the storehouses, magazines, laboratory and workshops such that in event of fire or explosion a part only would be damaged or destroyed:
- "3. The position being enclosed, the officer commanding can establish and support the necessary subordination."

Old records show the Frankford Creek to have been a navigable stream for seagoing vessels at that time, and an old woodcut of the arsenal shows it to have been enclosed by a high stockade. There is no record, however, to indicate that this stockade was constructed after the establishment of the arsenal, and it is probable, therefore, that it enclosed the historic establishment, the Cantonment on Frankford Creek.



A Brief Account of its Growth and Functions

The territory on which the Frankford Arsenal reservation is situated is a portion of a tract of land which was transferred by patent from John Penn, Thomas Penn and Richard Penn to Andrew Hamilton on May 19, 1742, at a price of one shilling, sterling, for each one hundred acres. As the reservation contains about ninety-two acres, its cost was a little less than a shilling.

Thomas Penn was a younger son of William Penn, and John and Richard Penn were grandsons of the elder Penn.

As a passing remark it may be of interest to state that for more than sixty-five years past there have been Penns employed at the arsenal who claim to be direct descendants of these old proprietors of Pennsylvania who bore that name.

Arrowheads and other Indian relics have been found in the vicinity of Frankford Creek, which is one of the boundaries of the reservation showing that Indians had a camp on this site. Here they lived as late as 1775 and inspired such names as "Tacony", "Wissinoming", "Tacawana", "Wingohocking", etc., which have been given to the streets and sections of Philadelphia in the vicinity of the arsenal.

The location of Frankford Arsenal was originally described as Exford Township, Philadelphia County, Pennsylvania. Subsequently, this location became known as Bridesburg, County of Philadelphia, Pennsylvania.

In 1811, an Act of Assembly was passed giving to Joseph Kirkbride authority to erect a bridge over Frankford Creek at Bridge Street. Kirkbride built the bridge and maintained it for many years until it was purchased by the county of Philadelphia. Prior to building the bridge, Kirkbride, from whom the borough of Bridesburg, formerly Kirkbridesburg, derived its name, had maintained a ferry at that point for several years.

The first Commanding Officer of the establishment as an arsenal was Captain Joseph H. Rees, Ordnance Department, who took command in 1816. An interesting event associated with the early history of the arsenal was the visit to the arsenal by Lafayette, who remained overnight there on September 26, 1824, enroute from Trenton to Philadelphia.

In 1850, the borough of Frankford was incorporated in the city of Philadelphia, so that from that date the correct description of the location of Frankford Arsenal is Frankford, Bridesburg Station, City of Philadelphia.

In connection with the Acts of Legislature of the State of Pennsylvania, consenting to the purchase by the United States of different portions of land comprising the Arsenal Reservation, it may be interesting to note that there is a provision in such acts reading as follows:

"That the Commonwealth may reoccupy and repossess the same as they had occupied and possessed the same heretofore whenever the United States of America shall cease to occupy the same for military purposes as a fort, magazine, arsenal, or with other needful buildings for the same."

The development of construction work of the arsenal may be divided into periods as governed by the acquisition of additional tracks of land. The first or original tract of land, bought in 1816, comprised approximately twenty acres, and on this tract within a few years after its purchase there were constructed several buildings, nearly all of which are still standing and in good condition.

Concerning these buildings it may be interesting to note that the Commanding Officer's Quarters were completed in 1823, and have been occupied as Commanding Officer's Quarters ever since that date.

Officers' Quarters, Nos. 2 and 3 were constructed prior to 1812, and were used as quarters for the Commanding Officer until 1823, when the building now used for that purpose was completed. Additions were made to the rear of this building about 1888, and it has been used as a double set of quarters since that time.

Officers' Quarters No. 4 were built in 1820 and used as a storehouse and then as a barracks until 1870 when an addition was made to it, along with other alterations, so as to adapt it for use as officers' quarters.

Officers' Quarters No. 5 were erected about 1820 for use as a commissary office; these quarters were later converted into a storehouse, and in 1902, into a set of officers' quarters.

Officers' Quarters No. 6 were completed in 1817 and were used as a mess hall, bake-house and kitchen, then as quarters for non-commissioned officers, and finally changed into quarters for a commissioned officer in 1909.

The building known as the West Storehouse was built in 1817, and is stone rough cast and pointed. This is the building at which President Madison officiated in the laying of the cornerstone. It is still occupied as a storehouse and is in excellent condition.

A carriage and storehouse building was built in 1820 and consists of brick piers or columns one story high originally filled in between with double doors, but now boarded up except at two entrances. It was originally used as a storehouse or gun shed for artillery, afterwards used as a storehouse, and now as a garage.

A barracks building constructed in 1817, stood on this tract of land, but was demolished some years ago by reason of the construction on the reservation of a more adequate barracks building in 1870. A magazine was constructed in 1819, and these buildings together with certain frame buildings used for stables, etc., completed practically all of the construction work at the arsenal until 1835, when a three-story and basement stone building, known as the East Storehouse, was completed and put in service.

In 1837 an additional tract of approximately three acres of land was bought, but no construction work of any importance followed this purchase. In 1849, however, a tract of approximately thirty-nine acres was acquired, and it would appear by an extract from a report of the Ordnance Board, made on March 6, 1847, that it was purchased with the purpose in view of enlarging the arsenal establishment. This extract reads as follows:

"In view of the peculiar nature of the manufacture of percussion caps for small-arms, the danger attending some parts

of the process, and the importance of having the means of making caps in large quantities and of undoubted quality, the board recommended that a separate establishment for the purpose be made at one of the minor arsenals, and they consider Frankford Arsenal to be the most eligible place for this establishment, as offering the greatest facilities for procuring materials and apparatus. They therefore recommend that a suitable site be procured adjoining the present arsenal grounds, as their present extent does not furnish a proper and safe location for the buildings."

In 1850, half of the former Administration Building was constructed, and in 1852 there were several comparatively small frame and brick buildings constructed and used in the manufacture of small arms ammunition, etc. Some of these buildings are still standing, but there was only one real substantial building built at this time. That was a nitre storehouse, as it was decided by the War Department to use the Frankford Arsenal as a storage place of nitre for war-time use, and a suitable building was required for that purpose.

From 1860 to 1865 many of the large manufacturing buildings at the arsenal were constructed, and included the present small arms cartridge factory, ammunition storehouses, blacksmith shop, tin shop, machine shop, magazine, hospital, etc.

The machine shop has been used for various purposes since its erection; first as a machine shop, then as a small arms ammunition factory, shrapnel shop, stock building, storehouse, printing shop, and at the present time houses the museum, library and photograph gallery.

From 1865 to 1895 there were very few new buildings constructed and, with the exception of the present barracks buildings, now the design section annex, proof house and detonating fuze shop, the construction work during this period was confined to wooden buildings and some additions to the regular shop buildings.

From 1882 to 1900 all illuminating gas for the Arsenal was supplied by a petroleum plant, which was abandoned and taken down in 1900, and in 1901 the present Instrument Department building was erected on the site. During that year the small arms annealing and draw press shop was constructed, and in 1902 a power plant was built which replaced three previously in existence. A large shrapnel shop was constructed in 1903, and a carpenter shop, which still occupies its original quarters in 1904. A fuze shop was completed in 1910, and an artillery ammunition assembling shop in 1912, and these buildings together with the foregoing, include the principal structures up to 1916.

While a number of large buildings have been erected since 1916, nearly all of the manufacturing operations at the arsenal are carried on in the old buildings which were erected prior to that date, but the new storehouses which were erected in recent years are all used practically to capacity.

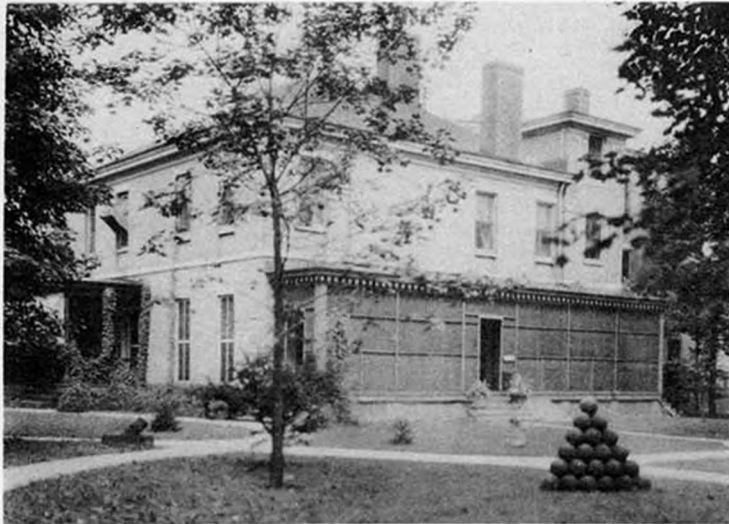
In 1916 a tract of land along the eastern boundary of the arsenal reservation was purchased, and this additional space permitted the construction thereon of a more practical proof house and a small arms firing range, as well as storehouses, dry houses, and magazines for taking care of materiel which previously had been without doubt kept too close to the manufacturing shops.

This additional ground also permitted the construction of large artillery ammunition buildings, i.e., forge, shell and case shops, which were needed during the World War.

In 1904 the instrument department was located in a single building with the exception of work in relation to plotting boards which was done elsewhere. This arrangement continued until 1911 when the instrument department was moved into the building it now occupies. The optical shop moved to the second floor of this building at the same time.

During the World War the demands on the instrument department increased to such an extent that more room was again required for its expansion. Building #112, which was the artillery case shop, was changed into a three story building and turned over to the instrument department in 1918. Building #45, also turned over to the instrument department at this time, was used to house the optical shop and for work in relation to plotting boards. The optical shop remained here from 1918 until the present time. In August of this year, however, the optical shop will occupy the new air conditioned quarters now being provided for it.

As has been stated previously, Frankford Arsenal, before its establishment as a Government Arsenal, was used by the Government as



Quarters No. 2 and 3, erected prior to 1812

a cantonment. The first officer in charge as shown by the records, was 1st Lieut. James Baker, who, it appears, was assigned in June, 1814 and was on duty as the Officer in Charge until August, 1816, but the first Commanding Officer of the institution as an arsenal was Captain Joseph R. Rees.

The following is a roster of the Commanding Officers of the Frankford Arsenal, with their ranks and the dates of their incumbency:

Name	Rank	From	To
James Baker	1st Lieut.	June 1814	Aug. 1816
Joseph H. Rees	Captain	Aug. 1816	Feb. 1821
Martin Thomas, Jr.	3rd Lieut.	Feb. 1821	Sept. 1824
Thomas J. Baird	1st Lieut.	Sept. 1824	Nov. 1827
E. M. Eakin	1st. Lieut.	Nov. 1827	Apr. 1828
Chas. Mellon	1st. Lieut.	Apr. 1828	Dec. 1830
J. B. Walbach	Major	Dec. 1830	Oct. 1832
W. J. Worth	Major	Oct. 1832	Jan. 1835
A. Mordecai	Captain	Jan. 1835	Oct. 1838
Geo. D. Ramsay	Captain	Oct. 1838	July 1845
H. K. Craig	Major	July 1845	Oct. 1845
A. H. Dearborn	2nd Lieut.	Oct. 1845	Mar. 1848
L. A. B. Walbach	1st Lieut.	Mar. 1848	Oct. 1848
G. D. Ramsay	Major	Oct. 1848	Sept. 1851
P. V. Hagner	Major	Sept. 1851	July 1860
J. Gorgas	Captain	July 1860	Mar. 1861
W. Maynardier	Captain	Apr. 1861	Mar. 1862
T. T. Laidley	Major	Mar. 1862	Aug. 1864
S. V. Benet	Captain	Aug. 1864	Oct. 1869
Thos. J. Treadwell	Major	Oct. 1869	May 1876
J. M. Whittemore	Major	May 1876	June 1880
S. C. Lyford	Major	June 1880	May 1885
S. Crispin	Colonel	June 1885	May 1886
D. W. Flagler	Lt. Col.	June 1886	Nov. 1889
T. G. Baylor	Colonel	Nov. 1889	Sept. 1890
Geo. W. McKee	Major	Oct. 1890	Nov. 1891
J. P. Farley	Lt. Col.	Feb. 1892	Mar. 1897
J. M. Whittemore	Colonel	Mar. 1897	Mar. 1900
Frank Heath	Major	Mar. 1900	June 1908
George Montgomery	Colonel	Aug. 1909	Mar. 1918
Samuel Hof	Colonel	Mar. 1918	Mar. 1919
Wallace L. Clay	Lt. Col.	Mar. 1919	Sept. 1919
William A. Phillips	Colonel	Sept. 1919	June 1921
Townsend Whelen	Major	June 1921	Dec. 1921
Odus C. Horney	Colonel	Dec. 1921	Dec. 1926
William P. Wilson	Major	Dec. 1926	June 1927
George C. Wall	Colonel	June 1927	June 1928
J. E. Munroe	Colonel	June 1928	Aug. 1934
Edwin D. Bricker	Colonel	Aug. 1934	Nov. 1939
W. P. Boatwright	General	Dec. 1939	July 1942
J. B. Rose	Colonel	July 1942	Date

Throughout the entire history of the arsenal it does not appear that the work of the establishment has been interfered with except in 1844, when it was necessary to suspend operations on account of riots in the city of Philadelphia and in the neighborhood of the arsenal. The suspension of work occurred after the Anti-Catholic rioters had burned St. Michael's and St. Augustine's churches, in May, 1844, and it was necessary first for the then commanding officer to call in a detachment of artillery, and later an entire company of artillery to defend the arsenal. The following is a copy of the first letter written by the Commanding Officer in connection with the matter:

Frankford Arsenal, May 11, 1844

Sir:

"I deem it proper to advise you that thus far the arsenal has not been molested. Lt. Blair with a detachment of Cap. Dranes Company consisting of 1 Sergt., 1 Corpl., and 12 men came to my assistance on the requisition of the sheriff on the evening of the 9th inst., and are now on duty here. Martial Law prevails in Philadelphia and large bodies of troops from the adjoining counties have been placed under the orders of Gen. Patterson. The morning papers induce the



West Storehouse, constructed 1817

hope that the supremacy of the law will be maintained. Since Monday I have been constantly prepared for attack. Although quiet may for the present be restored, it will, I fear, be a long time before the calamitous events of the week are forgotten, and under the circumstances a constant guard should be maintained at this arsenal. Indeed for some time past we have been annoyed by riotous parties from the city, and our heretofore quiet neighborhood has become one of much disorder. As my small force will not admit of a constant guard I have to request authority to hire a sufficient force, some eight or ten men, unless you prefer having a detachment of regular troops quartered at the arsenal."

(signed) Geo. D. Ramsay

Capt. of Ord. Comdg.

Col. Geo. Talcott
Ordnance Department

The manufacturing, design and other functions of the arsenal have expanded as has the building and construction program. As the various departments of the arsenal expanded and new departments were created, additional buildings and space necessarily had to be provided. Since this building and construction program has already been given, the expansion of the departments and the functions of the arsenal throughout the years from their conception to the present time will follow.

From 1816 until the War with Mexico the work at the arsenal consisted of repair work interspersed with certain manufacturing of such a nature as to show clearly that Frankford Arsenal has always been a manufacturing establishment rather than a collection of repair shops or storehouses. Ordnance materiel which this generation never heard of, but with which their grandfathers, if soldiers, would probably be thoroughly familiar, was manufactured there during that period. For instance, the archives show production of such articles as flint caps, grape shot, 12-pounder strapped shot, junk wads, quick matches, eprouvette beds, sabots, vent punches, bombazette cartridges, paper cups for 6-pounders, eprouvette balls, etc. Old letters still on file indicate that at an early date the Frankford Arsenal acquired a reputation for good workmanship and superiority of product — a reputation which it has ever since strived to maintain.

In the early "fifties" the capacity and variety of the products of the arsenal increased, and included 12-pounder wads, flannel cartridge bags, muskets changed from flint to percussion, screws for cavalry musketoons, Maynard's primers, tangent scales for howitzers, trunnion rules, instruments for inspecting cannon projectiles, vent gages, star gages, ring gages, gravimeters, pendulum hausses, elongated balls for musketoons,

musketoon cartridges, caliber .69; elongated ball cartridges, caliber .58; balls for Maynard carbine, Burnside's metallic cartridge cases and balls for same, etc.

These articles are mentioned particularly as indicating the period when the arsenal was being moulded into an establishment for the manufacture of small arms ammunition and instruments of precision. During this period a cap machine was manufactured at the Arsenal, shown at the exhibition of the Franklin Institute in Philadelphia, and was pronounced the best in the world.

From 1861 to 1865, during the War for Southern Independence, the operations at the arsenal assumed formidable proportions and its manufactures accentuated the value of its previous tendency toward a small arms ammunition and instrument factory.

In those days the products of its small arms ammunition shops were chiefly balls and ball cartridges, caliber .69; Maynard's ball cartridges, caliber .58; Burnside's metallic carbine ball cartridges, caliber .54; rifle musket ball, caliber .57; round ball, musket, caliber .71;



Commanding Officer's Quarters, constructed 1823

Sharp's carbine cartridges, caliber .54; Navy pistol cartridges, caliber .38; rifle musket cartridges, caliber .574; paper fuzes, percussion caps for muskets and pistols, etc.

The instrument shops at this time were producing front sights for field guns, gunners quadrants, searchers, search rings and staffs, fuze drifts, star gages, cylinder gages, trunnion squares, vent gages, callipers, drifts, etc. The records on file covering this period, while laying no stress on workmanship, show that the material was needed and that the Frankford Arsenal met the occasion by producing it promptly and in quantity.

After the close of the Civil War, the work at the arsenal for a year or two consisted chiefly of the manufacture of the Morse, Burnside, Maynard and rimfire cartridges, and cartridges for Gatling gun, caliber 1 inch. In the latter part of 1866, it was evident that the rim-fire cartridge would be superseded by the center-fire, and considerable attention was given to the production of a reliable center-fire cartridge.

Draw presses, then considered special machinery, were introduced for the manufacture of cartridge cases for the caliber .50 service ammunition. About this time also the change was made in the material of the anvil and the cap or primer, substituting copper for tin.

From 1867 until 1874 the work of the small arms ammunition shops at the arsenal was confined to the manufacture of service ammunition, caliber .50, and tools necessary in its fabrication, caliber .44 Smith & Wesson pistol cartridges; Martin Cartridges, Colt and Remington pistol cartridges, caliber .44; Remington carbine, caliber .50, for the Navy; primers, Drake's patent fuze, time and concussion fuzes, friction primers, etc.

In 1874 the caliber .45 service ammunition was adopted and its

manufacture carried on in such proportions as to meet the needs of the Service, and continued up until about 1896. During this time considerable attention was paid to the manufacture of primers, and various quantities of cannon percussion primers, etc., were produced. In the instrument department there were being manufactured laboratory apparatus, machines, brass breech sights, breech sights for the Hotchkiss mountain gun, Zalinski gun sight and elevating device, interpolator for pointing mortars, front and rear sight for various calibers of converted rifles, rear sight seats, gages, and instruments of precision, inspection and verification, for use in Government shops throughout the country.

The manufacture of caliber .30 cartridges was started as early as 1894 and in 1898 there was a daily production of this ammunition of 8,000 rounds together with caliber .45 rifle ball cartridges, caliber .45 carbine ball cartridges, caliber .30 blank and dummy cartridges and caliber .38 revolver ball cartridges. In the instrument department there were being manufactured tangent sights for 3.2-inch, 5-inch, 7-inch, 10-inch, and 12-inch guns, pointing arcs, gunners quadrants, gages of various descriptions, verniers, etc. About this time the artillery ammunition department of the arsenal began to turn out canister for the 3.2-inch rifle, shrapnel for the 3.2-inch rifle and cartridges for the 1.65-inch Hotchkiss gun.

The arsenal had now developed three distinct departments, i.e., Small Arms Ammunition, Instrument, and Artillery Ammunition Departments, and the output of all these was greatly increased during the Spanish-American War, all working at least two shifts.

Fire control instruments as well as instruments of precision kept the instrument department busy. Included in its manufactures then were



Old Museum and Library Building, erected 1869

observation telescopes, plotting boards, range boards, wind component indicators, predictors, range finders, battery commanders telescopes and rulers, testing levels, panoramic sights, etc. The artillery ammunition department was making 3.2, 3.6, 4.7, 5, and 7-inch shrapnel and 2.95-inch canister for the Vickers-Maxim gun, and the small arms department was turning out considerable quantities of the caliber .30 rifle ammunition and caliber .38 and .45 revolver ammunition.

Optical work of the instrument department developed about 1908 through the repair of telescopes, and the optical shop started in the basement of the present museum and library building. The first objective computed by the optical shop took place in 1909. The first instruments made were the telescopic sight, M1904; telescopic sight, M1906; and some panoramic sights.

Manufacture of these articles and many others, together with those of an experimental nature, was continued up until 1914, and this period (from the close of the Spanish-American War) was quite important in that the arsenal was educated to manufacture many articles of ordnance on a production basis, and a personnel was trained which became exceedingly valuable, not only to the arsenal, but to the country's commercial manufacturers, in furnishing materiel for the World War.

It would require more space than is allotted this article to recite the Frankford Arsenal's activities during the World War. Suffice to say that during the period from April, 1917 to November, 1918, it expended over forty millions of dollars in its manufactures.



Fire Control Design Department Annex, Frankford Arsenal

After the World War, which, besides accentuating the importance of preparedness, developed the possibilities of the airplane, radio, and gas, the activities of the arsenal materially changed. A retrenchment from a war-time production basis was necessarily effected until the arsenal operated with scarcely more than a skeleton crew up to a few years ago. The various departments of the arsenal, however, kept progressing and the transition was mainly from a quantity and quality production basis to essentially a quality production basis.

The artillery ammunition department, since the World War, has run the gamut in its variety of work; cleaning and slushing shell forgings for storage, making wind shields, fuze covers and shell for the Navy Department, manufacturing shell and shrapnel for experimental purposes, and has engaged in the making of parts for the Chelsea mechanical time fuze. This fuze, along with others subsequently manufactured, requires very accurate workmanship in the manufacture of the component parts, but the same mechanic accustomed in the past to turn a six-inch shell forging has adapted himself to do this work.

The publicity given the extraordinary caliber .30 rifle ammunition manufactured in the small arms ammunition department at Frankford and fired in the 1925 Palma Matches only records a result achieved, but few outside of the arsenal management and its employees can appreciate the inventive genius and mechanical ingenuity exercised in producing this cartridge with its boat-tailed, gilding metal bullet, improved primer and tested and retested case.

After the World War a .50 caliber machine gun cartridge was developed, and armor-piercing bullet with its tungsten steel core was perfected, and tracer ammunition was made to function in a reliable manner. In the small arms ammunition department also there have been broken up many millions of rounds of deteriorated ammunition made during the World War. The component parts were separated; the bullets, cases, clips and powder were sold as scrap; and not only thousands but hundreds of thousands of dollars were turned into the Treasury as a result of this salvage operation. When this work began to come into the arsenal by the barge-load, one of the employees conceived an idea for a machine costing but a few dollars to put together, whereby the work could be done cheaply. The machine functioned perfectly. The clips of five cartridges were fed into it as rapidly as hands could pick them up with the result that the clips would fall into one bin, the cases into another, the bullets by themselves, and the powder would flow into a receptacle some distance away through a chute or hose. A much greater return was made to the Treasury than was anticipated and the arsenal still has in its employ desirable, experienced, interchangeable and versatile employees who can operate a draw press, load or inspect; or, in fact, do many of the operations incident to the manufacture of small arms ammunition.

The instrument department carried the functions of the gage department until a gage checking and storage department was set up and made a part of the establishment. The first star gages for checking rifle

barrels were designed here, although, this function is now a part of another arsenal. Here millions of dollars worth of gages are checked, verified, and stored in such a manner that they are available for immediate issue to any commercial establishment with which contracts for certain ordnance material might be placed.

The mechanics and optical engineers of the instrument department have turned out quantities of radio transformers, receivers, etc., for the Signal Corps, U. S. A., various instruments for use in connection with aircraft, and remodeled and improved instruments of precision, levels, scales, and sights for various purposes.

Due credit should be accorded the mechanics engaged upon this work, which must be of the finest nature, as it takes more than an ordinary machinist or toolmaker to fit new parts to such articles as, for instance, certain optical instruments, wrist and stop watches, etc.

In 1910 all drafting for the artillery, instrument, and small arms department was conducted in one room. The drafting personnel was divided into three groups, one for each department, and that for the instrument department consisted of four men. Subsequently, the drafting personnel increased as the departments expanded until now each department operates separately.

Fire control design work, originally carried on by a small force working in conjunction with the instrument department, was started in the early 1900's. Soon after the World War, the Fire Control Design Department, the only one of its kind in the Army Ordnance Department, was established at the Arsenal; its purpose being the design and supervision of manufacture and test of models of various fire control instruments and equipment, including those required for aircraft, mobile and seacoast defenses. The nucleus of personnel about which this new department was established was brought to the arsenal from Washington, D. C. by Col. H. R. Rutherford, Ordnance Department. It is interesting to note that several of the original members of this personnel are still in the employ of the fire control design department of the arsenal at the present time.

This department carried on its work with a relatively small organization, until the start of the present conflict in 1939. Because of the nature of its functions, this department immediately assumed a place of

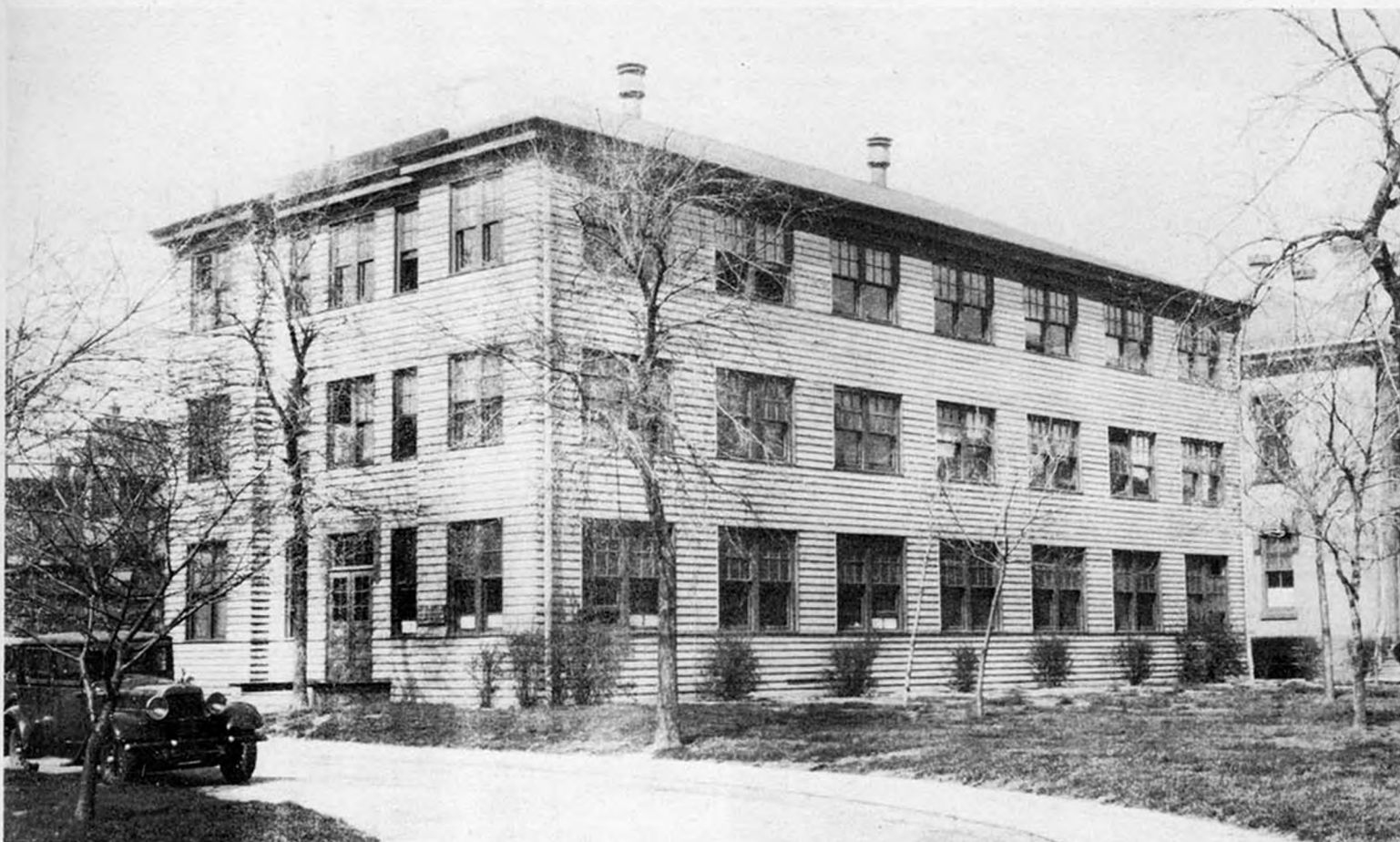
vital importance in the Ordnance Department. To handle the various responsibilities assigned to it, the personnel was increased several times over (at present there are over two hundred sixty employees), and the department expanded until it occupied a new building completed for it in 1940 and the major portions of two additional buildings. It is now responsible for the design and development of fire control equipment for all weapons used by the Ground Forces and the fire control for Air Force weapons larger than 37mm in caliber.

At the present time the department functions under the commanding officer of the arsenal and is administered by a department officer in charge who is assisted by eight other officers. These officers see that the department is kept informed of all developments related to the fire control field, correlate information received from the using services, check on the relative merits of preliminary designs, and approve all designs before quantity production begins.

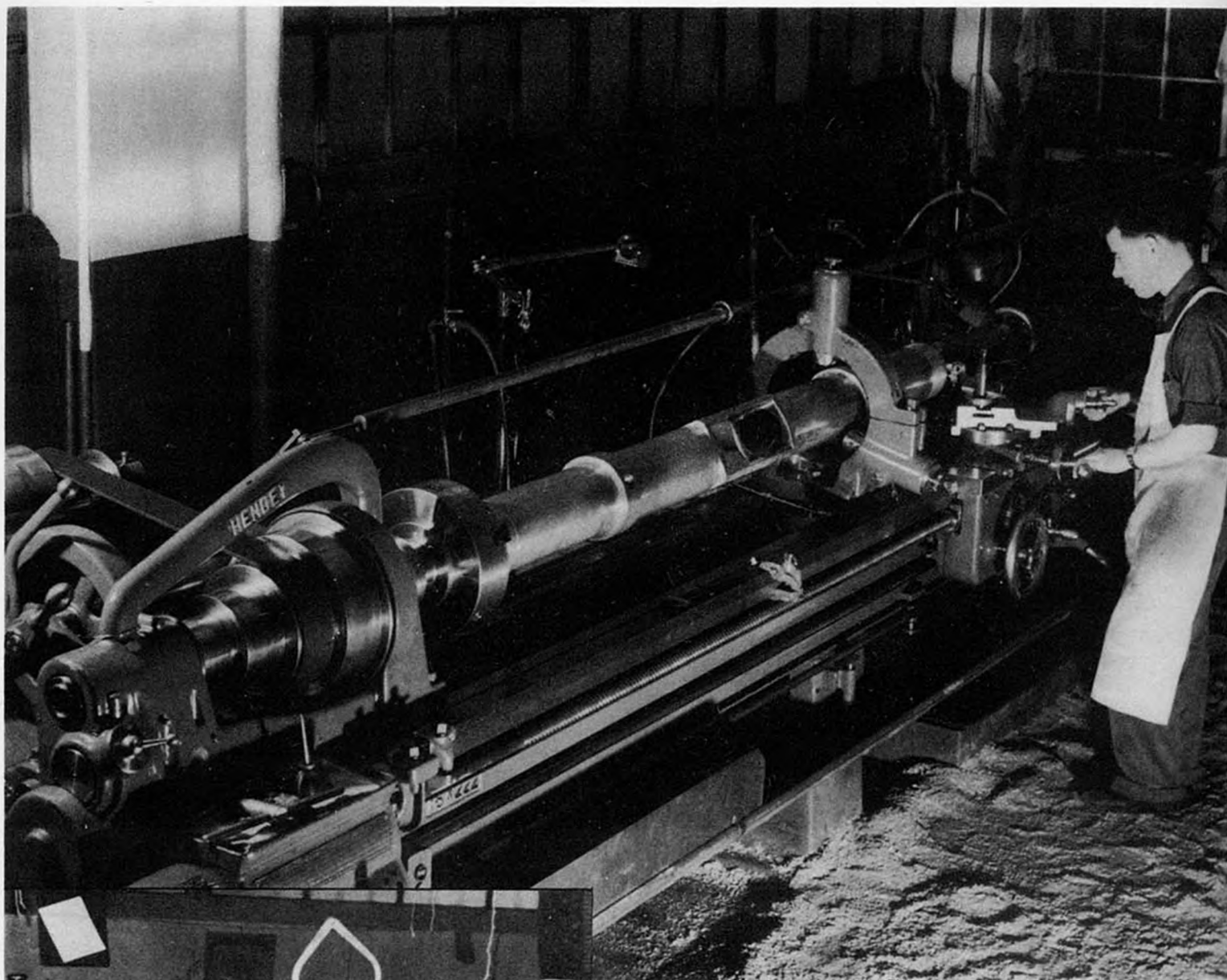
In this time of war the Frankford Arsenal, on a full production basis, can furnish but a small percentage of the required quantity of the particular ordnance material which it has been called upon to develop and manufacture. Quantity and quality are now the two principal factors to be met by the commercial establishments that are called upon to furnish the bulk of such material. These two factors, and more particularly that of quality, depend to a considerable extent upon the arsenal.

To construct a building it is first necessary to prepare the plans: the foundry-man requires a mold before the metal is poured; the shoe-maker uses a last for shaping the shoe; the automobile manufacturer needs patterns for each component part; the machinist must have a blueprint to guide him, and a druggist prepares from a formula the medicine to cure our ills. There are but few things that do not require a pattern before they can be produced.

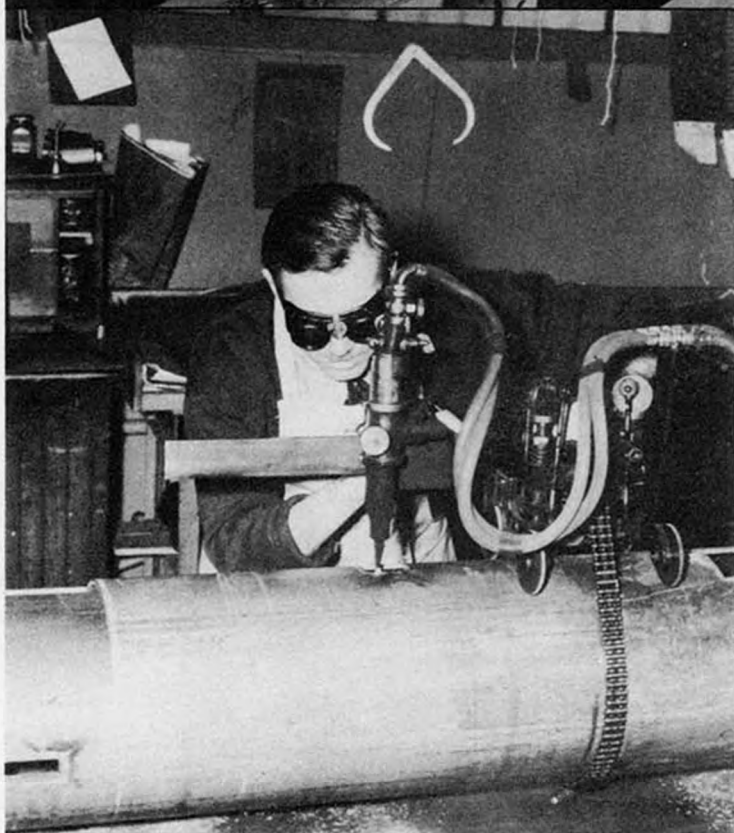
The Frankford Arsenal is the Government's institution for making and furnishing for the manufacture of certain articles of ordnance the patterns, designs, prints, formulas, or whatever may be seen fit to call the definite guides which our hundreds of commercial establishments must have to produce these articles of Ordnance material correctly in the present emergency.



Office Annex, Frankford Arsenal



Above: Machining optical tubes in which most of the elements are mounted requires special lathes. Left, Oxyacetylene torches save time in cutting from sixty to ninety openings in each Range Finder Tube.



Speaking of range finders on the new battleship North Carolina, Fulton Lewis, ace Mutual commentator, said in his broadcast of April 8th:

"Most important of all is the so-called fire control apparatus, the one great secret of the effectiveness of any fighting ship. The fire control equipment on this new U.S.S. North Carolina is the finest and most accurate that the world has ever produced. That of the German Navy is generally given second place — British types, a close third."

He might have added that the biggest of the Range Finders in the North Carolina, as with other modern American fighting ships, were made by Bausch and Lomb.

From the standpoint of size, complexity, workmanship, precision, and performance these are unquestionably the most remarkable instruments that optical science has produced. As details, it is interesting that a Range Finder may consist of 1500 mechanical parts; that there are almost 100 lenses, prisms, and other optical parts before cementing and assembling; that it takes half as long to build a Range Finder as a battleship.

First cousin to the range finder is the Height Finder and equally valuable. With this instrument the elevation of antiaircraft fire is controlled and accurate height determined for the timing of shell bursts.



Above: Range Finders are filled with compressed gas and immersed in water to reveal leaks. Below at left: Skilled hands prepare a Range Finder

tube for subsequent precise fitting of working parts. Below at right: Cast bronze shims are soldered on every opening for mounting mechanical and optical parts.



Both range finders and height finders employ the simple geometric principle that ... given the side of a triangle and two adjacent angles, all other dimensions may be determined. The length of the Range Finder is the base of the triangle, the target its apex. Imaging the target properly gives direct reading of its distance.

Range Finders must be able to "take it" and suffer no loss of precision under the shock of thundering salvos. Hence, a Vibration Machine (on a 192-ton concrete base) subjects them to final tests, duplicating the terrific shocks of actual warfare and propeller vibrations.



(Text and photos by courtesy of the Bausch and Lomb Optical Co.)

The FIRE CONTROL SECTION of THE ORDNANCE SCHOOL

Introduction

Until November, 1940, the Fire Control Section of The Ordnance School was in its infancy; set up primarily to inform noncommissioned officer's classes as to the general function of anti-aircraft fire control materiel and to instruct enlisted specialists in the field maintenance of fire control instruments other than anti-aircraft.

Prior to this time instruction on the actual maintenance of anti-aircraft fire control instruments was carried out by the commercial firms which manufactured the instruments. The load in each class that could be handled by these firms was sufficient for the field needs of that time.

At this time the instruction staff of the section consisted of approximately eight enlisted men. Classes were kept small for efficient instruction and instruction was as thorough as available facilities permitted.

The sudden expansion of the Army in 1940; the increase in fire control equipment of all types; the need for trained maintenance men for field units and as cadre personnel for newly activated organizations; and then the subsequent declaration of war; all necessitated a drastic revision of existing training schedules, which resulted in an unprecedented expansion of facilities, personnel, and instruction.

Expansion

In November, 1940, the Director School, which had been conducted by Sperry Gyroscope Co., of New York City and the Height Finder School, which was being conducted by the Kueffel and Esser Co., of New Jersey were moved to Aberdeen Proving Ground, Maryland, and instruction was



ANTI-AIRCRAFT FIRE CONTROL BUILDING

This building is being used only temporarily until the completion of a new permanent building.

taken over by The Fire Control Section of The Ordnance School. The number of students in other courses increased threefold.

The instrument repair course for enlisted specialists was changed from nine months to three months, and emphasis was placed on specialization.

The instructing staff expanded rapidly to keep abreast of changing requirements. Student output climbed from an average of ten per month, to twenty, thirty, sixty, a hundred, and is still increasing. The AA section climbed from three enlisted instructors to 15 officers and twenty-five enlisted men. The instrument repair section jumped from five enlisted instructors to four officers and 40 enlisted men. Both of these figures will probably be outdated before this article sees print.

by *L. F. Thayer*
CAPTAIN, ORD. DEPT.

Organization

The fire control instrument division of The Ordnance School is divided, for administrative purposes, into two technical sections; the anti-aircraft section and the instrument repair section. A section headquarters contains the necessary supply and clerical personnel for efficient administration. Each of these two main subdivisions is again subdivided into specific instruction units in such a manner as to simplify instruction to the utmost and take maximum advantage of available staff personnel, tools, and other facilities. The entire section is in charge of Capt. R. L. Johnson, Ord. Dept., who is section head and chief instructor. Behind the section are all the vast facilities of The Ordnance School, of which it is an integral part.

At the present time the Fire Control Section occupies temporarily three separate buildings, which will soon be insufficient to meet space requirements. This situation was wisely anticipated by the present Commandant, Col. G. W. Outland, some time ago, and a new, permanent fire control building is now midway to completion. When ready it will house the entire section and should be ready for occupancy early this fall. This building will be exclusively fire control, will be air conditioned, and has been specially designed to meet the individual problems and requirements of the Fire Control Section.

Scope of Instruction

Very few members of the military service realize the tremendous scope of the instruction involved in the training of fire control and instrument personnel.

The theory and principles incorporated in the design of AA fire control materiel include electricity, internal combustion engines, mathematics, optics, acoustics, electronics, hydraulics, and many others. For AA specialization an educational background of physics and mathematics to include trigonometry is essential. Practical mechanical experience of a precision nature will be found of exceeding value, also.

Instrument repair includes optical theory, machine shop practice, and an ability to analyze and improvise under field conditions. Students for instrument repair should be of above average intelligence, skilled precision workers, and have a general high school background to include some elementary optical theory. Mechanical experience of any type, but especially that of a precision nature will be found of value.

The instruction presented for all courses is as thorough as time permits. In general, all instruction includes theory, use and operation, inspection, disassembly and assembly, maintenance, repair and adjustment, and painting, cleaning and sealing. Adequate and appropriate texts are furnished all students and every effort is taken to encourage spare



INSTRUMENT REPAIR

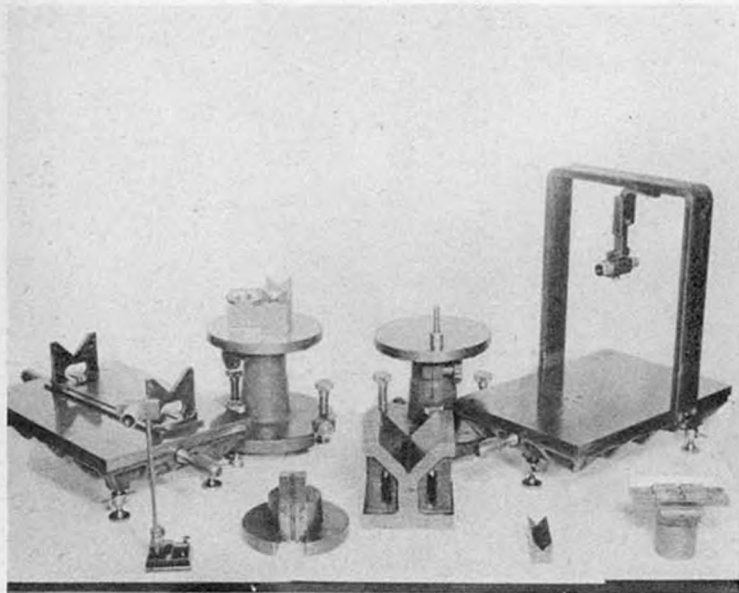
Class performing disassembly and assembly.

time study. In keeping with this objective facilities are made available for this purpose.

Students

At the present time the Fire Control Section is training four distinct types of students. These include officers, officer candidates, enlisted specialists, and selected civilians in the employ of the Ordnance Department.

Courses have been designed to meet the particular requirements of each classification, and vary in duration, ranging from four weeks to three months. Officers and officer candidates are instructed with the realization that they will soon be acting in a supervisory position as a shop officer or in some similar capacity. Specialists, who will be required to perform actual field maintenance operations, are given every opportunity to acquire the practical skill which only experience can give. Civilians are specialized in keeping with the requirements of their jobs. All instruction is thorough, detailed, accomplished with small groups, and emphasis is obtained by repetition, review and extensive use of visual aids and reference texts.



JIGS AND FIXTURES

Only a few of the jigs and fixtures required for instrument repair work. Students are familiarized with all of them.



INSTRUMENT REPAIR

Enlisted specialists receiving instruction on the Type EE Field Glass

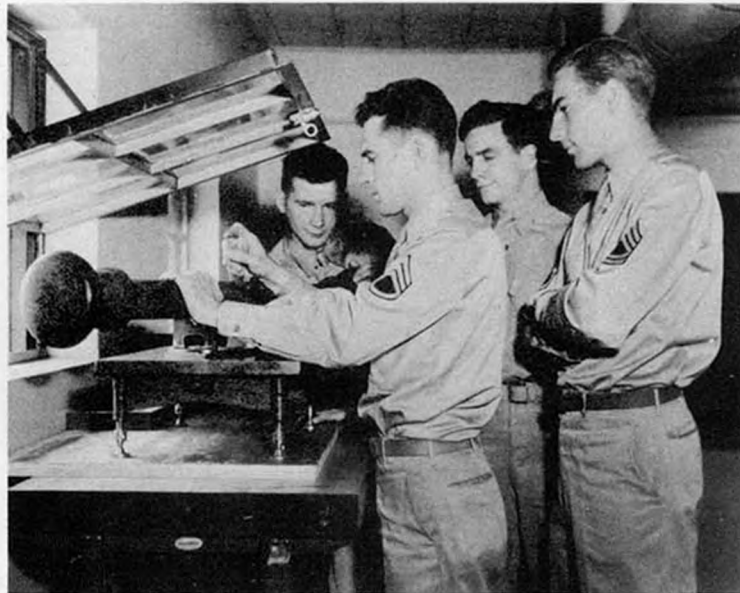
The need for qualified and experienced fire control personnel, both AA and general, has necessitated specialization to a certain extent, in all courses. This allows a maximum of instruction on any particular phase of the subject covered, and, while individual efficiency may be more limited, it is in no way reduced.

Courses

The following are the courses available at the present time at the Fire Control Section of the Ordnance School. For convenience they are classified as AA or Instrument Repair. The code designations are the official course numbers. Each of the courses listed below is a comprehensive treatment of the subject matter indicated, with the emphasis, and greater amount of time, devoted to the problems of field maintenance.

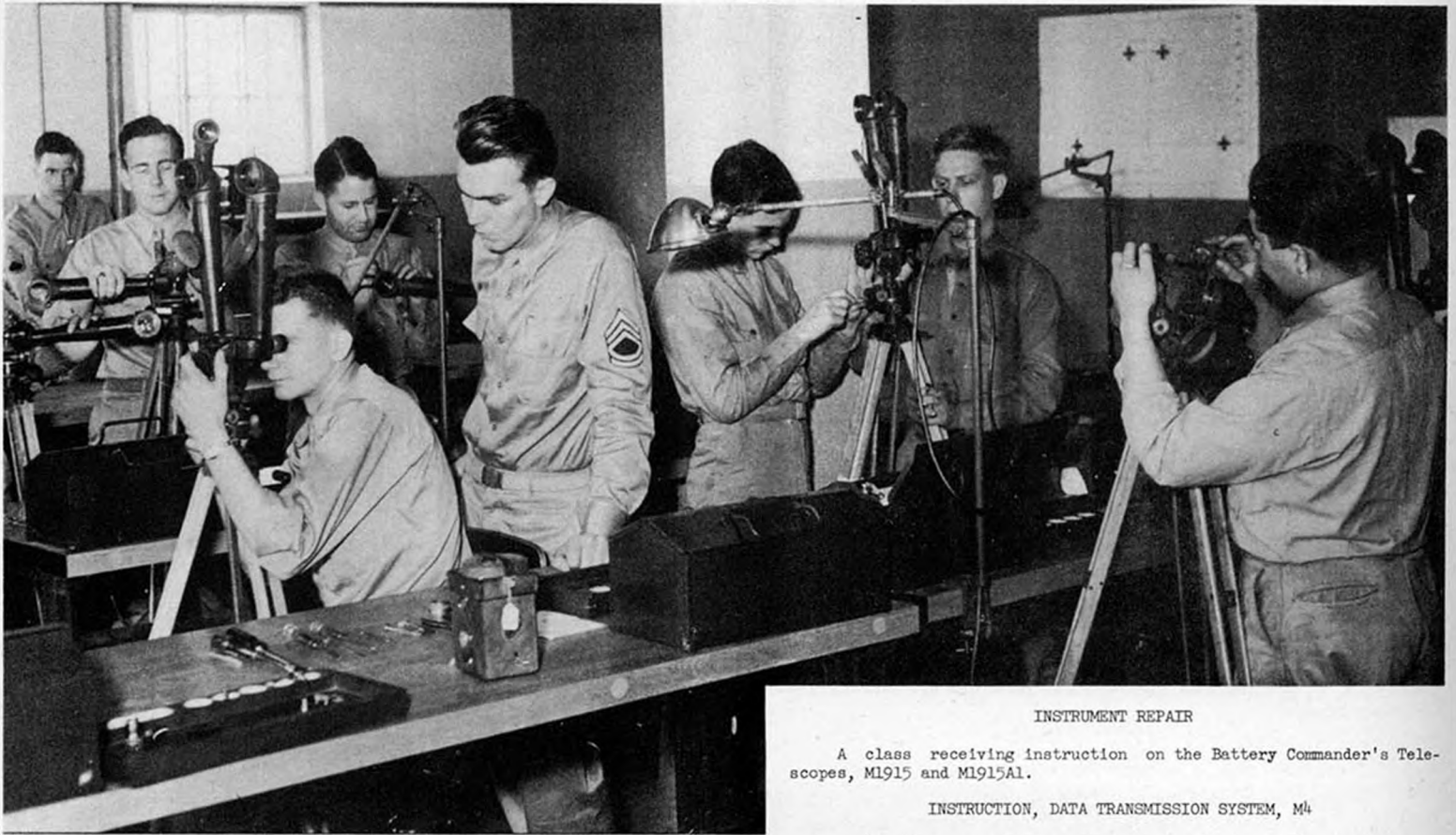
Antiaircraft Courses

- AAFC-110 A six-week course for enlisted specialists on the Directors, M4 and M7.
 AAFC-210 A four-week course for enlisted specialists on the Directors, M5 and M6.



RANGE FINDER CLASS

Demonstration, by instructors, facilitates and simplifies comprehension by students.



INSTRUMENT REPAIR

A class receiving instruction on the Battery Commander's Telescopes, M1915 and M1915A1.

INSTRUCTION, DATA TRANSMISSION SYSTEM, M4

Instruction on the Data Transmission System, M4, includes the theory of electricity, the generating unit, cable system, and on-carriage components.



- AAFC-310 An eight-week course for enlisted men on the Remote Control System, M2 and Cable Systems, M1 and M2.
- AAFC-410 A four-week course on the Data Transmission System, M4 and M6 and Generating Units M4, M5 and M7. For enlisted men.
- AAFC-510 A four-week course for enlisted men on the Remote Control Systems, M1 and M5.
- AAFC-610 A four-week course for enlisted men on the Height Finder, M1.
- AAFCCO (Light) A four-week specialized course for officer candidates on light AA equipment to include Directors M5 and M6, and the Remote Control Systems, M1 and M5.
- AAFCCO (Heavy) A four-week course for officer candidates on heavy AA equipment to include Directors, M4 and M7, Remote Control System, M2, Height Finder, M1, and the Data Transmission, M4.
- AAFC160 An eight-week course for officer specialists which is the same as the heavy AA course for officer candidates. More extensive in coverage and twice as long.
- AAFC260 A four-week course for officer specialists on light AA equipment which is the same as the course for officer candidates on this same materiel.

Instrument Repair

- IR Specialist A comprehensive three-month course for instrument repairman covering all the instruments encountered in infantry, cavalry, and field artillery units.
- IR100 An eight-week specialized course for enlisted specialists.

ANTI-AIRCRAFT FIRE CONTROL PERMANENT BUILDING

This building, shown here in the process of construction, will house the complete Fire Control Section of The Ordnance School when completed.

- IR200 An eight-week course for enlisted specialists. This course is complementary to IR 100. The two together are a more comprehensive coverage of the old three-month course.
- IROC A four-week course for officer candidates specializing in general fire control.
- IR160 An eight-week course for officers specializing in general fire control and instrument repair.

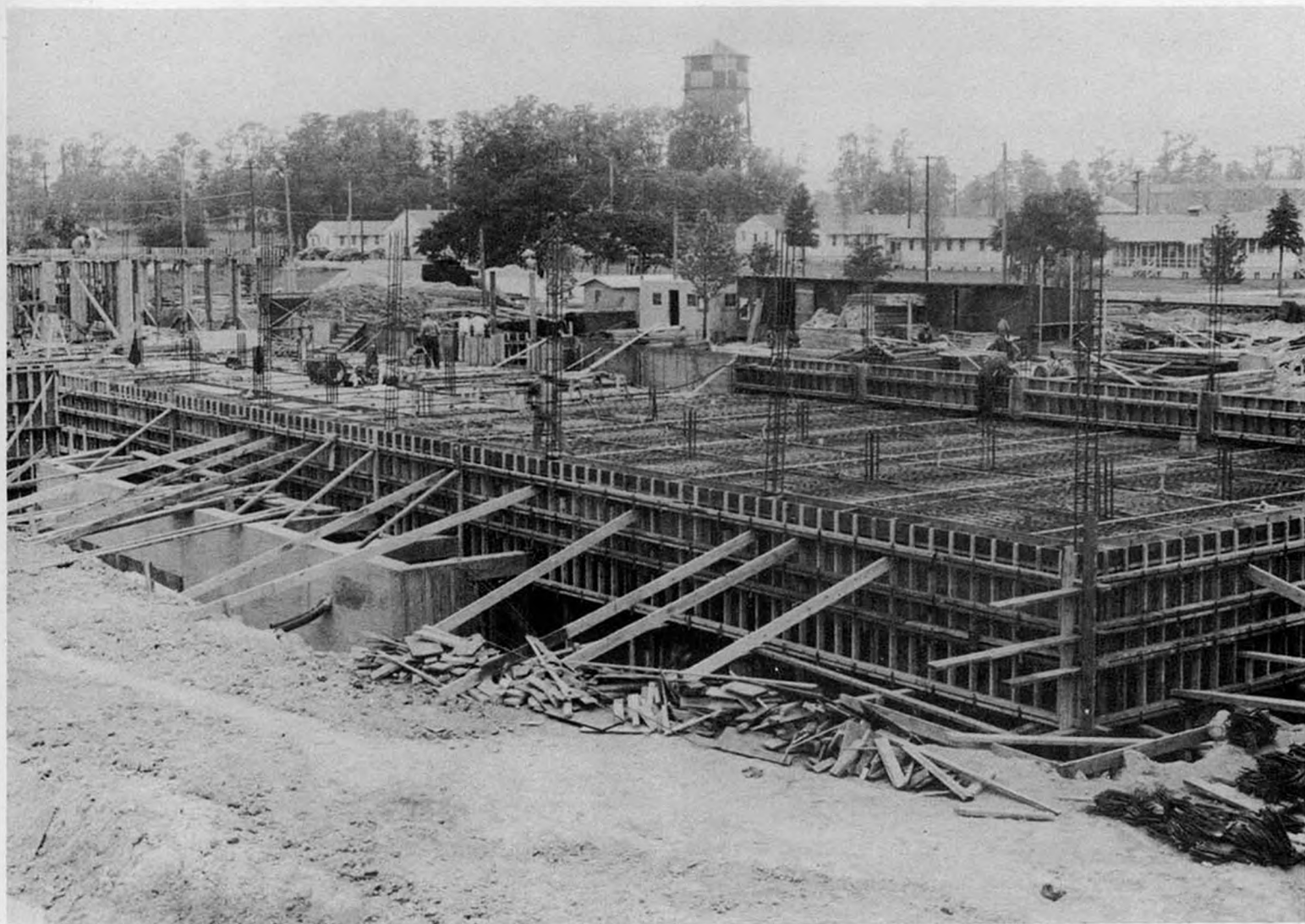
Each of the courses outlined above has been designed for a specific purpose to meet existing field requirements and may be modified as conditions require. All courses keep up with the latest equipment and instruction is always up to date. Every attempt is made to anticipate field problems before they occur. Key instructors with previous field experience maintain contact with incoming students and graduating students as one means of doing this. Letters from the field, usually from graduates, requesting information, help enormously in attaining this same objective. More letters of this type would be welcomed.

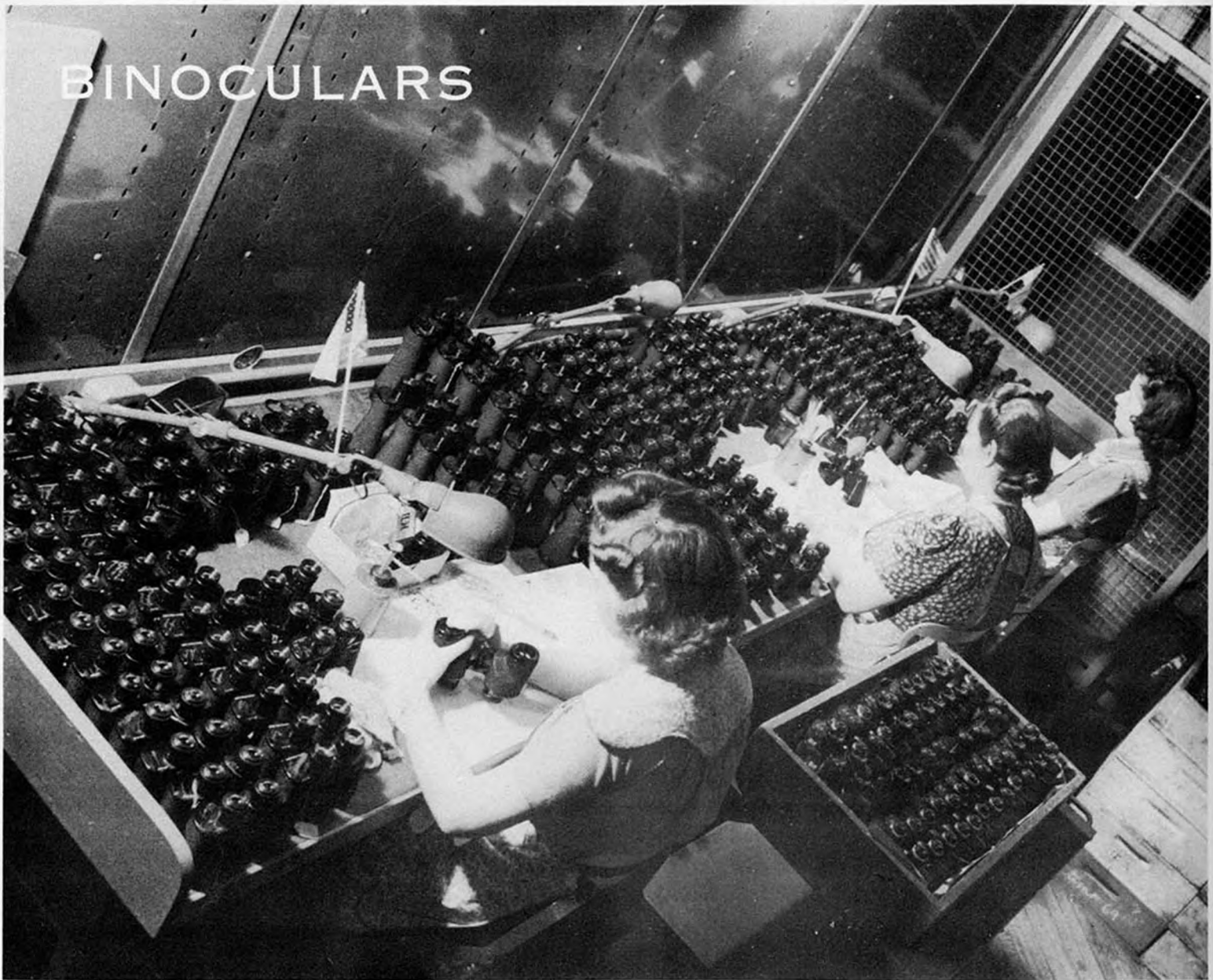
Previous graduates of the fire control section of The Ordnance School will realize, from the courses listed above, the tremendous expansion the section has undergone.

Summary

The Fire Control Section is expanding proportionately with the rest of The Ordnance School as the American Army grows in strength and striking power. What next year will bring in the way of training requirements cannot be foreseen at the present time. But lessons learned in the past year and the experience gained in that year have resulted in an elastic section organization and a staff of experienced personnel that is still capable of tremendous expansion.

(Continued on page 172)

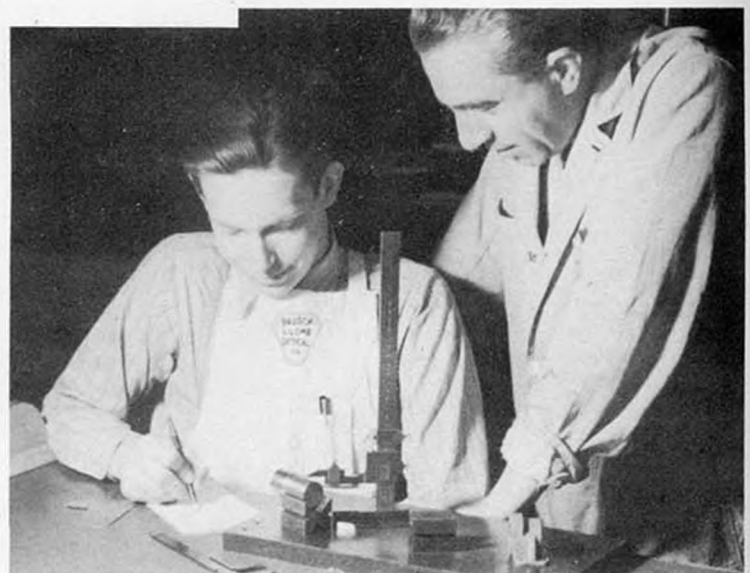
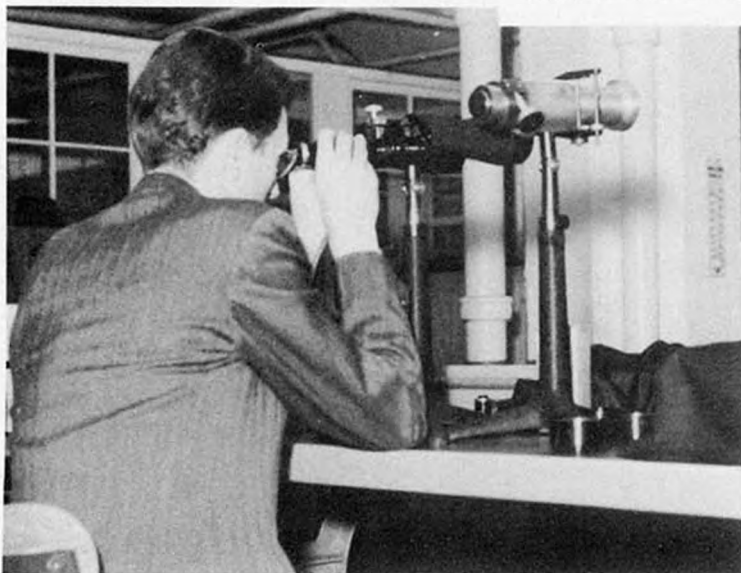




Above: After they have passed a number of rigid tests for critical performance, Binoculars are finally checked, recorded, and made ready for

prompt shipment to central supply depots. Below at left: There is continued effort to improve the performance of military glasses. Here an optical engineer tests an experimental design. Below at

right: Theory and practice go hand in hand. Proper training calls for minds that can comprehend and hands that are properly trained.





Making the Mould for a Navy Night Glass. Sand casting supplements die-casting to speed up production of this essential model.



Pouring the molten aluminum alloy into the moulds. The Bausch and Lomb Foundry is on a three-shift basis with a 24-hour working schedule.



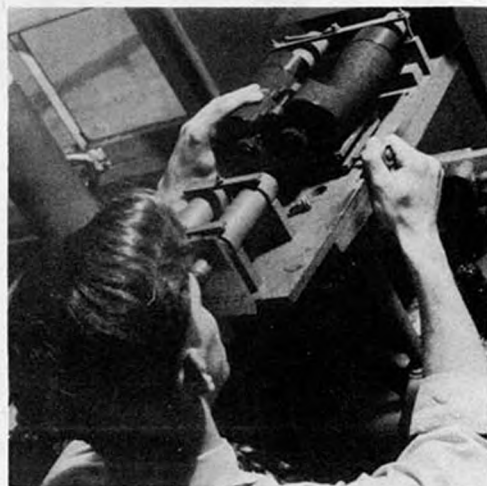
The interior optical parts of a military binocular, after final rinsing, are assembled in temperature-controlled rooms that are supplied with dust-free, filtered air.

Binoculars are the universal long range eyes of defense upon which the safety of millions depends. Used to observe antiaircraft fire, to correct the fire against fast-moving tanks, to study terrain, to spot submarines. . . no wonder more and still more are needed now.

Bausch and Lomb binoculars are today recognized as the world's finest by competent military authorities after comparative tests. Making them so requires adherence to mechani-

ical and optical specifications as exacting as those of fine microscopes.

Fortunately, Bausch and Lomb has built binoculars to Army and Navy standards for many years. Now, when defense needs multiply requirements, there are no new habits of greater precision to be learned. Trained operators are available to supervise, direct, and share their skills. Manufacturing procedures have been established. Extensive expansion has been possible with minimum difficulty.



Adjusting to practical parallelism the two prismatic telescopes that form a binocular.

An inspector makes a final test for definition, optical performance, and resistance to shock.



Introduction

All fire control equipment is classified as F-Group materiel in the Ordnance Catalogue. It is further subdivided into two main groups; namely, "Fire Control Instruments" and "Sighting Equipment."

Fire control instruments include all those instruments, accessories, and devices used to gather, compute, and collate firing data and to observe the effect of fire. This group is often referred to as "off-carriage fire control equipment".

Sighting equipment comprises all those instruments mounted directly on the gun or carriage, by which the firing data, previously gathered, is applied to move the gun through the requisite angles of azimuth and elevation. It also includes similar instruments used for direct sighting, as well as such accessory equipment as bore sighting equipment, testing targets, and aiming posts and stakes. This group is often referred to as "on-carriage fire control equipment".

For the purpose of discussion, all of this materiel is best grouped according to general physical characteristics and optical construction.

the target is also formed. Since both the reticle and the image of the target are in one plane, at a certain distance in front of the gunner's eye, it enables him to view rapidly and simultaneously both reticle and target. Furthermore, if any magnification is present it is an added advantage, since far objects will appear proportionately nearer.

An added advantage of the use of a reticle in preference to the open front sight is that the reticle may be graduated with an appropriate scale to allow rapid visual estimation of any deviation between shell burst and target.

When a straight tube telescope is intended for use simply to establish a line of sight, the pattern of the reticle is very simple, usually

FIRE CONTROL INSTRUMENTS and

With this in mind, all F-Group materiel falls readily into one of the eleven following classifications:

1. Straight tube sighting telescopes.
2. Binocular instruments for observation.
3. Elbow telescopes.
4. Range and position finders.
5. Azimuth measuring instruments.
6. Mounts and quadrants.
7. Panoramic Telescopes.
8. Computing and plotting devices.
9. Miscellaneous angle measuring or setting instruments.
10. Antiaircraft fire control and sighting equipment.
11. Miscellaneous F-Group materiel.

The instruments falling into any one of the above mentioned groups are best discussed as a group since they are similar in use, construction and optical characteristics. It must be kept in mind that, though many instruments in each group will be mentioned briefly, there are far too many to include in the space available. Those selected for discussion are the instruments most apt to be encountered in the field at the present time, and, for the most part, instruments that were standard at the time of writing.

Straight Tube Sighting Telescopes

Practically all straight tube telescopes in common use are used as direct sights to provide rapid alignment on fast moving terrestrial and aerial targets. Since excessive magnification limits the field of view, these telescopes are usually of a very low power or provide no magnification at all. Since most of the instruments in this group have no magnifying power it may not be apparent how they could be of any practical advantage.

The straight tube telescope with a reticle is superior to an open sight for several reasons. With an open sight the gunner is required to view simultaneously, or at successive intervals, the front sight and the target, which are obviously at greatly differing distances. The construction and method of functioning of the human eye makes this both inconvenient and inefficient. In a straight tube telescope a reticle (Figure 1) is provided in the focal plane of the instrument where the image of

a pair of crossed lines. (See Figure 1.) However, since the apparent dimensions of the reticle remain constant, reticle scales represent convenient means for measuring small angles. The angle subtended by any two points on the reticle is the angle, the tangent of which is d/f , where d is the linear distance between the two points in question and f is the equivalent focal length of the objective. This formula holds true only when there is no lens between the objective and reticle, but is entirely unaffected by any changes in the optical system traversed by the light after passing through the reticle.

Straight tube sighting telescopes of this nature are used at the present time largely for direct sighting equipment on antitank guns, tank guns and light antiaircraft guns. Occasionally small arms utilize telescopic musket sights of a similar nature.

The straight tube telescopes in common use for sighting purposes are the Telescopes M5, M5A1, M6, M7 and M15. The telescopes M19, M21 and M32 are used as major components of periscopes used as tank sights. Basically, all of these instruments consist of a straight metallic tube so constructed as to hold securely the optical components which comprise the telescope proper. A typical optical system is shown in Figure 2.

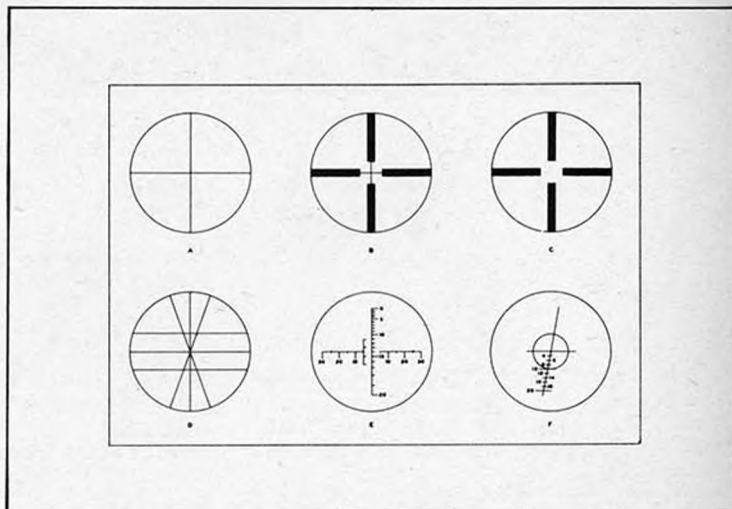


Fig. 1. -- Some Common Reticle Patterns.

Straight tube telescopes are designed usually with a lens erecting system as shown in this drawing. Occasionally, when it is desired to shorten the length of the instrument, a prism erecting system is used instead.

The maintenance of this materiel is comparatively simple, since the instruments are ruggedly built. Adequate reference materiel in regard to the repair and adjustment is available. The most common defects encountered in the field are parallax and broken optical elements.

SIGHTING EQUIPMENT

BY
Joseph F. Kennelly
2ND LT., ORD. DEPT.

Ordinary care and precautions will materially prolong the life of straight tube telescopes and contribute to efficient use and operation. Since no movable parts or mechanical components are included, this is a relatively simple task.

Binocular Observation Instruments

Any instrument used for the observation of fire or for ordinary observation purposes must show a maximum of detail. A monocular telescope of the straight tube type, such as has been adapted for direct sighting, is unsatisfactory for this purpose, even if possessed of high magnification. A stereoscopic instrument affords the best results.

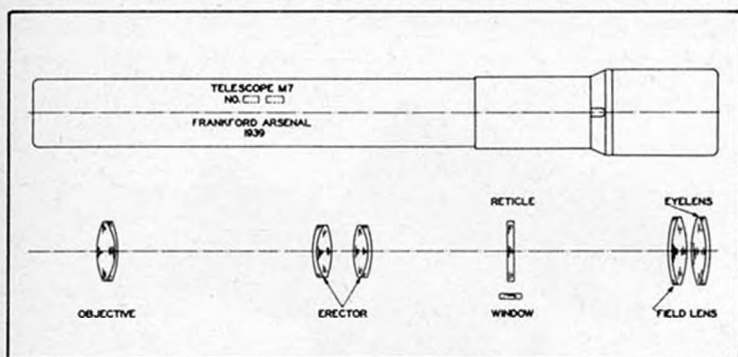


Fig. 2. -- Optical System of a Straight Tube Telescope.

True stereoscopic vision is based upon the fact that the two eyes of the observer see objects from slightly different points. This is illustrated in Figure 4.

The drawing shows a cube, level with the eyes of the observer. It will be seen that the images received by the two eyes differ slightly. These two images are fused in the visual centers of the brain to produce a three dimensional, stereoscopic image, which is interpreted in terms of relief. The fact that the two eyes receive different impressions differentiates the true stereoscopic effect from the relief obtained by the use of perspective and light and shade. The illusion produced by the last would persist if one eye were closed, while it is absolutely necessary that both eyes be employed if stereoscopic relief is to be obtained.

When the distance from an object to an observer exceeds a certain amount, the angle subtended by the two eyes is so small that the images received by both eyes are essentially alike. True stereoscopic effect ceases to exist, and any appearance of relief beyond this point is due to perspective or light and shade. The approximate radius of stereoscopic vision with the unaided eyes is 500 yards.

If, however, the eyes are assisted with a pair of binoculars, such as the ordinary field glass, the radius of stereoscopic vision is greatly increased. In the first place, if the binocular power is 6, an angle of 5" after magnification is apparently an angle of 30°. Therefore, the radius of stereoscopic vision with the binoculars should be the distance at which

the eyes subtend an angle of 5", i.e., 6 x 500, or a distance of 3000 yards. Furthermore, if the individual telescopes of the binoculars are of the porro type, the maker must turn the telescopes so that the objectives are farther apart than the eyepieces. The observer views the object from two objectives which are separated by twice the distance between the eyes. This then, doubles the radius of stereoscopic vision once again, so that with a six power binocular of this type the radius of stereoscopic vision is 6000 yards. The formula for the radius of stereoscopic vision is:

$$R = a \cdot \frac{l_2}{l_1} \cdot 500 \text{ yards}$$

where a is the magnification of the binoculars, l_2 the distance between the centers of the objectives, and l_1 the distance between the eyes.

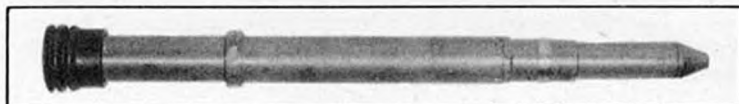


Fig. 3. -- Telescope, M5.

The Battery Commander's Telescope, M1915 and M1915A1 is a large binocular telescope mounted on a tripod and particularly designed to give a large radius of stereoscopic vision. When the two types are in the horizontal position l_2 is approximately 27 inches. The power of the instrument is ten. Substituting in the above equation:

$$R = 10 \cdot \frac{27}{2.6} \cdot 500 = 52,000 \text{ yards}$$

This instrument is particularly desirable for spotting distant shots, as the stereoscopic relief is of immense value in determining whether a burst is short of the target or over it. A binocular instrument in which the distance between the objectives is much greater than that between the eyes is frequently termed a stereobinocular in order to emphasize the enhanced stereoscopic effect which is obtained thereby.

The two binocular instruments commonly employed in the military service for observation purposes are the Field Glass and Battery Commander's telescope. There are two models of each instrument. The Glass, field, type EE, now limited standard, is rapidly being supplanted by the new Binocular, M3. These two models are both 6 power, 30 mm aperture, all service glasses, and are effective for observation purposes to a distance of 6,000 yards. This may be limited by prevailing atmospheric conditions.

It should be remembered that the importance of a binocular as an observation instrument lies in the manner in which it extends the radius of stereoscopic vision rather than mere magnification.

While the field glass is effective to a distance of six thousand yards, a more powerful instrument is required for the observation of artillery fire which is used at much greater distances. The Battery Commander's telescope is used for this purpose. The M1915 and M1915A1 are the two

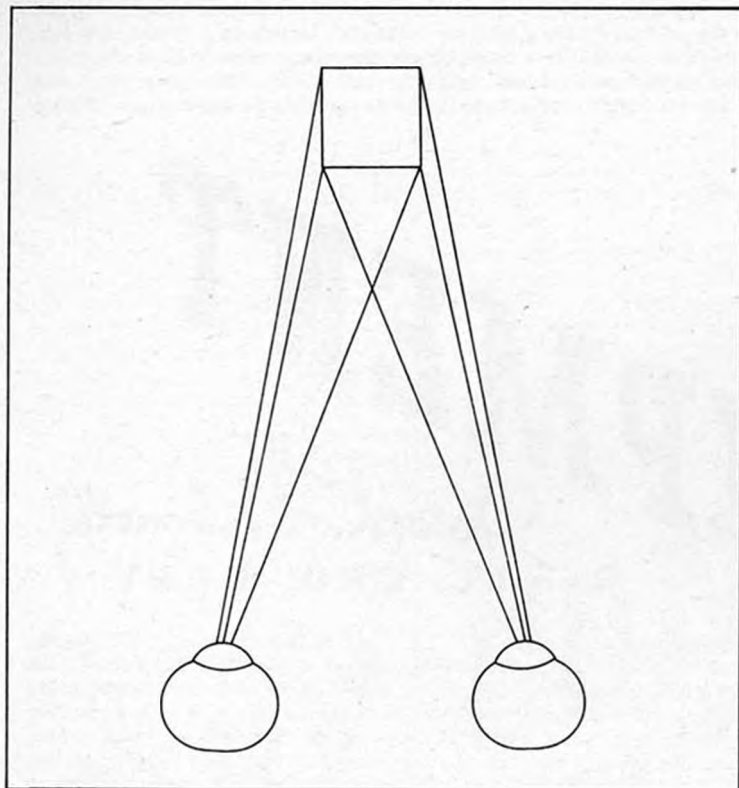


Fig. 4. -- Diagram of Stereoscopic Vision.

models in common use though a limited number of French B.C.'s will be found in service dating from 1915. All are very similar, differing only in minor variations.

Being of ten power, these instruments are mounted on tripods, since it would be impractical to hold them in the hands due to the excessive vibration. They may be used in the vertical position for periscopic vision, or in the horizontal position for maximum stereoscopic vision.

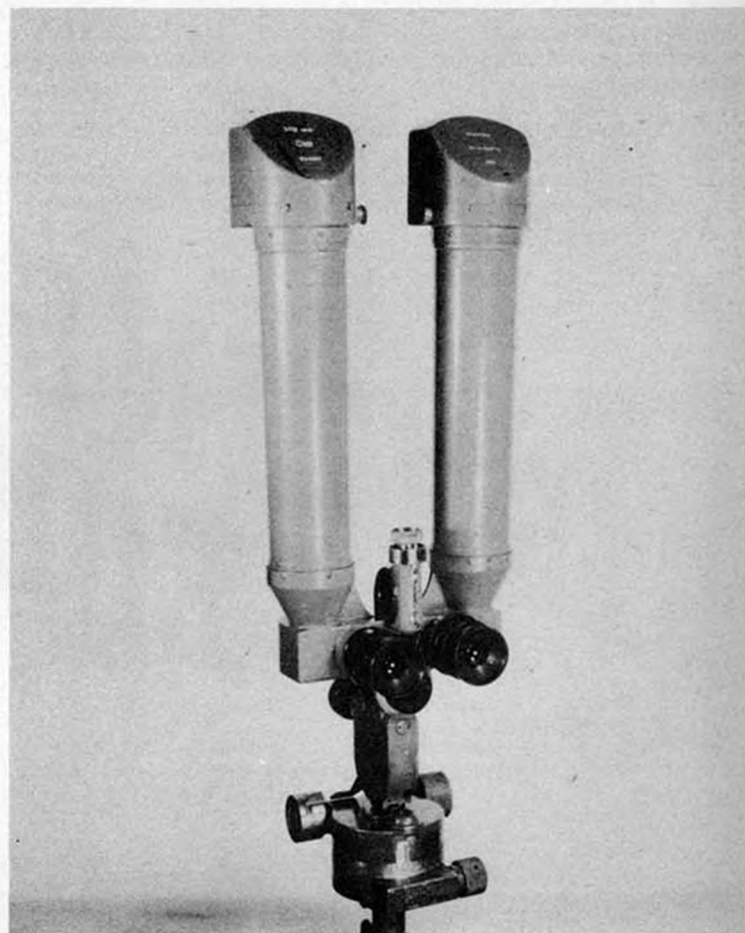


Fig. 5 -- Battery Commander's Telescope (French) M1916.

Both the field glass and the B.C. Scope are precision optical instruments. Being binocular in design, they are subject to "double vision",

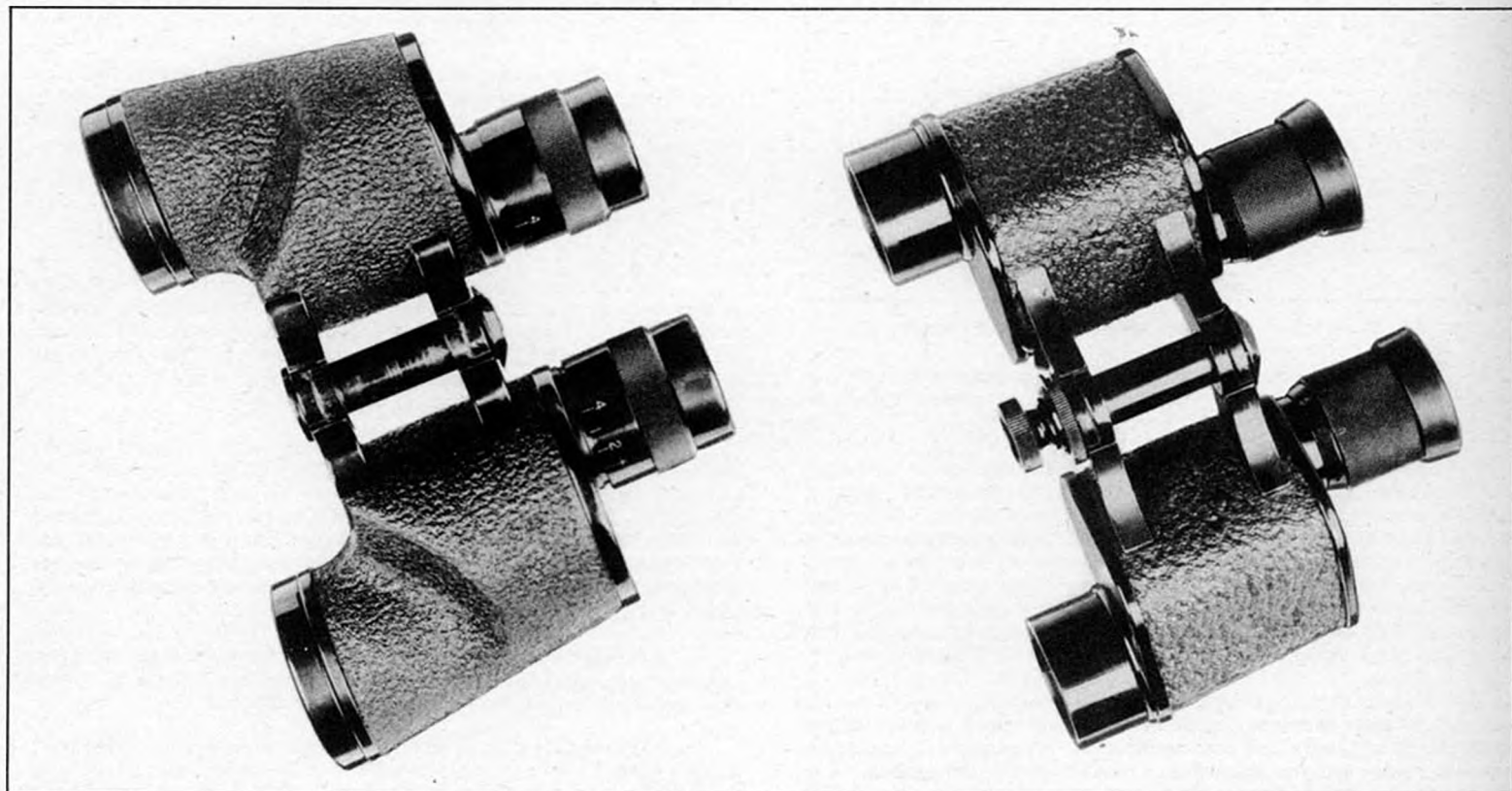


Fig. 6. -- Left: Binocular, M3. Right: Glass, Field, Type EE.

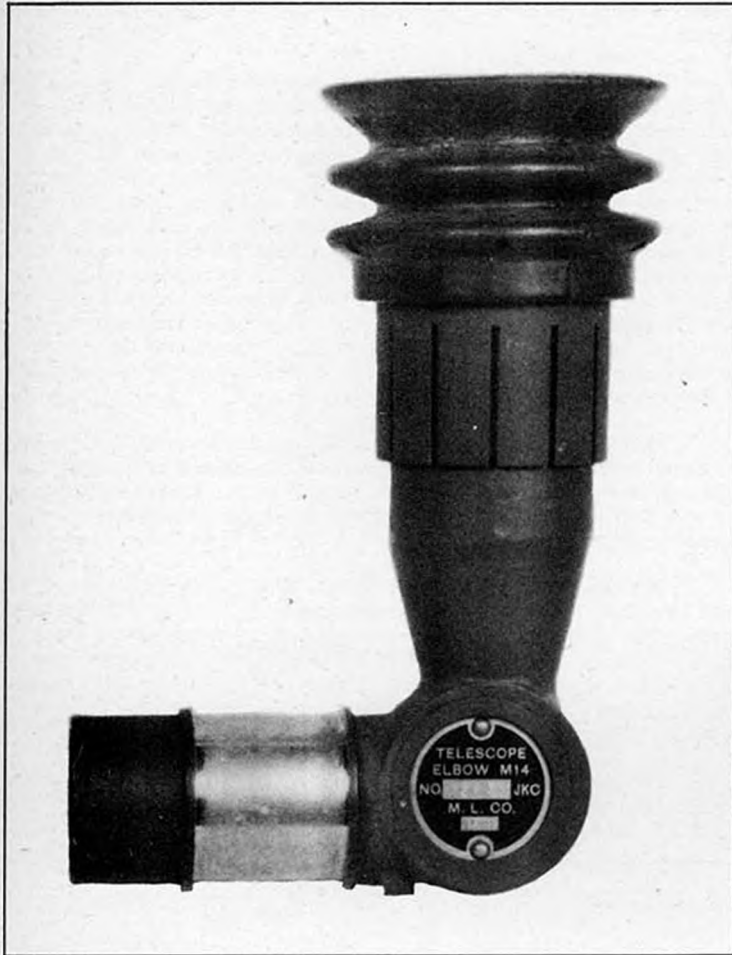


Fig. 7. -- Elbow Telescope, M14.

a defect peculiar to binoculars which occasion a great deal of tedious maintenance and adjustment for its elimination. Double vision is caused by the fact that the optical axes of the two telescopes comprising the instruments are not parallel with each other and with the mechanical axis of the hinge pin. Parallax is another defect common to all instruments with reticles, and is particularly troublesome when it is desired to attempt measurements with the use of the reticle.

The maintenance of binocular observation instruments is quite extensive, and should be attempted only by qualified ordnance personnel. Preventive maintenance can eliminate a great deal of routine maintenance, and the rendering of technical advice with this goal in mind should be an objective of all ordnance maintenance personnel in the field.

Adequate and appropriate reference material is available and reference to FM 21-6, "Index to Training Publications" and to SNL F-1 will show the scope of the War Department publications relative to this materiel.

Elbow telescopes

Elbow telescopes, in a wide variety of sizes and models, are used for three main purposes in the military service.

a. Since the main characteristic of an elbow telescope is the fact that the eyepiece is offset 90 degrees perpendicular to the objective assembly, elbow telescopes are used for direct sighting purposes where it is necessary for the gunner to stand at the side of a weapon. This may be required by the presence of a large gun crew or the position of the handwheels which he must manipulate. The instrument still allows a line of sight which is parallel to the axis of the bore, thus fulfilling the same essential function as a straight tube sighting telescope.

The elbow telescopes, M5 and M14, used with 75mm materiel, and the elbow telescope, M16, used with 105mm materiel, are instruments of this type. The elbow telescope, M29 is used with the 3" carriage (AA) as an emergency antitank sight. These are typical of the group, and many other instruments exist for similar purposes.

Usually, when employed in this manner, the elbow telescope and the mount provided supplement, rather than replace, the regular sighting equipment which is normally employed for indirect fire.

b. Elbow telescopes are universally used as tracking instruments on antiaircraft fire control materiel. Their design permits elevation and azimuth trackers and observers to keep their head and eyes in a comfortable position which is less fatiguing than attempting to track an overhead target with a straight tube telescope. This is entirely possible, but hardly comfortable. The elbow telescope, M6, used with the director, M4, is the largest in this group. Two are employed with each director, one for tracking in elevation and one for tracking in azimuth. Other tracking telescopes in this class are the M22 (tracking) on director M7; the M17 (tracking) on directors M5 and M6; M7 (tracking) on the height finder M1; and the M1A1 (spotting) on directors M4 and M7. These are only a few of the many models in common use.

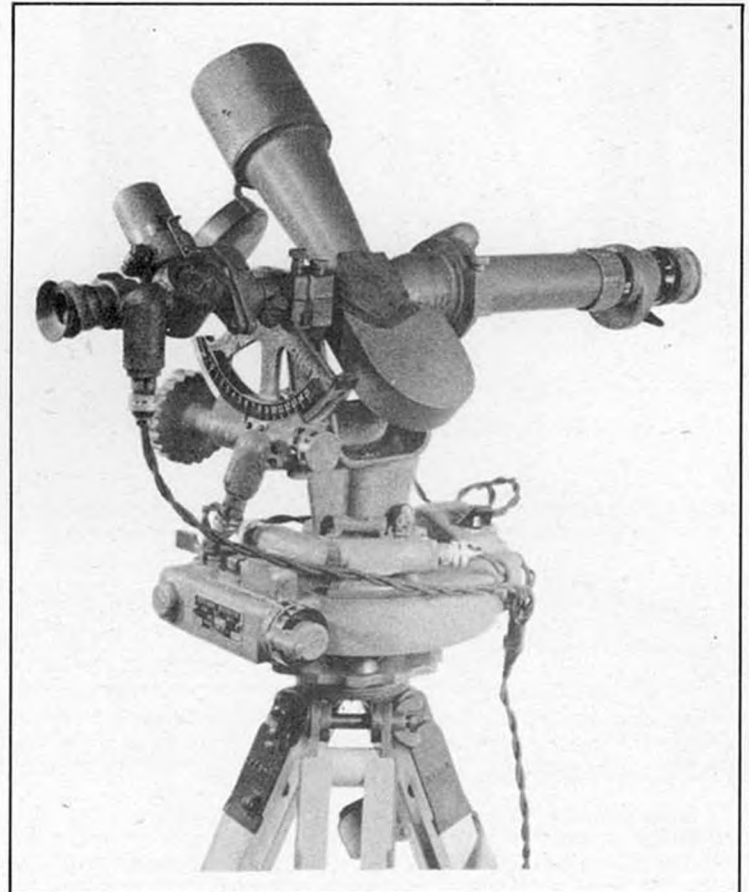


Fig. 8. -- Instrument, Observation, AA, B.C., M1.

c. Elbow telescopes are also used as components of other instruments, usually where the observation or tracking of rapidly moving terrestrial or aerial targets is the essential purpose. The observation instrument, AA, B.C., M1, employs two telescopes in this manner, and the Flank Spotting Instrument, M1, uses one. All altimeters employ elbow telescopes in a similar manner.

Regardless of use, all elbow telescopes are sensibly similar, differing usually in power, reticle pattern and size. These characteristics are determined by the use of the instrument. Reticle patterns vary widely, being either cross hairs or more elaborate scales graduated in either yards or mills. Magnification is dependent on the type of target expected in use. For artillery direct sighting the magnification is usually low, about two, three or four power, while for antiaircraft work it is usually higher.

Low magnification in any instrument has two distinct advantages. If the power is four or less no focusing movement is necessary in the eyepiece assembly. This saves time in using the instrument. Also, a low magnifying power allows the largest field of view which is valuable in picking up rapidly moving targets, especially for anti-mechanized defense.

Innumerable models of elbow telescopes exist in all of the classi-

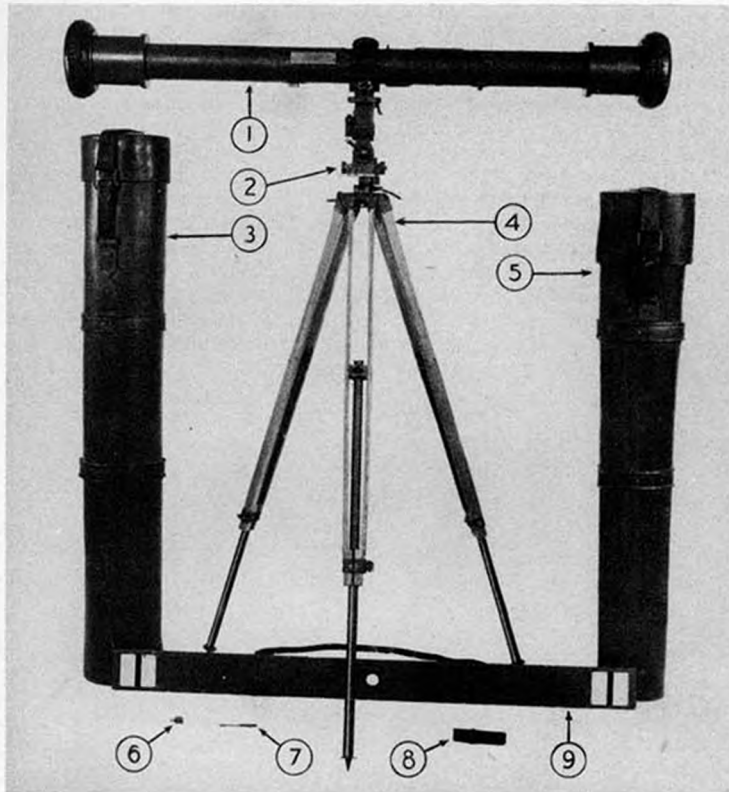


Fig. 9. -- FINDER, RANGE, 1 METER BASE, M1916.
(COMPLETE)

- | | |
|---------------------------------------|--------------------------------------|
| 1. Range Finder. | 5. Carrying Case (Tripod and Mount). |
| 2. Mount. | 6. Correction Wedge Key. |
| 3. Carrying Case (Range finder). | 7. Camel Hair Brush. |
| 4. Tripod. | 8. Tube sight. |
| 9. Adjuster Lath with Carrying Strap. | |

fications discussed. Their maintenance varies but little and a thorough knowledge of any one instrument will permit efficient work on all the telescopes in the group.

The optical system differs from the straight tube group only in the fact that a roof angle (Amici) prism is employed as (1) an erecting system and (2) to reflect the light through the requisite angle to permit an elbow design. On some of the elbow telescopes, especially those employed on AA instruments, a ray filter may be found in the eyepiece assembly. This is necessary in AA instruments since it is often necessary to observe or track directly into the full glare of the sun.

The optical defects encountered in the straight tube group apply to the elbow group as well. Parallax is the most troublesome. There are no outstanding optical or mechanical defects peculiar to the elbow group alone. Consequently, personnel experienced in the maintenance of straight tube telescopes are usually capable of performing routine field maintenance operations on the elbow group. With this in mind it is possible and desirable, for most efficient results, to combine these two groups of optical instruments as a single group for training purposes.

Range and Position Finders

A range finder is an instrument that gives the range, in yards or meters, to the target.

A position finder gives the range and position of a target in relation to the instrument.

Theoretically, there are innumerable principles upon which instruments could be developed for each of the above purposes. It is entirely feasible to design instruments which can measure ranges or locate targets by (1) utilizing the velocity of sound in air; (2) using the known length or height of distant targets; (3) using a fixed short base; (4) using

a fixed or variable base for triangulation; and (5) using the stereoscopic principle.

In actual practice the possibilities are most limited. Tactical, as well as technical, requirements must be taken into consideration. Infantry and cavalry require a range finder for use at ranges up to 5000 yards which must be mobile, compact, ruggedly constructed and capable of manual transportation. Mobile artillery units need an instrument for use to much greater ranges, which may be less mobile, but must still be capable of convenient truck transportation and manual carrying in emergency. The Coast Artillery, working from fixed and semi-fixed emplacements, can use an instrument that need not be mobile, but must be capable of measuring ranges to very great distances with extreme accuracy. Since mobility does not enter into important consideration, size itself is no object. Antiaircraft units require an instrument that can stay on fast moving targets, and where speed of computation and measurement is the primary consideration.

These various, and at times conflicting, requirements have led to the development of a variety of instruments for range and position finding, utilizing, in the main, the same basic principles of operation, yet differing widely in design and size. A few of these many instruments are discussed briefly here.

The one-meter base range finder, M1916, Figure 9 and 10, is used by mobile artillery units. It measures ranges from 400 to 20,000 yards. This instrument may be used to measure horizontal and vertical angles, though it is not convenient for this purpose. This instrument is of the horizontal base, inverted field, coincidence type. It measures ranges optically, by triangulation, the one meter distance between the objectives of the instruments forming the base of the triangle.

The range finders used by Infantry and Cavalry are of the 80 centimeter base type. The M1914 and M1914M1 range finders are of the horizontal base, inverted field, coincidence type, and measure ranges from

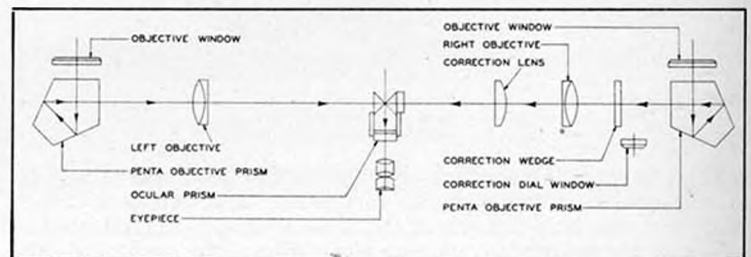


Fig. 10. -- Optical System of the Range Finder, 1-meter base, M1916.

400 to 10,000 yards, by triangulation. The M1917 and M1917M1 80 centimeter base range finders are of the horizontal base, inverted field, azimuth type. Their operation is based on the principle that an object, to be in coincidence, must occupy a predetermined horizontal position in the field of view. This allows a line in the field of view to be calibrated in terms of range.

Basically, all of the range finders discussed above, except the azimuth type, are two separate telescopes, laid horizontally, and the two images are viewed by a common eyepiece. The light rays entering the right telescope form an accurate angle of ninety degrees with the instrument. Thus, for purposes of triangulation, the base of the triangle and the right angle are predetermined or fixed. The light rays entering the left telescope form an angle which varies with the range, and which is measured optically to solve for range by the instrument. The range is read from a calibrated range drum, either in yards or meters.

Range finders of this nature can be designed with any reasonable base length. If the base length is small, there is an inherent error that increases proportionately with the range. As the base length of an instrument increases the inherent error decreases. However, base lengths are always limited by the tactical requirements of the using service.

Coast artillery units use range finders of nine and fifteen foot base line, (see Figure 12), while the Navy uses instruments of even greater base length. The trend, however, in larger range finders, is toward those operating on the stereoscopic principle.

The stereoscopic sense alone will not permit very great accuracy in the direct estimation of distance, but an observer, artificially aided optically and specially trained, can tell when two objects are at the same distance with remarkable accuracy, due to this same stereoscopic

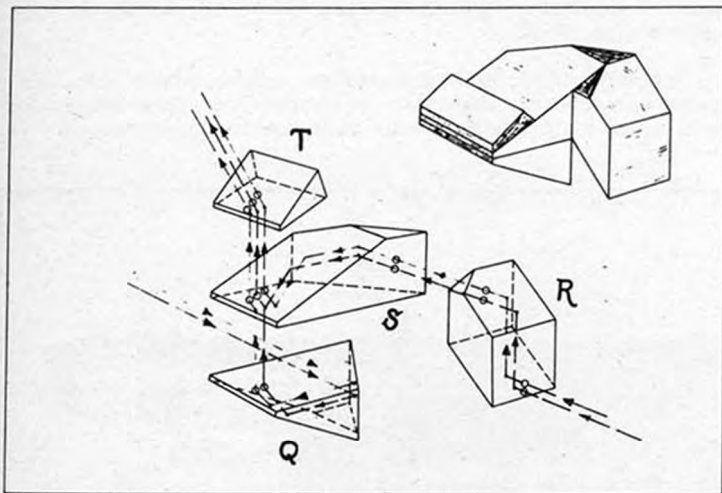


Fig. 11. -- Ocular Prism.

sense. It is this ability which is utilized in the design of stereoscopic range and height finders.

Stereoscopic range and height finders are used for anti-aircraft work primarily, and also for seacoast defense. There are two models in common use, the M1 and M2. Both have two eyepieces (necessary since these are stereoscopic in function and design), two objectives, a base length of approximately 13-1/2 feet, and are selectively either twelve or twenty power. Theoretically, they can measure ranges to 400 miles. For practical purposes the measure ranges accurately from 550 to 50,000 yards. A more detailed discussion of the AA Height Finder will be found

Azimuths are read from an azimuth scale and micrometer.

The M1 Depression Position Finder superseded the older Lewis and Swasey types, which utilized the same principles of operation. The telescope M1, used with the M1 D.P.F. is selectively 10 or 30 power. At ten power the field of view is 6° and 9' while at thirty power it is 2°3'. This illustrates how an increase in magnifying qualities cuts down the field of view.

The maintenance of all range and position finders is a task for highly trained specialists found among qualified ordnance instrument personnel. These instruments are among the most delicate found in the F-Group category and are easily thrown out of adjustment and rendered inaccurate by carelessness in use, transportation or storage. All personnel should treat them as precision instruments, avoiding all temptation to adjust or tamper with them, and to confine lubrication and adjustment to the limits outlined in appropriate War Department publications.

Space does not permit a detailed description of these instruments, nor of other instruments or systems which fall into this group. Further information can be found in pertinent technical manuals of the 1000 and 2000 series. Titles can be found in the latest copy of FM 21-6, "Index to Training Publications". For maintenance purposes refer to the 1000 series; for general information to the 2000 series ("Instruction Guides").

Azimuth Measuring Instruments

The accurate measurement of angles of deflection or azimuth in a horizontal (and vertical) plane is usually accomplished by instruments specifically designed for that purpose. These essential elements of firing data must be accurately measured. Instruments varying widely in design, construction and purpose are used for this. In general, they may be classified under the rather ambiguous term of "azimuth measuring instruments," though strictly speaking the term is not completely correct.

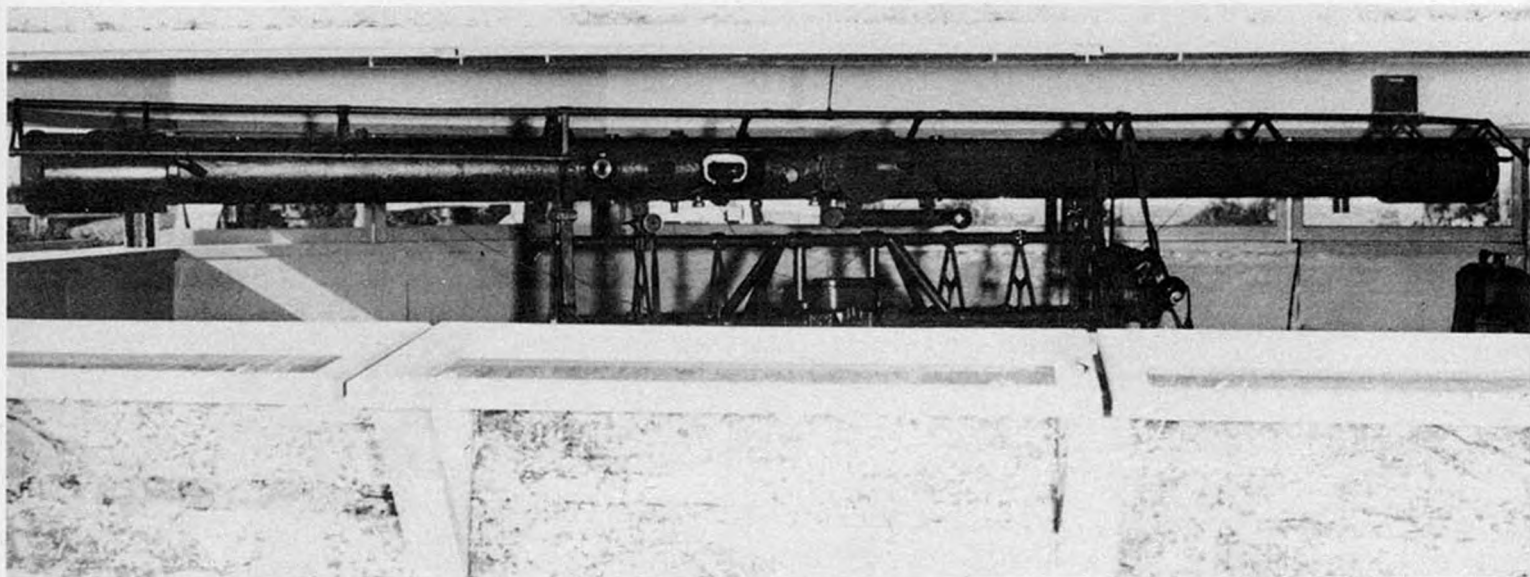


Fig. 12. -- Fifteen-foot, Coast Artillery Range Finder.

elsewhere in this issue of THE ORDNANCE SERGEANT. (See "AA Fire Control Materiel: Height Finder").

The Depression Position Finder, M1, (see Figure 13), is typical of the position finder group. It is an instrument used for measuring from heights above sea level the true horizontal range of an object on the surface of the sea, as well as the azimuth of an object from the azimuth reference line. It consists of a telescope, mount, tripod, and the necessary accessory mechanisms for control, direction and calculation. The telescope is used to measure mechanically, from its position above sea level (on shore), the depression angle of the target (at sea). The correct horizontal range, corrected for curvature of the earth and normal atmospheric refraction, is read directly on a range scale graduated in yards.

Internal correction adjustments compensate for tidal variations, abnormal atmospheric refraction, and for heights of instruments other than those for which the range scale is graduated.

Aiming circles are used by infantry, cavalry, field artillery, and other units, for the accurate measurement of (1) azimuth, or deflection, and (2) angles of site or elevation. These instruments are also used as a means of orienting the firing battery and laying the guns in parallelism. They are no doubt the most used instruments employed by field artillery units.

All aiming circles employ compass needles, and can measure horizontal angles of azimuth either from magnetic north or from a known reference point. Readings obtained are easily converted to "grid" or "true north" data, as the situation may require. A graduated reticle permits accurate measurement of angles of site. These instruments may also be used for general survey work.

Aiming circles generally employ a four power, prismatic telescope to establish a straight line of sight. The necessary mechanical movements are incorporated in the design of the instrument, and the whole is conveniently mounted on a mount and tripod. The instruments are ruggedly constructed for field usage and can be easily transported manually.

Four models of aiming circles are in common use in the service today. These are the Aiming Circle, M1 (New American, and latest model shown in Figures 15 and 16); the M1918, (French); the M1916; and the M1916M1. The general description, use and operation, precautions for use and handling, and optical characteristics are concisely presented in FM 6-220, "Field Artillery Fire Control Instruments." Technical

manuals covering all pertinent maintenance operations are available, also, to ordnance personnel.

Aiming circles are subject to the optical defects common to straight tube prismatic telescopes. In addition, since these instruments are designed for precision measurement, mechanical defects such as

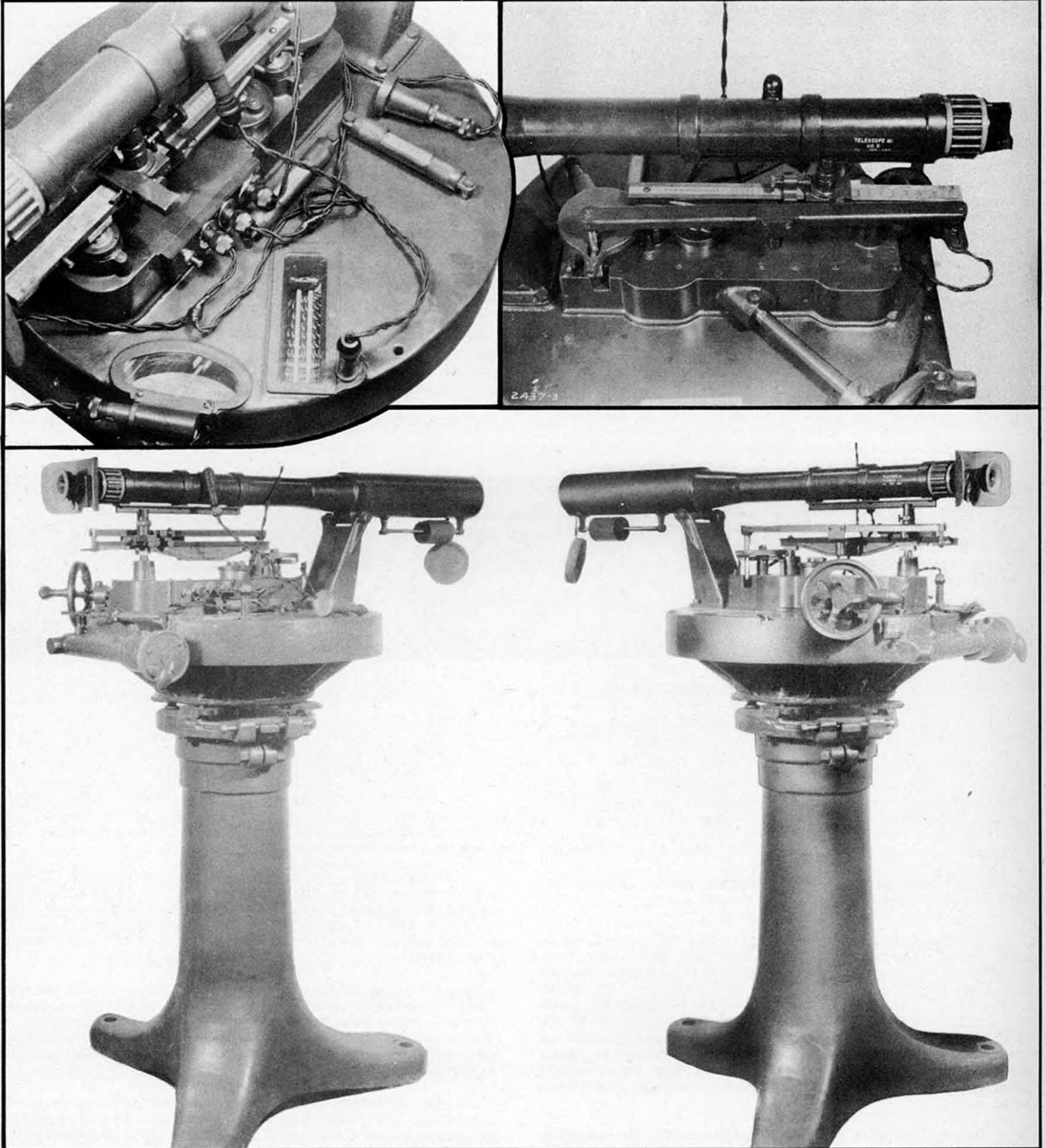


Fig. 13. -- Depression Position Finder, M1.

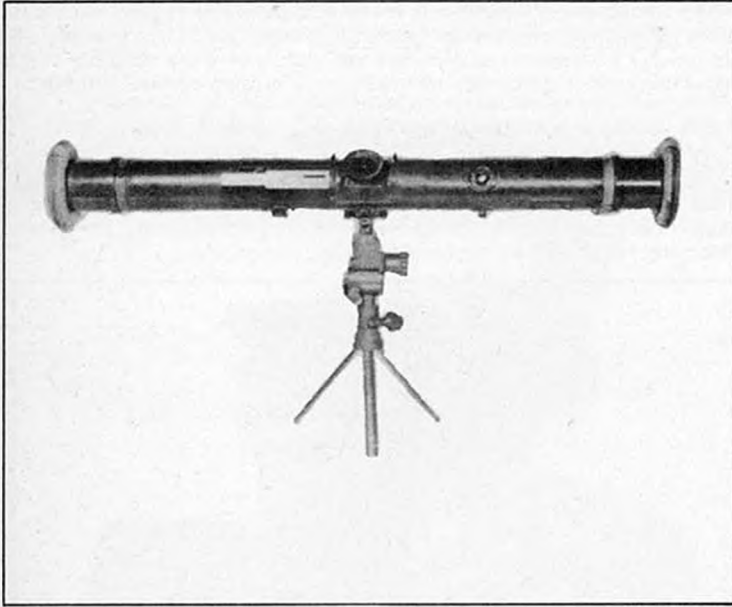


Fig. 14. -- Range Finder, 80-cm Base, M1914M1, with Type S Tripod.
(For use in prone position).

backlash, end-thrust, and lost motion in worm and gear mechanisms are particularly undesirable. Occasionally the warping or bending of bearing surfaces or plates may lead to incorrect horizontal or vertical movement on traversing or elevating the instrument. This contributes to inaccuracy and should be avoided by frequent inspection.

Another group of instruments in the classification discussed here are commonly known as "Azimuth Instruments". They are used by Coast

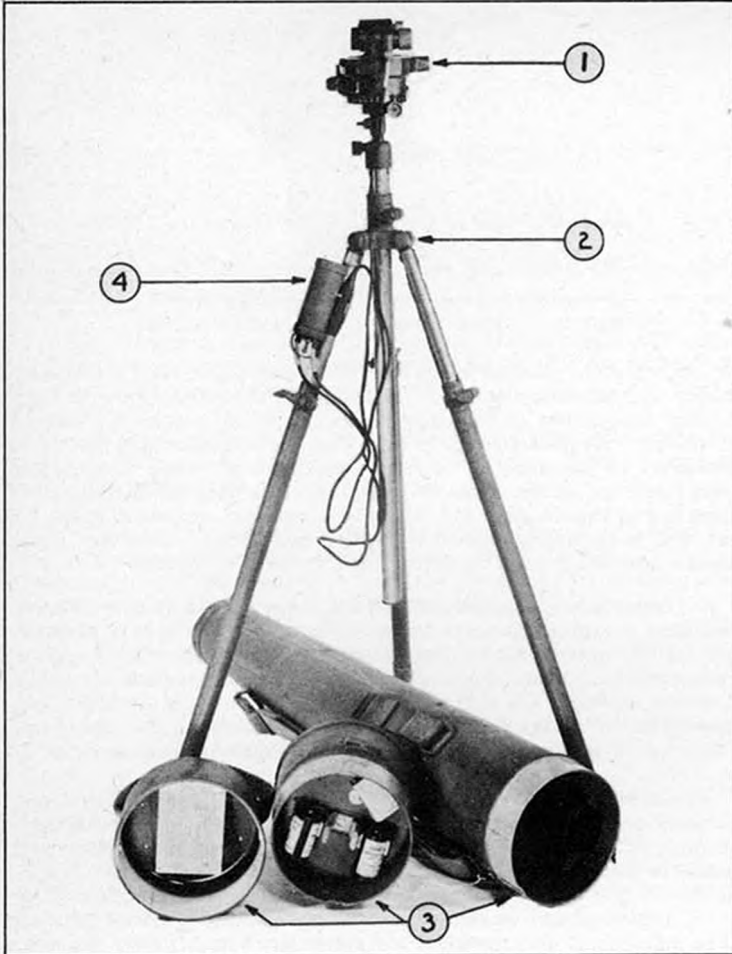


Fig. 15. -- AIMING CIRCLE, M1, (COMPLETE).

- | | |
|-------------------|-----------------------------------|
| 1. Aiming Circle. | 3. Carrying Case, M6A1, with lid. |
| 2. Tripod, M5. | 4. Instrument Light, M2. |

Artillery and Field artillery units and have been in use for many years.

Azimuth Instruments, M1910 and M1910A1, are for use in base end and spotting stations. (See "Seacoast Position Finding and Fire Control Article" elsewhere in this issue). These instruments measure accurately horizontal azimuth angles from 0 to 360 degrees. Movement, but no scales, are provided in elevation. Mounts, M1910 and M1910A1, are utilized with these instruments in addition to the tripod, Type A, and necessary mechanical and electrical accessories. Both instruments are very similar, and are graduated in degrees rather than mils.

The azimuth instrument, M1, is primarily a modification of the Azimuth instrument, M1918. While the M1910 and M1910A1 have interchangeable eyepieces of 10 and 15 power, (both allowing a field of view of 3 degrees) the M1 has a single 10 power eyepiece. No splash pointer mechanism is furnished and the reticle has a grid scale instead of the azimuth deflection scale for seacoast use. The M1 is used strictly by Field Artillery. The M1910 and M1910A1 are for use by Coast Artillery.

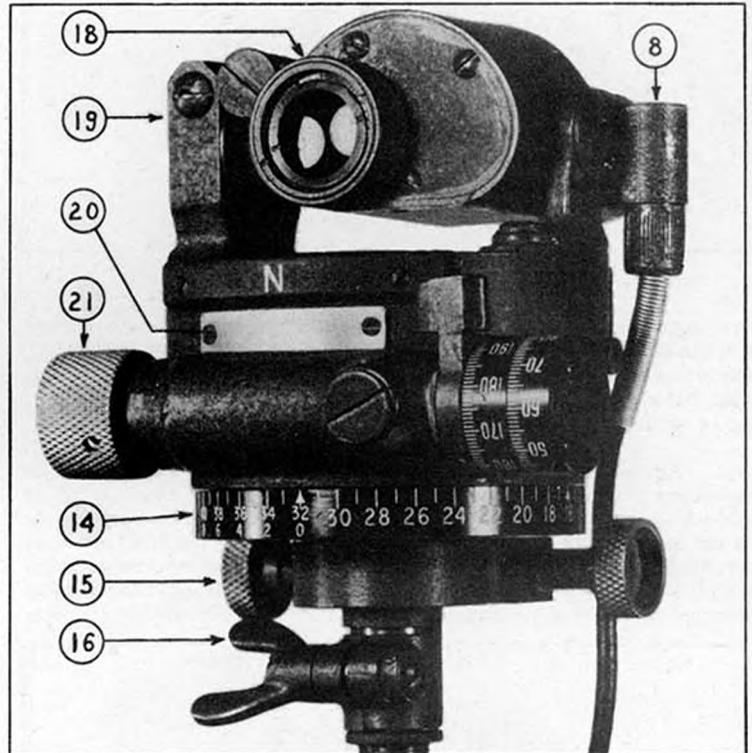


Fig. 16. -- AIMING CIRCLE, M1. (FRONT VIEW).

- | | |
|----------------------|---------------------|
| 8. Instrument Light. | 18. Telescope Body. |
| 14. Azimuth Scale. | 19. Left Bracket. |
| 15. Orienting Worm. | 20. Notation Strip. |
| 16. Wing Nut. | 21. Azimuth Knob. |

All azimuth instruments are designed for the accurate measurement of azimuth. They may be used as observation and spotting instruments and are valuable as surveying instruments to a limited extent.

Azimuth instruments, regardless of type, use rather large prismatic telescopes in their design. The erecting system is of the porro prism type, to diminish the length of the instrument. The field of view of the M1918A2 is four degrees. Instrument lights for the illumination of the reticle and scales at night are provided.

Maintenance of these instruments is a job for specialists. Texts are available, and can be located by reference to the "Index of Training Publications", FM 21-6.

All of the instruments discussed above were specifically designed for the accurate measurement of azimuth. In actuality, mechanical components can be added to practically any telescope instrument, whether monocular or binocular, to perform this same function as a secondary purpose.

The B. C. Telescope, M1915 and M1915A1, have the necessary mechanical components and level devices to permit measurement of azimuth, elevation, or site. The Instrument Observation, AA, B. C., is similarly designed. Some range finders, observation instruments of a miscellaneous

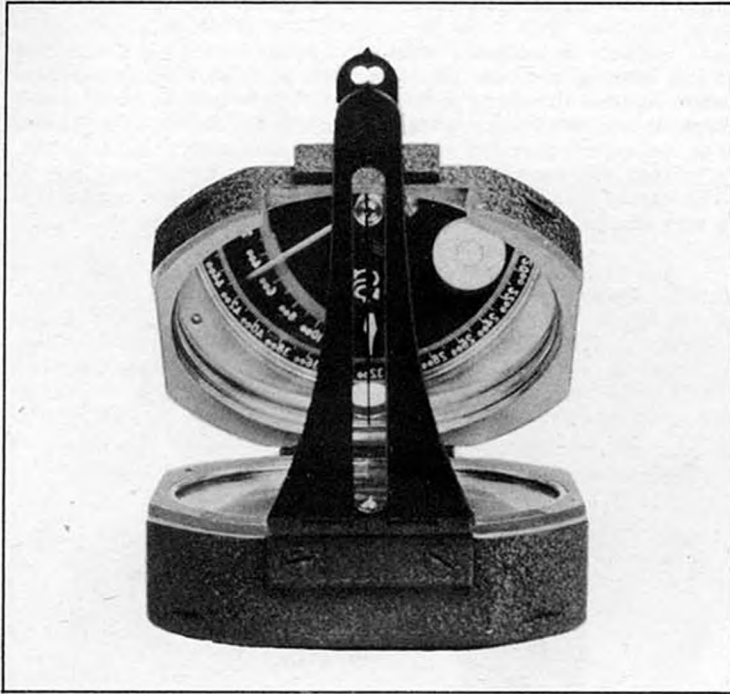


Fig. 17. -- Compass, M2, Observer's View, Azimuth.

type, compasses, etc., have similar secondary uses to a limited extent. It might be noted at this point that the new Compass, M2, (see Figure 17), which replaces the M1918 type as standard cannot only be used as a compass, but also for measurements of azimuth, and is adapted to measuring or setting off angles of site and clinometer readings.

All instruments which are designed for either the primary or secondary purpose of measuring angular units of any kind should be subject to frequent inspection in order to check for accuracy. An efficient inspection of this type can only be performed by qualified ordnance personnel. Using troops need not wait for periodic inspections to accomplish this. When any indication of malfunctioning or inaccuracy is apparent a request will result in prompt and efficient service by ordnance.

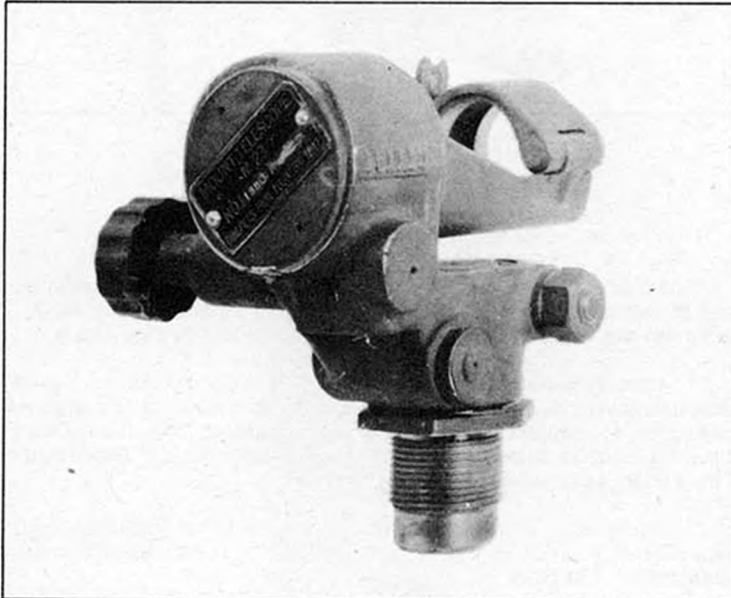


Fig. 18. -- Mount, Telescope, M23.

Malfunctioning should always be anticipated, since a close check for minor defects is the best guarantee that the instrument will be ready for efficient combat service at all times. The prompt correction of minor defects may be a matter of minutes. It may obviate the necessity for an extensive overhaul at a later date that might take the instrument out of service for an indefinite period. This could very easily occur at a crucial moment in a remote theater of operations with no possibility of immediate replacement.

Ordnance personnel - at every available opportunity - should stress preventive rather than corrective maintenance. As a matter of fact, proper preventive maintenance will eliminate more than fifty per cent of the routine corrective maintenance on all fire control materiel.

Mounts and Quadrants

All mounts and quadrants are classified as "sighting equipment" in the ordnance catalogue. All are attached directly to the gun or carriage, either permanently or as required, and consequently are more often referred to as "on-carriage" fire control equipment.

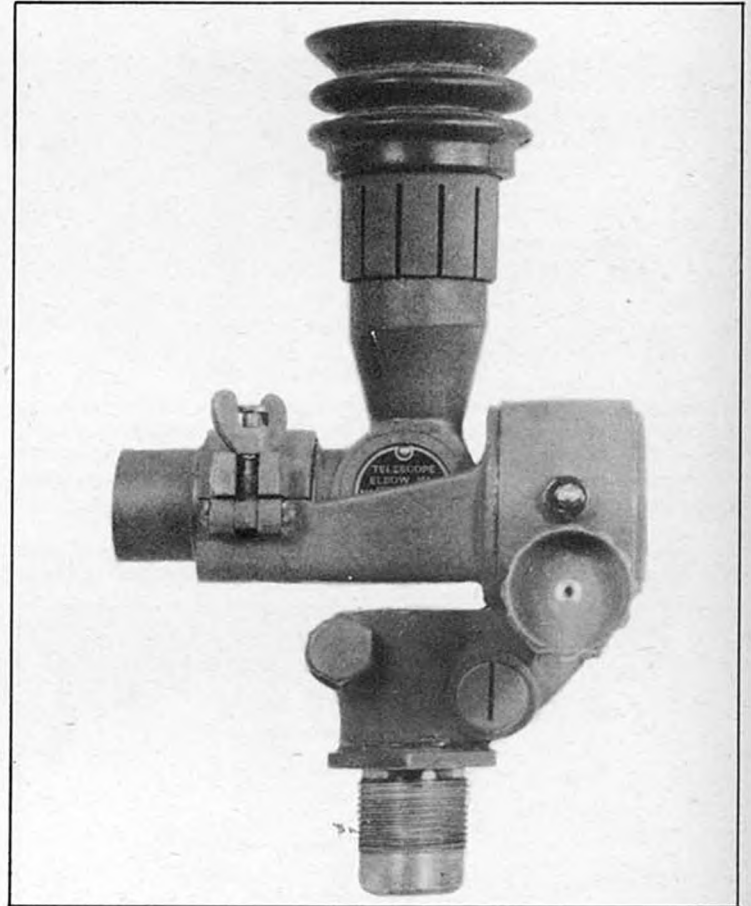


Fig. 19. -- Elbow Telescope, M14, with Mount, M23.

A mount, when an individual component of sighting equipment, usually accompanies elbow and panoramic telescopes to permit these sighting instruments to be adapted to a particular weapon in a certain manner or a predetermined position. There are innumerable models in existence, far too many to be enumerated in detail here. Practically every telescope of the elbow or panoramic type used for sighting purposes has an individual mount, which is a separate component within itself, and is treated individually in reference texts. However, some models exist which are common to two or more instruments.

Some mounts consist of nothing more than a simple bracket permitting a sighting telescope (either panoramic or elbow) to be mounted in a certain relationship or angle in relation to the bore of the weapon it accompanies. Others, especially the more recent models for artillery of various calibers, are of the azimuth compensating type, automatically applying the necessary azimuth correction for trunnion cant. One mount of this type is the Mount, M22 used with the 75mm gun carriage M2A3.

Mounts, as described above, contain no optical components, and maintenance is a comparatively simple problem. They are ruggedly constructed, and defects bringing them into the shop for maintenance will usually be such as to require complete replacement.

Individual and separate mounts are usually provided with (1) elbow telescopes, when provided for direct fire with artillery weapons, and (2) panoramic telescopes and sights. Straight tube telescopes for sighting are always attached directly to the weapon, (which seldom exceeds 37mm in caliber for this type of sighting equipment), in such a manner as to have the line of sight parallel to the axis of the bore. Some

types of sighting materiel, (such as the mortar sights M4, M2 and M2A3), are attached to their weapons by direct bracketing through use of a dove-tailed slot.

There is one important precaution to be observed in all handling and servicing of mounts. This is to keep the bearing surfaces, lugs or

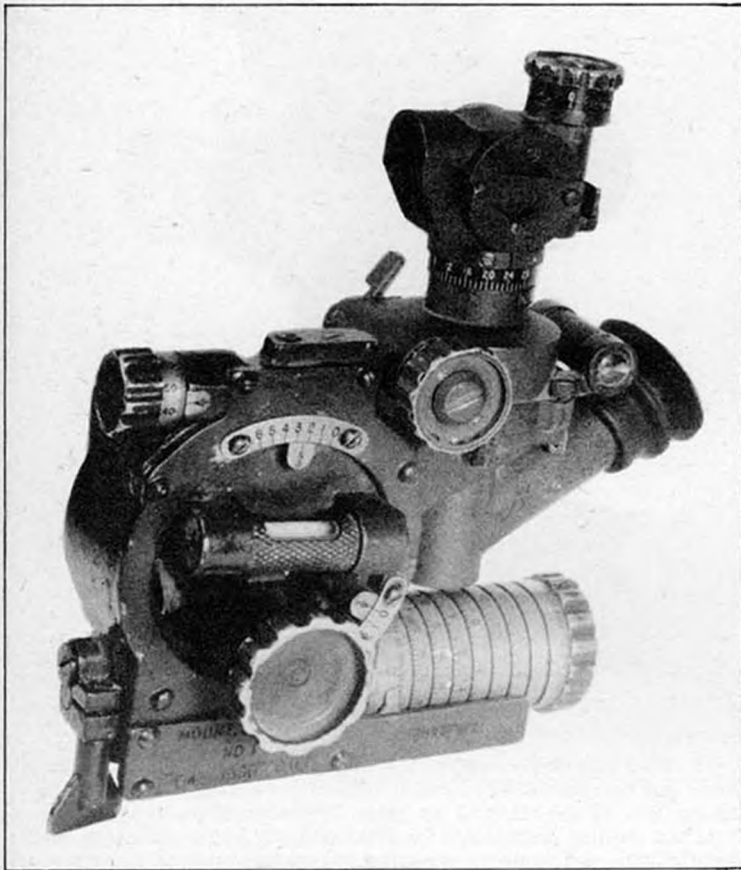


Fig. 20. -- Panoramic Telescope, M2, as used with Mount, M3.

rings, free of dirt, dust, grit, burrs, dents, etc. Every effort should be made to prevent damage of this type.

The mounts used to adapt fire control instruments to their tripods are usually considered as an integral part of the major item, and have not been considered in the foregoing discussion.

A range quadrant is a mechanical device attached to a gun carriage, by which the gun is laid in quadrant elevation. These devices may be used for either direct or indirect fire.

The range quadrant M3 (see Figure 22) is typical of the group as far as general construction is considered. As an illustration of the application of this type of materiel there are three possible methods which may be employed in the use of the M3 range quadrant:

- (1) Quadrant elevation may be set in mils by using the elevation scale and micrometer.
- (2) Quadrant elevation may be set in mils by combining angle of site in mils and elevation in mils.
- (3) Quadrant elevation may be set by combining angle of site in mils and range in yards.

Model numbers of range quadrants for artillery vary with the caliber and model of weapon. Many types and models exist for specific carriages.

An illustration of the application and scope of sighting equipment for a single weapon to include a mount and quadrant, is illustrated below:

The 105mm howitzer carriage, M2, sighting equipment consists

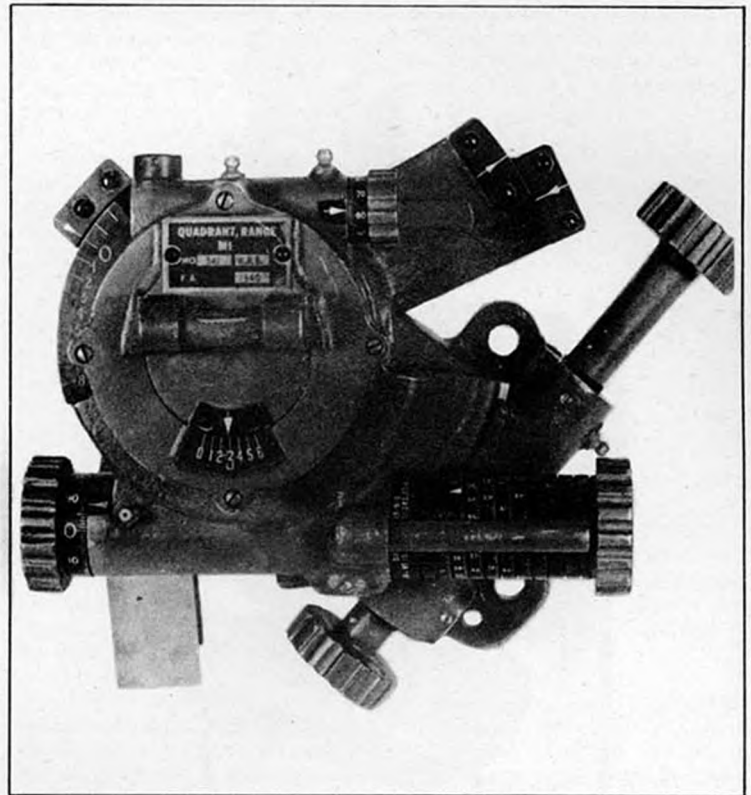


Fig. 21. -- Range Quadrant, M1.

of (1) A mount, telescope, M21, for use with either the panoramic telescope, M5A3 or M12A2, and (2) a range quadrant; M4. This is the indirect fire setup. A mount, telescope, M23, and Elbow Telescope, M16, are used for direct fire, together with the range quadrant, M4, which is also used.

The panoramic telescope, M5A2, as used in the mount, M21, is used to lay off angles of deflection or azimuth, i.e., to point the gun in

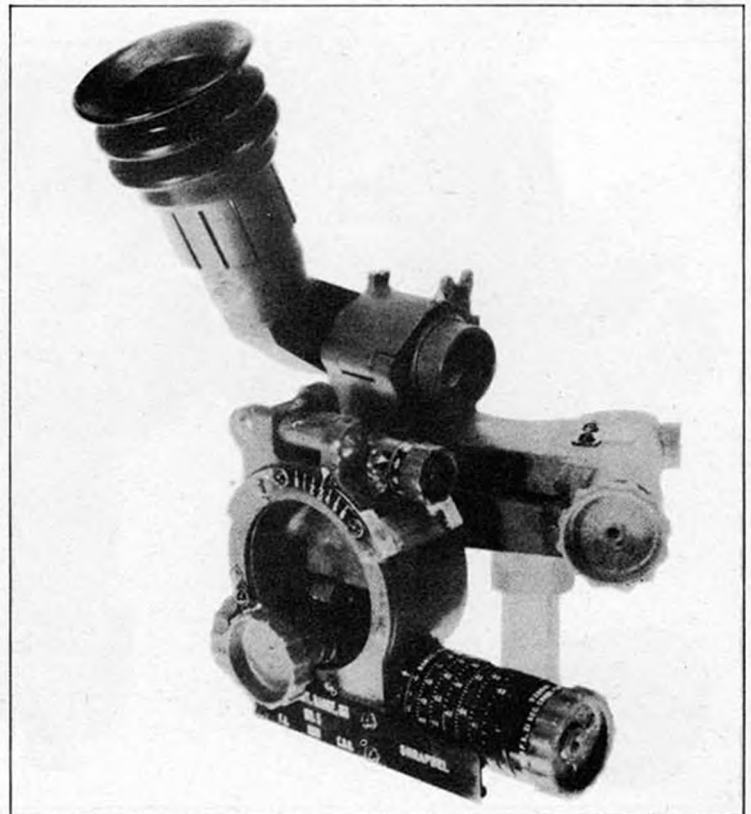


Fig. 22. -- Range Quadrant, M3, with Elbow Telescope, M5.

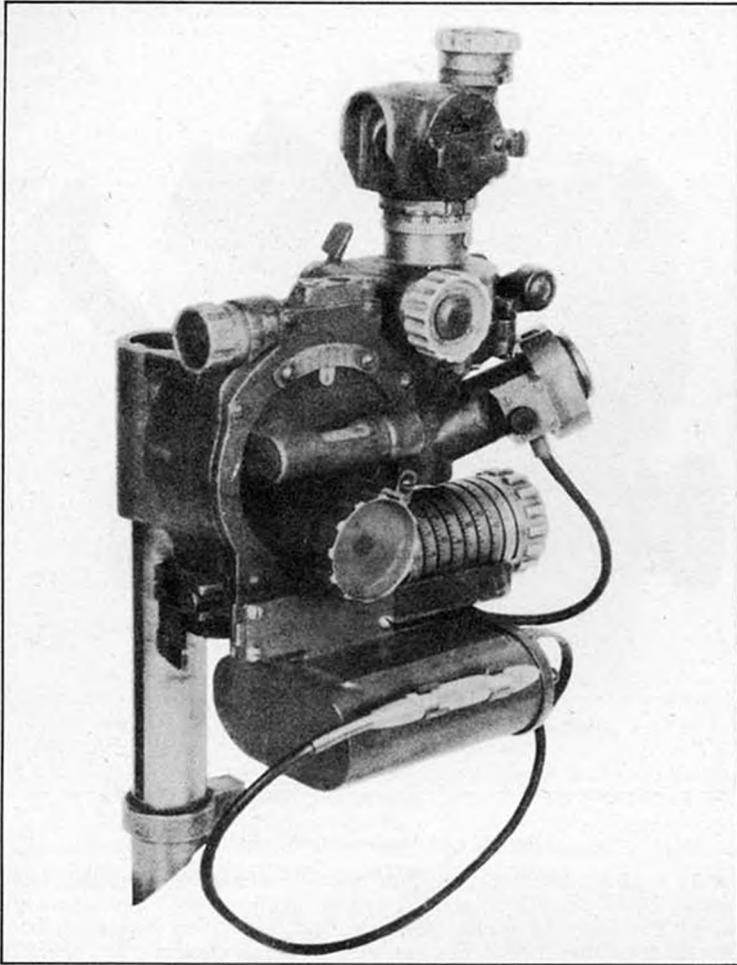


Fig. 23. -- Mount, Telescope, M3, with Instrument Light.

direction. The elbow telescope, for direct fire, is used for close or rapidly moving targets. The range quadrant, M4, is utilized for both direct and indirect fire.

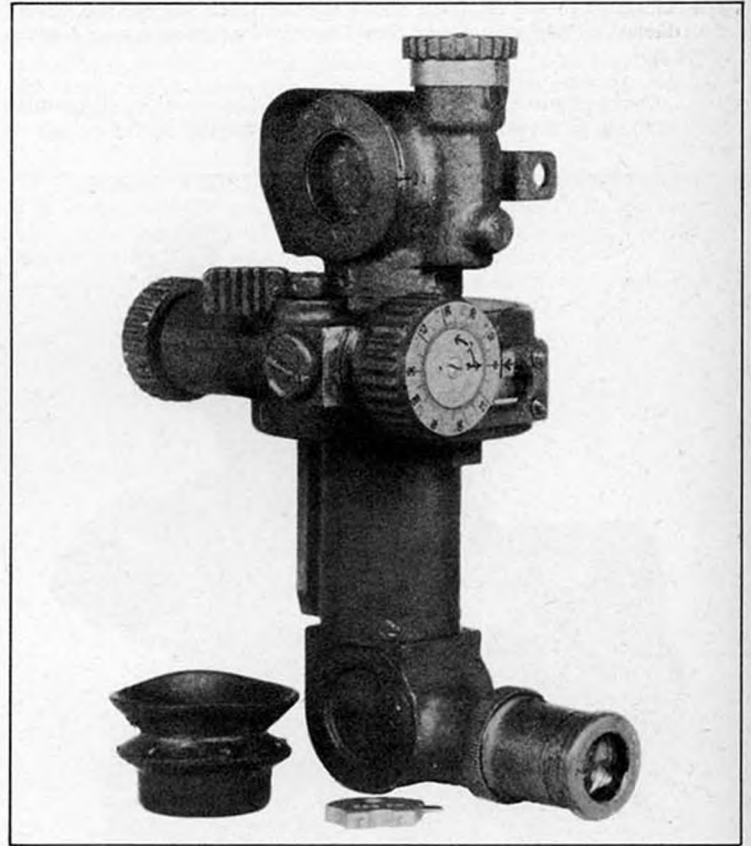


Fig. 24. -- Panoramic Telescope, M6.

As a further illustration, the range quadrant, M1, is attached to the 75mm gun carriage M2A2 in such a manner that any motion in elevation of the gun will be indicated by an index. This range quadrant includes a level and leveling mechanism for establishing a horizontal datum plane, angle of site, and angle of elevation mechanisms, which introduce and add together their respective elements of firing data, a range drum whereby range settings may be made in lieu of angle of elevation, and a pair of indices to indicate actual and computed gun positions. Graduations on the range drum are for the ammunition to be used.

The maintenance of range quadrants includes the elimination of backlash, end thrust, and lost motion in worm and gear mechanisms, scale filling, replacing of components, replacement of broken level vials, lubrication, and adjustments where necessary for accuracy. No optical components are involved. Appropriate and adequate reference material exists relative to these operations.

It is obvious that in the space available a complete list of mounts and quadrants, and instruments of a similar or related nature, is impossible. If further information is desired, reference to published War Department technical manuals is advised.

The above discussion does not include such instruments as gunner's quadrants, quadrant sights, mortar sights, and similar instruments. These will be treated under a separate classification.

Panoramic Telescopes

Panoramic telescopes were developed for indirect fire, when the range of artillery increased to the point where targets were no longer visible. These instruments are used in conjunction with artillery of all calibers as sighting equipment for laying the weapon in azimuth.

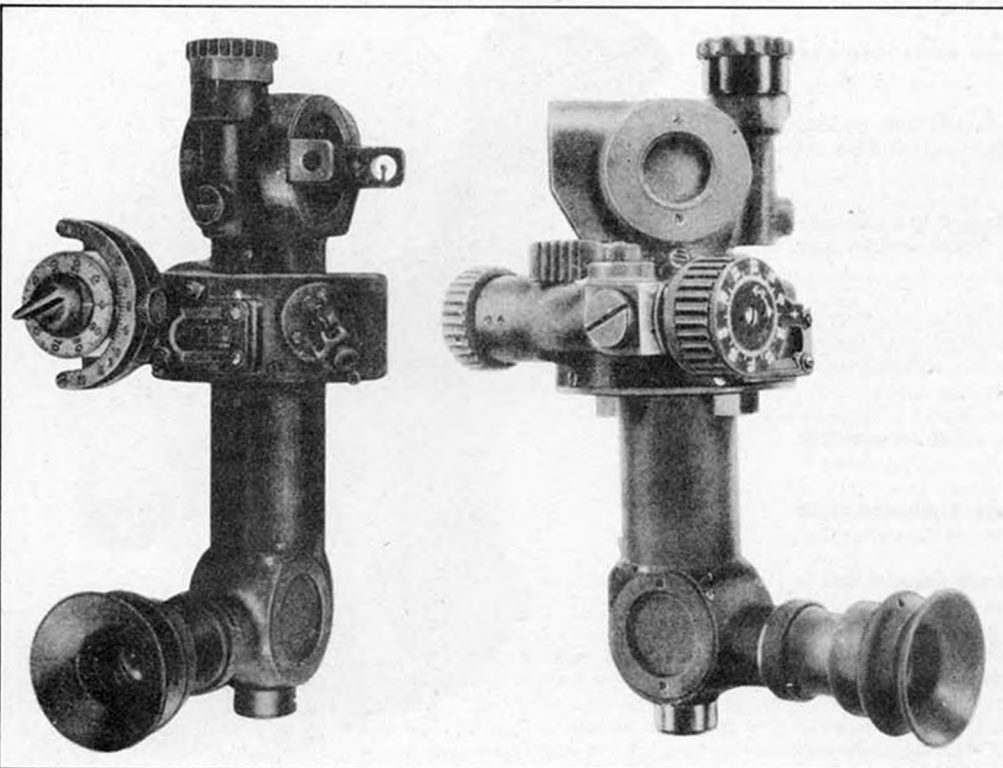


Fig. 25. -- Left: Panoramic Telescope, M4. Right: Panoramic Telescope, M5A3, M5A4, M5A5, M5A6.

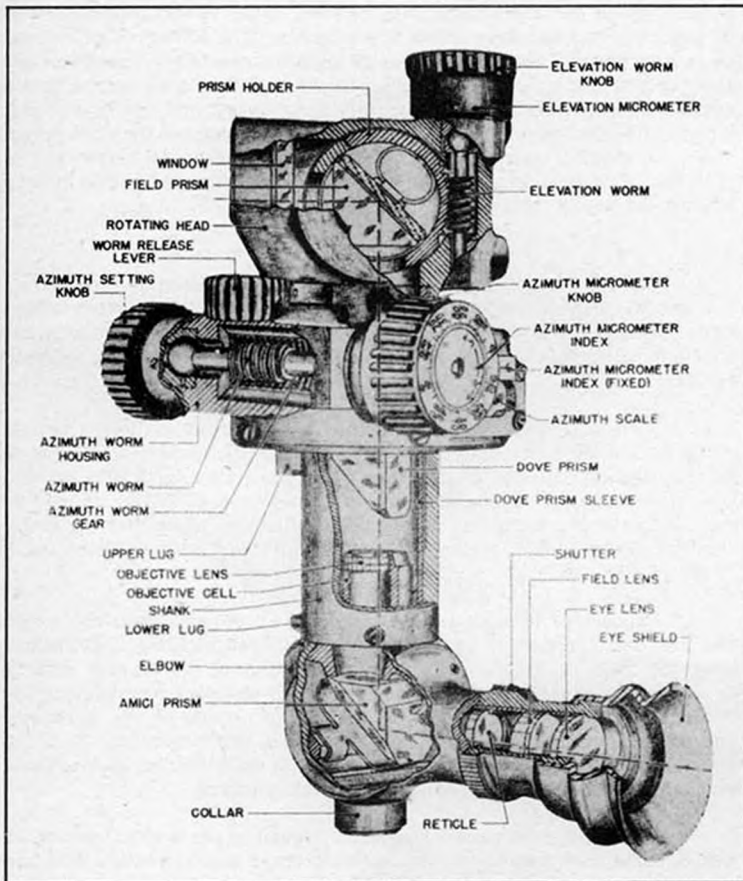


Fig. 26. -- Arrangement of Internal Parts, Panoramic Telescope.

The characteristic feature of the panoramic telescope is the provision of motions for directing the line of sight through any predetermined angle in an horizontal plane. In addition, the line of sight may be raised or lowered, within certain limits, to keep the target or reference point in the field of view.

A panoramic telescope is a vertical telescope of the periscopic type, with an optical system of reflecting prisms and lenses so arranged that an object in any horizontal direction can be viewed through a fixed eyepiece.

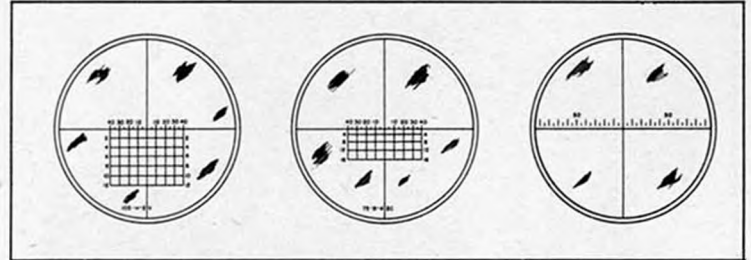


Fig. 27. -- Reticles for Panoramic Telescopes.

There are many types of panoramic telescopes in service; some of world war vintage, and many of fairly recent design. All are substantially similar, the commonest variations from normal design being the reticle pattern and method of mounting.

The models in current use include the following: Panoramic telescopes, M1917M1, M2A1, M3A1, M4, M5A2, M5A3, M5A4, M5A5, M5A6, M6, (see Figure 24); M1, and some models of the new M12 series. All are graduated in mils with the exception of the M3A1, which is graduated in degrees.

Panoramic telescopes are usually four power instruments, of the fixed focus type, periscopic in shape, and employing an amici prism erecting prism. The field of view is always large, usually 10 degrees, to facilitate rapid laying.

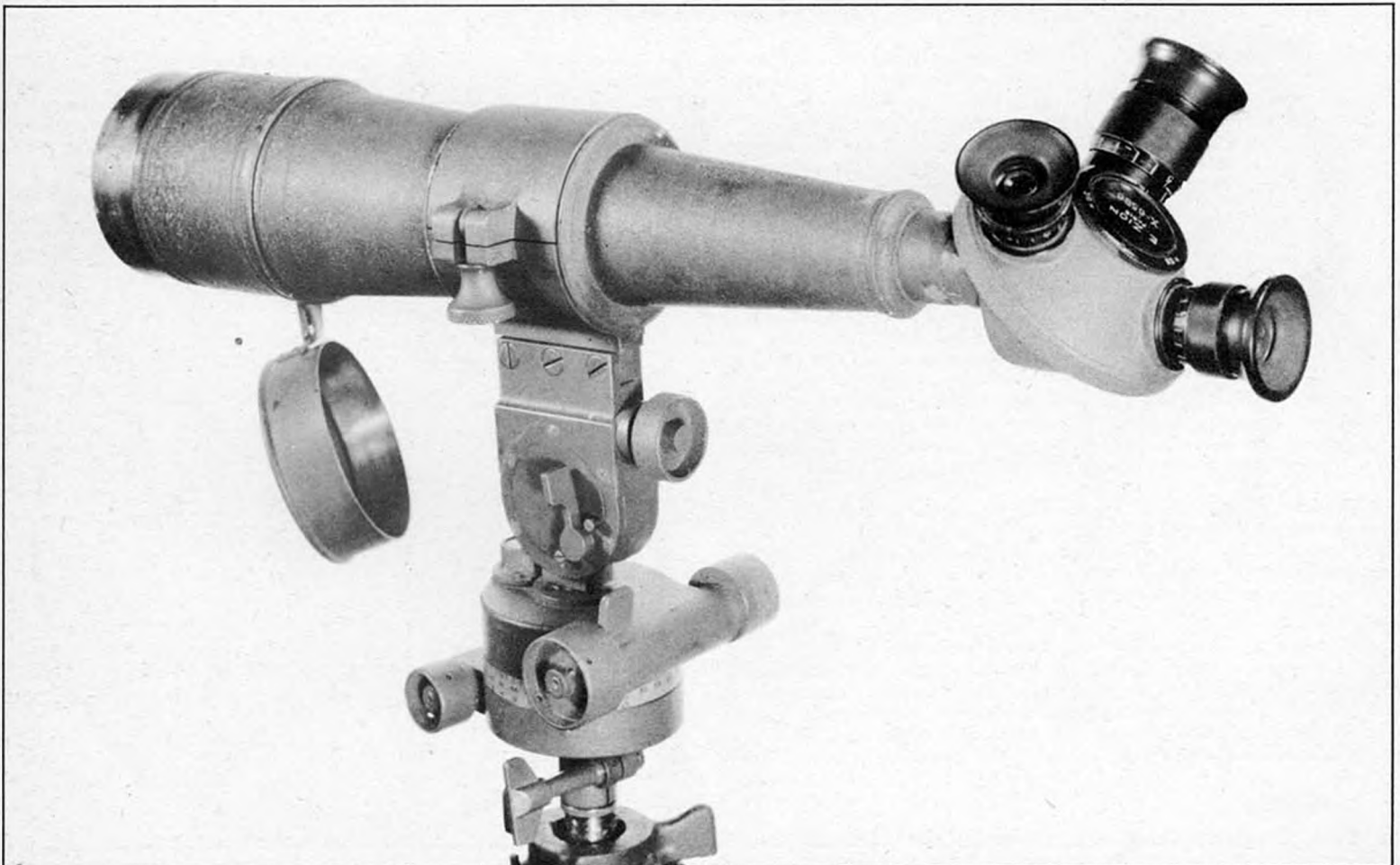


Fig. 28. -- Observation Telescope, M1917.



Fig. 29. -- Telescopic Sight, M1.

The arrangement of internal optical elements, which is practically standard for all models, is shown in Figure 26. The objective lens, and parts below the objective lens, form a simple right angle (elbow) tele-

scope. These parts are fixed with relation to the telescope shank. The 90 degree prism and dove prism are movable. The 90 degree prism can be rotated to raise or lower the line of sight and can be traversed through any desired angle. The dove prism is geared to the 90 degree prism with its relation fixed initially so that the image seen by the eye is vertical. When the 90 degree prism is traversed, the gear rotates the dove prism about its vertical axis at half the angular rate of the 90 degree prism rotation. This maintains the necessary relationship of the two prisms to keep the image vertical.

The M5 series of panoramic telescopes will soon be replaced by the new M12 series for artillery of all calibers. The new series varies little optically from the older models, but mechanically is much more efficient. Reticles have been redesigned with new patterns for better results.

Panoramic telescopes are subject to numerous malfunctions; all of the optical defects common to straight tube telescopes; and many of the mechanical defects common to F-group materiel of this nature. Qualified ordnance personnel only should attempt adjustments and repairs. However, there are several adjustments permitted the using service, limitations of which are outlined in instruction guide manuals (TM's of 2000 series).

Panoramic telescopes are in use by all the armies of the world and are the oldest and most commonly employed sighting instruments used for indirect fire. A complete description of all current models provided for American military use and comprehensive maintenance instructions will be found in TM 9-1583. This is one of the most excellently illustrated TM's published, and well worth reading. It is invaluable to the instrument repairman, and is an ordnance maintenance manual published as a field handbook for this purpose.

Additional reference material in regard to panoramic telescopes will be found in the sighting equipment chapters of those technical manuals which deal collectively or individually with various artillery weapons.

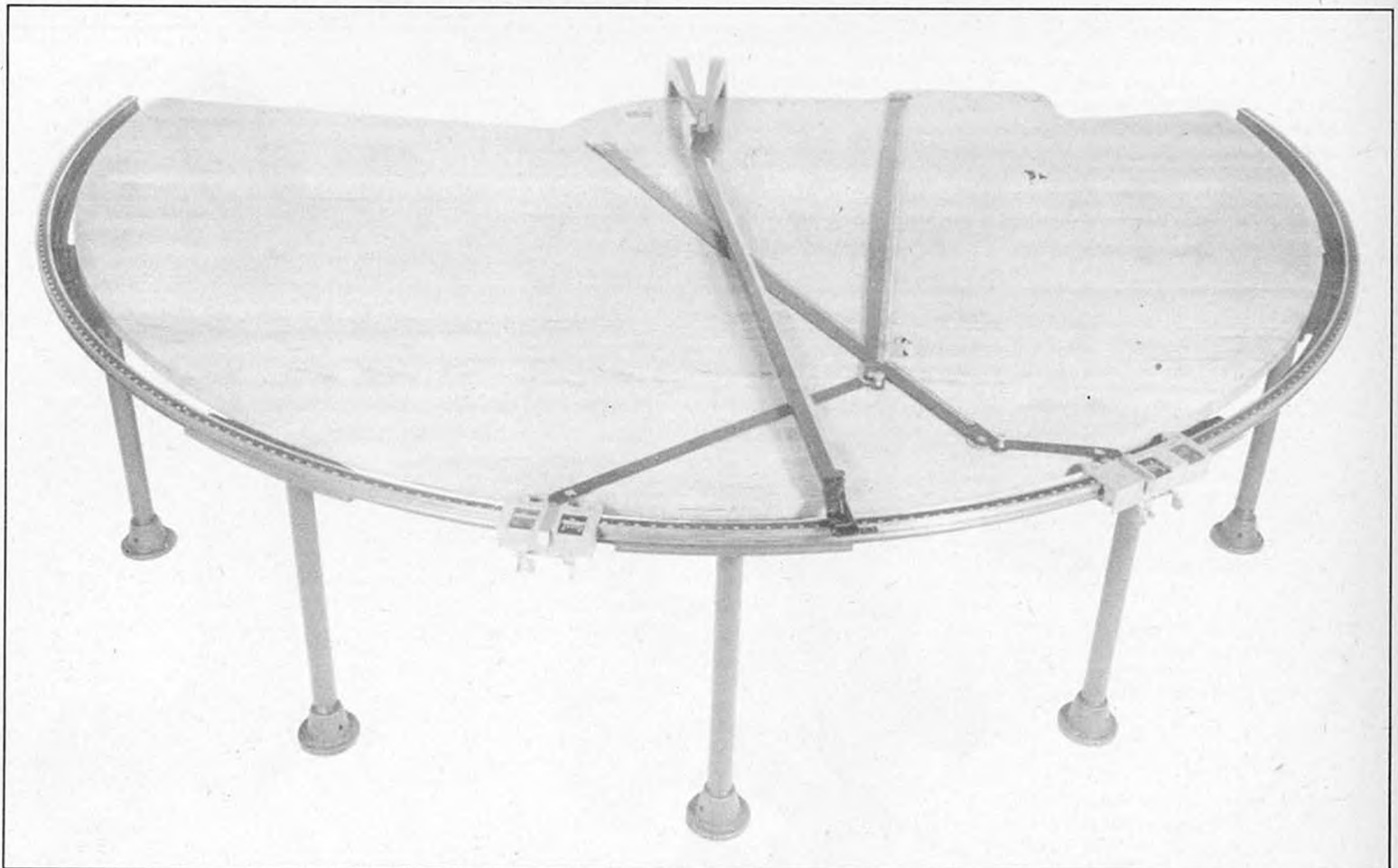


Fig. 30. -- Plotting Board, M3.

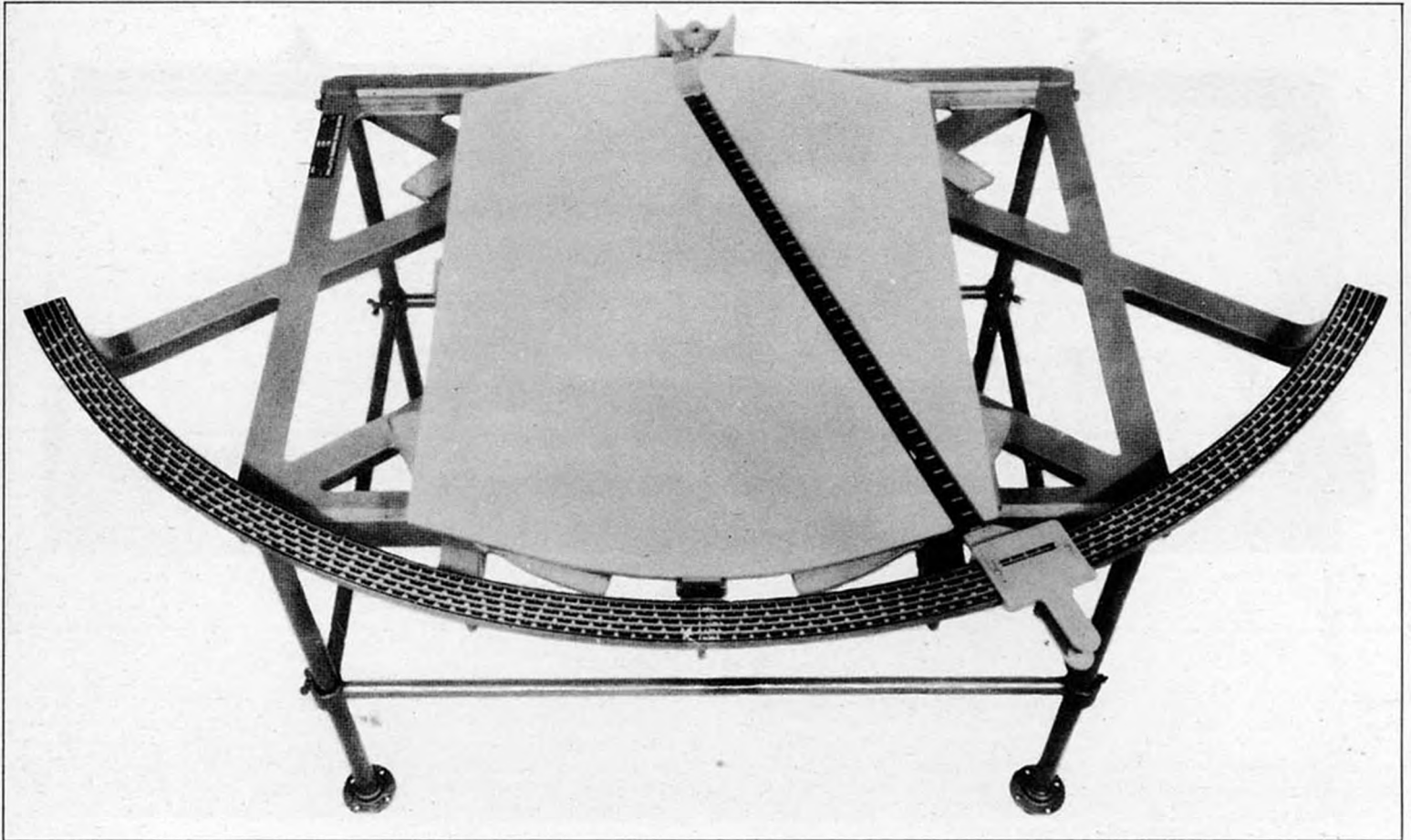


Fig. 31. -- Sound Range Plotting Board.

At this point it might be well to point out that, from the military viewpoint, all telescopic instruments are divisible into three classes. (1) Straight tube telescopes; (2) Elbow telescopes; and (3) Panoramic telescopes.

Straight tube telescopes, as has been seen, are used for (1) sighting instruments, (2) occasionally as observation instruments, though

stereobinocular instruments are better for this purpose, and (3) as components of other instruments.

Elbow telescopes are used for (1) tracking instruments in elevation and azimuth, (2) sighting instruments for direct fire with artillery, (3) spotting instruments, (4) observation instruments under certain conditions, usually for AA work, and (5) as components of other instruments.

Panoramic telescopes are used only as sighting equipment for certain weapons.

It might be interesting to mention a straight tube telescope, used on a tripod, which is used for observation purposes. This is the observation telescope, M1917. (See Figure 28.) It has provisions, as a secondary function, for azimuth and site measurements. It is of particular interest because of the high powers employed. It has a variable power eyepiece which allows magnifications of 15, 23, and 30 power. A most interesting effect is achieved by looking through the wrong end of this instrument at a fairly distant target. Minifications, rather than magnifications, of 15, 23, and 30 are obtained with most curious visual results.

The telescopic sight, M1 (see Figure 29), does not fit readily into any of the classifications being discussed. It is a sight of the periscopic type used with the Browning machine gun, cal. .50, M2. Due to its physical appearance it may easily be classified with the panoramic group, although technically speaking, it is not a true panoramic telescope.

It is used as an aiming device for either direct or indirect fire. The necessary elevation and deflection mechanisms are provided. It is 3.25 power and has a field of view of 12 degrees. The M1 telescopic sight is locked directly to the gun, and is removed when not in use. It is a rather delicately constructed instrument, and subject to numerous malfunctions which are easily induced by carelessness in use and handling.

For direct fire quadrant elevation is set in mils or ranges in yards. Deflection is added and the gun is moved (in elevation or depression, and azimuth) until the point of the reticle is on the target. Ob-

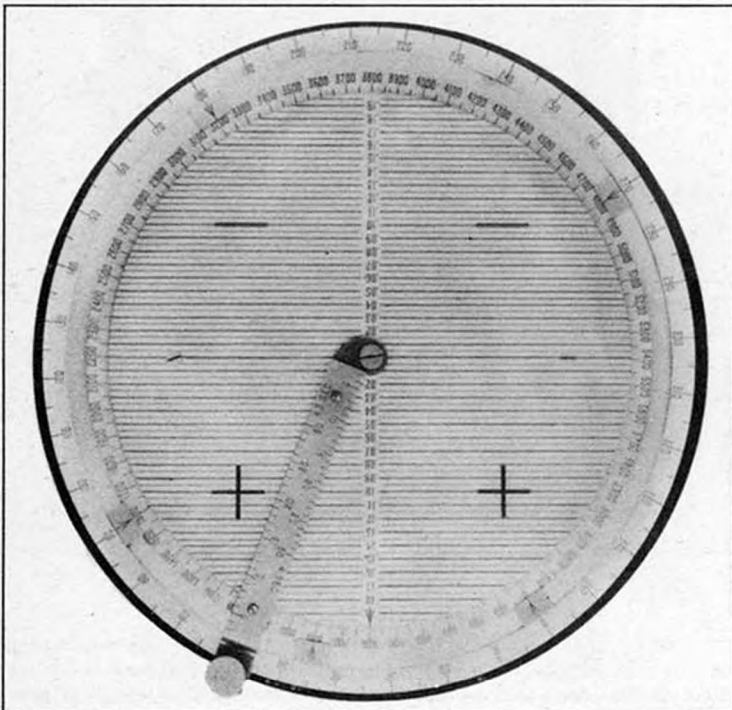


Fig. 32. -- Sound Range Wind Corrector.

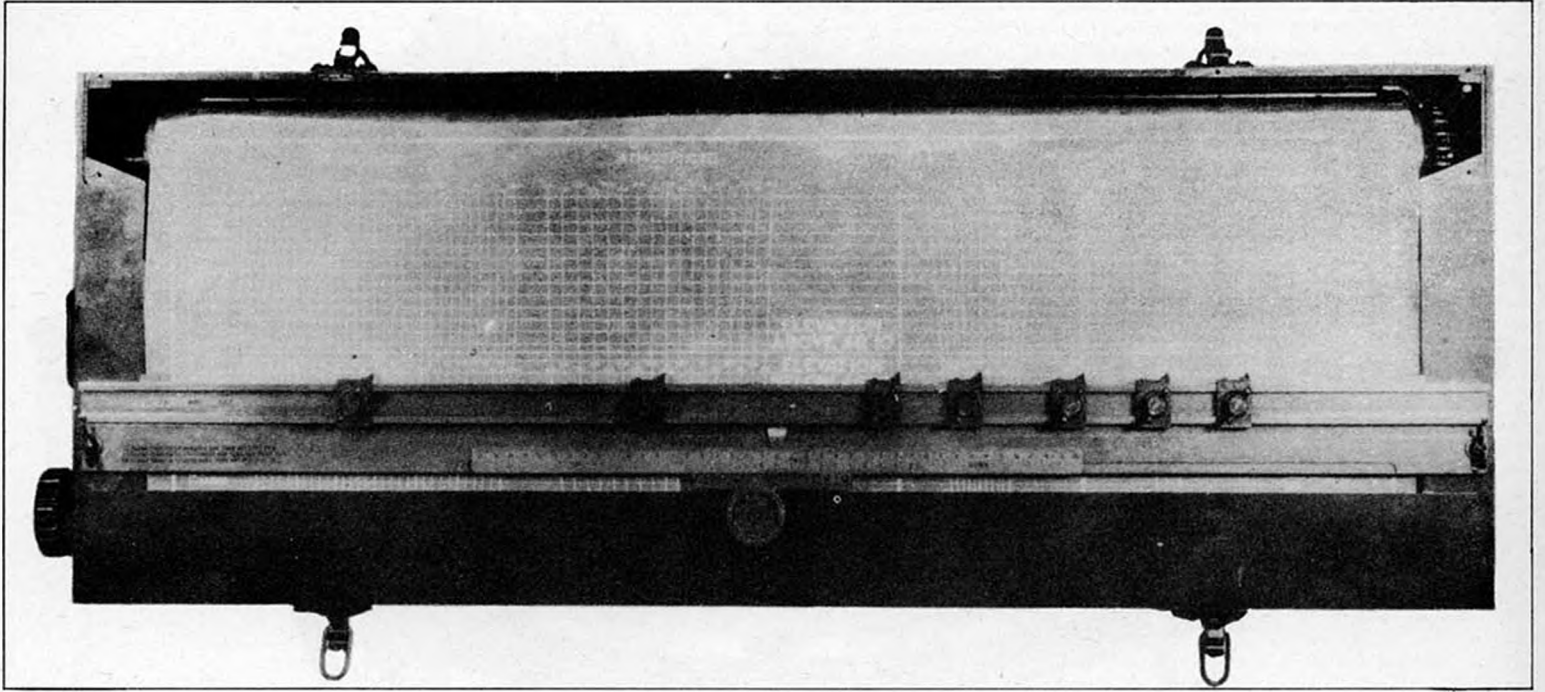


Fig. 33. -- Range Correction Board.

servation of fire may necessitate subsequent correction for lateral or range deviations of bursts.

The procedure for indirect fire is substantially similar, except that an aiming or reference point supplants the direct target.

Computing and Plotting Devices

The term, "computing and plotting devices" could be construed to include eighty percent of all F-Group materiel. As discussed herein, however, the classification is narrowed to include only the non-optical fire control instruments which fall readily into the sub-classifications below. The descriptions given are general to the extreme, since it is obvious that a detailed analysis of these instruments would require a text of encyclopaedic dimensions.

The computing and plotting devices peculiar to the antiaircraft fire control system have been ignored here entirely, and are treated separately in another article in this issue.

Most of the information below has been extracted and summarized from a Frankford Arsenal inspection manual.

Plotting boards and supplementary equipment, including deflection, correction, spotting and fire adjustment boards, are instruments for use in reducing the data obtained by base line and observation stations so that the corrected azimuth and range from the battery of guns to the target, or, in the case of a moving target, to the set forward point, may be determined. The necessary corrections include those for travel of target, wind, drift, atmospheric density, and variations in muzzle velocity.

The plotting board for guns is a board on which the range and position, or, in the case of a moving target, the course of the target is plotted. See Figure 30.

Sound range plotting boards are devices for use in determining the terrestrial location of a sound source by plotting the sound ranging observations of a group of standard microphone sub-base stations. The microphones are located on standard curved or straight line bases. A separate platen is furnished for each base line setup of stations. See Figure 31.

In operation, the carriage (which is movable beneath the range arm) on which has been placed a map or grid, is positioned to successive midpoint centers and the movable end of the range arm is set successively, on the time scale, to the observed time difference for each midpoint position. A line is drawn on the map or grid at each setting of the range arm. The point of intersection of all lines gives the sound source or target location.

The sound ranging wind corrector is an instrument used in conjunction with the sound ranging plotting board. It is used to determine the amount of correction necessary to the observed time interval of sound travel to two or more separated sound recording stations, due to velocity and azimuth of wind. The instrument is disc shaped and consists of an azimuth ring, a wind arm, and a correction disc. See Figure 32.

In operation the wind arm is set to azimuth of wind on the azimuth scale and clamped thereto. The azimuth scale is then rotated to the azimuth of the recording station and the correction is read from the correction scale at the particular graduation of the wind arm which represents the velocity of the wind of the moment.

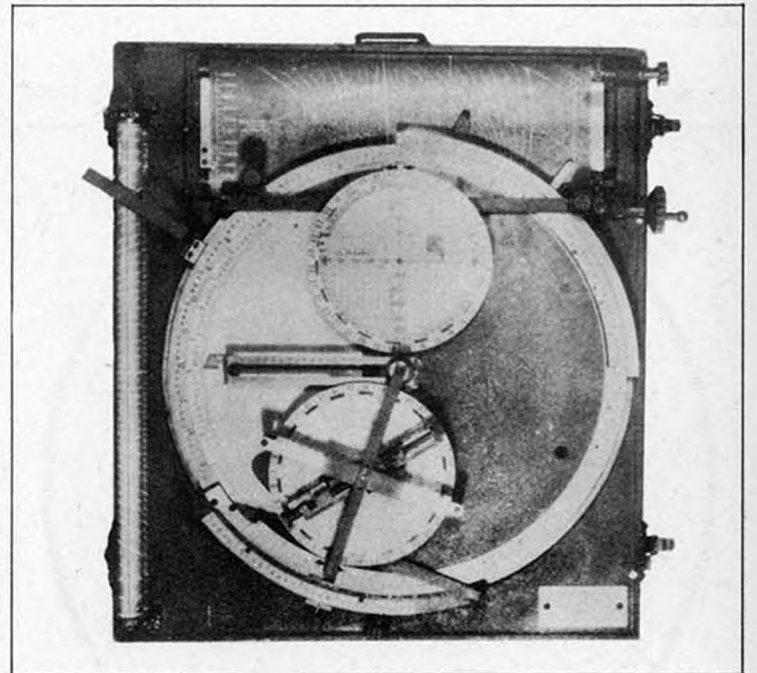


Fig. 34. -- Universal Deflection Board, M1.

The range correction board is an instrument for determining the amount of correction necessary to the plotted range to compensate for the effect on the range of the projectile due to variation in weight of projectile, density of atmosphere, rotation of the earth, drift due to difference in wind, difference in tide, etc. See Figure 33.

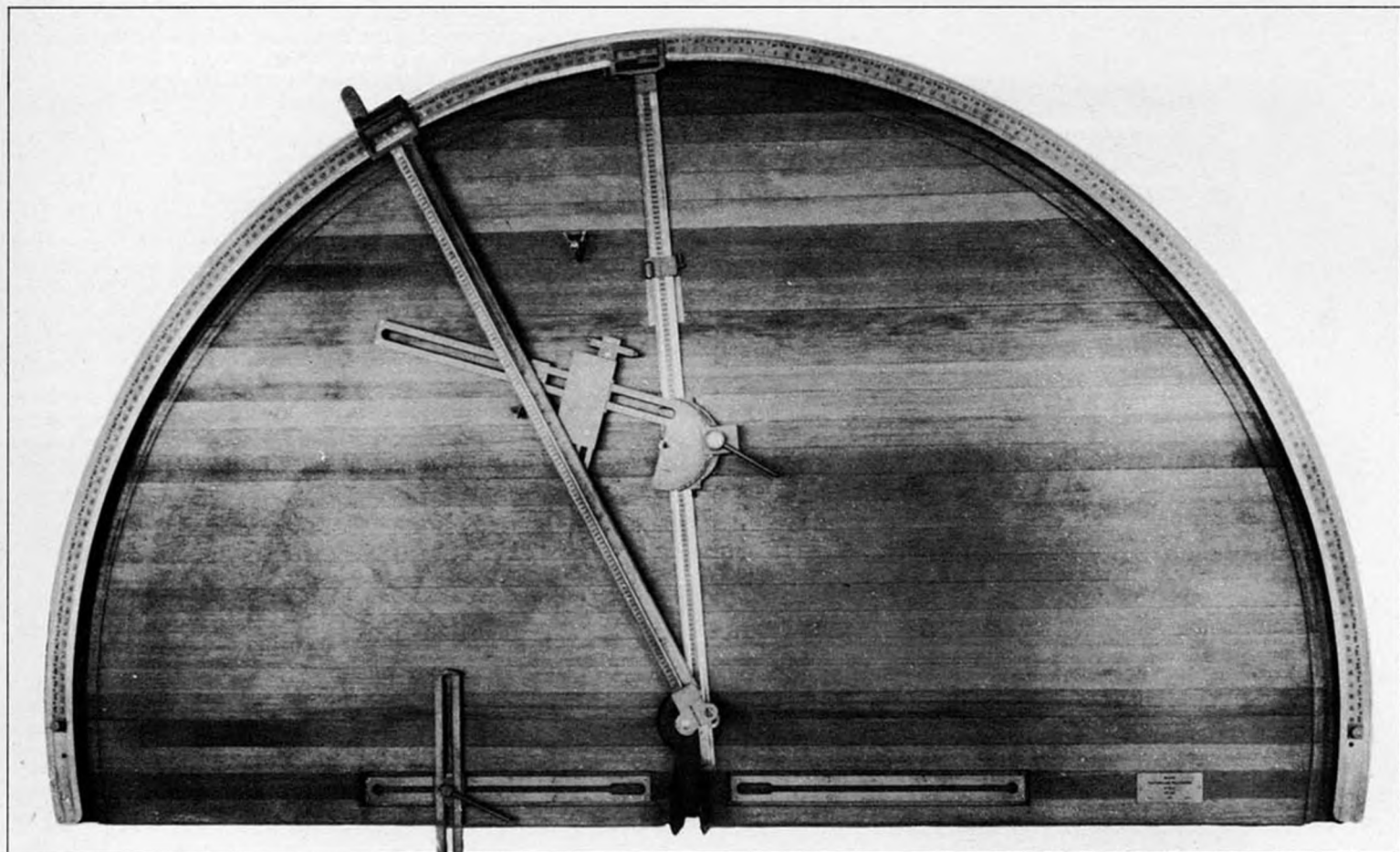


Fig. 35. -- Plotting and Relocating Board, M1923.

The deflection board is an instrument for correcting the plotted or observed azimuth of a gun, by mechanical computation, for effects of wind, drift, earth rotation, and angular travel of target during flight of projectile. See Figure 34.

The principal devices of the universal deflection board are the corrected azimuth scale mechanism, the wind component indicator mechanism, the wind drift and rotation of earth charts mechanism, the angular travel mechanism, and the gun displacement correction mechanism.

The corrected azimuth scale mechanism contains the main azimuth scale, which registers the least readings in .05 degrees and unit

degrees, up to ten, of the corrected azimuth reading. Readings higher than ten and in units of ten are read from the azimuth scale of the wind component.

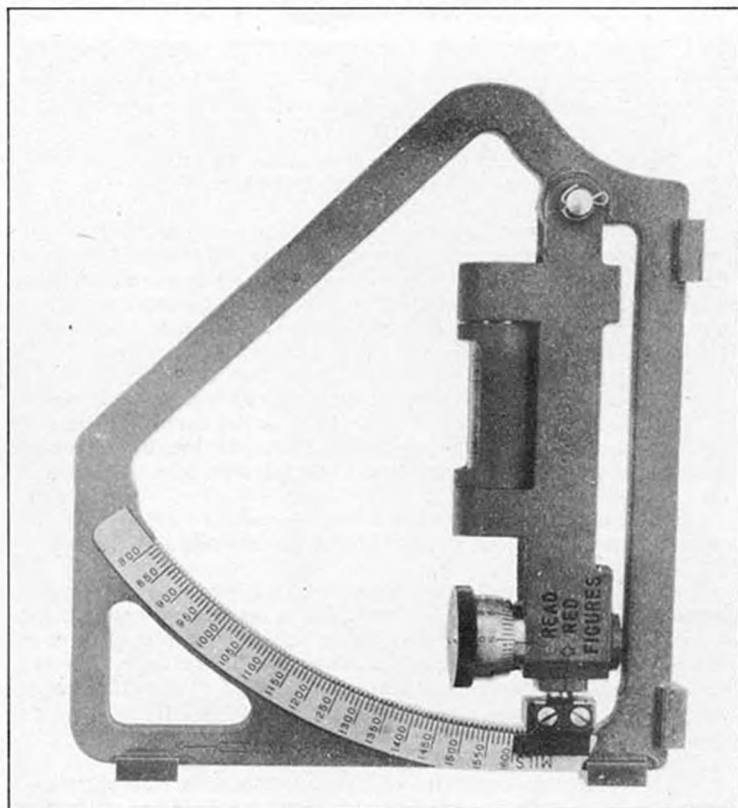
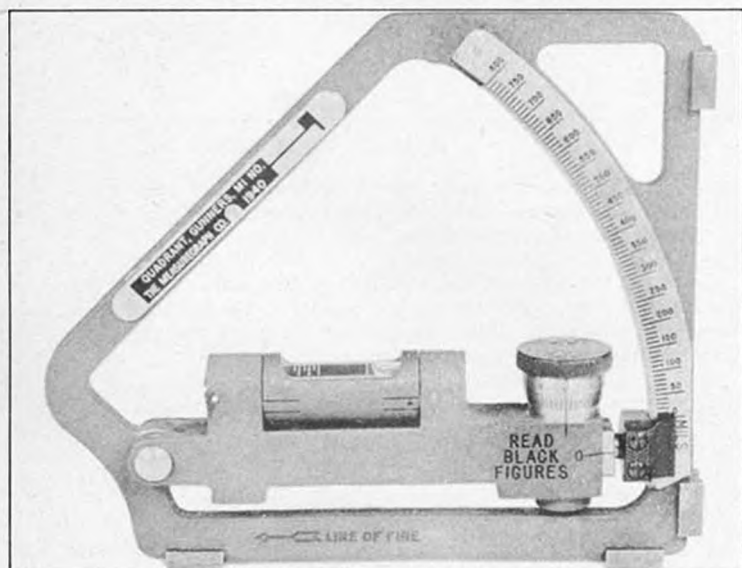


Fig. 36. -- Left: Quadrant, Gunner's, M1, showing 0-800 Mil Scale. Right: Quadrant, Gunner's, M1, showing 800-1600 Mil Scale.

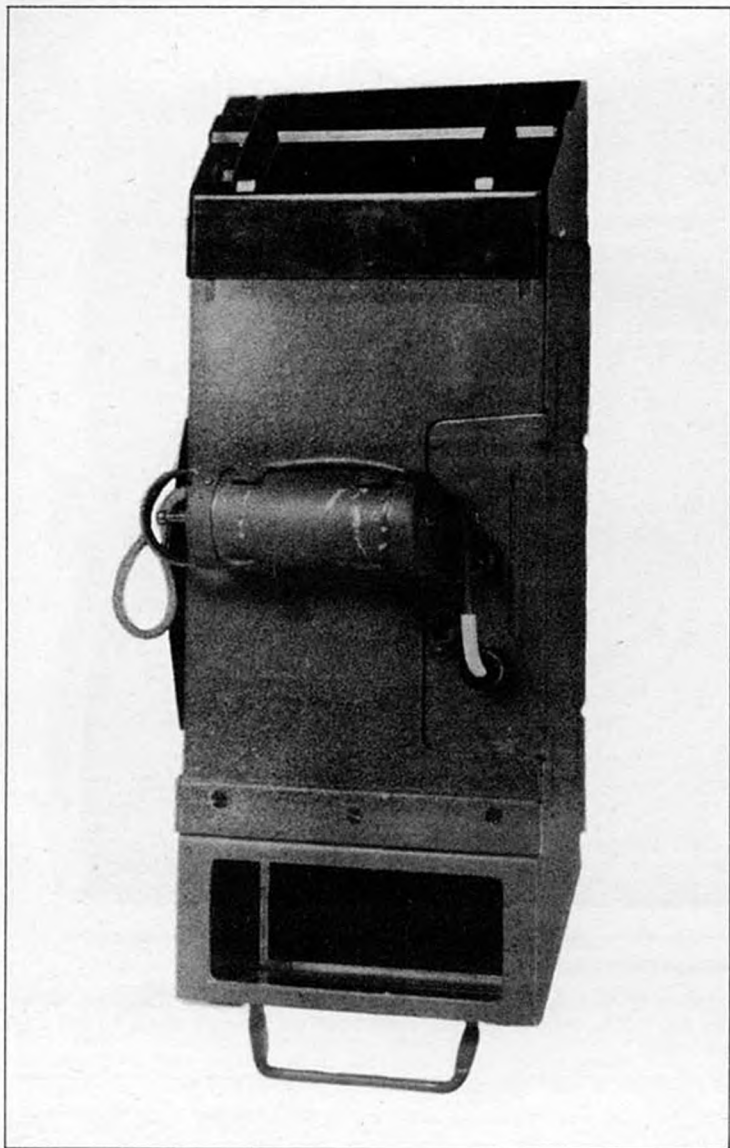


Fig. 37. -- Periscope, M1, with Night Lighting Device attached.

The wind component indicator mechanism determines the proper wind drift curve to be followed on the wind drift chart.

The wind drift and rotation of earth chart mechanism contains curve charts and pointers. When the respective pointers are adjusted to the normal lines of the chart there is no correction added to the azimuth scale, but as the successive pointers are moved to the curves which represent the abnormal condition of the mount the azimuth reading is altered.

The angular travel mechanism determines the correction necessary to the gun azimuth for the travel of the target during the time of flight of the projectile. This correction does not enter into the corrected azimuth of the board but is transmitted to the gun as a separate factor.

The gun displacement correction mechanism determines the corrected azimuth for a gun displaced from the directing point or gun.

The percentage corrector determines the correct range or elevation by combining corrections determined on the range correction and fire adjustment boards with the plotted or known range. In addition to algebraically adding corrections from the range correction and fire adjustment boards, the percentage corrector also, by means of an interpolation device, determines the corrected range for guns firing at intervals other than the usual 30-second period.

The percentage corrector operates on the slide rule principle. Ruled tapes operated by rollers at each end of the body are utilized in combination with fixed and sliding scales and pointers to determine the correct range or elevation.

The fire adjustment board is used for the purpose of graphically plotting a group of shots, of known deviation to determine the center of impact of the group, and to determine the amount of correction in range, necessary to bring the center of impact on the target.

The spotting board is an instrument for converting splash readings of two base line observation stations into factors of longitudinal and lateral deviations of the splash. The splash readings are read from the splash scales of the observation stations telescopes when the crosslines of the telescopes are in coincidence with the target.

Mine prediction rules are of ordinary slide rule construction and are used in conjunction with plotting boards on which the location of mines are laid out to scale. The course of the moving target is plotted on the map of the board. By means of the mine prediction ruler and the plotted points on the map the time required for the target to reach the nearest mine, from the last plotted point, is predicted.

In addition to the instruments discussed above there are many miscellaneous instruments which fall into the classification of computing and plotting devices. These for the most part include a miscellany of

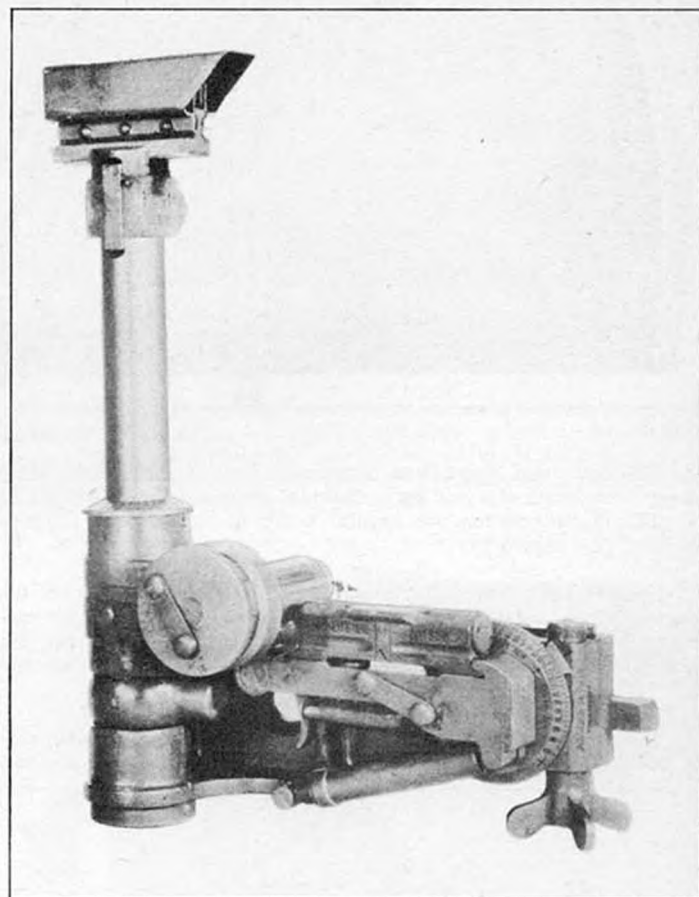


Fig. 38. -- Collimator Sight, M1901.

triangular plotting scales, protractors, range deflection fans, etc. Also, many models of varying construction and date of design may exist in any one classification discussed above.

All of this materiel is classified as fire control equipment, and is utilized, for the most part, by the heavier artillery units, especially seacoast defense units. Maintenance is a function for experts, and should never be attempted by unqualified personnel.

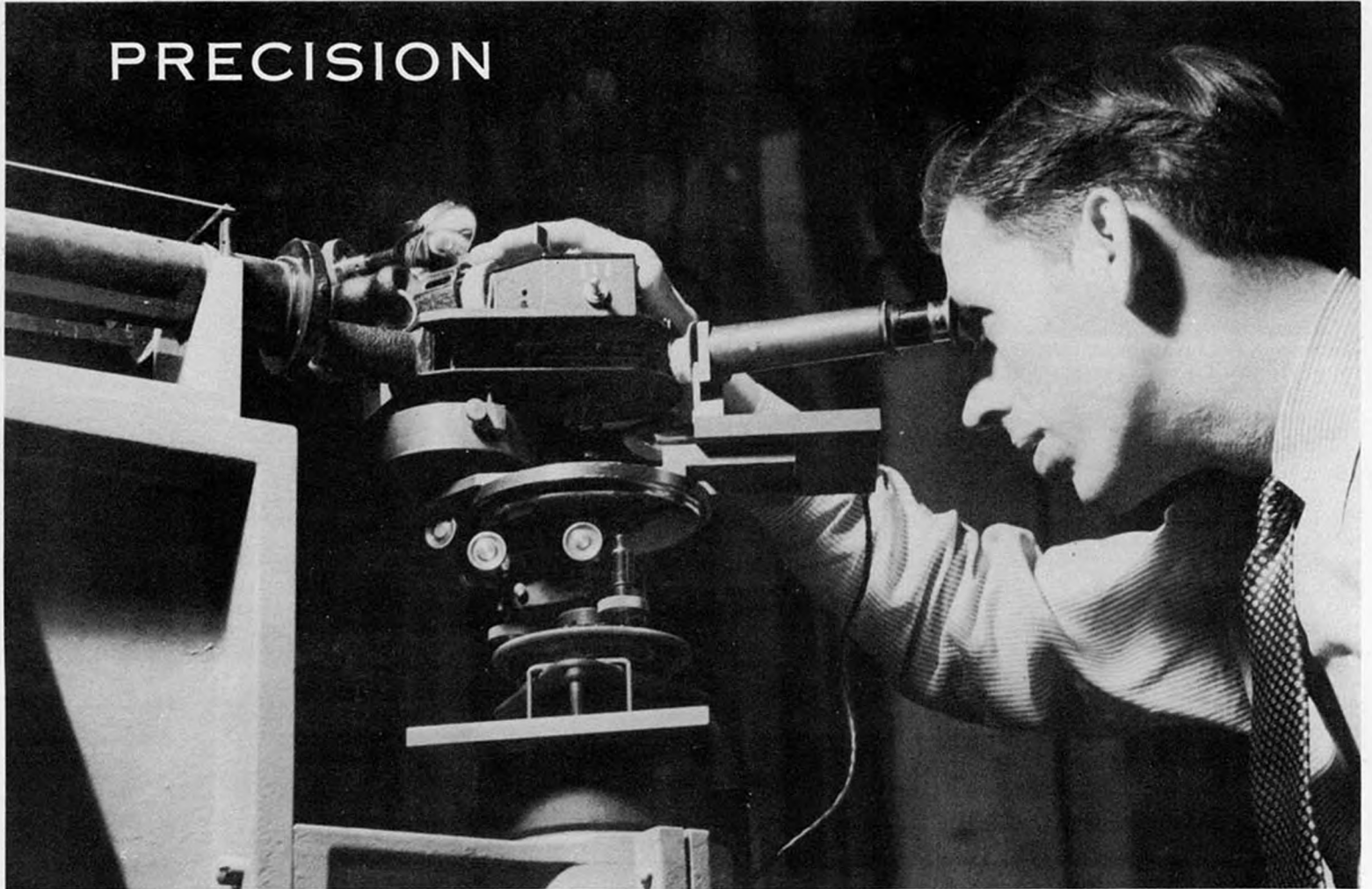
Ordinary care and precautions, and strict adherence to published instructions will keep the materiel in serviceable condition for many years.

Miscellaneous Angle Setting and Measuring Instruments

The gunner's quadrant is used for laying a weapon in elevation, and for leveling the piece during bore sighting operations. The gunner's quadrant, M1, is standard for issue with all field guns and howitzers. See Figure 36.

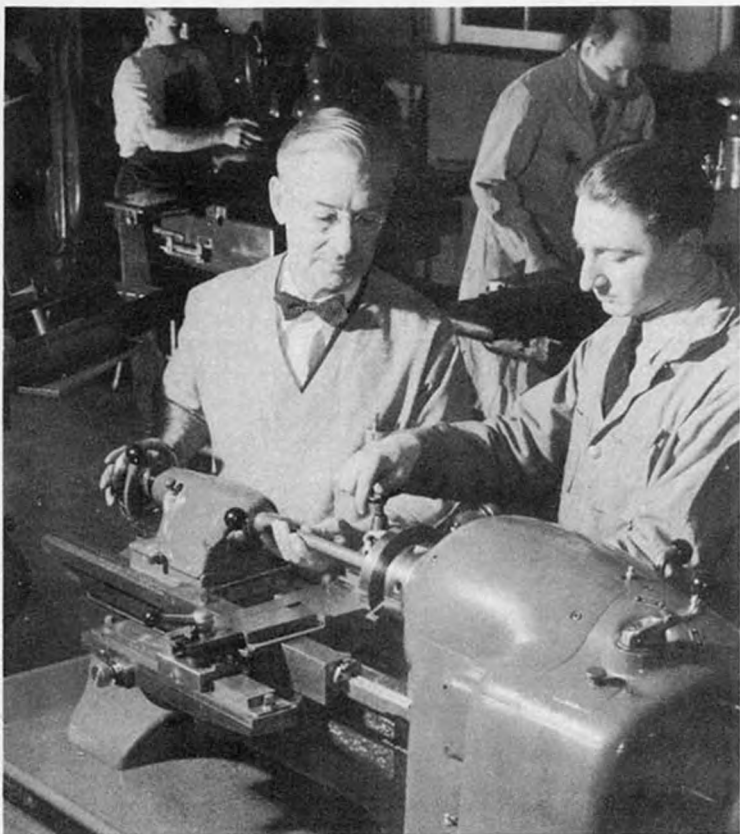
(Continued on page 172)

PRECISION



Above: Inspecting a Bubble Sextant, a precision instrument which provides its own artificial horizon for navigation on the sea or in the air. Below at left: At Mechanics Institute, Rochester, New York, technical school,

young employees learn fundamental machine tool operations from a Bausch and Lomb foreman. Below at right: The stereoscopic trainer schools operators in the proper use of the stereoscopic range finder.



The unprecedented scope of modern warfare and the tendency toward constantly increasing fire power through the development of new automatic weapons and other arms has enormously increased the responsibilities of the instrument section in the field. New weapons necessitate more efficient fire control instruments and sighting equipment. This in turn proportionately increases maintenance operations and complicates the ordnance field problem.

The large number of instruments, accessories and devices that fall into the fire control category of materiel at the present time is sufficient to tax the ingenuity of the most skilled ordnance instrument men. Only careful planning, maximum use of available personnel and facilities and an appreciation of the problems inherent to this type of work by section leaders will result in efficient field performances.

As time goes on it is obvious that the increasing number, and complexity, of fire control instruments will further test the initiative and technical skill of ordnance maintenance units. It is as equally obvious from past records that the Ordnance Department is fully capable of efficiently mastering the problems encountered.

Composition and Duties of the Instrument Section

The instrument section is part of the medium maintenance company. A technical sergeant exercises immediate supervision over the section, coordinating his work with that of the company, and being responsible to the shop officer and company commander.

The instrument section has charge of the maintenance and repair of all fire control materiel, sighting equipment, tripods, accessories and other devices in the F-Group of ordnance materiel. It supplies replacements for unserviceable materiel, and repairs or adjusts such items. It may be called upon to inspect materiel in the hands of troops and to render technical advice to the commanders of units in regard to preventive maintenance operations, storage, cleaning and preservation. It works in close cooperation with other units of its company to render most efficient service. The complete scope of duties and responsibilities, and the training, of the instrument section is covered in detail in TM 9-2602, "The Instrument Repairman, General Information".

With this variety of duties it is important to keep in mind the fact that the "ideal condition" will seldom be encountered in the field. The section will generally accomplish its work under the most trying conditions. This calls for proficiency on the part of all personnel and careful planning and supervision on the part of the noncommissioned officers of the section.

Equipment

The instrument repair truck is the field shop. It is completely equipped with the necessary machine tools, accessories, hand tools, jigs, and fixtures necessary to the operations of the section.

An excellent policy for the instrument section to follow is to supplement this equipment with additional special tools especially required under certain local conditions. It is surprising how complete a set of punches, drifts, jigs, etc., can be made by a competent machinist, in slack periods, from discarded firing pins, old bolts, and other scrap material.

The section leader should encourage enterprise of this sort as well as discussion and suggestions from members of the section as to possible new tools, jigs and fixtures, which may simplify or render more efficient the work of the section. Particularly commendable results and time saving devices should not be kept a secret but passed on to other components and organizations by means of THE ORDNANCE SERGEANT or some other source for the dissemination of technical information.

Personnel

Instrument repairmen are technicians. The nature of their work requires an above average intelligence and skill as well as excellent judgment and an ability to weigh carefully analyses of jobs to be done.

It should be the responsibility of the section leader to see that his personnel are given every opportunity to increase their skill and technical knowledge. This can be done by allocation of work to allow all personnel to familiarize themselves with all types of materiel being serviced. It should be kept in mind that an efficient instrument man is first of all a machinist. All should be able to operate the machine tools available. In

addition all personnel should have a knowledge of the paper and administrative work connected with the operation of the section. They should be thoroughly familiar with all reference material which is pertinent to their work, and every opportunity should be taken to increase the reference texts on hand.

The section leader, and his assistant, should be on the alert for new developments and plan accordingly. New instruments, new methods, and constantly changing regulations, must be absorbed and passed on to the section personnel. The section leader should be thoroughly acquainted with the capabilities of all men of the section, weed out the unfit and inefficient, encourage the efficient, and keep an eye toward possible instrument men throughout the company.

The work done by the section will indicate the efficiency of the section leader. And under the grave conditions of present day life there is no room for inefficiency.

Preventive Maintenance

A large proportion of ordnance instrument maintenance work in the field is due to lack of proper preventive maintenance. This is largely traceable to carelessness in use and handling by troops, the attempts of battery and company mechanics to make repairs and adjustments which are strictly an ordnance function, and an apparent reluctance on the part of using personnel to seek competent technical advice.

It is important that the using troops know to what extent they are permitted to adjust and repair fire control materiel. It is equally important that they know the limitations of their responsibilities as far as lubrication, painting, and sealing goes.

Careless lubrication by the using service may occasion irremediable damage to instruments, while painting done in a careless or inexperienced manner is equally destructive to delicate optical and precision components of fire control materiel.

Proper storage and cleaning cannot be over-emphasized. Indications that this is not being done should be brought to the attention of the units concerned, and courteous suggestions offered as to improvement.

The rendering of competent technical advice is one of the most important phases of preventive maintenance. Advice of this nature is incorporated in the many excellent technical manuals of the 2000 series issued as instruction guides to the using arms. It can be supplemented by practical suggestions on the part of the instrument section to company commanders, supply sergeants and mechanics. It is expected that non-commissioned officers of the ordnance department will offer technical advice in such a manner as to create the most favorable impression and in the most helpful manner. If appropriate literature is available, and can be spared, it may be passed on, or pertinent extracts from it.

In many camps, company and battery artificer schools have been conducted by medium maintenance companies, for the purpose of passing on working instructions to using units, with most gratifying results. These schools must be arranged through command channels, carefully supervised, and so planned as to aim at a single objective, i.e., the preservation of ordnance materiel, so as to have it in the best possible working condition at all times. This naturally results in increased combat efficiency. In any school of this nature, which should not exceed more than two afternoons a week, preventive maintenance should be stressed and driven home.

Inspections.

Inspections are an important part of any preventive maintenance program. They may be periodic, or they may be called as conditions require. It is the duty of the instrument section to conduct all inspections of the materiel they service.

In the carrying out of routine inspections the instructions found in TM 9-2602 will be found exceedingly helpful and insure the most efficient accomplishment. It must be remembered that any inspection should be so planned as to offer a minimum of interference to any training programs being conducted by the using arm.

General spare parts being available and on hand, minor repairs that can be accomplished on the spot will save valuable time, both to the using arm and ordnance. The decision of inspecting parties as to disposition of malfunctioning equipment is extremely important and should



PHOTOS BY ORDNANCE SCHOOL PHOTO SECTION

by V. E. EDSTROM, T. Sgt., Ord. Dept.

The illustrations with this article show the equipment, adaptability and versatility of the Instrument Repair Truck, ML. This truck is equipped and designed as a mobile field shop for the Instrument Section in the field.

be relegated to either the section leader, his assistant, or an experienced member of the section.

Routine inspections should always be conducted with the use of the instrument truck, and emergency inspections in the most expeditious manner.

At the present time, when American troops are preparing for active combat, the inspection of their equipment, prior to moving into the theater of operations, is of primary importance to the success of their mission. Once in combat little time is available for repair and maintenance of any extended nature, and it is the duty of inspecting personnel to be sure that all equipment necessary to combat efficiency is in A-1 working condition.

When inspections are conducted in a unit's area the instrument truck should not be crowded with too many men, tools or spare parts. Check in advance as to what equipment and types will be encountered and plan accordingly. Small field tables may be advantageously taken along in the half-ton emergency repair truck, as well as additional parts. Good use can be made of improvised and portable testing targets and master instruments. This may facilitate adjustments which would otherwise require shop facilities.

Testing targets should be of white oil cloth, if it can be procured. This material will be found much more durable than ordinary target cloth. It may be backed up by plywood of appropriate thickness. Arrangements for truck storage can be quite easily made.

A type of inspection that should never be overlooked is the shop inspection preliminary to adjustment and repair. This may uncover defects which would otherwise have been overlooked. A shop inspection should always be accomplished on all materiel that enters the shop, since in many cases, the using unit is not sure of what is wrong with the equipment.

Adjustment and Repair

All instruments arriving in the section, after a thorough inspection, will be repaired and adjusted to the extent of making them ready for efficient combat duty.



New and unfamiliar instruments should not be disassembled indiscriminately, even by experienced personnel. Rather, forward them to higher echelons of maintenance, and issue a replacement instrument to the using arm, until such time as the unserviceable one is returned.

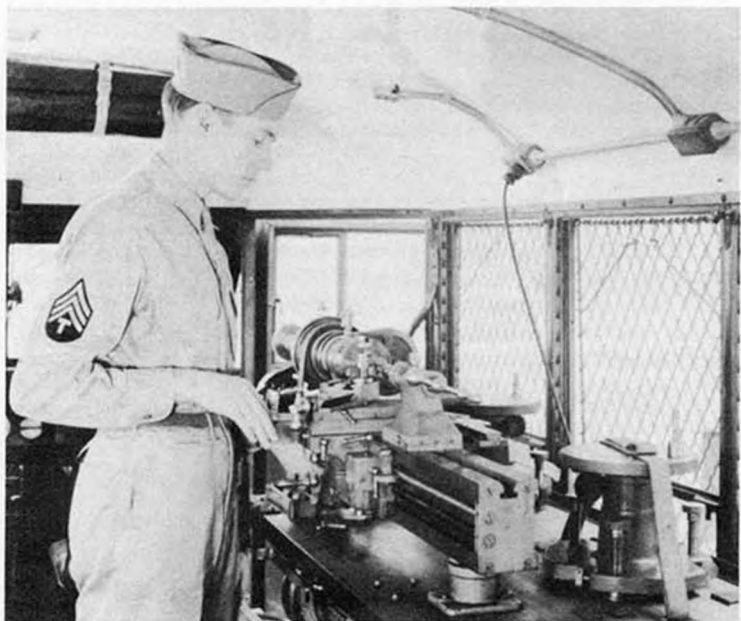
The primary consideration governing all questions of policy is that the using arm must be fully equipped with serviceable instruments to keep them at the peak of their combat efficiency at all times.

It does not require a vivid imagination to visualize an aiming circle improperly adjusted making a slight error in measurement of azimuth; the firing battery missing the target because of this; and, because of this miss never having an opportunity to fire again.

The instrument repairman, or any technician, is of as much importance to victory as the front line troops.

Under combat and field conditions facilities for maintenance and repair will vary. A section in the tropics will certainly encounter problems which are different from those encountered in the arctic. Conditions in desert warfare will hardly approximate those of jungle combat. Maintenance problems will vary with the locality and only experience and individual ingenuity will master them all.

Regardless of locality there is one thing that must be done. Before returning any instrument to the using arm, give it a thorough inspection to make sure it is in serviceable condition, and accurate in every detail. If an instrument is returned to service and bounces back for re-



pair in a week or two it is seldom a compliment to the efficiency of the section that first serviced it.

Maintenance of Stock and Spare Parts

Stock levels of the section should never be allowed to fall below the estimated minimum requirements. On hand in the spare parts truck and instrument truck should be the full quota of authorized spare parts. If these parts are being used continually they should be requisitioned as soon as the stock levels approach the danger line, rather than waiting till the actual minimum is reached. This is a matter that is up to the discretion and judgment of the section leader, shop officer, and supply section of the company.

Special care should be taken to check stocks often and thoroughly, paying particular attention to the supply of authorized lubricants, lens cleaning supplies, sealing compounds and parts with a rapid turnover. All records must be accurate and up to date to permit rapid inventory.

It is always good policy to work on the assumption that your organization may be ordered into the combat area within twenty four hours. Is the section ready?

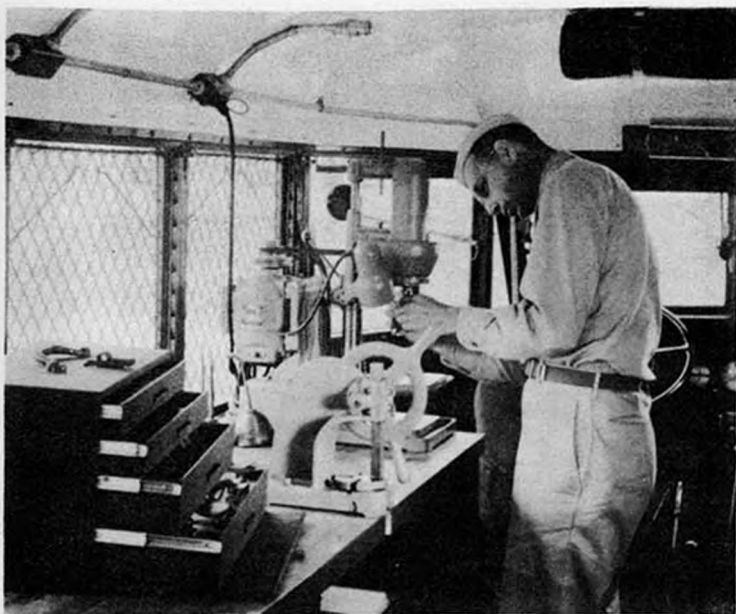
Instruments carried as replacement items should be kept in first class working conditions, under proper conditions of storage, and inspected frequently. The responsibility for the storage of these instruments rests with the instrument section.

In the field, parts should not be discarded simply because they fail to work in a particular instrument. A mistake may have been made, and even if no mistake was made, so many parts are interchangeable that it is poor policy. Before any parts are discarded they should be inspected and declared unserviceable. Serviceable parts which are not required should not be discarded, but reported as excess and disposed of in an authorized manner. There might be a need for just that part in some unit in another part of the country.

Texts and Publications.

There are available to the instrument section innumerable War Department publications which are very valuable in the daily operations of the section. These include the various standard nomenclature lists, ordnance field service bulletins, circulars and memoranda, technical and field manuals, and many others.

All personnel of the section should be familiar with the indexes to all of this pertinent reference material. FM 21-6 is an index to training publications. SNL's F-1, F-2 and F-3 are indexes to the F-group of materiel in the ordnance catalogue. The OPSI is an index to the entire ordnance catalog. Familiarity with these publications will eliminate the need of memorizing many manuals and their numbers.



These reference texts, are, in most cases, not used to the extent they should be. Much excellent information of value to everyday maintenance and adjustment can be found in the 1000 series of technical manuals ("Ordnance Maintenance" series), while the two thousand series ("instruction guides") are of use to the using service and ordnance personnel. A few hours spent in reviewing these publications and their scope will amply repay any instrument repairman.

For a list of texts which are particularly applicable to the instrument section consult TM 9-2602 and FM 21-6.

Complete files of pertinent texts should be maintained, with up to date changes and revisions in either the section or the company. They are procured in various manners but inquiry will determine the proper procedure.

They are of particular value in training the basic soldier in the trade of instrument work. The section leader cannot get along without them. Check the files of reference material in your section today.

Training

A program for the training of the instrument section can be found in TM 9-2602 and is capable of being molded to local conditions with little change. The importance of thorough training in all phases of instrument repair work is too obvious for comment. In addition to training adapted to local conditions and training schedules, the facilities of the service schools are available.

The Ordnance School has trained thousands of key men for instrument repair and anti-aircraft fire control work in the past year. Many thousands more will be trained in the months to come. The fire control section of the Ordnance School, and its training activities, are discussed elsewhere in this issue.

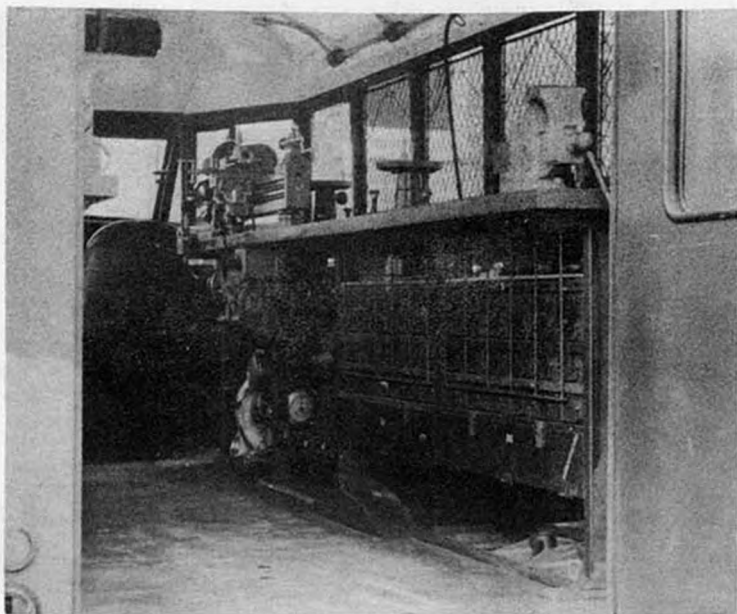
One phase of training too often neglected is that of keeping up to date as new materiel is introduced. This often involves changed methods of maintenance, and new adjustments which require planning and training beforehand.

The efficient ordnance sergeant in charge of an instrument section never lets himself get caught short in this respect.

Summary

The instrument section's work in the last few years has increased enormously. The skilled repairman is a rarity in the field at the present time due to the swiftness with which our army has expanded. This condition is being remedied rapidly.

The work of the instrument section is of the utmost importance to eventual success of any mission. The accuracy of American weapons has wreaked destructive havoc on the enemy in all operations of the war to date, and this is largely traceable to the excellent fire control instruments and sighting equipment used with the various weapons.

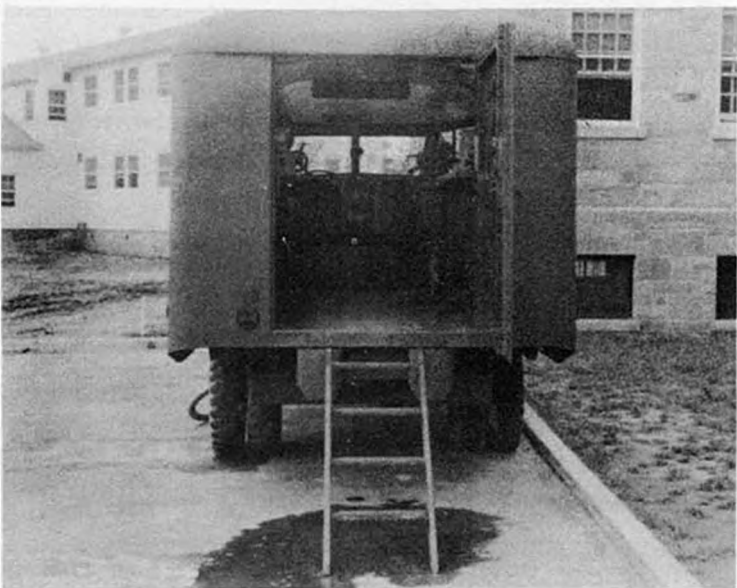


The job of keeping these instruments in serviceable, working condition is as important as firing the guns themselves. And that is the job of the instrument section. Whether you are a section leader, assistant section leader, or a technician member of an instrument section, remember you have but one function, and that is to "Keep 'em firing!"

The September issue of THE ORDNANCE SERGEANT will tell as completely as possible the story of "Ordnance Maintenance in the Field". This discussion will include reviews of the basic fundamentals of Ordnance Service from the War Department General Staff down to include the Division. It will help us get better acquainted with ourselves and with our responsibilities.

The October issue of THE ORDNANCE SERGEANT will present a series of articles pertaining to Ordnance Special Vehicles. You may work in a tool and bench truck now, and be thoroughly familiar with the vehicle and its equipment — a few weeks or months may find you almost lost trying to find your way around in an instrument repair truck, or a small arms repair truck, or in a railway machine shop car. The October issue will try to acquaint you with as many of these vehicles as possible.

Late in 1941 an issue of THE ORDNANCE SERGEANT attempted to tell the story of the Armored Force. We will try it again in the November issue, for the simple reason that the Armored Force, and therefore its Ordnance components, has developed rapidly during a year of experience. There will be much to learn from this November issue.





Introduction

Fire control equipment for antiaircraft artillery has become enormously complex during its short period of development. This complexity is almost entirely the result of one circumstance — the fact that airplanes travel at great speed in a medium of three dimensions.

In order to hit such a target it is first necessary to determine its position, speed, and direction of motion. From this data its position at some future instant, as yet unknown, must be computed. Second, this future position must be converted into data for the guns; namely, firing azimuth, quadrant elevation and fuze setting. Furthermore, all of this computation must be done continuously and instantaneously, and the results kept continuously set at the traversing, elevating and fuze setting mechanisms at the guns.

From the foregoing the requirements for a fire control system for a battery of antiaircraft weapons may easily be summarized. First, from the functional form of view, the following will be required:

- (1) Position finding devices.
- (2) Computing devices.

- (3) Data transmission equipment.
- (4) Power equipment for positioning the guns.

Second, from the tactical viewpoint, the devices enumerated should be at least as mobile as the guns, which means that the whole system must be capable of being broken down into convenient loads.

Different types of weapons have been developed as the tactical opponents of different classes of military aircraft. Paralleling this development is that of specialized fire control systems, each used with a specific type of weapon. Omitting machine guns from the discussion, it becomes apparent that there are two types of antiaircraft artillery; light and heavy. Each has fire control equipment peculiar to itself.

As has already been noted, the trend since the beginning has been toward increasingly complex instruments and other equipment. At the present time a typical fire control system for either light or heavy AA artillery consists of delicate optical instruments, intricate automatic computing instruments, a complicated electrical wiring system, portable electric power generators, and, sometimes, a hydraulic power system.

The articles which follow will describe, rather briefly, certain components of each type of fire control system.



General

Light AA fire control equipment includes the instruments and accessories used to calculate position; aid in positioning; or actually position; weapons, up to and including 40mm automatic AA guns. Prior to the present war the instruments used to control the fire of light AA weapons were relatively clumsy and inaccurate. Accuracy was dependent solely on the ability of "spotters" to observe tracer fire and relay their observations to a central switchboard where the reports were compiled and sent by telephone to the gun crews. The gun crew used this information to correct errors in aiming and inherent errors due to dispersion. This method of antiaircraft fire control was obviously clumsy and slow.

The increasing speeds of modern warplanes and the advent of the dive bomber made it imperative that a type of fire control be developed for light AA weapons that would eliminate the time lag in the application of correction data and minimize the possibility of personal error.

Tactical Mission of Light AA Fire Control

The purpose of any fire control instrument is to control accurately the fire of the weapon with which it is used, so that the target may be hit and neutralized. This is the functionary purpose. The tactical purpose is slightly different. The tactical purpose is governed by several important considerations. What is the weapon's effective range? What type of hostile target is it best suited for use against? How may it be coordinated with other weapons?

There may be several weapons that will qualify with similar answers to the above questions. These weapons will fall naturally into a common classification or group having a similar, yet slightly different, purpose. By applying the analysis it is seen that the 30 cal. M.G.; 50 cal. M.G.; 37mm AA gun; and the 40mm AA gun may all be classified as light AA weapons.

These weapons are used against low flying strafing planes, dive bombers, and other hostile aircraft operating against troops or establishments at an altitude less than the minimum fuze range of the heavier AA artillery. For example, the minimum fuze range of the 3" AA gun is approximately 3,000 yards. This means that a hostile plane can operate within this range without danger from 3" AA batteries because the 3" shell will not burst until at least 3000 yards from the gun. This makes the heavier 3" gun of little value in combating low flying aircraft. The 3" AA fire control equipment is limited to a rate of change in altitude equivalent to 250 miles per hour plane speed. Thus, it is no good against dive bombers which usually release their bombs at an air speed of 350 to 400

miles per hour at an altitude well within 3,000 yards. Where the lower limits of operation of heavy AA fire control equipment prevent effective use the light AA fire control equipment and weapons are used.

Equipment

This discussion will deal with the light AA fire control equipment itself. For the present, the 30 and 50 caliber machine guns will be disregarded; only the equipment for the 37mm automatic AA gun being described. The fire control equipment for this weapon is identical with that used for the 40mm automatic AA gun. Credit must be given the British for its development.

The fire control equipment for the 37mm automatic AA gun consists of: (1) Director, M5 or M6, (2) Remote Control System, M1, (3) accessories and packing chests.

The Director, M5

The Director, M5, (Fig. 1.), is a combination of mechanisms and electric motors which determine the present position of an airplane or

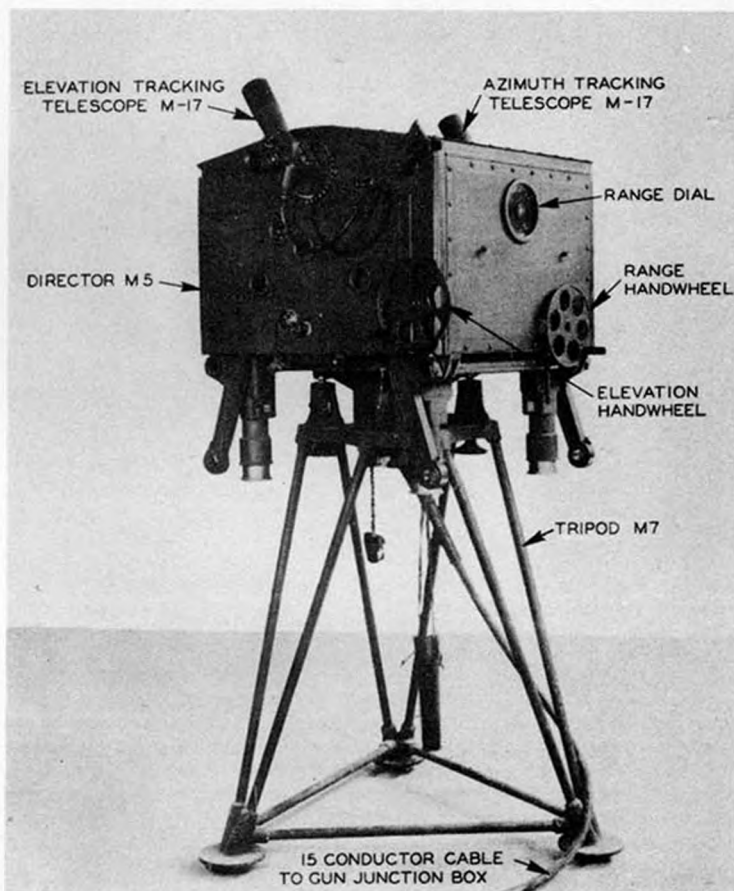


Fig. 1. -- Director, M5.

target in three dimensional space, and predicts where that target will be at the given future instant when the projectile from the weapon (which is controlled by the director) intersects the predicted future position of the target.

In order to calculate the future position of the target it is necessary to know the present position and the rate of travel in elevation (vertical) and azimuth (lateral). The Director, M5, has two elbow telescopes which are positioned by handwheels and provide a means of tracking and observing the target. When the azimuth and elevation telescopes are sighted on the target by the operators or "trackers", the present position of the target (T_0) in space is fixed by present azimuth (A_0) and present elevation or angular height (E_0). By following the target in flight the trackers establish the rate of the target in azimuth (Σ_a) and elevation (Σ_e). The elements just mentioned are input data to the director.

The third element of input data is the range. With the M5 director the range is estimated by the range operator, who is in command of the

director crew. This estimated range is put into the director by means of a handwheel, and is indicated on the range dial on the back side of the instrument. This range may be from 400 to 2800 yards. For a fixed muzzle velocity of the weapon, range is a function of time of flight of the projectile, i.e., it will take the projectile approximately one second to go 900 yards, two seconds to go 1800 yards, etc., if the muzzle velocity is 900 yards per second.

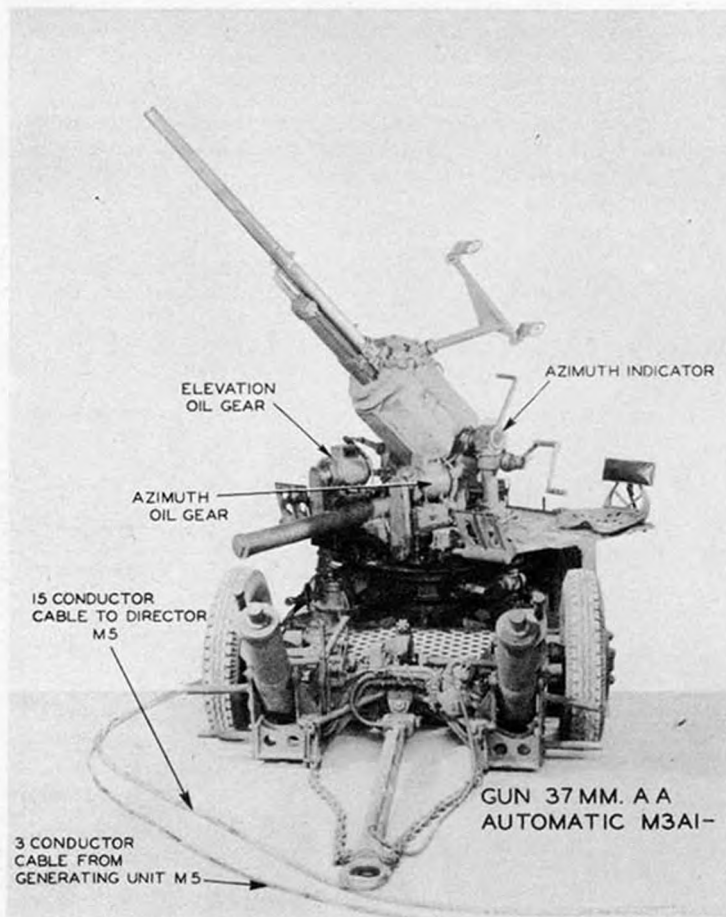


Fig. 2. -- Electrical Remote Control System.

Range is used to establish a fictitious time of flight (t'). This is called a fictitious time of flight because there is no fuze setting on the 37mm projectile. The projectile has a supersensitive point detonating fuze which causes the explosion only when it contacts the target, whereas the 3" projectile has a time delay fuze and will burst after a predetermined interval of time whether the target is contacted or not. Each 37mm round, however, is provided with a burn-through tracer element which gives a tracer pattern to correct fire, and serves to destroy the projectile at a slant range of 3500 yards if it does not contact the target.

To summarize: the present position of the target has been established along with the rates of travel of the target, vertically and laterally, and the estimated range of the time of flight of the projectile. All that is necessary to compute the future position of the target is to multiply these rates by the time to determine the leads or deflections vertically and laterally, and add these deflections to values of the present position of the target.

The mechanisms of the Director, M5, are so designed that they automatically multiply the rate by the time of flight and add this value to the present position of the target to give the result (output data) of future position in azimuth and elevation. The two elements of output data, i.e., firing azimuth (Af) and quadrant elevation (QE) are thus determined by the director.

The Remote Control System, M1

This information is now sent to the gun (Fig. 2) by means of an electrical remote control system. This remote control system is analogous to a flexible shaft, in the respect that one rotation of the

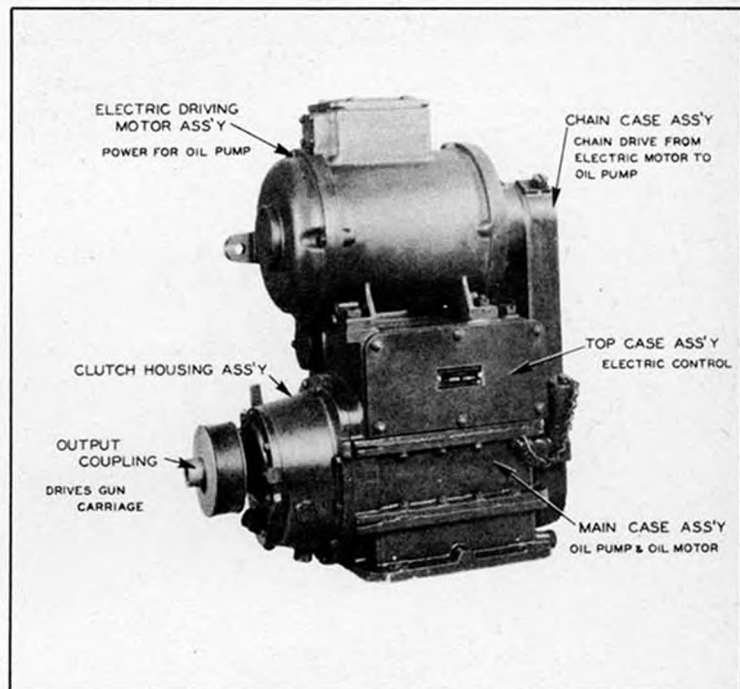


Fig. 3. -- Oil Gear, Remote Control System, M1.

electrical device (a selsyn transmitter, similar to an elector motor) at the director, produces one rotation of the gun electrical device (selsyn receiver). Thus the future position may be transmitted as angular rotation by the director selsyn transmitters. The receiver selsyns at the gun receive the data as a rotation.

This rotation is utilized to control a device which positions the gun. If the rotation of the receiver selsyn were powerful enough it could be used to position the gun directly, but the selsyn is a relatively small unit, and it does not have sufficient power to position the weapon. The rotation of the receiver selsyn must be amplified in respect to torque or power in order to position the gun according to the data sent from the director. This is accomplished by the oil gear.

The Oil Gear

The oil gear is a hydraulic mechanism consisting of an oil pump, an electrical control device, and an oil motor. (See Figure 3.) The oil pump is driven by an electric motor. It produces pressure in the oil line which is fed to the oil motor. The electrical control device is con-

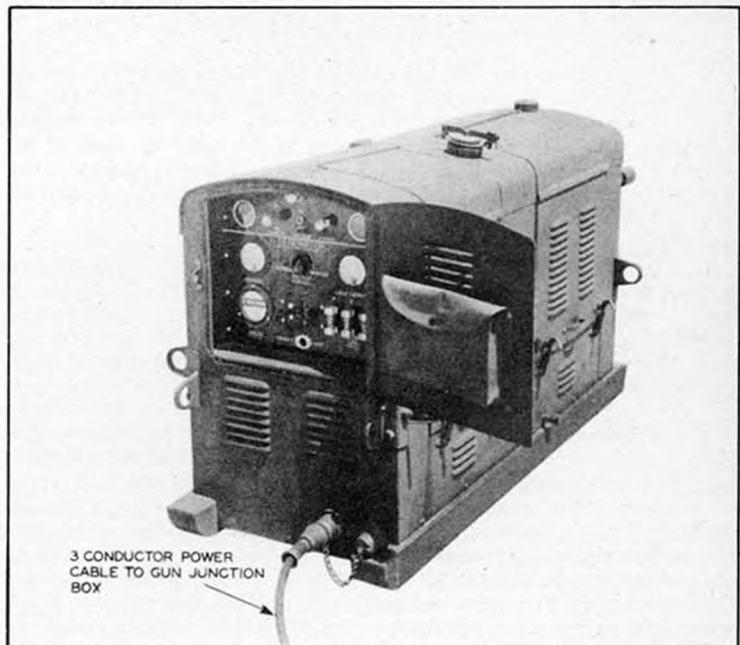


Fig. 4. -- Generator, M5.

trolled by the director selsyn transmitter. A sensitive valve arrangement controls the direction and speed of rotation of the oil motor by controlling the flow of oil to the motor from the pump. The valve arrangement is controlled by the electrical control device. Thus the train of control is complete. The gun carriage is equipped with an azimuth oil gear and an elevation oil gear, each operating independently of the other.

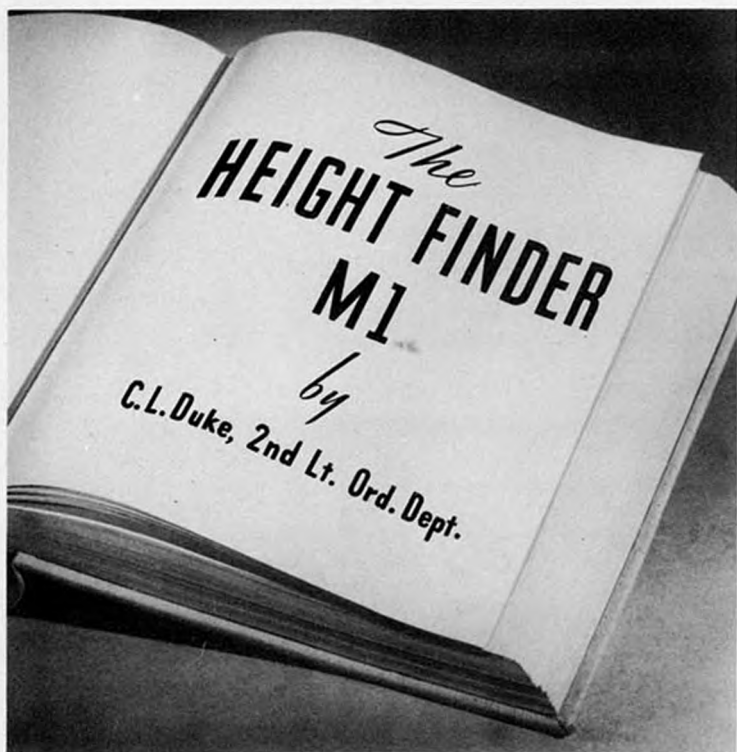
Summary

The complete flow of data is as follows: (1) The trackers on the Director establish the present position, and rates in azimuth and elevation of the target. (2) The Director, M5, calculates the lead in azimuth and elevation, and adds this to the present position to establish a future position. (3) The Director electrical selsyn transmitters send the future position data by means of a remote control system to the oil gears on the

gun. (4) The oil gears position the weapon according to this calculated future position.

Electric power for the Director, M5, and Remote Control System, M1, is furnished by the gasoline generating set (M5). (See Figure 4.) This makes the complete system portable, and independent of other power sources. The entire system is completely automatic from the time the trackers engage the target in the telescopes until the projectile is actually fired, except for the supply of ammunition and the firing of the weapon. This, however, is not classifiable as fire control, in the strictest interpretation of the phrase.

No attempt has been made in this article, due to limitations of space, to furnish any technical details of construction or maintenance of the system.



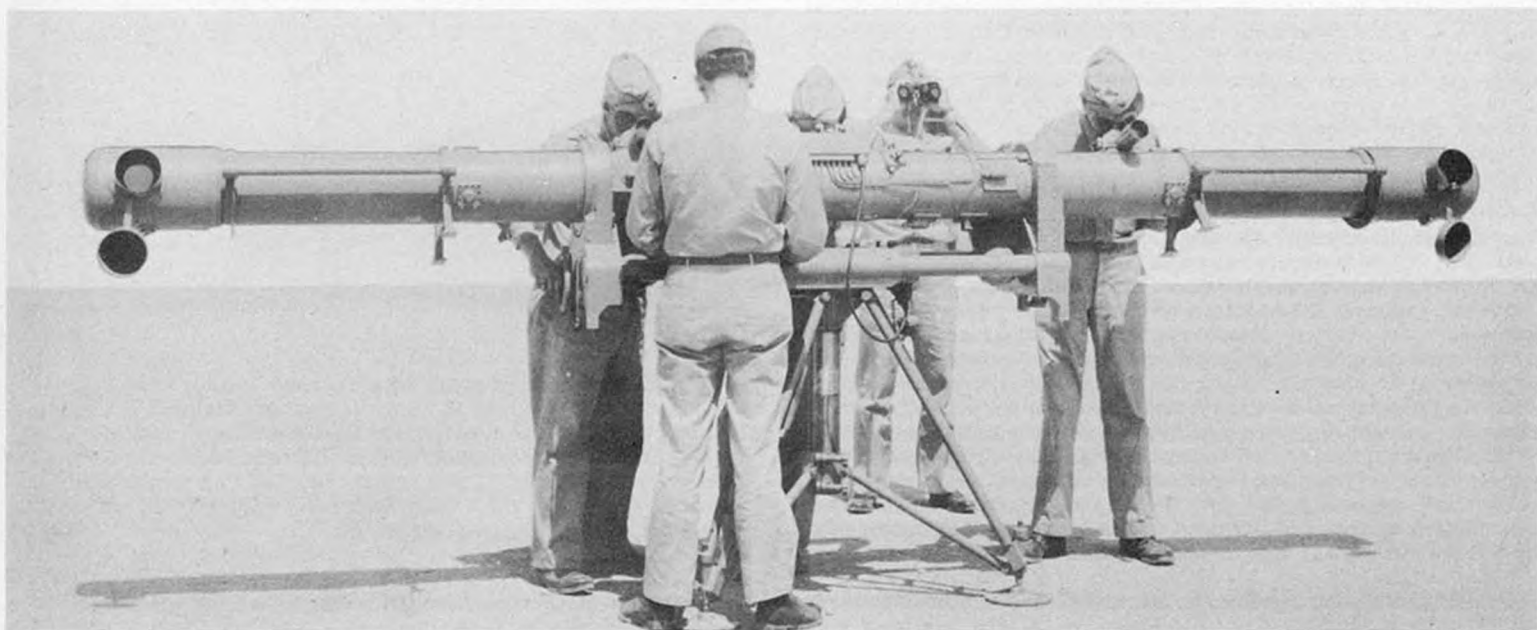
Height finders are employed in the 3" and 90mm anti-aircraft batteries to determine either altitude or horizontal range to aerial or land targets respectively; this information then being relayed through a data transmission system to a director, where it is utilized in the computation of firing data used to position the guns.

During the first world war, and shortly thereafter, the altitude of aerial targets was computed by a complicated and laborious method of triangulation. As a result, the percentage of effective hits was extremely low due to the time element which lagged far too much for the relative speed of the targets. These old type instruments were not adaptable to rapidly moving targets and were rapidly rendered obsolete by the development of the modern warplane. It became necessary to find an instrument that could adequately handle the problem, and the stereoscopic height finder was introduced.

The Height Finder, M1, is a self-contained, stereoscopic height finder with a 13-1/2 foot base length and magnifying powers of twelve and twenty-four diameters which may be used as either a range or height finder. (See Figure 5.) It utilizes the observer's sense of depth perception or stereopsis and operators are carefully selected with these qualifications in mind. It is considerably more advantageous than the older types because it is more accurate, it may be used as either a range or height finder, it can operate under adverse weather conditions, it can range on targets moving very rapidly, and the time lost in measuring range is reduced to a minimum.

The instrument consists of three main assemblies; the tripods; the cradle; and the height finder proper. (See Figure 6.) The tripod is collapsible and weighs approximately 175 pounds. It can be carried by three men. The cradle weighs about 175 pounds and requires four men to conveniently carry it. The heightfinder proper weighs in the neighborhood of 600 pounds and eight men can transport it manually. Carrying cases are provided for the tripod and cradle. The case in which the cradle is stored and placed for transportation also contains spare tools and ac-

Fig. 5. -- HEIGHT FINDER, M1. This shows the instrument in action for instructional purposes. No hookup to the director is shown.



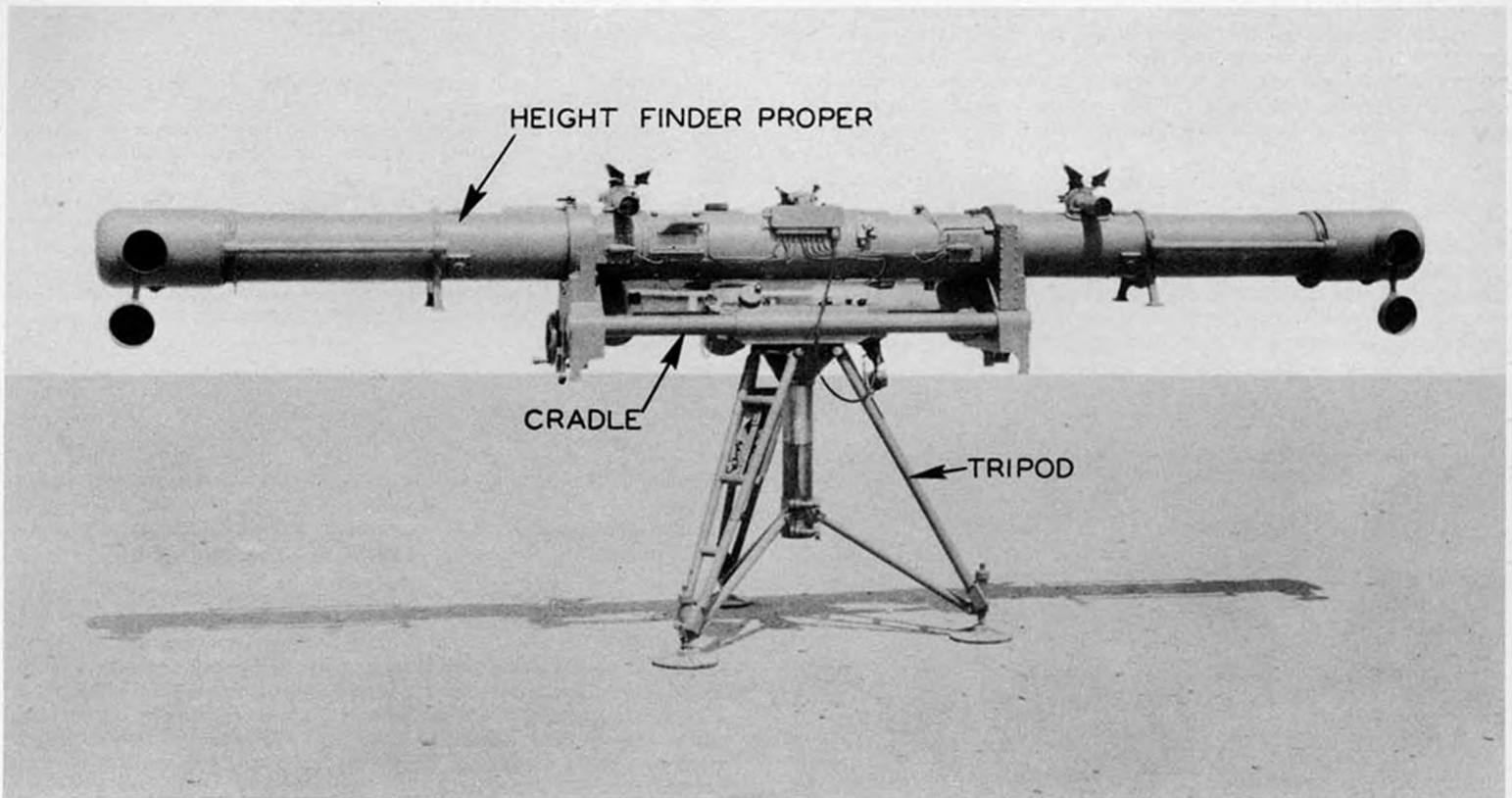


Fig. 6. -- Height Finder, M1.

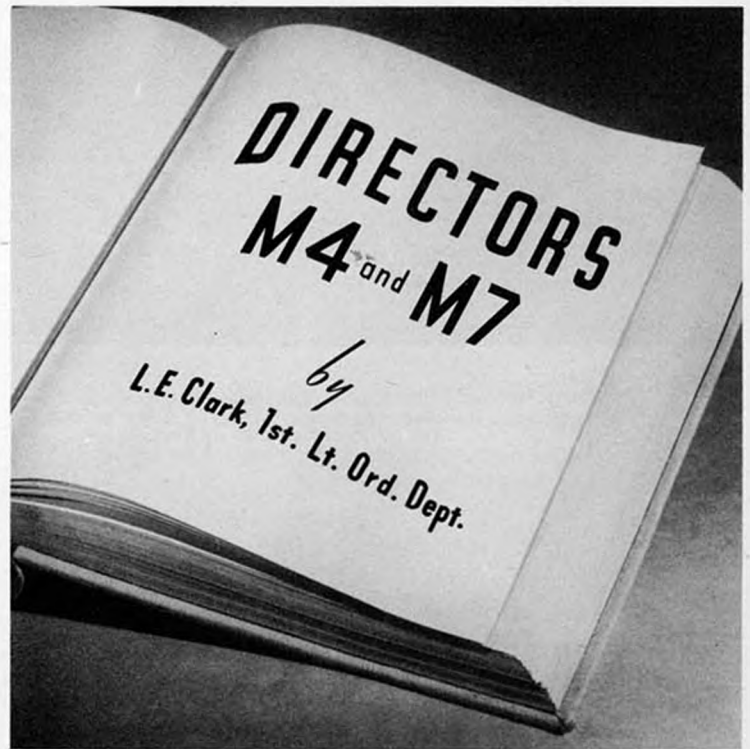
cessory adjusting devices. There is a large tube provided, also, for the storage and transport of the height finder proper. This case contains a shock mounted cradle upon which the tube rides. The instrument complete, with cases and tubes for storage, weighs approximately 2,100 pounds.

The instrument must be accurately set up before it can be used. This means; accurate adjustment in the shop, accurate leveling and field adjustment before orientation and synchronization. Orientation refers to the mechanical adjustment of the height finder so that when it is pointed in a given direction, the mechanical pointers for azimuth and elevation agree with the direction in which the instrument is pointed. Synchronization refers to the setting of pointers at the receivers of the electrical system so that when the transmitters read a certain value, the corresponding receivers will read a like number.

In order for the instrument to function properly after being set up, it must first receive certain elements of data, usually from the director. The elements received are present azimuth and present elevation of the target. The function of the azimuth and elevation receivers of the height finder is to make certain that this instrument is trained on the same target as the director, which is computing the data. Once the director and height finder are tracking the target the observer must then bring the target into stereoscopic contact with respect to the height finder reticles, during which operation he causes a system of optical wedges to rotate, moving the range scale drum. This action converts slant range into altitude.

Four men are required to operate the height finder, M1. There is an azimuth tracker who operates the azimuth handwheel, keeping the vertical reticle of the elbow telescope aligned on the target. The elevation tracker, operating the elevation handwheel, keeps the horizontal reticle of a separate elbow telescope aligned on the same target. When both trackers have the target perfectly positioned in their respective fields of view the third operator goes into action. He is the stereoscopic observer and it is he who is responsible for the accuracy of the readings obtained. He looks into the two eyepieces provided and brings the target into stereo-contact with respect to the reticles in his field of view. When he has obtained stereo-contact he says "take" and the altitude reader then sets the range corresponding to that on the scale upon the altitude transmitter. Instantaneously, this data is relayed over the electrical data transmission system, and positions the dial of the altitude receiver at the director, where it is used in the computation of the firing data.

From this point the director takes over the fire control problem and its ultimate solution.



Introduction

Since the dawn of warfare nations have steadily tried to improve the efficiency of artillery in combat. Until the advent of the airplane, artillery units had to contend only with comparatively slow moving targets with a two dimensional movement. The sudden development of air warfare in the first world war brought on an entirely new artillery fire problem. They now had a target that was relatively fast, and also one capable of three dimensional movement.

This new phase of warfare brought about the development of anti-aircraft guns which were given the name of "Archies". Although it was the consensus of opinion that these guns were not very effective, the

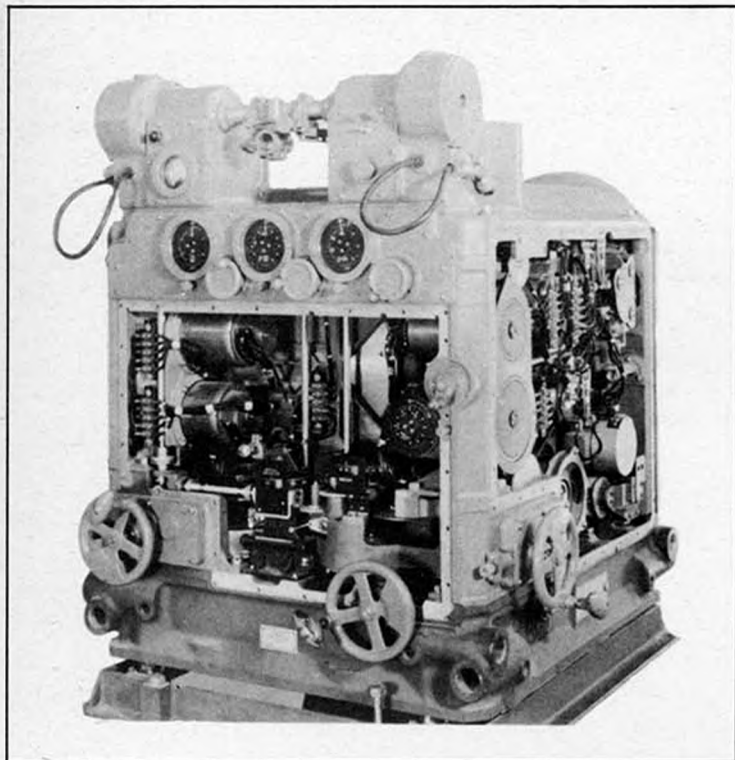


Fig. 7. -- DIRECTOR, M4. (Side Plates removed for instruction).

records show that from twenty-three to fifty percent of the total planes shot down during World War I were brought down by these anti-aircraft guns.

The development of the modern warplane has created a still more difficult problem of fire control in which "TIME" has become the predominant factor. Planes of today are capable of extremely high speeds and are actually within range for only a very few minutes from the time the plane is first sighted. This has necessitated the development of an automatic system of fire control by which firing data is instantaneously and continuously computed by mechanical means and electrically transmitted to the guns.

Directors

The heart and brains of this fire control system is the computing director. Generally speaking, a director is a computing instrument which receives continuously the elements of data pertaining to the continuously changing present position of the target and which uses this data to compute the predicted position of the target and then converting this pre-

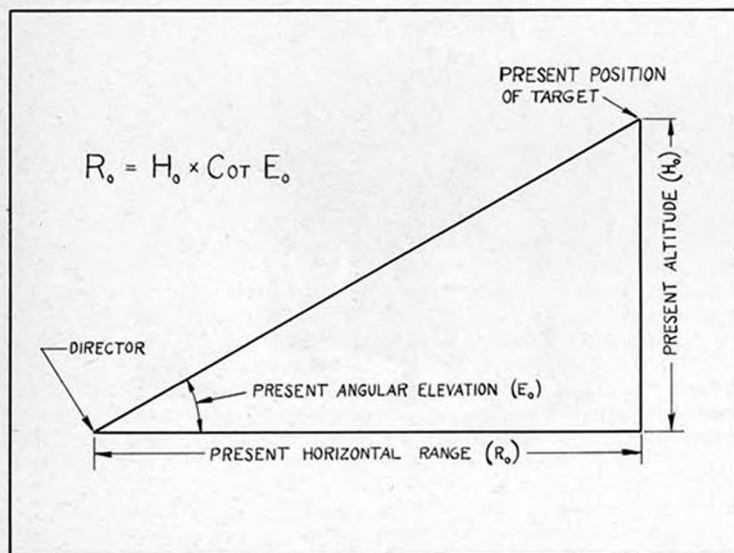


Fig. 8. -- The Trigonometrical solution.

dicted position into the data necessary to position the guns for continuous and accurate laying of fire.

There are many types of directors, both possible and actual. The first method of classifying them is according to the type of ballistic data computed and the value of "time of flight" used; namely; (1) Ballistic Directors, (2) Semi-Ballistic Directors, and (3) Non-Ballistic Directors.

Ballistic Directors

Ballistic directors are computing instruments that use true ballistic "time of flight" in the computation of the predicted position of the target and are provided with a means for setting in variations from standards, of muzzle velocity, atmospheric density and temperature, ballistic winds, etc. Theoretically, the output data of this type of director is the true gun data and will not require correction. However, this type director is very costly, difficult to manufacture, and much too large for efficient use with mobile units. Today they are used primarily with coastal defense batteries in permanent emplacements.

Semi-Ballistic Directors

Semi-ballistic directors are those that compute gun data for standard conditions of muzzle velocity, temperature, and atmospheric density. An approximate value for the ballistic wind effect is set in. The data provided by this type of director is not true data, and, therefore, a mechanical means of correcting this data is provided through the use of spotting controls. Most present day directors, in common use in the AA fire control system, are of this type.

Non-ballistic Directors

Non-ballistic directors use an approximate value for "time of flight" and compute approximate output data for standard conditions. They may or may not provide a means of correcting this output data. Non-ballistic directors are entirely unsatisfactory for use with heavy anti-aircraft artillery.

Another Classification

A second method of classifying directors is according to the method used to compute the predicted position of the target. The two most common are the angular travel method and the linear speed method.

The angular travel method is the method whereby instantaneous rates of change of the azimuth and elevation angles of the target are determined and multiplied by the time of flight of the target. In this method, the slant range of the target may be estimated. The M5 director, used with the 37mm gun, and the M6 director, used with the 40mm gun, work on this principle.

The linear speed method is the method whereby the instantaneous linear velocity of the target is resolved into components parallel to the three reference axes. Each component is multiplied by the time of flight and the results combined to predict the future position of the target.

Director, M4

The M4 director used with the three-inch AA gun is of the semi-ballistic type and uses the linear speed methods to determine the predicted position of the target. (See Figure 7.) This director performs three essential functions. It determines the present position of the target and resolves this into three components; it determines the future position of the target; and it computes the ballistic data that will enable the burst of the shell to occur at the predicted position of the target.

The present position of the target in space is determined by the following factors; The altitude, which is received from the Height Finder, on a self-synchronous indicator; the horizontal angle or azimuth; and the angular elevation. The azimuth and elevation angles are determined by the angular position of two tracking telescopes, mounted on the director, by which two operators track the changing path of the target. Corresponding dials on the director are connected to these telescopes and the angular position of the target is determined automatically. As can be seen from Figure 8, this is solved for trigonometrically. This is accomplished through the use of a three dimensional cam.

Present horizontal range, along with present azimuth, is plotted on the present disc and slide mechanism. Ballistic winds and the target speed are resolved into components and multiplied by the time of flight

which is solved for by the director. This gives a prediction, which, when added to the present position, gives a predicted position. This predicted position of the target positions a ballistic cam (Fig. 9) which solves for the firing data that is necessary to position the guns. The input data to the Director, therefore, is present azimuth, present altitude, and present angular height or elevation. The output or gun data is quadrant elevation, angle of train, and fuze setting. These output values are indicated on self-synchronous indicators and dials which instantaneously and continuously transmit this data through the data transmission system to the guns of the firing battery.

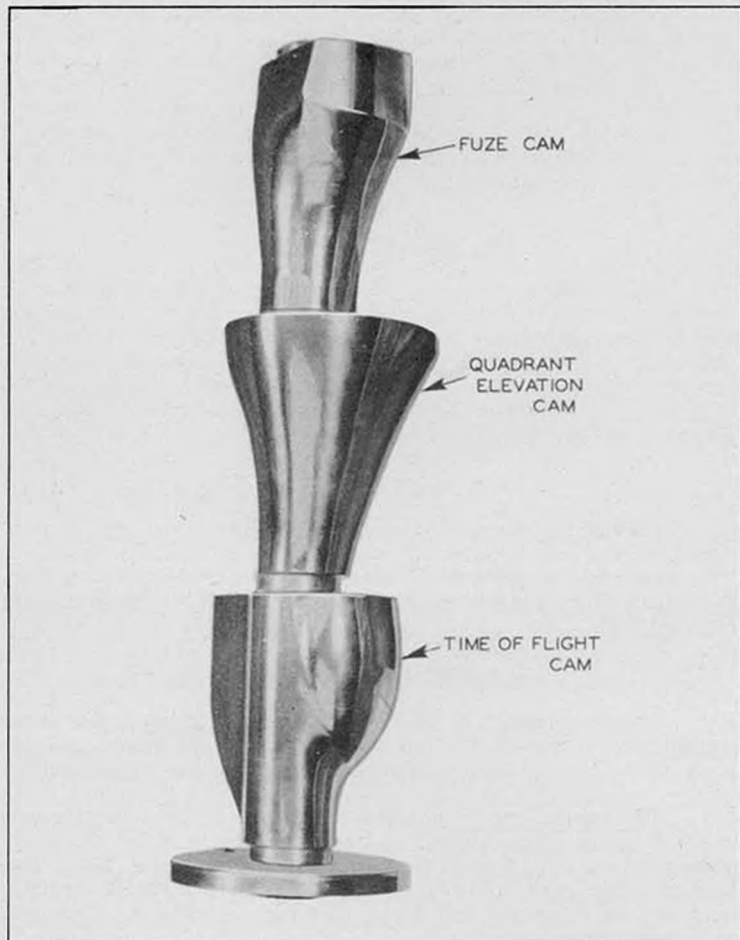


Fig. 9. -- Ballistic Cam for Director.

As already mentioned semi-ballistic directors do not compute true gun data and a means must be provided to correct the output data. This is accomplished by the use of the following spotting controls on the director: Fuze spot; Lateral spot; Vertical spot; and Altitude spot. Referring to Figure 10, the above named spots affect the burst of the shell in the manner shown. These spots, when put in the director, automatically change the value of the firing data, and the gun is repositioned to provide correct and accurate fire at the target.

Operation of the M4 Director

The M4 Director requires five operators, namely; an elevation tracker, who tracks the plane in elevation; an azimuth tracker, who tracks the plane in azimuth; an altitude operator and range operator, who, by matching pointers on their respective dials, continuously solve for present horizontal range; and a fifth operator who observes the bursts of the shells and puts in the necessary spot corrections to correct these bursts.

Director, M7

The M4 Director, though serving its purpose well, has been largely superseded by the more efficient M7 Director which is used in the fire control system of the 90mm gun. (See Figure 11.) This director is also of the semi-ballistic type and is the same as the M4 with the exception of the following modifications:

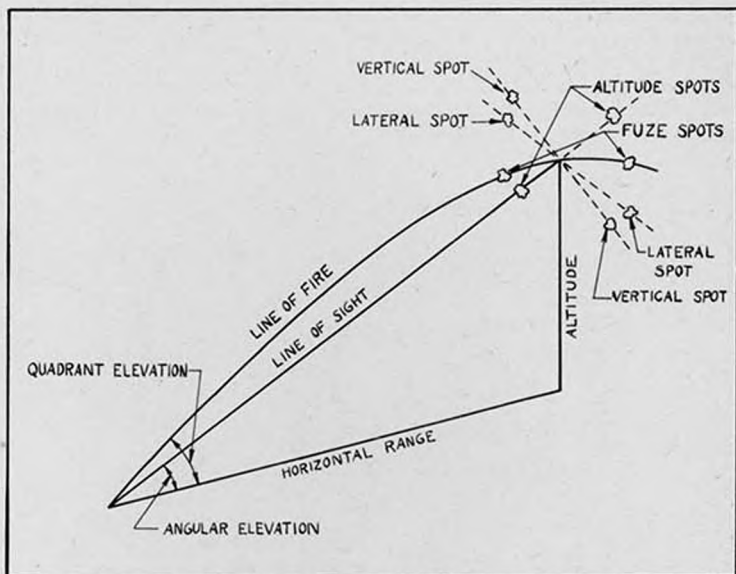


Fig. 10. -- Use of the Spotting Controls on the Director.

- (1) A fuze dead time mechanism.
- (2) A drying compound in the director to prevent the formation of moisture.
- (3) Provisions for the automatic setting in of rates of range and altitude to provide continuous and automatic solving for present horizontal range.
- (4) Additional safety devices to insure longer operation of the director without breakdown.
- (5) Increased limits of operation in altitude to take care of the increased range of the 90mm gun.

The most important of these modifications is the fuze dead time mechanism. Fuze dead time is defined as the interval from the time the fuze is set by the fuze setter until the shell is inserted into the gun and fired. This device takes the fuze rate of change from the ballistic cam, multiplies it by the reciprocal of the fuze dead time and the resultant is the predicted fuze.

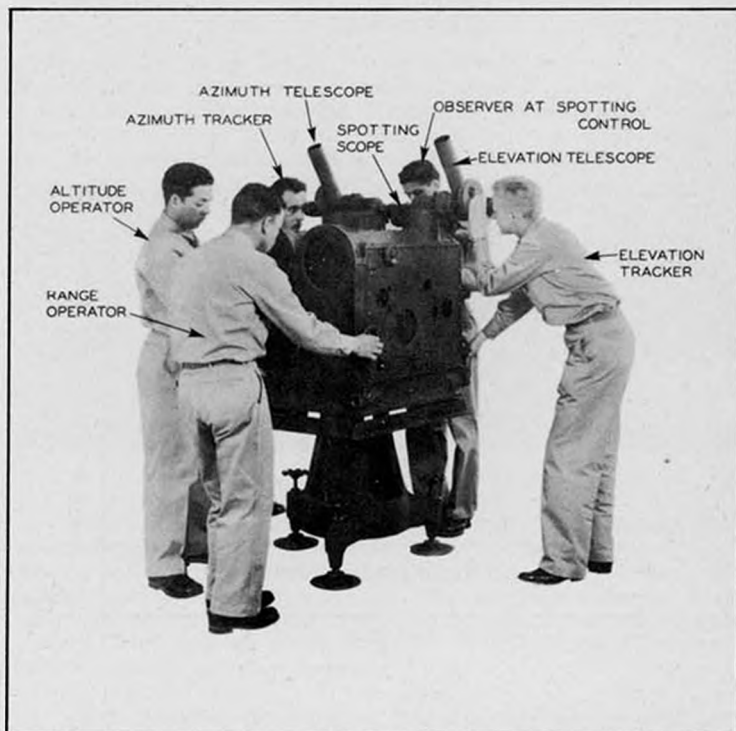


Fig. 11. -- DIRECTOR, M7. (Setup for Instruction).

Precautions

The M4 and M7 Directors, although built to withstand the rough conditions of field usage, are nevertheless delicate, precision instruments and certain precautions must be observed at all times during their handling and transportation.

(1) The Director proper should be removed from the pedestal when it is to be transported.

(2) When the director is in storage it should be exercised at two week intervals by running the various motors and rotating the different handwheels.

(3) When the director is in storage the heater lamp should be kept burning to prevent the formation of moisture.

(4) The director should be kept covered at all times it is not actually in use.

(5) The director should be completely overhauled and lubricated every six months, if necessary. This should be done in a base shop.

(6) The director is dust sealed. Therefore the side plates should be removed only when absolutely necessary to maintenance and then only by qualified AA specialists in this type of maintenance.

(7) Last, but not least, the using service should make only those adjustments they are authorized by existing, current regulations.

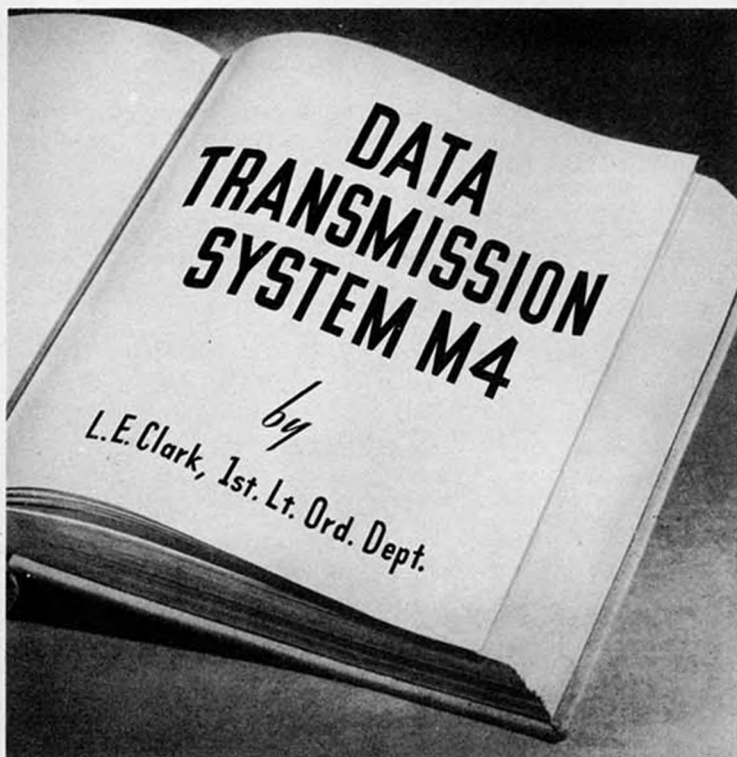


Figure 12 is the layout of an anti-aircraft battery. The data transmission system is the means whereby the various fire control instruments are interconnected, and connected to the guns, to provide continuous and instantaneous transmission of firing data from the instruments to the guns, and to allow continuous and instantaneous application of this data at the guns. It was designed for use with the M3, M4 and M7 Directors.

The various units that compose the Data Transmission System, M4 are classed in two groups: On-carriage equipment, consisting of those units located on the guns; and off-carriage equipment, consisting of the external units.

The on-carriage equipment is composed of the following:

- (1) Receptacle box.
- (2) Distribution box.

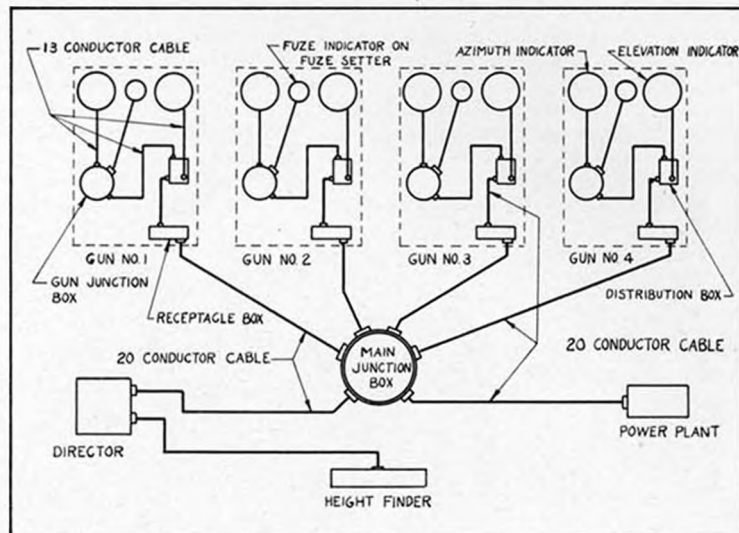


Fig. 12. -- Layout of Fire Control Equipment.

- (3) Gun junction box.
- (4) Indicators and transmitters.
- (5) Fuze setter.
- (6) Breech lamp bracket.

The only unit of the on-carriage equipment requiring explanation is the fuze setter and the indicators. The indicators are A. C., self-synchronous motors with the necessary dials and indices to indicate the quantities of firing data as received from the director. The fuze setter (Figure 13) is composed of the fuze indicator that indicates the correct fuze setting as determined by the director, and a mechanical means of setting this fuze reading on the shell.

The off-carriage equipment is composed of the following:

- (1) Main junction box.
- (2) Power plants (two).
- (3) Twelve 225-foot portable cables with the necessary plugs and receptacles.

The main junction box, as seen from Figure 12, is the means of electrically connecting the generators to the various units that comprise the system. The power plants are four-cylinder, 10 H. P. gasoline units with a direct-drive 2-1/2 KVA Alternator with a built in exciter and the necessary control and protective equipment. (See Figure 14.) The portable electric cables are twenty-conductor, flexible, rubber covered cable. The conductors are color coded to facilitate circuit identification, and this color arrangement is carried throughout the entire system.

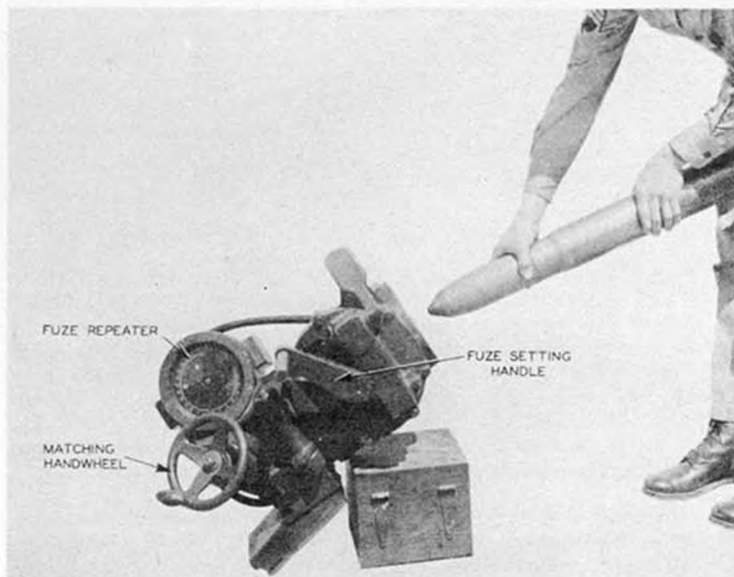


Fig. 13. -- Fuze Setter, M8. (Setup for Instruction).

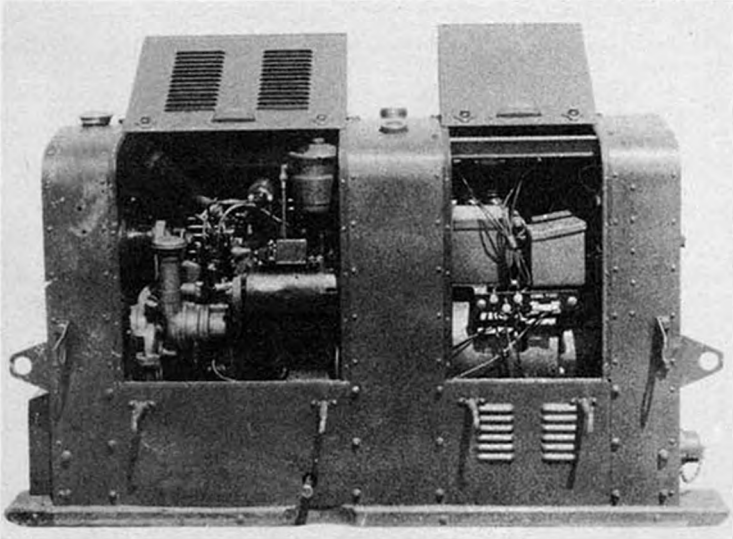


Fig. 14. -- Generating Unit, M4. (Setup for Instruction).

The Data Transmission System, M4, has proved to be entirely satisfactory for field use, and is so built that but little maintenance is required, even under the most rigorous conditions of field usage.

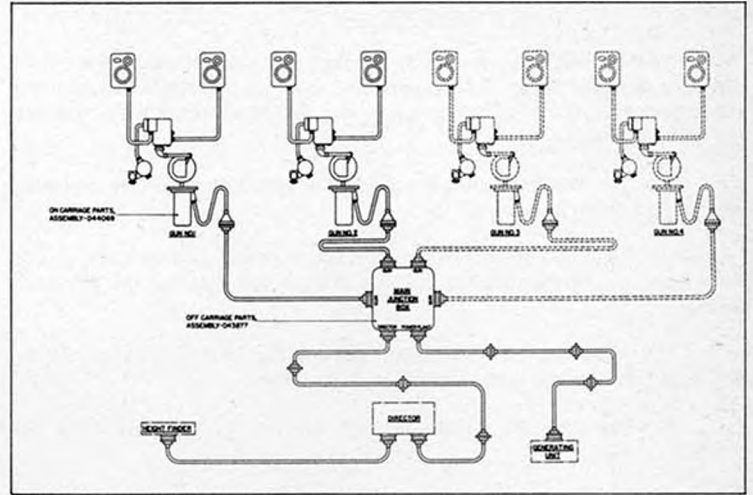
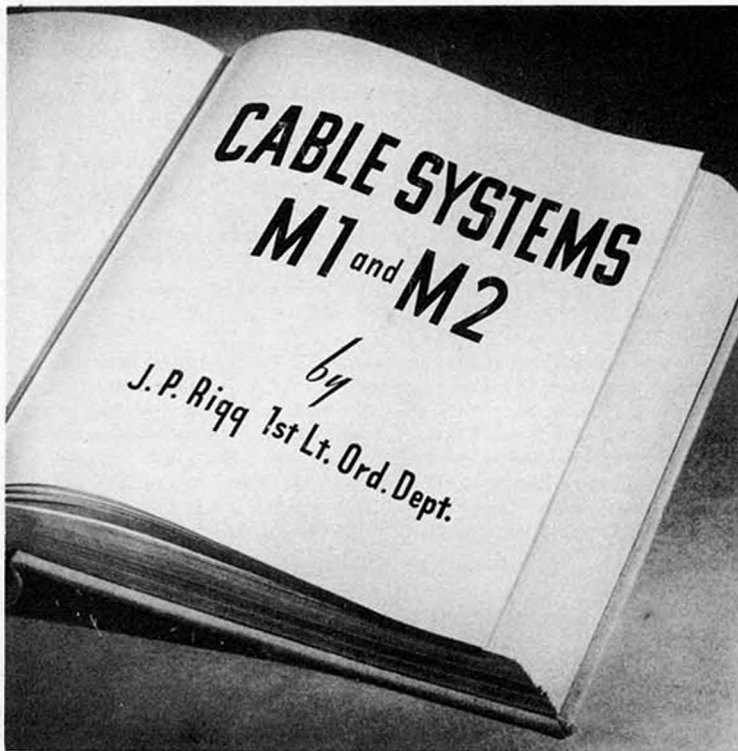


Fig. 15. -- Layout of the M1 System.

Early synchronous units were of the direct current type; however, A. C. synchronous transmitters and repeaters of the type called "selsyns" in civilian industrial practice proved far superior and have been standard for many years.

The Cable Systems, M1 and M2, have been designed for use in conjunction with the Remote Control System, M2, and the 90mm gun mount, M1A1. The two systems are essentially the same except that



One of the most important requirements of an antiaircraft fire control system is that the various elements of data should be continuously and instantaneously transmitted from their point of origin to the point where they may be used. As a concrete example, the gun data computed by the Director must be applied at the guns at the same instant the computation occurs. Otherwise this data would require correction for the time lag between the instant of computation and the instant it is "set" at the guns. Telephonic data transmission is unsuitable where data changes rapidly, although emergency systems make use of this method.

In order to satisfy this requirement, electrical data transmission systems were developed. From the earliest to the latest, they employ the same type devices, namely, synchronous transmitters, and repeaters, suitable indicators, multi-conductor cables, enclosed terminal boards called junction boxes, and gasoline powered electrical generators.

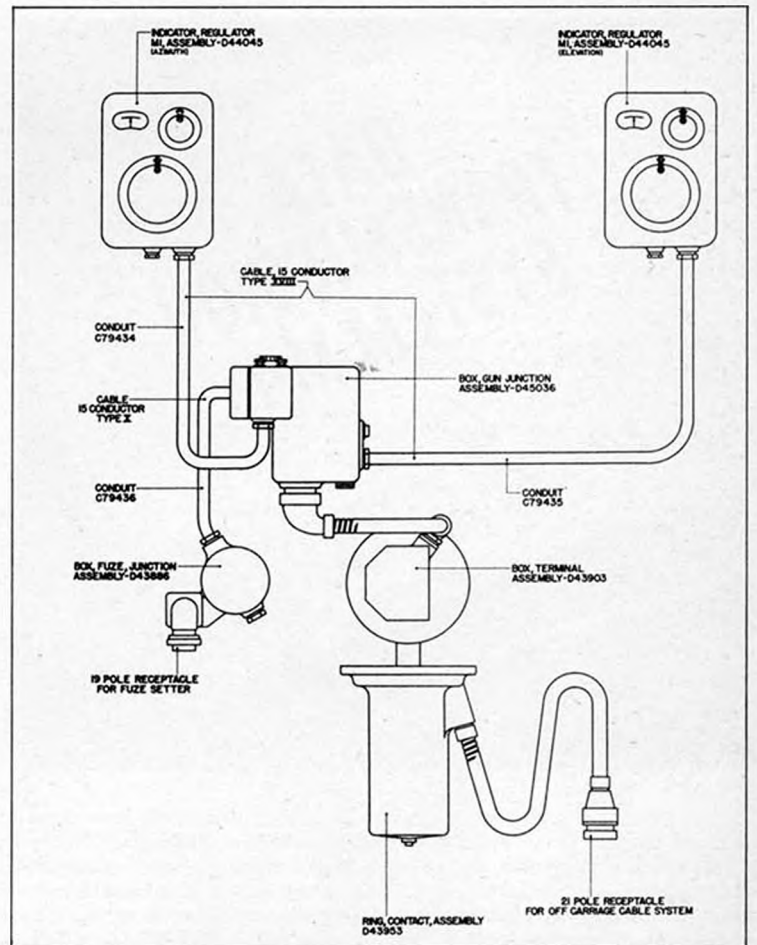


Fig. 16. -- Arrangement of On-carriage Parts for One Gun.

the M1 has sufficient 21-conductor cables to accommodate a battery of four guns, while the M2 system is for a two-gun battery.

The cable system, M1 or M2, may be divided into the off-carriage or portable components and the on-carriage or fixed components. The layout of a complete M1 system is illustrated in Figure 15, while the on-carriage units and their arrangement are shown in Figure 16. War Department pamphlet, "Notes on Materiel," Cable Systems M1 and M2",

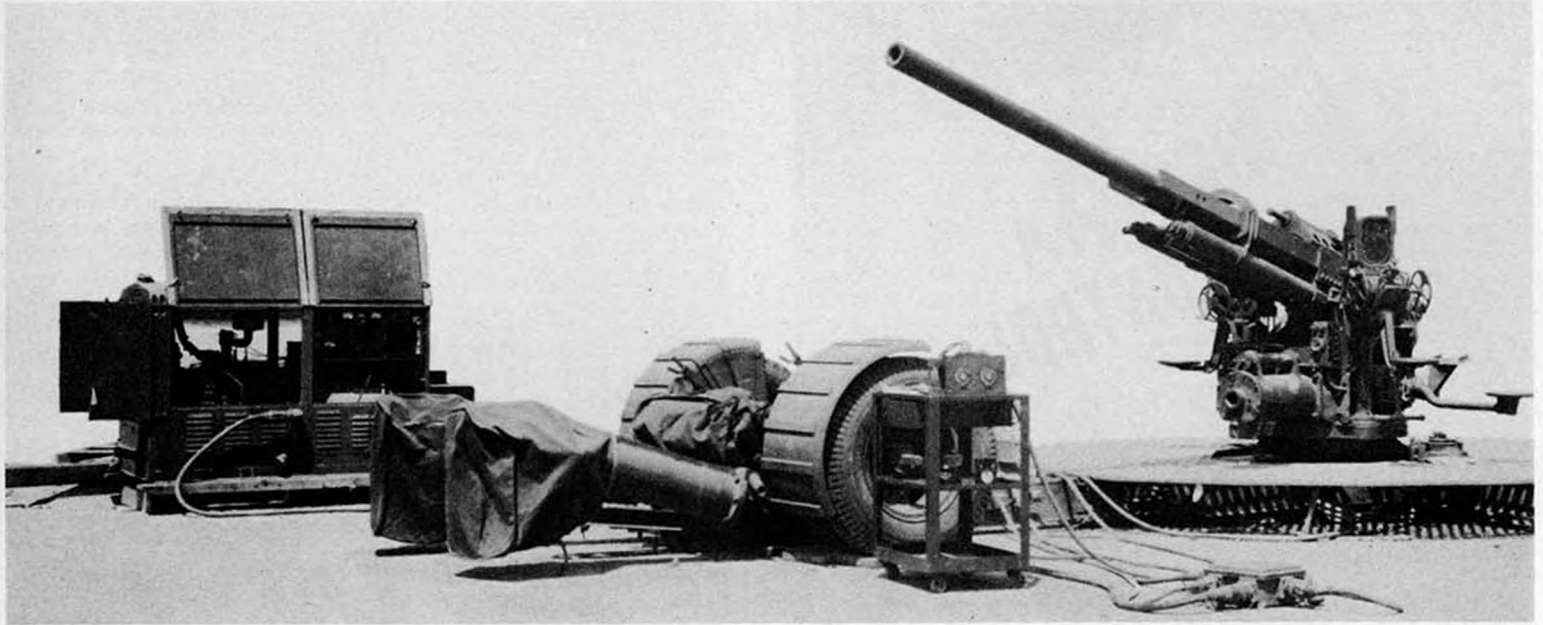


Fig. 17. -- 90mm Gun, M1, with Remote Control System M2.
(Setup for Instruction).

dated February 15, 1942, contains an excellent description and a great deal of valuable information for the maintenance man.

The indicator regulators of this system differ from the indicators of earlier systems in that they contain units which either are part of or are required for the operation of the Remote Control System, M2.

In place of the 2-1/2 KVA, single-phase, A.C. generating units used with earlier data transmission systems, the M1 and M2 cable systems are designed for use with the M7 generating unit, which is a 35 KVA, 3-phase alternator with a suitably powerful gasoline engine. The unit weighs slightly over one and one-half tons and is mounted on its own trailer. Figure 17 is an illustration of an instruction set-up of the generating unit, a modified cable system, and a 90mm gun equipped with the remote control system.



The difficulty of maintaining, during firing, an accurate match of pointers led early in the development of AA fire control materiel to experiments designed to develop satisfactory power equipment for the

positioning of the guns and the entire elimination of manual control in this respect. The latest result of this constant experimentation is the Remote Control System, M2, used on the 90mm AA gun mount, M1A1.

The system consists of both electrical and hydraulic units. The function of the system is to position the gun in azimuth and in elevation according to the data furnished by the director, thus replacing handwheel operation. Briefly, the system may be divided into three groups, according to function; the signal group, the stroke control group, and the hydraulic group.

The signal group receives the data from the Director, suitably modifies it, and transmits it to the stroke control group. The stroke control group receives the modified signals which are actually certain A.C. voltages, and converts these into a mechanical control movement for the hydraulic system. The hydraulic system is actually a hydraulic variable speed drive, governed in speed and direction by the stroke control system, using an electric motor as a source of power.

In Figure 17 is a 90mm AA gun, M1 equipped with the remote control system, while Figure 18 illustrates a bench layout of the system used for instruction purposes.

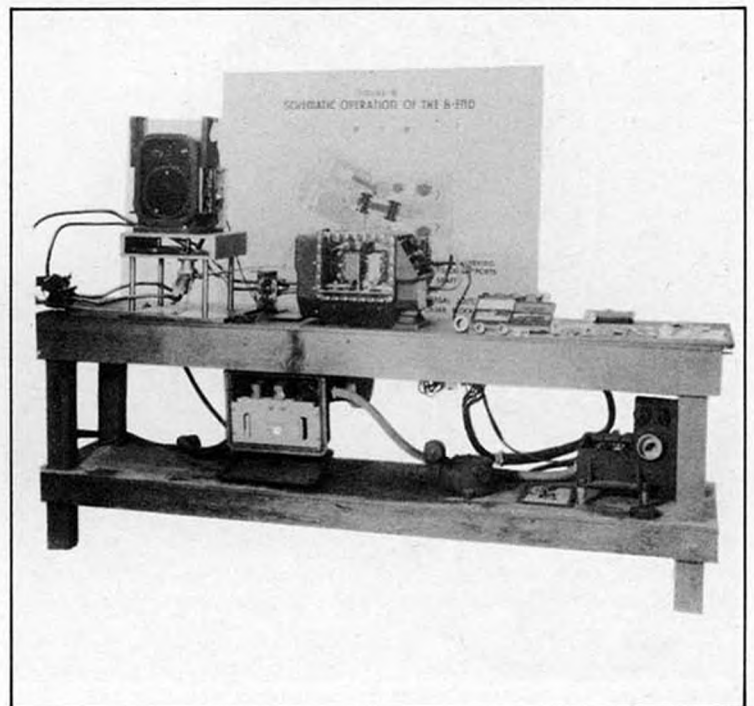
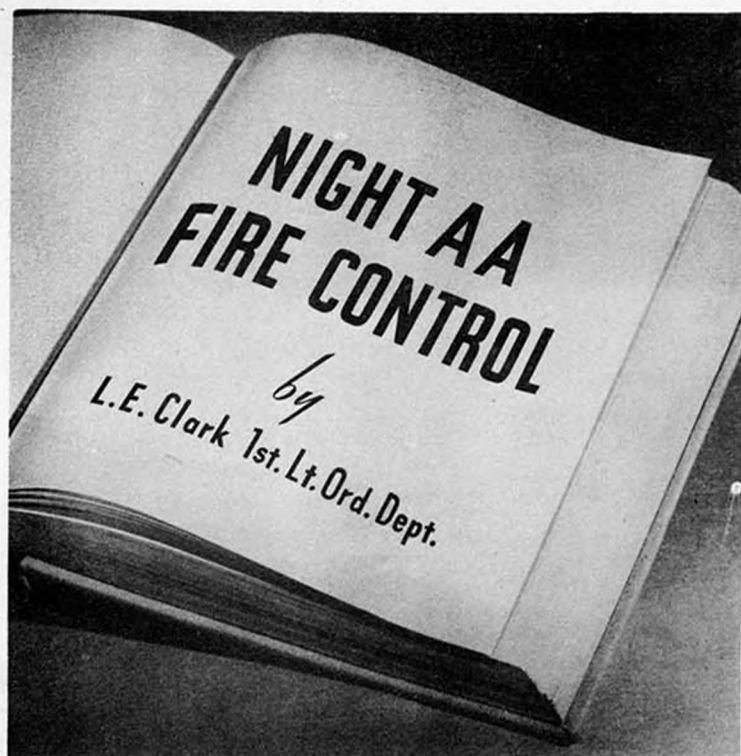


Fig. 18. -- Remote Control System, M2. (Bench Layout)



The AA artillery fire control system, of which the Director and Height Finder are the heart, can function only if the target can be seen through the various tracking telescopes of the system. For night operation an accessory system, consisting of a Searchlight, Control Station, Power Plant, Data Transmission System, and Sound Locator, is necessary. This supplementary system, which is in no way connected to the regular Director setup, has a twofold function: (1) It warns of the approach of enemy aircraft in sufficient time to permit adequate preparation for fire, and (2) It illuminates the target, allowing the Director system to function in the normal manner from then on.

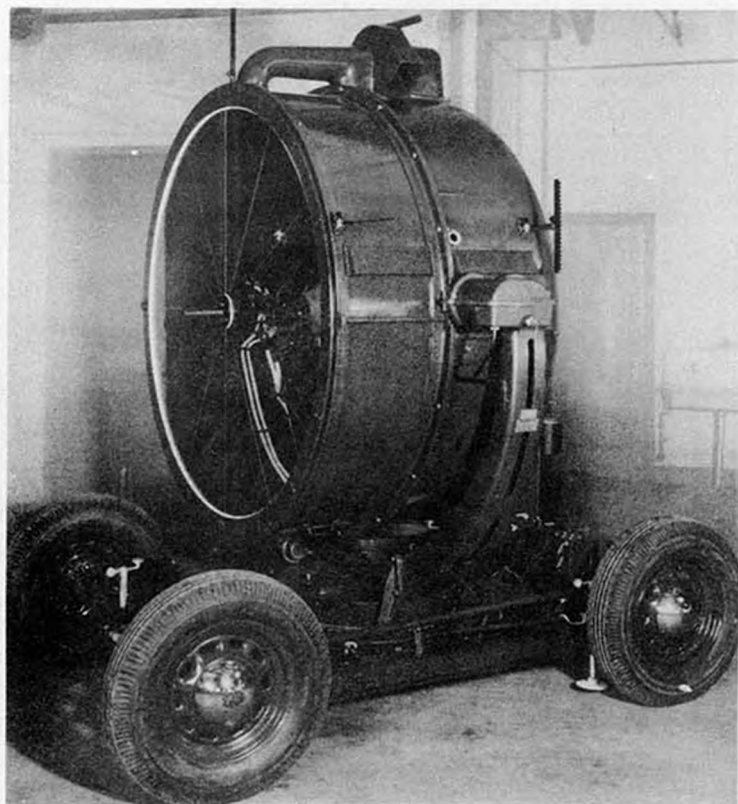


Fig. 19. -- Sperry, 60-inch High Intensity Searchlight.
(Courtesy Sperry Gyroscope Co., Inc.)

The components of this system are discussed in brief below.

The Searchlight

The Sperry, 60-inch, high intensity searchlight (Figure 19) consists of a high intensity carbon arc, automatically maintained at or near the focal point of a 60-inch parabolic mirror. The arc and mirror are protected by a drum container. This drum is so mounted as to permit continuous rotation in azimuth and movement in elevation from approximately 200 μ depression to 1800 μ elevation. The drum is equipped with a ventilating system so that the interior surfaces may continually be swept free of dust and vapors given off by the carbon arc.

The searchlight has an illuminating intensity of 800,000,000 candlepower and a range of 6,000 to 12,000 yards, depending on atmospheric conditions.



Fig. 20. -- Control Station (Courtesy Sperry Gyroscope Co., Inc.)

The Control Station

The Control Station (Figure 20) is the brains of the night-time system. It provides, (1) synchronization of the searchlight with the sound locator, (2) remote control of the searchlight, and (3) control of the observer's binocular and open sight assembly, which enables the operator to track the plane once the searchlight has been turned on.

The control station is operated by three men. Two of these men act as observers to position the searchlight in azimuth and elevation as indicated by the data transmitted by the sound locator while the other observer can also control the searchlight in azimuth and elevation when he is tracking a target.

The Power Plant

The power plant (Figure 21) provided for this unit consists of the following:

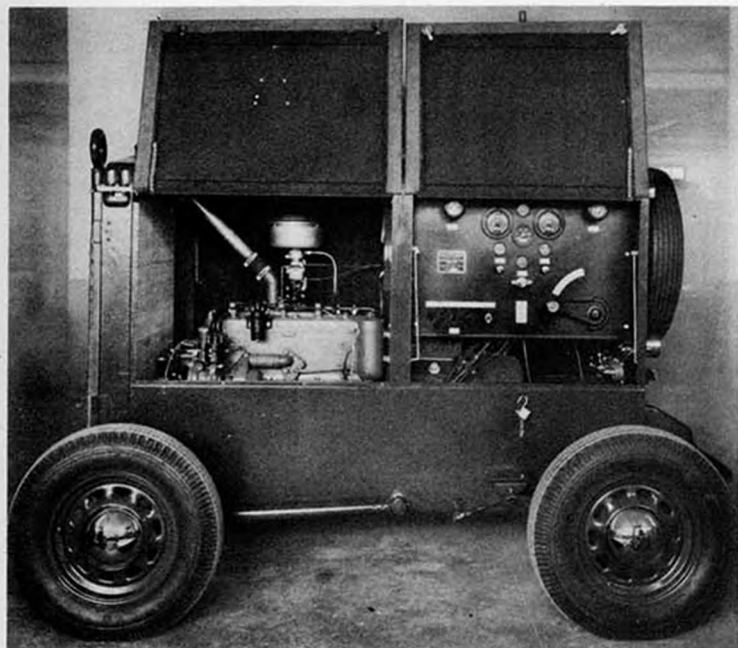


Fig. 21. -- Power Plant for Sound Locator and Searchlight.
(Courtesy Sperry Gyroscope Co., Inc.)

- (1) A 45-H.P., 6 Cyl., Hercules Gasoline Engine.
- (2) A Westinghouse D. C. Generator rated at 16.5 KW with a direct drive to the gasoline engine.
- (3) Control equipment consisting of the necessary governors, relays, resistors, and indicating instruments for both the engine and the generator.
- (4) A chassis and housing suitable for military transportation.

Ordnance Materiel

The only part of the entire system that is classified as ordnance materiel consists of the Sound Locator, M2 and the Data Transmission System. The Data Transmission System consists of two 450-foot lengths of nine-conductor, flexible, rubber covered cable, used to electrically

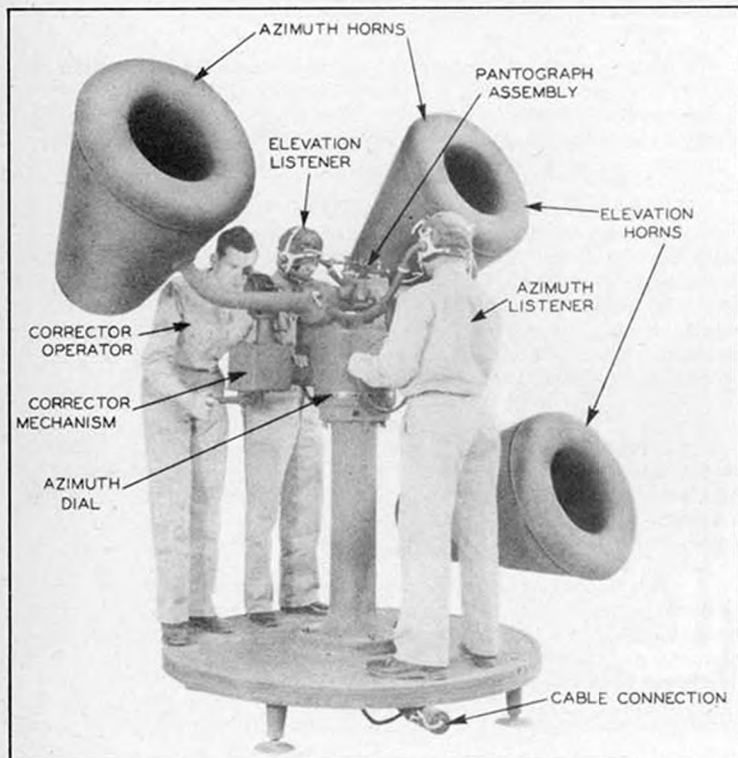


Fig. 22. -- Sound Locator, M2. (Being used for Instructional Purposes)

connect the sound locator, control station, searchlight, and generator together. Each length of cable is carried on a drum and both drums are carried on a portable reel.

The Sound Locator, M2

Binaural sense is defined as that faculty which enables a person to determine the approximate direction of a sound source by comparing the times of arrival of a sound wave at the two ears. It is easily understandable, then, that a person could more accurately determine the direction of a sound source if the base line between the ears could be lengthened. This is the basic principle on which the sound locator operates.

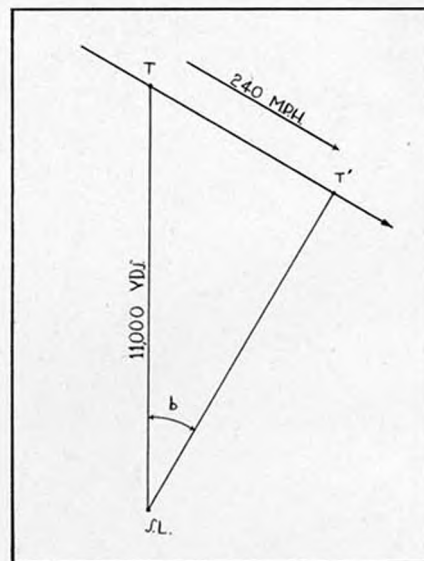


Fig. 23. -- Effect of Sound Lag.

The Sound Locator (Figure 22) consists of three horns mounted on a common structure and so placed as to be five feet from center to center and located at the vertices of a right triangle, one leg of which is rotated in a vertical plane and the other in a horizontal plane. The horn at the right angle vertex serves a dual purpose, being used for both azimuth and elevation and as a result has a split sound path.

The horns are so constructed as to reduce to a minimum (1) reverberation in the horn structure, (2) wind effect, (3) mechanical noises from the locator itself, and (4) all air borne noises except those in the direction of the target. The horns comprise one unit of the acoustical system. The remaining units are the sound conducting tubes, which are made of rubber, and the operators' helmets, which are similar to an aviator's helmet, and so constructed as to reduce to a minimum all sound except that coming through the tubes. Two operators are required to position the horn in azimuth and elevation and thus point the instrument at the sound source.

Theory of Operation

The speed of sound is approximately 1100 feet per second. Consider an airplane flying at a speed of 240 mph and at a range of 11000 yards when it is picked up by the sound locator, T (Figure 23). The time required for the sound waves to reach the listener's ears is thirty seconds. During this interval the plane has moved to a new position, T' or 3420 yards distant. It is evident, then, that if the searchlight was turned on, the plane would not be in its beam; that T is only the apparent position of the target; and T' the actual position. The sound locator points at the apparent position and is in error by the amount of angle b, (Figure 23). This angle, b, is known as the sound lag angle, and will be henceforth referred to as such. It can also be readily seen from Figure 23, that the sound lag angle can be an elevation angle, and also an azimuth angle, depending on the direction of flight of the target. Referring to Figure 24, a target picked up at T would, during its period of flight to T' form a sound lag correction angle in azimuth of b and in elevation of a.

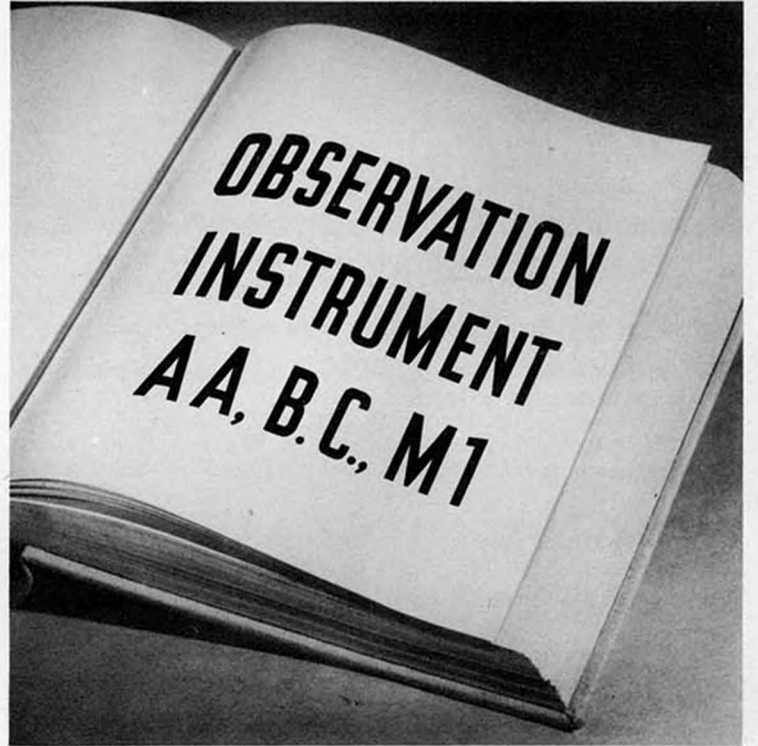
Pantograph

The means of correcting for these sound lag errors is accomplished by the use of a pantograph and corrector sight. (See Figure 25.) This is so arranged as to set up Figure 24 in miniature, forming a working

(which is the distance from the sound locator to the searchlight), is set by a man who operates the correction mechanism. By looking into the correction mirror he keeps the luminous pointer of the pantograph alined in the cross hairs of the mirror, and thus makes the correction. This correction is transmitted to the control station, and, as a result, the searchlight is pointed at the actual position of the target.

Once the searchlight has been turned on, and the target is illuminated, the director fire control system takes over the actual computations necessary to aim and fire the AA battery.

Radio direction indicators, which received considerable publicity, during last winter's air Battle of Britain, may eventually render the sound locator system obsolete. No information on this is available at the present, and since it will fall into the classification of Signal Corps materiel, will be of but passing interest to the Ordnance Department.



This instrument enables the battery commander to study and identify possible targets and to follow the course of firing on a target. It is also used to determine the coordinates in space of trial shot bursts. It may be used in lieu of a transit for orienting the firing battery.

It consists of a telescope, mount, and tripod. (See note below.) The instrument is controlled by a battery commander's observer who keeps the instrument on the target by means of traversing and elevating handwheels. This leaves the commander free to concentrate an observation. The battery commander's telescope is adjustable to either ten or twenty-power. The observer's is eight power. A reticle is provided in the battery commander's telescope bearing graduations in mils along vertical and horizontal axes, the least reading being five mils.

A four-volt lighting circuit is provided with sockets for illuminating the azimuth scales, elevation scale, observer's cross hairs and the mil graduations. The amount of illumination may be varied by a cartridge rheostat.

Since this instrument is basically two elbow telescopes with the necessary mechanical movements, all on a standard mount and tripod, maintenance is not confined to AA specialists. This instrument may be repaired and adjusted by any qualified instrument repairman if the necessary tools and facilities are available.

A photograph of this instrument will be found on page 173.

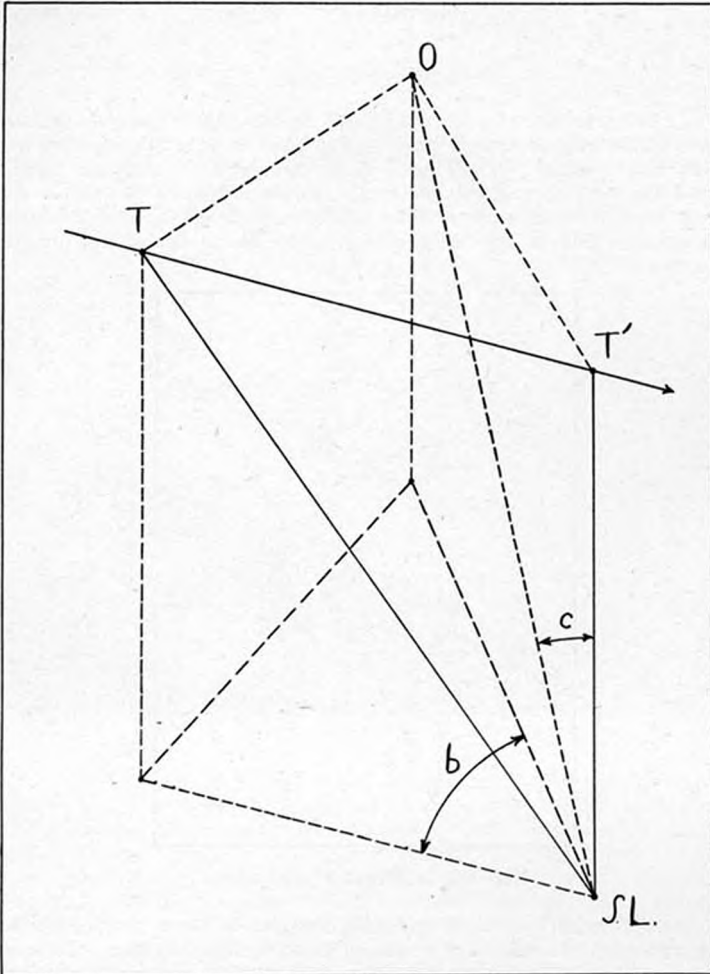


Fig. 24. -- Sound Lag Correction.

scale model, and thus make a correction for sound lag for varying speeds of the target. It is evident, though, that the direction of travel of the plane must be known in order to make the required corrections in the proper direction. A mechanism called the Ball Analyzer is used to determine this. It works on the principle of a "castor", and as the plane is tracked in azimuth and elevation, the miniature plane riding on the castor is positioned in parallel to the direction of travel of the target. This sets on the pointer of the pantograph the proper compensation for the sound lag correction. The correction for sound lag, and also for parallax

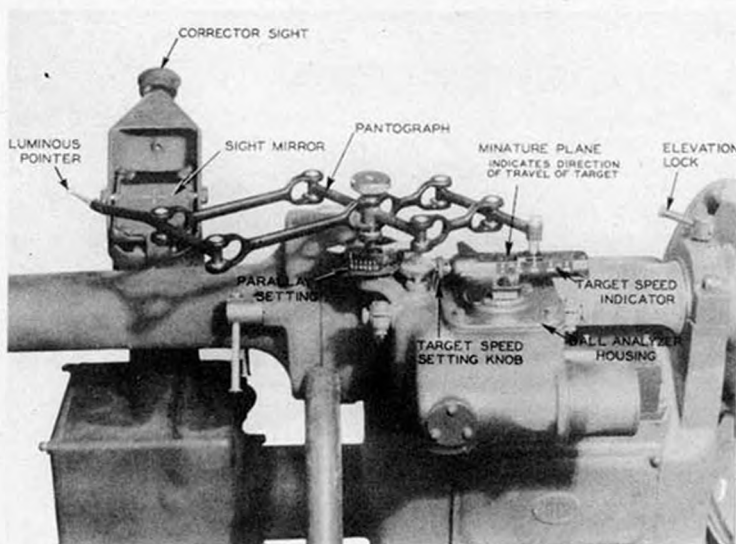
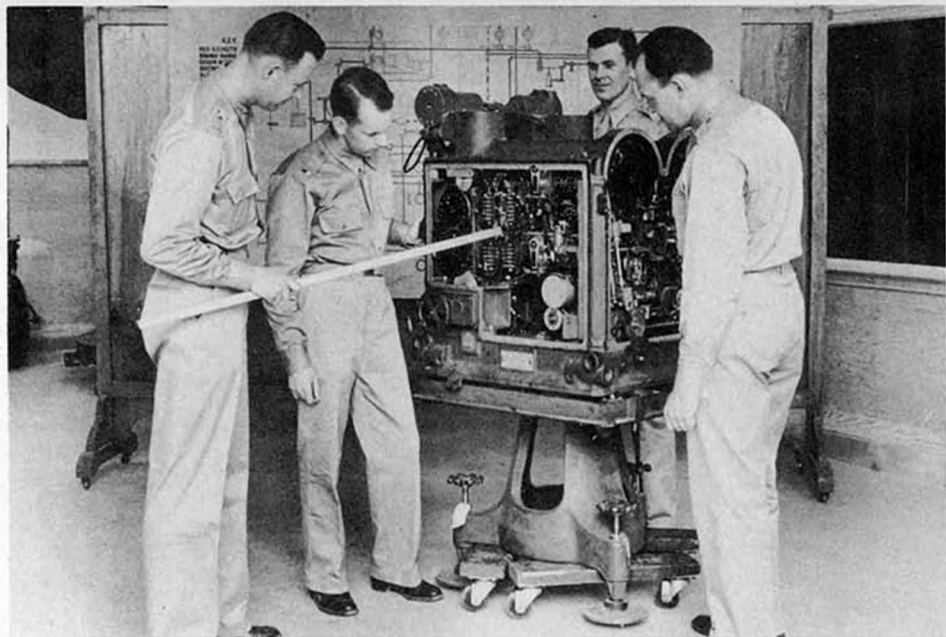
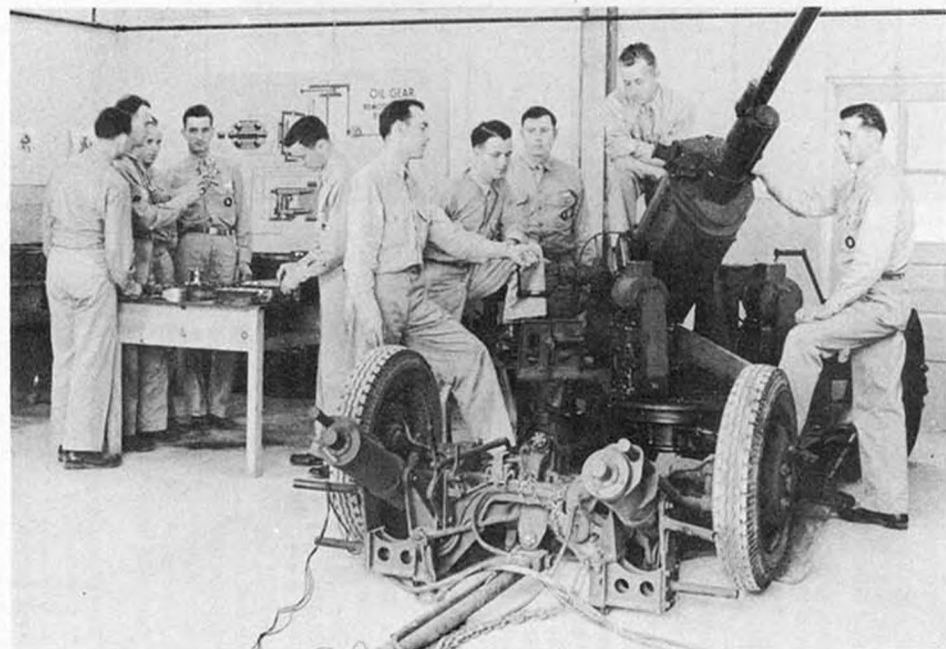


Fig. 25. -- Pantograph Sight Mirror Assembly of Sound Locator.



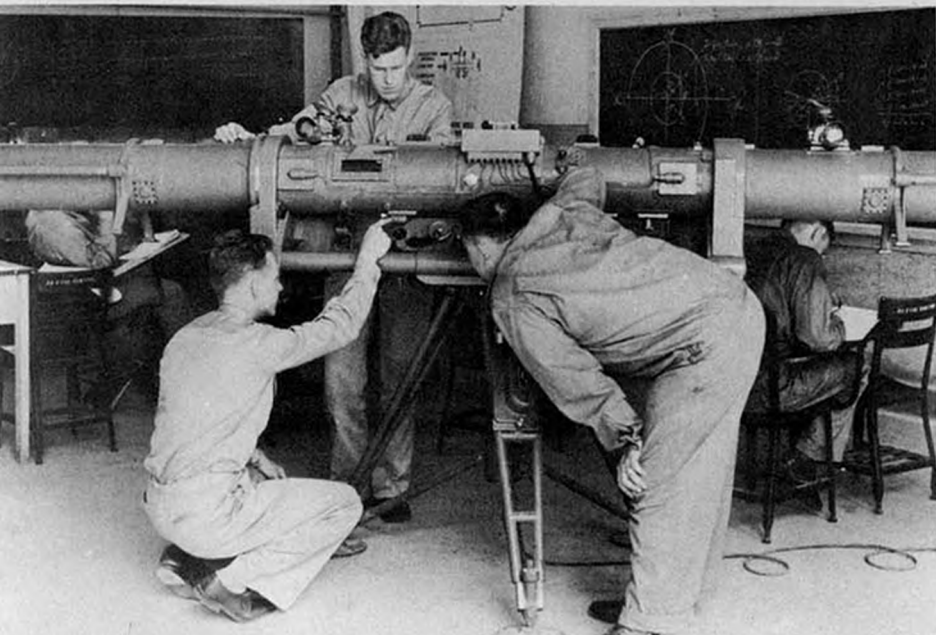
INSTRUCTION, DIRECTOR, M4

Instruction on the Director, as evidenced by the above picture, goes into the innermost workings of the instrument.



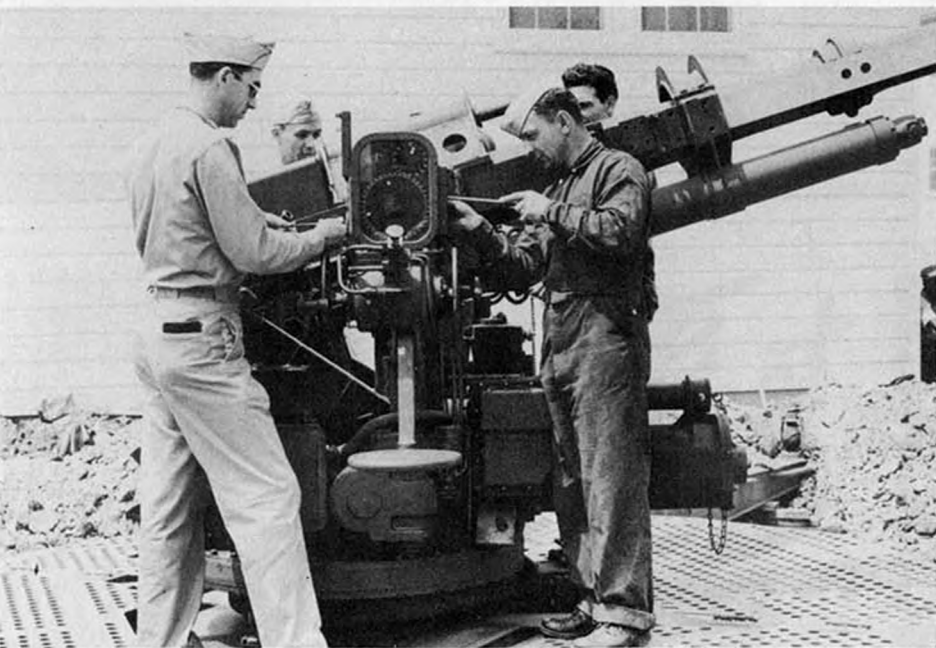
INSTRUCTION, REMOTE CONTROL SYSTEM, M1

The Remote Control System, M1, is also an electrically controlled hydraulic system. It is used with the smaller guns. The above photograph shows a class receiving instruction on this materiel.



INSTRUCTION, HEIGHT FINDER, M1

Instruction on the Height Finder includes the optical design and the mechanical operation of the instrument as well as field maintenance.



INSTRUCTION, REMOTE CONTROL SYSTEM, M2

The Remote Control System, M2, is an electrically controlled hydraulic system. The above photograph shows students working on the on-carriage components of this system.

FUNCTIONING of Sea Coast Fire Control and Position Finding Systems

Introduction

The article below has been adapted and extracted from FM 4-15, "Seacoast Artillery: Fire Control & Position Finding", dated 1940. This manual, in its entirety, is recommended as essential background material for all ordnance personnel participating in fire control and instrument work.

The information below is of special interest in illustrating the application of many computing and plotting devices which are issued and maintained by the Ordnance Department.

While more modern equipment than that discussed is being used extensively, and radical changes in seacoast fire control and gunnery are contemplated and in development, the older systems still find wide use, pending the arrival of newer equipment.

The American artillerist has more than once demonstrated uncanny accuracy. This is largely due to excellent weapons, efficient fire control materiel, extensive and rigid training, and the high level of intelligence of the American soldier. The efficiency and accuracy of heavy American artillery was amply demonstrated in the devastating havoc wreaked by our artillerymen on enemy materiel and troops at Wake and Corregidor.

In previous years ordnance personnel had little contact with the maintenance operations pertinent to seacoast fire control materiel. Civilian mechanics, and the arsenals, performed these operations. The present war, however, has changed this situation. Ordnance maintenance personnel in the field will be expected to perform innumerable tasks for the duration which were previously considered strictly a base shop or arsenal function. The limitations previously imposed on field maintenance are more and more being determined by the exigencies of the situation and the geographical location of the theatre of operations.

Efficient ordnance personnel are aware of this development and are taking every possible opportunity to widen their acquaintanceship and broaden their experience in regard to unfamiliar materiel.



Plotting Room in Action. (Courtesy of The Coast Artillery School).

Since seacoast fire control materiel is more or less unfamiliar to most ordnance personnel, the following article has been adapted to illustrate the broad scope of this subject. If, after reading it, further information is desired, consult FM 4-15 from which it has been extracted.



General

The equipment to be found in the plotting room of any one seacoast artillery battery will differ from that in almost any other battery. There are several reasons for this. The newly developed instruments are not furnished to all batteries, especially the older batteries. Again, the requirements of the different batteries are different, depending on caliber and range. And finally, minor modifications are made in the systems to suit the preferences of the battery officers.

In previous years Ordnance personnel had little contact with the maintenance operations pertinent to seacoast fire control materiel. The present war, however, has changed this situation.

Obviously, it would be impossible to describe the operation of all possible combinations of the numerous instruments and improvised instruments that are in use without burying the main idea in a mass of detail. It has been thought best to describe the operation of one system only, and to give in later paragraphs necessary notes on the variations of this system when other instruments are substituted. Only the more important cases of this kind are considered.

The system chosen is that shown in Figure 1. It is for a battery of fixed guns of major caliber, and the plotting room is equipped with a 110° plotting board; range correction board, M1; deflection board, M1; percentage corrector, M1; spotting board, M2; and fire adjustment board, M1. The base end observers and the azimuth observers are equipped with azimuth instruments, M1910A1.

Action Before Target is Assigned

Before the target is assigned, all preparations for the calculation of firing data must be made. The range officer, having maintained his equipment in adjustment by frequent tests, makes a quick survey of the most important features. All communication lines are tested by the men who operate them.

The meteorological message is received by the man designated for that duty and is recorded on a form drawn up by the range officer. Air temperature can be taken from the message at once, but the proper ballistic density, and ballistic wind to use, cannot be determined until the target is assigned and its range determined.

The tide message is received from the tide station and recorded. All possible information as to weights of projectiles is received from the battery executive. By coordination within the battery, this information can be in the hands of the range officer well in advance of the time the projectiles will be used.

A record of all available information as to the powder on hand in the battery is maintained by the range officer. This includes information as to its previous performance, reduced to standard temperature, to-

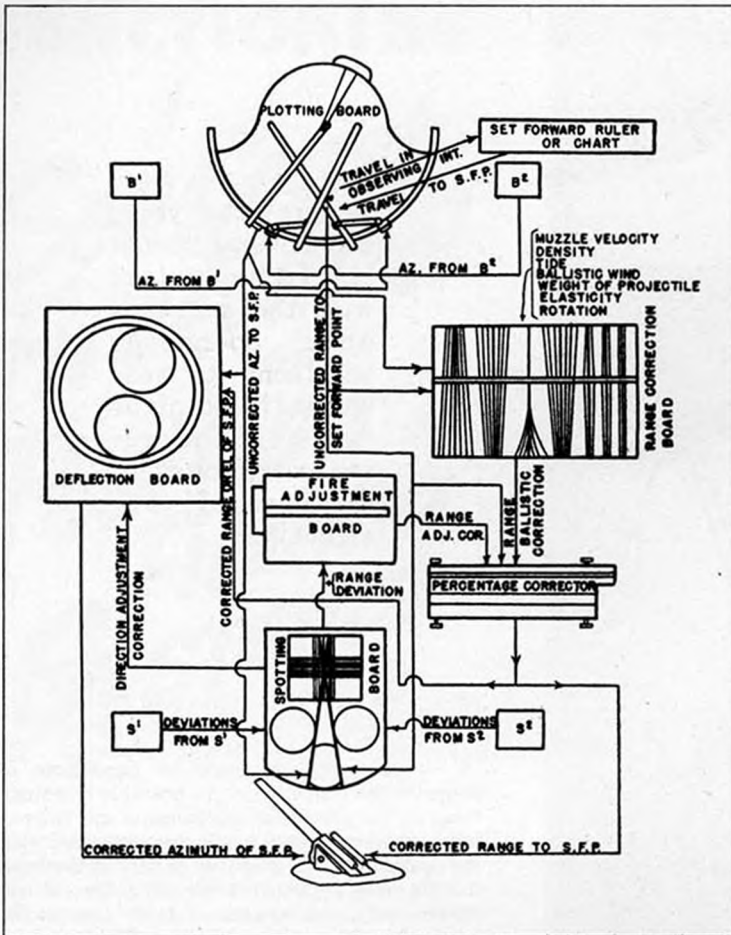


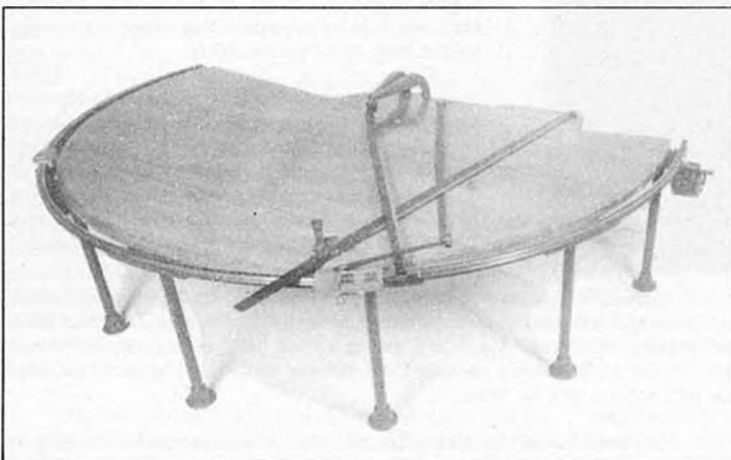
Fig. 1. -- Diagram of Routing of Position Finding and Firing Data

gether with powder tag markings, present temperature and other information. The range officer will have determined beforehand the muzzle velocity to be assumed with any combination of ammunition likely to be used, and insofar as possible the battery commander will give both the range officer and the battery executive advance warning as to the combination that will be ordered.

Action When Target is Assigned

The assignment of the target to the battery by the group commander will be followed by its assignment to the various elements of the battery by the battery commander. This assignment will convey the battery commander's decision as to the ammunition, the observation and spotting stations, the case of pointing, and the method of tracking to be used.

The following steps are taken immediately by the plotting room detail:



Plotting Board, M3.

(1) The plotting board is made ready for tracking, using the stations and method of tracking ordered.

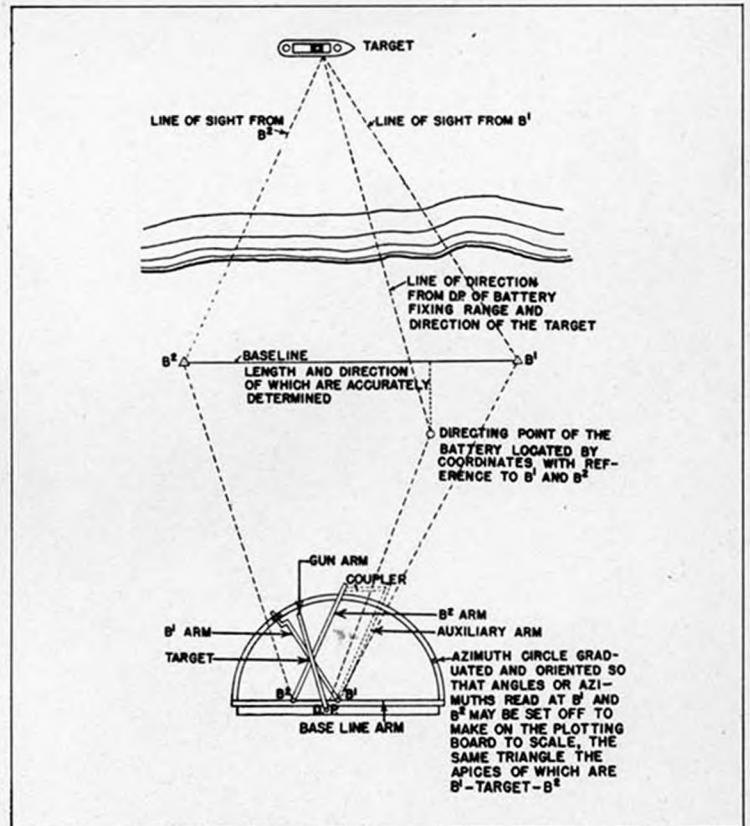
(2) The required communication setup is arranged by proper manipulation of the switchboxes.

(3) The spotting board is made ready for spotting, using the stations ordered.

(4) The operators of the range correction board, percentage corrector, and deflection board turn to the charts corresponding to the ammunition ordered.

(5) The operator of the range correction board makes notation as to the muzzle velocity, height of site (tide), weight of projectile, and temperature (elasticity) curves to be used.

(6) The observers designated to track the target, and the gun pointers when case II pointing is ordered, identify the target and bring



Relation between Plotting Board and Field of Fire.

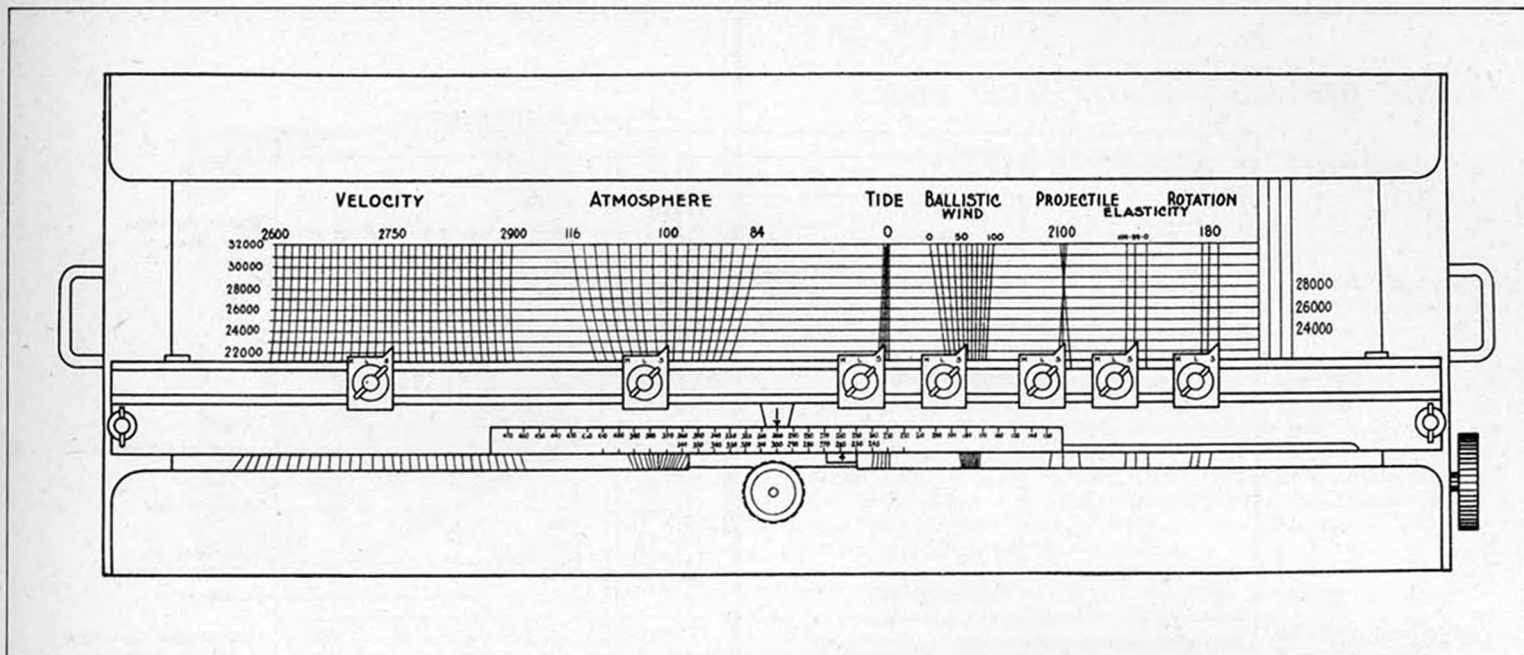
their instruments or guns to bear on it. Each then reports, "___ on target". As each reports on target, a battery officer commands "Track", without waiting for others to get on.

(7) The observer follows the target with his instrument, keeping the crosswires thereof accurately centered on the observing point of the target. When the third bell of each time interval signal strikes, he stops following the target long enough to permit his reader to read and transmit to the plotting room the desired data.

(8) If vertical base tracking has been ordered, the observer tracks in azimuth as described, and in addition he tracks in range by keeping the horizontal wire of his instrument at the waterline of his target. At the third stroke of the bell he holds both the azimuth reading and the range reading stationary long enough for the reader to transmit them to the plotting room.

Approximate Data

As soon as the plotting room has received the first readings from the observation stations, the position of the target is plotted and the plotter calls out, "Approximate Data". He then reads off the range to the plotted point, and the operator of the gun arm reads off the azimuth to

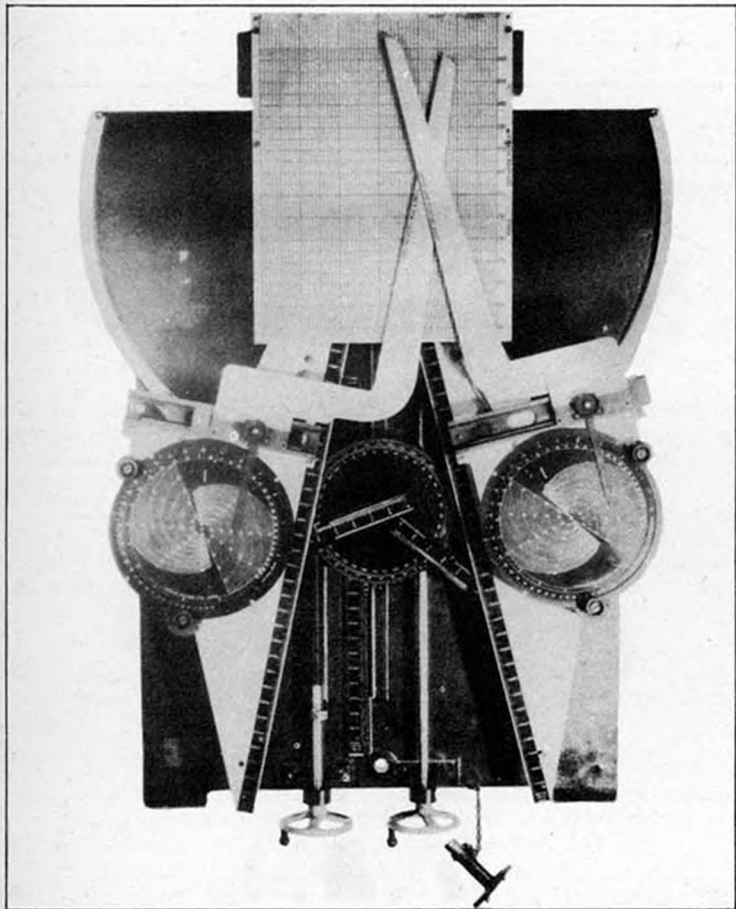


Range Correction Board, M1

that point, both loud enough to be heard by all in the plotting room.

Using this approximate range, the ballistic wind zone is selected and the ballistic wind and ballistic density are taken from the meteorological message by the range officer. The ballistic density and rotation curves to be used on the range correction board are noted. The direction and speed of the ballistic wind are set on the deflection board.

The deflection board operator turns the deflection board to the approximate azimuth. This determines the range and lateral components



Spotting Board, M2

of the ballistic wind for use on the range correction board and on the chart of the deflection board itself. The chart is turned to the approximate range, the pointer is brought to the curve corresponding to the lateral wind component, and a first (approximate) reading is sent to the guns (in case III pointing) so that they may be traversed to the target.

The range correction board operator turns his chart to the approximate range, takes the range component of the ballistic wind from the deflection board, and determines an approximate ballistic correction. This he transmits to the operator of the percentage corrector.

The percentage corrector operator turns his range scale to the approximate range and transmits the range to the guns except when ranges are set on the guns in angular units (as elevations), in which case he reads off an approximate elevation which he sends to the guns. After receiving the ballistic correction he sends to the guns a second approximate range (or elevation) if it differs materially from the first.

The spotting board is set to the approximate range and azimuth.

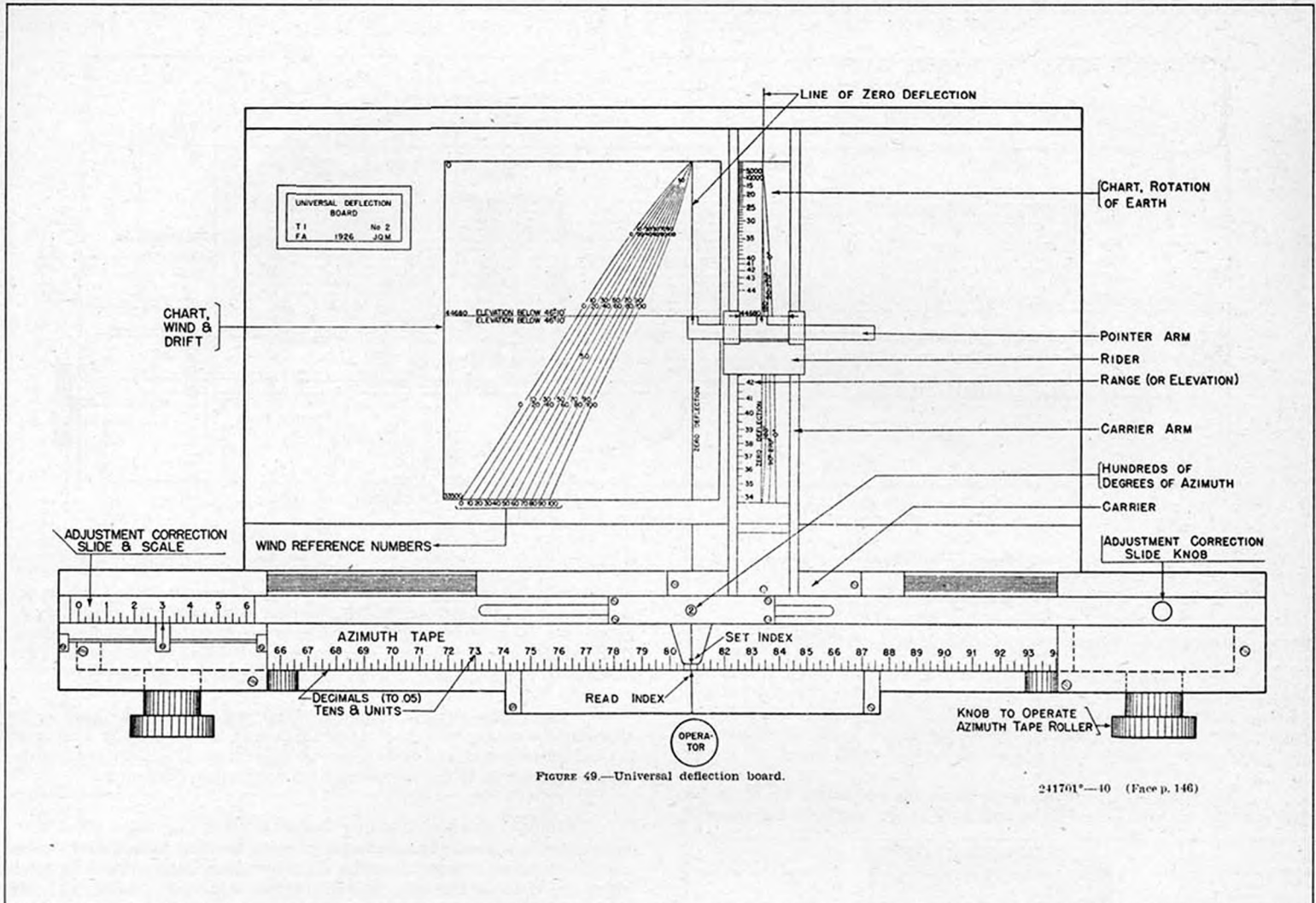
Corrected Data

After the course of the plotted points has steadied so that prediction is possible the plotter makes a prediction. The range and azimuth of the set forward point are called out for all to hear. All other data are transmitted in tones as low as reliable transmission will permit. The outstanding characteristic of a well trained range section is that it is quiet.

The percentage corrector operator sets the range to the set forward point on his board, uses the ballistic correction already set, and if necessary converts this range into elevation. He transmits the firing range or the firing elevation to the guns immediately or holds it for transmission on signal, according to the method in use at that particular battery.

The deflection board operator sets the range and the azimuth of the set forward point on his board, using the lateral component of the ballistic wind that shows on the wind component indicator after the azimuth is set. If pointing is by Case III, the corrected azimuth is read from the board by the assistant operator. If pointing is by Case II, travel is computed by a device built into the board. This device is operated by the assistant who computes the deflection and transmits it immediately to the guns.

The range correction board operator sets the range to the set forward point on his board, follows the curves, and gives a new ballistic correction to the percentage corrector operator when it changes by 1/10 of 1 percent.

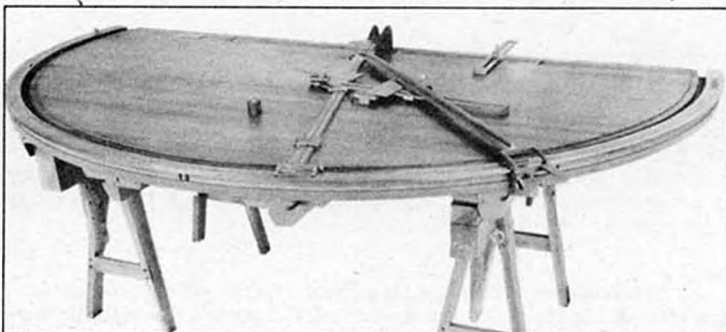


Functioning When Using Other Equipment

(1) Prediction Scale. - When the prediction scale is used, a set forward rule or set forward chart is required to give the plotter the travel during the dead time plus the time of flight. In this case the operation is performed by the set forward device operator. The set forward rule or chart should be graduated in terms of elevation or range as this is sent to the guns, so that it will not be necessary to put time of flight graduations on the percentage corrector strip and have the percentage corrector operator making an extra reading of time of flight. The ruler or chart operator will simply set what is sent to the guns.

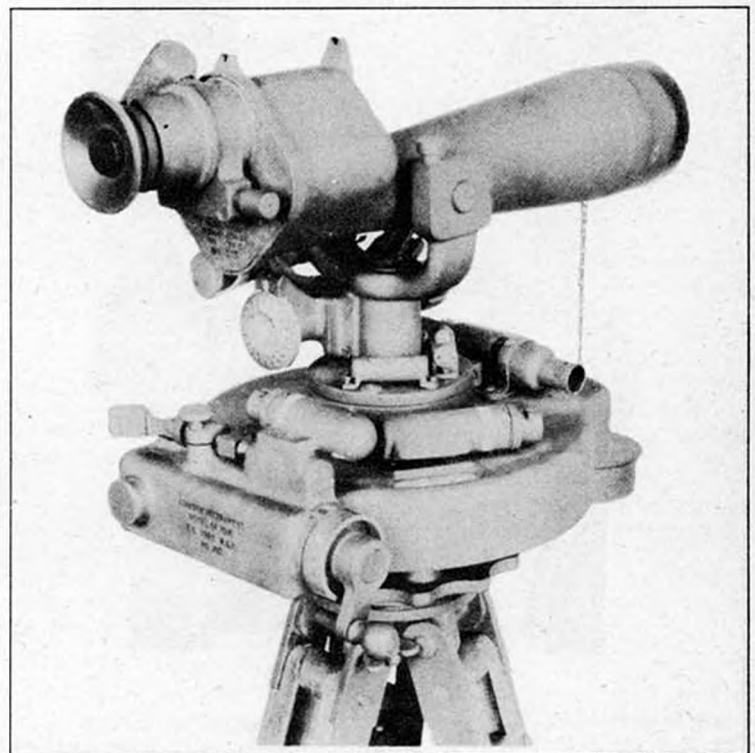
(2) When the plotting and relocating board, M1 is used an additional operator, called the platen operator, is needed.

(3) Whistler-Hearn Plotting Board. - The essential features in which the Whistler Hearn plotting board differs in operation from the other plotting boards are that it has a built-in device for computing
(Continued on page 173)

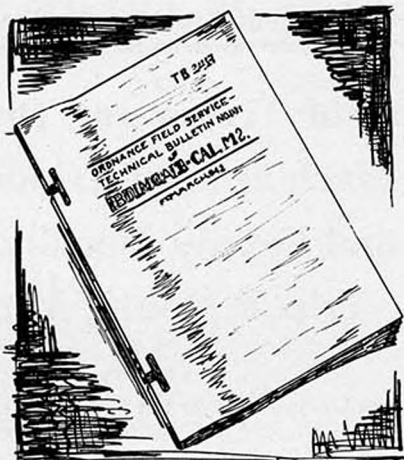


Board, Plotting and Relocating, M1923

Universal Deflection Board.



Azimuth Instrument, M1918



Under this heading THE ORDNANCE SERGEANT reproduces advance information pertaining to Ordnance Field Service Technical Bulletins. These Bulletins are not yet published in most cases, and in almost every instance this information will reach readers prior to complete distribution of the Bulletins in the field.

For some items the exact form of the forthcoming Bulletin is given (less its number), while for others only a preliminary version of the text which will be used in the Bulletin is available in time for publication.

In either case these items are OFFICIAL, being published by direction of The Chief of Ordnance.

Half-Track Vehicles Without Hydrovac System: Emergency Repair of Vacuum Booster Brake System

July 3, 1942

In the event of failure of the Vacuum Booster Brake System by puncture of the Booster Cylinder, fracture of the Cylinder Head, or failure of the system by any other means, the following emergency repair shall be made at once.

(1) Remove pin #A-214523 from the yoke end #A214526 which is attached to Vacuum Booster Assembly #D48121.

(2) The Piston Rod Valve end shall be securely tied in the extreme outward position so as to preclude actuation of the Booster Mechanism.

After the Vacuum Booster Cylinder has been disconnected, extreme care must be exercised in the operating of the vehicle and the correct repair or replacement performed as quickly as possible.

Selby H. Frank
Colonel, Ordnance Department

Cars, Half-Track: Starting Motor Drive Housing Breakage

July 4, 1942

Several instances of breakage of the drive housing on the starting motor, D48136, have been reported. In order to eliminate the causes of this breakage, the following instructions will be adhered to:

(1) In starting the engine, pressure will be applied to the starter button until the engine has either started or turned over for a period not exceeding 10 to 15 seconds. In case the engine fails to start or makes a false start, it must be allowed to come to a complete stop before the starter button is again pressed. (Refer to TM 9-710, Paragraph 7bl.) If the starter button is pressed before engine reaches a complete stop, especially after a false start, the Bendix drive may engage on rock-back with a force sufficient to break the housing.

(2) Care will be taken to see that the timing mechanism on all vehicles is in proper adjustment. A kick-back caused by the engine timing being too far advanced will in many cases either destroy the Bendix Spring or break the drive housing as the housing and drive take the full force of the kickback.

(3) In mounting a starting motor on the engine, care will be taken to see that the Bendix drive gear is in its disengaged position on the worm. When mounting is attempted with the drive gear in its engaged position, the drive gear teeth may bind or ride the teeth of the flywheel ring gear, causing the starting motor housing to break when the motor assembly is tightened to the flywheel housing.

When the drive housing breaks, the broken end may drop off the shaft and fall into the flywheel housing. This will leave the spacing washers free to fall off and may give the impression that the starter has been improperly assembled. To remove these pieces it is necessary to remove transmission, clutch, and in some cases, the flywheel.

Selby H. Frank
Colonel, Ordnance Department

Scout Car, M3A1: Improved Type of Ignition Coil and Radio Shielding Unit

July 4, 1942

To eliminate failures of ignition coils from the accumulation of excessive temperatures within the coil box, a new ignition coil and radio shielding capable of withstanding higher operating temperatures have been designed. This new ignition filter and adapter assembly (W1-400809) will replace Filter Assembly (W1-376654), and ignition coil (W1-62321). Part No. W1-400809 includes a new type ignition coil mounted in a better ventilated radio shielding filter unit as well as necessary adapters so that it is interchangeable with the old coil and radio shielding unit.

This is considered an easy replacement inasmuch as all that is required is that the dash be redrilled to suit the new ventilated radio shielding filter unit. The new type of ignition coil assembly will be issued upon requisition from the field for ignition coil assembly only after the stock of the old type has been depleted at the supply depots.

Vehicles of production later than June, 1942, will be so equipped at the point of manufacture.

Selby H. Frank
Colonel, Ordnance Department

Scout Car, M3A1: Preparation for Shipment

July 4, 1942

The cooling system should be completely drained and drain cocks on radiator, engine block and water pump cleared by inserting wire, and left open.

(1) A large tag reading "NO WATER" shall be firmly wired to the steering wheel, thereby indicating the vehicle has been drained.

Fuel tanks, filter, fuel pump and carburetor should be completely drained and engine run to use up any remaining fuel.

(1) When vehicles are shipped with troops, draining of fuel is not required and unloading will be expedited.

The positive battery cables should be disconnected, taped, and tied away from the batteries.

Tires should be inflated 10 pounds above normal pressures.

Gear shift levers should be in neutral position and drive shaft brake set.

Ignition switch should be in "off" position.

Tops, curtains, and cushions should be bound and secured against loss and damage due to inclement weather. Doors should be closed and lashed. Windshield armor should be blocked to prevent possibility of crashing down on windshield glass.

All loose property and tools should be packed and secured in boxes. Hoods should be sealed down with car seals and radiator shutters should be closed.

Keys should be placed in small cloth bag securely wired to steering wheel.

In case of shipment by water, preparation is, with certain modifications, the same as that indicated for shipment by rail. Special attention should be given to rust prevention. All exposed unpainted metal and working parts should be greased.

This information is published pending revision of TM 9-705.

Selby H. Frank
Colonel, Ordnance Department

Piston Ring Change in R975-C1 Engines, Medium Tanks

July 6, 1942

A change in the ring installation in production of R975-C1 Continental Engines has been made. The old and new installation is tabulated below.

Old	New
1st groove CO-201406	CO-201406
2nd groove CO-201406	CO-201952
3rd groove CO-201406	CO-201952
4th groove CO-201898	CO-201898

The following will be noted from the above tabulation:

(a) Bevel back taper face ring CO-201406 will henceforth be used in groove No. 1 only.

(b) The new bevel back straight face ring CO-201952 will be used in grooves No. 2 and 3.

(c) The oil ring CO-201898 is still used in groove No. 4.

Change will be made to the new ring set-up at the next engine disassembly.

The above does not apply to R975-EC2 engines as these will shortly be subjected to conversion to the R975-C1 model.

Omission of Traversing Dials from Cal. 30 Machine Gun Tripod Mount, M2, and Cal. 50 Machine Gun Tripod Mount, M3

July 9, 1942

Recent investigations indicate that the traversing dials on Mount, tripod, machine gun, Cal. 30, M2, and Mount, tripod, Machine gun, Cal. 50, M3, are not of sufficient use to warrant placing them on mounts of future manufacture. Therefore, this component is being omitted on mounts now being manufactured.

E. D. Billings
Captain, Ordnance Department

Feed Mechanism of Aircraft Cannon, 37MM, M4

WAR DEPARTMENT, ORDNANCE OFFICE
WASHINGTON

Ordnance Field Service Technical
Bulletin No.

FEED MECHANISM OF AIRCRAFT CANNON, 37MM, M4

1. Several cases of failures in the feed mechanism of Aircraft Cannon, 37mm, M4 have been reported to this office. These malfunctions apparently are due to sharp corners at the junction of the rear plate, B163412 and D36326a left half of feed box case assembly, C70542.

2. As a result of these reports, all guns produced in the future will have the above mentioned parts modified.

3. The following information is to be used in modifying the feed mechanism whenever failure to feed is observed.

4. Disassemble such parts of feed mechanism as are necessary to facilitate work on the rear end of the opening on the left side of the feed box. At this position the rear Plate, B163412, left half of the Feed Box, D36326a, and Bearing, B163363 are joined together. It will be noted that the rear end of the opening in the feed box is slanted outwards. The forward edge of the bearing may project beyond the inner edge of the feed box. Maintaining the angle on the rear end of the feed box opening as closely as possible, file across the rear plate, feed box and bearing forward into the feed box without interference if they should contact the surface. Clean out all chips and metal particles and reassemble feed mechanism.

BY ORDER OF THE CHIEF OF ORDNANCE:

H. R. KUTZ
Brigadier General, Ordnance Department
Chief of Field Service.

Trail Hinge Pin Bushings for 37MM Gun Carriages, M4A1 and M4

WAR DEPARTMENT, ORDNANCE OFFICE
WASHINGTON

Ordnance Field Service Technical
Bulletin No.

TRAIL HINGE PIN BUSHINGS FOR 37MM GUN CARRIAGES, M4A1 & M4

1. Frequent reports of failure of the Trail Hinge Pin Needle bearings used on the 37MM Gun Carriage M4A1 and M4 have been received in this office. As a result, the needle bearings will be replaced with bronze bushings on all carriages of future manufacture. In addition a supply of bronze bushings is available at Rock Island Arsenal for issue to the field to replace needle bearings which have failed.

2. Whenever failure of the needle type bearing occurs, the method of repair will be as follows:

(a) Disassemble the trail hinge assembly as prescribed in Par. 46 TM 9-1245, January 15, 1941, and remove old needle bearings and hinge pins.

(b) Press into place in the trail hinge pin housing located in the axle support, lower bushing B195592 and upper bushing, B195591.

(c) Drill hole to lower bushing to receive grease fitting CLDX5K.. The grease hole must be drilled to the lower bushing only as lubrication is supplied to the upper bushing through the trail hinge pin.

(d) The thrust washers used with the needle bearings are to be modified for oil grooves as shown on drawing A168738. However, if they are in an unserviceable condition, they should be replaced with washers in which the grooves have already been machined.

(e) Clean out all chips and foreign matter, reassemble trail hinge assembly using new type trail hinge pin B156552. It will be noted this new type pin has the grease hole only to the upper bearing. On the old type the hole is drilled to both upper and lower bearings.

3. All necessary parts, bushings, pins, and washers are available at Rock Island Arsenal.

BY ORDER OF THE CHIEF OF ORDNANCE:

H. R. KUTZ
Brigadier General, Ordnance Department
Chief of Field Service



HISTORY AND DEVELOPMENT OF FIRE CONTROL

(Continued from page 107)

periscope of the prismatic type with a double reticle or graticule near the middle of the range finder tube. U shaped range finders of the coincidence type have also been employed for use in turrets to facilitate the mounting in these close quarters.

A T-shaped periscopic range finder which can be carried on the shoulders very easily by one man and which has a very short base is in common use by several major European armies, although it has never been seriously considered as a standard for the American service.

In use in Europe also are Dip range finders and sitometers; outside base range finders with three types of stadimetric eyepieces (micrometric, duplicated images and split lenses); and varying types of stereoscopic instruments designed for range or position finding.

The pseudo stereoscopic range finder is of interest. In this instrument an optical arrangement allows the right eye to see the image intended for the left and vice versa. A double image is presented in the split field of view; one a normal image and the other an image which is inverted stereoscopically, or is pseudo stereoscopic. Instead of a stereoscopic impression of relief the image appears inside out or in reverse relief. This presumably allows better coincidence to be secured. It is of interest as a curiosity item only and has never seen any wide practical application.

Twentieth Century

The situation at the start of the twentieth century showed telescopic sights in common use, as well as range and position finders of the self-contained type. Geodesic range finding was still being used for seacoast work to a limited extent. The entire scope of fire control material had widened perceptibly and all major nations were now using a variety of telescopic instruments and devices for fire control and sighting purposes.

At the start of the First World War all of the participants, on the allied side, were yet sadly behind the Central Powers for fire control and sighting materiel. The impetus given the development of this equipment by this war is discussed in a separate article in this issue of THE ORDNANCE SERGEANT. (See "Fire Control Materiel in the First World War").

The first world war saw the use of artillery to an extent that confounds the very imagination. The table below is illuminating as a comparison.

YEAR	BATTLE	DAYS DURATION	ARMY	Rounds of ART. AMMUNITION EXPENDED
1863	Chickamauga	2	Union	7,325
1863	Gettysburg	3	Union	32,781
1870	St. Privat	1	German	39,000
1904	Nan Shan	1	Japanese	34,047
1904	Liao Yang	9	Russian	134,440
1904	Sha Ho	9	Russian	274,360
1915	Neuve Chapelle	3	British	197,000
1916	Souchez	1	French	300,000
1916	Somme	7	British	4,000,000
1917	Messines Ridge	7	British	2,753,000
1918	St. Mihiel	4	United States	1,093,217

To further illustrate the incredible increase in the use of artillery in warfare that was initiated in the First World War, the average number of rounds, expended in artillery ammunition only, for one month in 1918, by the French and British alone, was 12,710,000 rounds. This is an average of a year's figures.

The consumption of small arms ammunition for this same period was in astronomical billions of rounds.

In the light of these figures it is no wonder that the number of guns in use would necessitate the development of precision sighting and fire control equipment. In addition guns were put to new uses, requiring new designs, and new instruments. The First World War saw the use of tanks, planes, submarines, and trucks for the first time in warfare. It was period of innovations in warfare and revolutionary changes in tactics and equipment. New and faster weapons and better fire control equipment were needed and developed.

Eighty percent of the instruments now classified as fire control and sighting materiel were developed in the period 1914-1920. The anti-aircraft category of instruments was conceived to meet the threat of the airplane. The antitank weapon and sighting equipment was born to combat the tank. Tank guns and sights were needed and invented. The speed of targets resulted in the first extensive use of calculating and computing devices since mental calculation was no longer effective.

Summary

The story of the history and development of fire control materiel has yet to be written. This particular phase of military science is only now coming into its own, and more and more is occupying a place of growing prominence in the scheme of modern total warfare.

The lessons being learned from contemporary hostilities have yet to be applied. The developments to ensue as a result of the Second

World War are certain to result in a revolutionary change in tactics and gunnery. The application of scientific fire control to the antitank, anti-aircraft, tank and aircraft problems is still in a state of development. Until definite progress is indicated by positive reports from the various theaters of operation, no concrete suppositions as to the trend of future design would be advisable.

That the field is expanding with bewildering rapidity is evident. What was previously almost a strictly optical field now includes instruments embracing hydraulics, internal combustion, electronics, electricity, radio, and many others. Hardly a science exists which has not found some

application in making modern gunnery and fire control more efficient.

What the future of fire control and sighting materiel will be like must, for the duration at least, be locked in the necessary fog of wartime secrecy.

Note: The writer wishes to take this opportunity of extending his appreciation to Pvt's first class J. J. Osterday and L. J. Fourcroy, of the Fire Control Section of The Ordnance School for their assistance in the preparation of illustrations to accompany this article. This work was largely done on their own time.

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FIRE CONTROL IN THE FIRST WORLD WAR

(Continued from page 113)

A new type was developed. It weighed one eighth as much as former designs and was more powerful than any produced before this time. Its most striking innovation, from the standpoint of the nontechnical observer, was the absence of the front glass through which the beams of the older types were sent. The absence of this glass, while reducing the weight and cost of the light, also increased the intensity of the beam, since any glass, no matter how conducive to rays, absorbs light to a considerable extent.

When we went into the war there was

only one firm in the country which could manufacture large searchlight mirrors, but two other concerns soon developed methods and facilities. The mirrors used cost about \$1000 at pre-war costs. The maximum output prior to the war was three 60-inch mirrors a week. As the result of governmental encouragement there were 15 a week soon being produced at a saving in cost of approximately 30 percent as compared to prewar prices.

Our inventors during the nineteen months of hostilities succeeded in reducing the size of carbons used in 200 ampere lamps from two

inches in diameter to 1-1/8 inches. This cut the cost of carbons in two, but the improvements tripled the amount of light developed.

The searchlight section of the Corps of Engineers also developed optical finding devices which doubled the range of all searchlights without requiring the modification of the lights themselves.

The range of the world war (1917) searchlight, when the target was a ship at sea, was about 15,000 yards; when the target was an airplane, about 15,000 feet.



FIRE CONTROL SECTION (The Ordnance School)

(Continued from page 125)

The Fire Control Section's instructional staff contains many men with years of practical experience as instructors, and practical experience in the field. From their experience they can answer almost any question on any phase of maintenance of fire control materiel that may arise.

The section welcomes the opportunity, as well as considering it a duty, to render any technical advice of this nature of which it is capable.

Field organizations with fire control maintenance problems are invited to take advantage of this. Include complete details in your letters and address them to the Fire Control Section in care of THE ORDNANCE SERGEANT.



FIRE CONTROL MATERIEL

(Continued from page 144)

This instrument is also used for checking the leveling plates on the breech of a weapon as well as in cross leveling the carriage on the axle.

Maintenance operations are primarily concerned with (1) broken

level vials, (2) checking for accurate functioning, and (3) removal of burrs, etc., to insure accurate base leveling surfaces.

The gunner's quadrant, M1918 may be issued as a substitute for the M1. Other models of older design are in existence, but are basically of similar construction to those mentioned above.

A clinometer is an instrument very similar to a gunner's quadrant for use in laying machine guns in elevation, or, when the gun is laid, for measuring the angle of elevation or depression.

The angle of site instrument, M1917, is an instrument of the clinometer type for use in measuring vertical angles of site with reference to the horizontal and for use as a clinometer or a gunner's quadrant in laying a gun in elevation or depression.

The features of this instrument may be described as being the same as those of the gunner's quadrant, except that the range of angular planes that can be measured or set is much less with the angle of site instrument and that in addition to the plane measuring feature, this instrument contains a pair of sights for use in conjunction with the level bubble and scale to measure angles of site.

The prismatic compass, M1918, is actually a combination compass and clinometer. The compass dial sets below the clinometer dial and is secured to, and swings with, the compass needle. The name of the compass is derived from the fact that readings are taken through a 90 degree magnifying prism.

The compass, M2 is the new standard compass for issue. It has provisions for measuring angles of site, as well as ordinary compass

readings for direction and azimuth. It can be used as a leveling device or for clinometer readings with reasonable accuracy.

There are many other instruments of a miscellaneous nature used to measure and set angular units. Some are complete instruments, while others are integral parts of other major items.

The maintenance of all devices of this nature is routine and can be performed by ordnance personnel with an average amount of training and experience in instrument repair work. Field maintenance operations on all fire control materiel will always be limited by three factors; the skill of personnel, availability of spare parts, and facilities for accomplishing necessary work.

Antiaircraft Fire Control and Sighting Equipment

The nature of antiaircraft fire control instruments and sighting equipment is so highly specialized that it has been considered desirable to treat them as a separate subject entirely. A symposium of brief articles on AA materiel will be found elsewhere in this issue of THE ORDNANCE SERGEANT.

Summary

The purpose of this article has been to show the vast scope and variety of fire control materiel and give the reader who is unfamiliar



Instrument, Observation, AA, B.C., M1.

with this group of ordnance equipment a general picture of what it includes. The changing requirements of warfare are constantly increasing the number of instruments in this classification, which makes a general picture all the more difficult to present.

It must by no means be considered that the above discussion has covered all fire control materiel. Numerous models have been ignored entirely, because they did not fall readily into the classifications considered, or for the sake of brevity. Many models falling into these classifications have not been mentioned for the same reason. Only representative types have been discussed in each main grouping. Even a casual examination of the scope of fire control work will show that the subject is much too vast for any single treatment to be all-inclusive.

Included also in the fire control group are a host of miscellaneous instruments, devices, and accessories, the maintenance of which falls upon instrument personnel of the ordnance department.

These include tapes and rules, watches, time interval recorders,

aiming stakes and posts, instrument lights, (see Figure 37), tripods, leather and electrical accessories, testing targets, bore sighting equipment, mortar sights, quadrant sights, rocking bar sights, collimating sights, (see Figure 38), periscopes, (see Figure 37), aiming rules, and many other optical and non-optical instruments as well as a wide amount of inactive and obsolescent materiel still finding a limited application and use for training purposes.

All of this wide variety of instruments, devices, and accessories is classified in the F-Group of ordnance materiel. New maintenance problems are coming to light continually with the constant introduction of newer and better instruments of increasing complexity and variety.

The servicing of this materiel in the field is a function of ordnance troops and requires skill, intelligence, ingenuity and experience necessary to very few other types of maintenance.

It is certain that in the future fire control will be of increasing importance to the successful completion of any military mission or task. Fire control materiel has always been considered as the eyes of the army; it has now reached a point of development where it is the ears and brain as well.



SEACOAST FIRE CONTROL

(Continued from page 168)

angular travel, and the azimuth of the set forward point is read on the gun (or mortar) arm azimuth circle.

(4) Angular Travel Computer. - No deflection board other than the M1 computes its own angular travel. When any deflection board other than the M1 is used with a plotting board other than the Whistler Hearn, it is necessary in computing deflections for Case II pointing to use some device, usually improvised, to compute the angular travel. No. 1 performs this operation.

(5) Wind Component Indicator. - The wind component indicator is used when the battery is not equipped with the deflection board M1. It is operated by the range correction board operator.

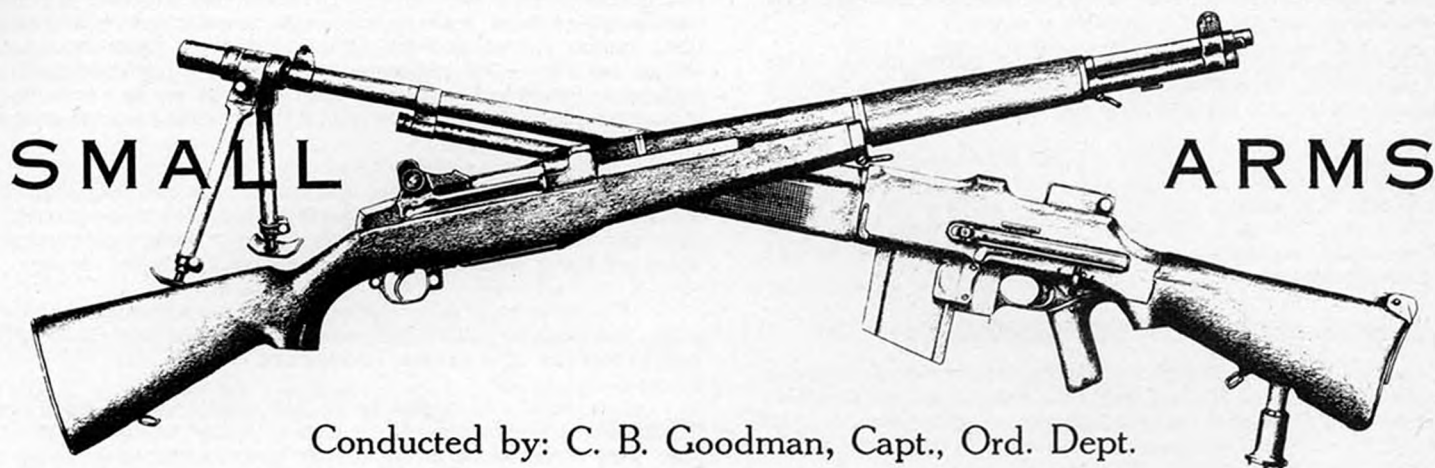
Functioning of Spotting System

Each spotting observer tracks the target, keeping the vertical wire of his instrument on the observing point. When the splash occurs, tracking is stopped immediately, and the angular deviation of the splash is then read from the deflection scale in the instrument and is transmitted to the spotting board. Axial observers observe on the center of the splash; flank observers observe on the edge of the splash nearest to the battery.

To assist the spotting observers in identifying the splash, a stop watch kept at the spotting board is started when the shot is fired, and, when the time of flight has elapsed, the warning "splash" is called out to observers.

The angular deviations observed by the spotting observers are set into the spotting board. Range deviations in percentage are read off the spotting board and transmitted to the range adjustment board operator. If lateral adjustment of fire is being conducted, either by use of a separate observer stationed at or near the directing point or by the method of jumping splashes, lateral deviations need not be read from the spotting board unless desired as a check on the lateral deviations determined by other means. If lateral deviations determined on the spotting board are to be used as the basis for the lateral adjustment of fire, they are read in angular units and are transmitted to the person designated to make the adjustment. Lateral adjustment corrections may be determined graphically on an improvised board similar to the fire adjustment board used for range adjustment, or they may be determined by simple paper and pencil computations.

Range adjustment corrections are usually set on the percentage corrector, but there may be cases when they are set on the range correction board.



Conducted by: C. B. Goodman, Capt., Ord. Dept.

MACHINE GUN TRIPOD MOUNT, CAL. .30, M1917A1

by J. MUSENBECK, S. Sgt., Ord. Dept.

The following notes on the Machine Gun Tripod Mount, Cal..30, M1917A1, do not mention all the smaller parts and assemblies. Only the larger groups and some assemblies as they function as groups are mentioned in order to give the student and Ordnance shop man a knowledge of the function of the mount as a whole, and of its two groups that cause most of the trouble. Those two groups are:

1. The elevating and traversing mechanism.
2. The cradle pintle clamping screw assembly with the pintle clamping block.

MACHINE GUN MOUNT CAL..30, M1917A1

The machine gun tripod mount, cal..30, M1917A1, is composed of the following major groups:

1. Cradle.
2. Cradle pintle, which is part of the cradle group.
3. Elevating and traversing mechanism, which is part of the cradle group.
4. Tripod.
5. Cradle pintle clamping screw assembly, which is part of the tripod group.

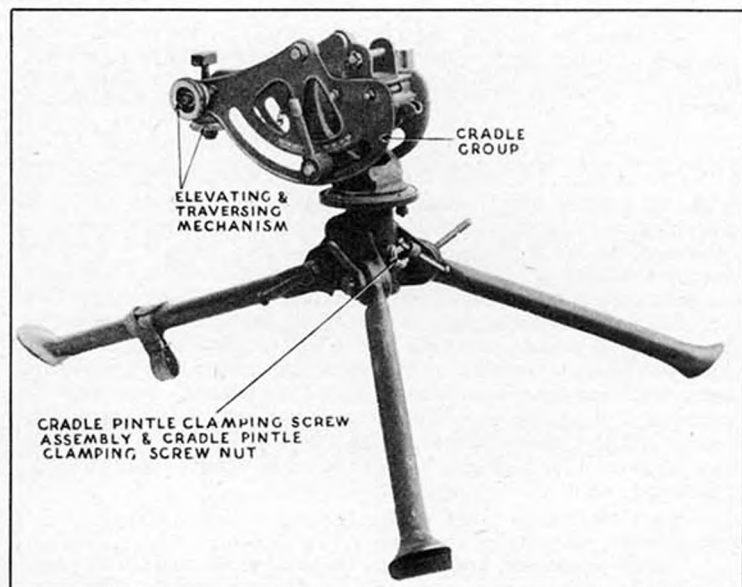


Figure 1. - Machine Gun tripod Mount, Cal..30, M1917A1.

The cradle group, of which the elevating and traversing mechanism is a part, is seated in the pintle socket, the latter being part of the tripod group.

The cradle pintle assembly, which is one of several assemblies of which the cradle group is composed, fits into the pintle socket.

The elevating and traversing mechanism is located in the rear portion of the cradle group.

The tripod is the base for the cradle group and the gun when mounted and has in its center between the three tripod legs the pintle socket assembly.

The cradle pintle clamping screw assembly and the pintle clamping block, which is attached to the bottom of the cradle pintle clamping screw, are seated in the front center part of the pintle socket.

The elevation and traversing mechanism group and the cradle pintle clamping screw with the pintle clamping block are the two groups on the above described tripod mount that cause most of the troubles. An experienced ordnance shop mechanic usually has little, if any, difficulty in detecting the malfunctions encountered in the two above described groups, commonly caused by ignorance and carelessness.

ELEVATING AND TRAVERSING MECHANISM GROUP ASSEMBLED

The two main troubles found in the above named mechanism are:

1. Binding or too much clearance between the traversing screw and the elevating and traversing mechanism body.
2. Binding or too much clearance between the elevating screw and the elevating screw sleeve bushing.

Binding of the traversing screw may be caused by one or more of the following reasons:

1. The two hex-head cap screws, located on the upper front end of the elevating and traversing mechanism body (Fig. 2, front view) screwed too tight into the elevating and traversing mechanism body. Since the latter is split in front for the purpose of adjustment for proper clearance between the threaded portion of the elevating and traversing mechanism body and the traversing screw, tightening one, or both, of the hex-head capscrews a trifle too much will cause the elevating and traversing mechanism body to contract against the traversing screw. This causes either difficulty in rotating the traversing knob or totally prevents rotation of same, since it is connected with the traversing screw by the "woodruff key".

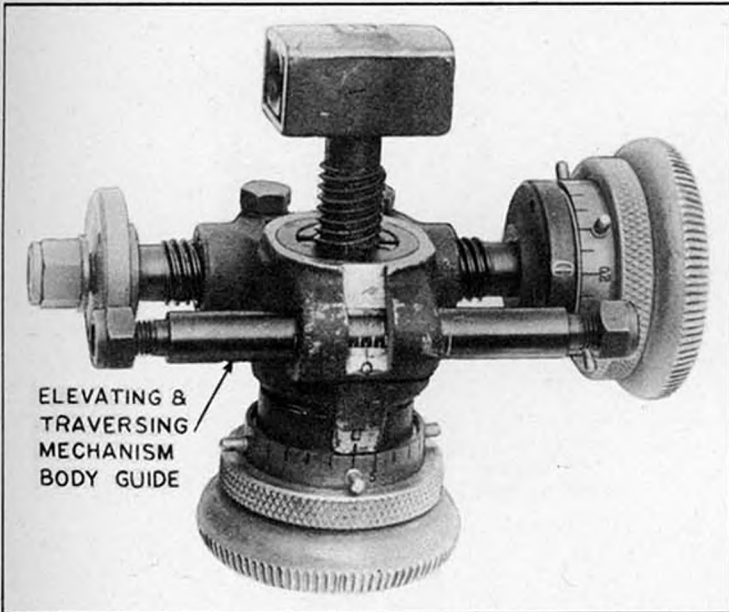


Figure 2. - Elevating and traversing mechanism group, assembled, rear view.

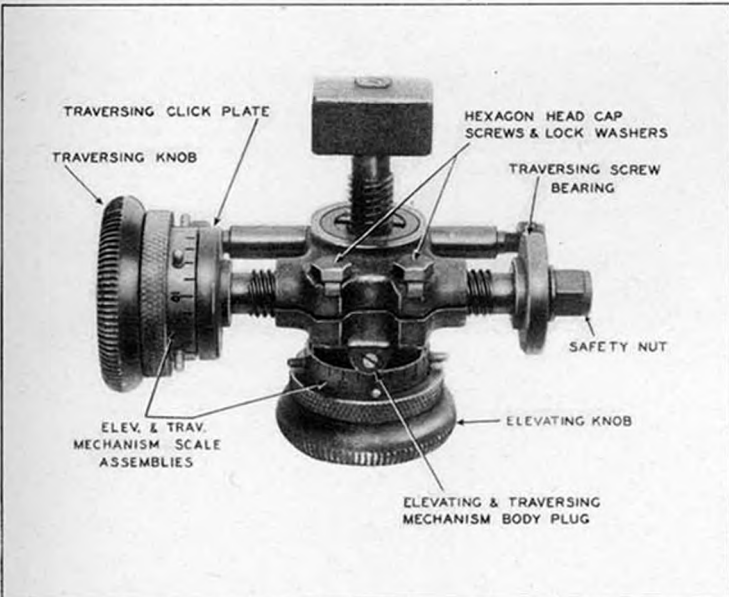


Figure 3. - Elevating and traversing mechanism group, assembled, front view.

2. A bent or burred traversing screw usually caused by careless handling.

3. One or both safety nuts on the right and left of the right and left side plates respectively screwed up too tight. This causes the traversing screw bearing and the traversing click plate to be drawn too tight against the right and left side plates, thereby causing binding of the traversing screw to such an extent that the traversing knob cannot be rotated. (Fig. 2, rear view.)

4. A bent or burred elevating and traversing mechanism guide, usually caused by careless handling or loading on trucks. (Figure 2, rear view.)

5. Rusty traversing screw.

6. Sand, grit, foreign matter between the traversing screw and the threaded part of the elevating and traversing mechanism body.

Too much clearance between the traversing screw and the threaded portion of the elevating and traversing mechanism body may be caused by:

1. Worn threads in elevating and traversing mechanism body.

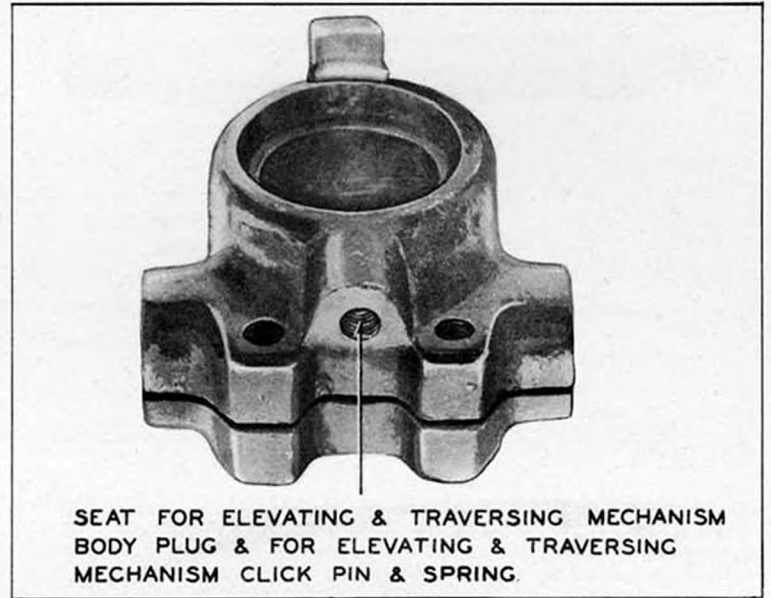


Figure 4. - Elevating and traversing mechanism body.

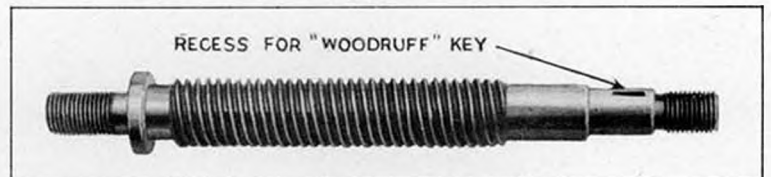


Figure 5. - Traversing screw.

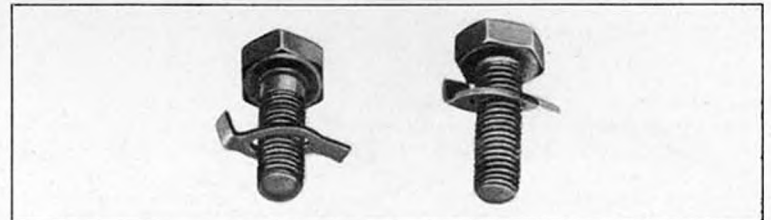


Figure 6. - Hexagon head cap screws and lock washers.

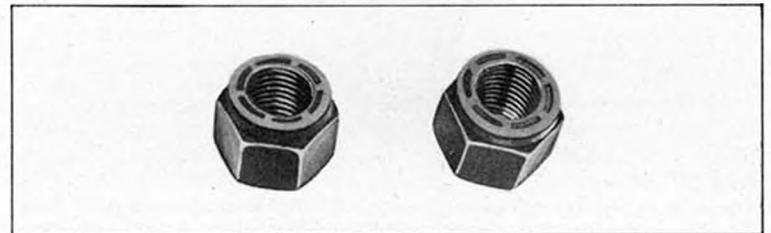


Figure 7. - Two safety nuts.

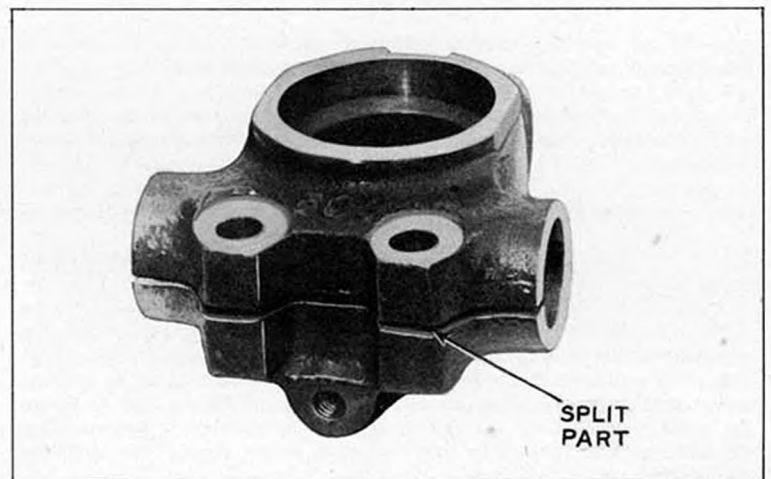


Figure 8. - Showing split part on elevating and traversing mechanism body.

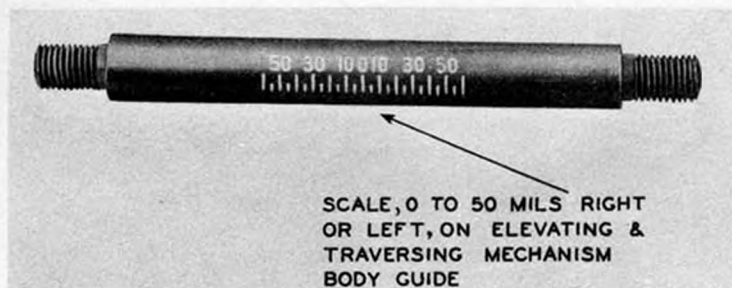


Figure 9. - Elevating and traversing mechanism guide.

2. A worn traversing screw.
3. Both above named parts worn.

Binding of the elevating screw may be caused by one or more of the following reasons:

1. Elevating screw sleeve bushing screwed too far into the elevating screw sleeve, causing the elevating screw sleeve bushing, by means of its tapered shape and three vertical slots on it, to contact against the elevating screw. This causes difficulty in rotating the elevating knob since the latter is interconnected with the elevating screw sleeve by the elevating knob key.

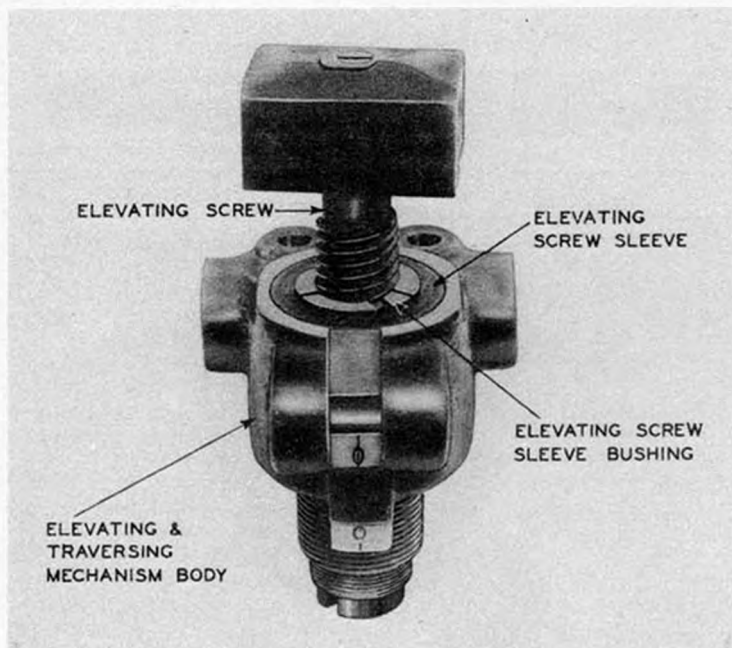


Figure 10.--Top view of elevating and traversing mechanism body with elevating screw sleeve, elevating screw sleeve bushing, and elevating screw assembled to the elevating and traversing mechanism body.

2. A bent or burred elevating screw, caused by carelessness in handling and loading on trucks with other heavy objects on it.
3. Rusty elevating screw, elevating screw sleeve and elevating screw sleeve bushing. This condition in most cases is the result of carelessness.
4. Sand, grit, foreign matter in the elevating mechanism.

Too much clearance between the elevating screw and the elevating screw sleeve bushing is caused by:

1. Elevating screw sleeve bushing not screwed far enough into the elevating screw sleeve, causing the former to expand, away from the elevating screw. This is allowed for by the three vertical slots on the elevating screw sleeve bushing, which is tapered from the top down to where the three vertical slots end and the threaded portion of it begins. That threaded portion screws into the elevating screw sleeve (use elevating mechanism wrench - Figure 11.)

2. A worn elevating screw.

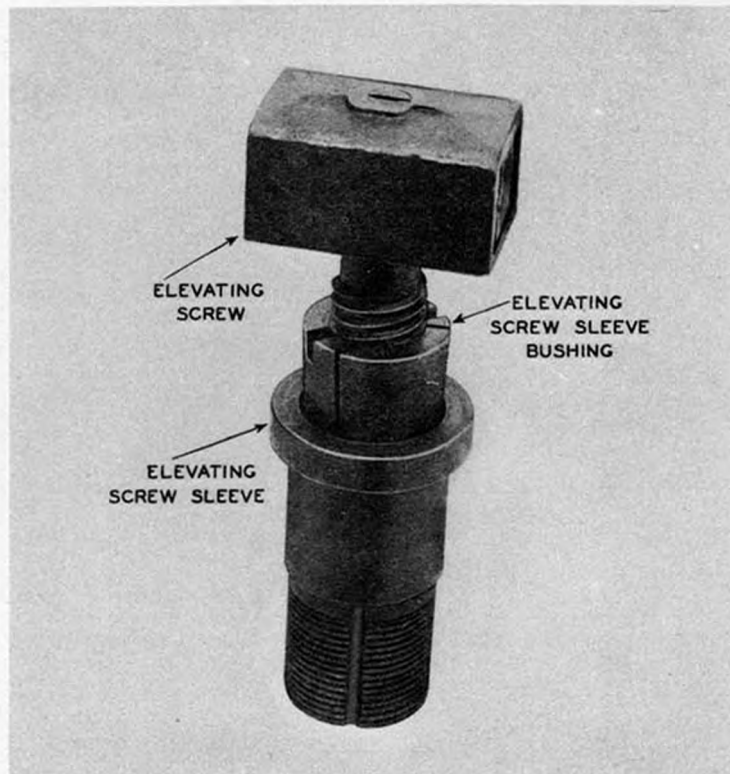


Figure 11. -Elevating screw sleeve bushing partly unscrewed from the elevating screw sleeve with elevating screw in the elevating screw sleeve bushing.

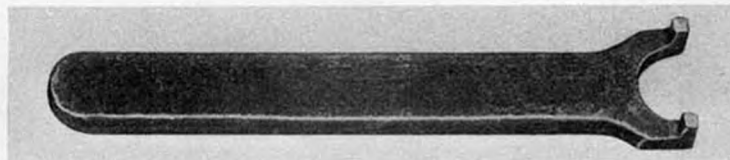


Figure 12. -Elevating mechanism wrench.

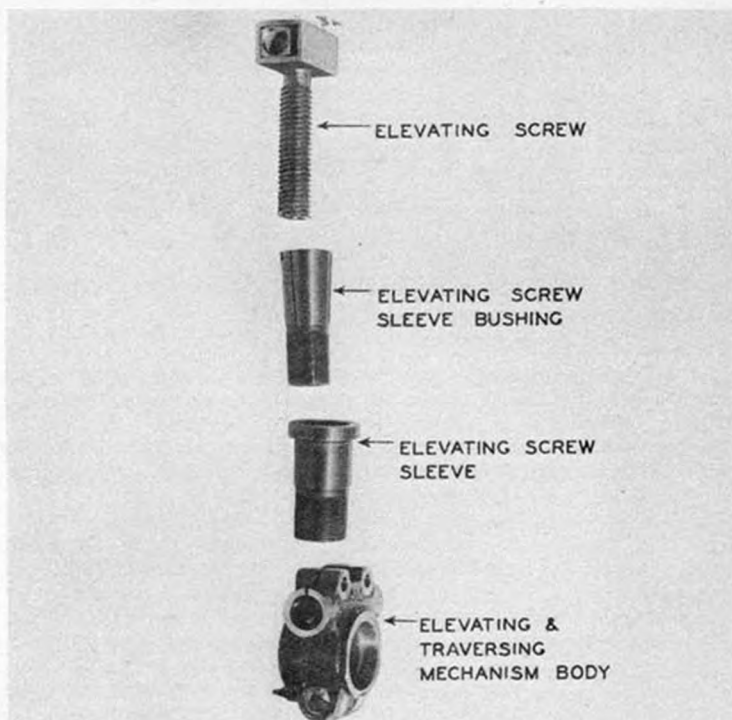


Figure 13. -Elevating screw.
Elevating screw sleeve bushing.
Elevating screw sleeve.
Elevating and traversing mechanism body (disassembled sequence of the four parts)

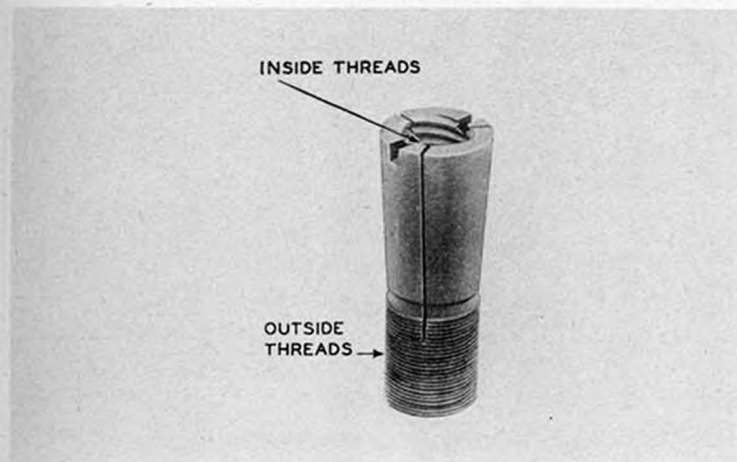


Figure 14. -Elevating screw sleeve bushing (side view).

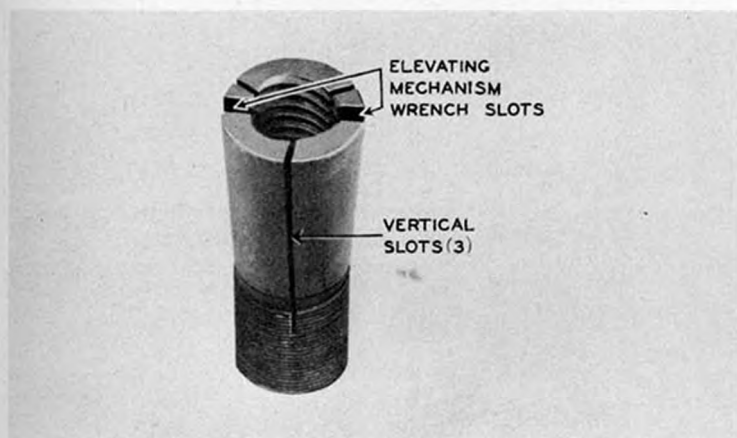


Figure 15. -Elevating screw sleeve bushing (top view).

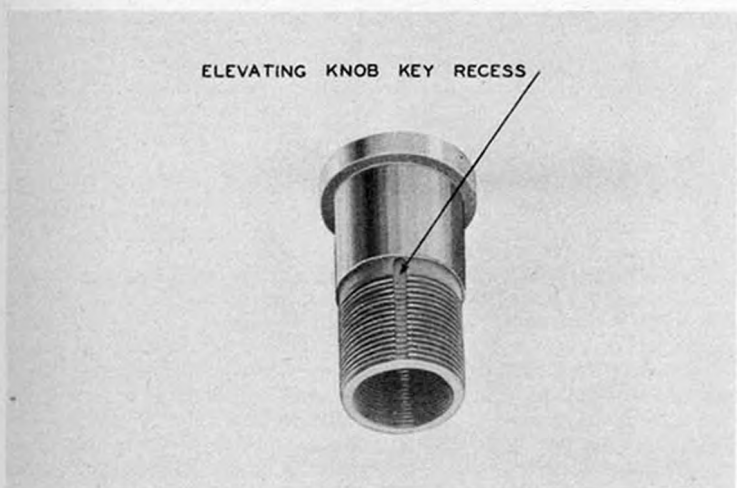


Figure 16. -Elevating screw sleeve.

3. A worn elevating screw sleeve.
4. A worn elevating screw sleeve bushing.
5. Any number or all of above named parts worn.

To eliminate binding of the traversing screw one or more of the following procedures may be applied:

1. Loosen the two hexagon head cap screws on the upper front end of the elevating and traversing mechanism body (Figure 2) which will allow the split portion of the latter to expand, releasing too much tension against the traversing screw.

2. Replace a bent traversing screw.

3. Remove burrs on traversing screw with a fine file, or stone, being careful not to take off too much metal.

4. Remove rust from all parts and lightly oil same.

5. Replace, or stone if burred, a bent elevating and traversing mechanism guide.

6. Partly unscrew one, or both, safety units on the right and left ends of the traversing screw until ease of rotation of the traversing knob, which is connected with the traversing screw by the "Woodruff" key, is obtained.

7. Thoroughly clean mechanism from sand, grit, etc. and lightly oil same.

To reduce excessive clearance between the threaded part of the elevating and traversing mechanism body and the traversing screw proceed as follows:

1. Tighten the two hexagon head cap screws on the upper front end of the elevating and traversing mechanism body until proper clearance between the latter and the traversing screw is obtained. Be sure the lockwashers are properly bent in place, or:

2. Replace a worn traversing screw.

3. Replace a worn elevating and traversing mechanism body.

4. Replace traversing screw and elevating and traversing mechanism body, if both parts are worn, which usually is the case.

5. Tighten one, or both, safety units on the right and left of the traversing screw so that there is no lateral movement of the traversing screw between the traversing click plate and the traversing screw bearing. At this point it must be kept in mind that the traversing click plate, listed as such in the SNL A-5, also forms the traversing screw bearing for the right end of the traversing screw.

The last named procedure (5) has no effect upon proper clearance between the traversing screw and the elevating and traversing mechanism body, but it will do away with the lateral movement of the traversing screw.

6. If no parts are available for replacements in order to eliminate too much clearance between the elevating and traversing mechanism body and the traversing screw proceed as follows:

Remove the two hexagon head cap screws with the lock washers from the elevating and traversing mechanism body. Put the split forward portion of it in a vise and clamp it until the upper and lower parts of that split portion contact. Then use a hacksaw and cut through the metal (brass) where the two split portions contact all the way to the threaded inside. In many cases this procedure has the desired effect to do away with excessive clearance between the traversing screw and the threaded part of the elevating and traversing mechanism.

Binding of the elevating screw may be eliminated by:

1. Unscrewing the elevating screw sleeve bushing from the elevating screw sleeve until proper clearance between the elevating screw and the elevating screw sleeve bushing is obtained. This is accomplished by using the elevating mechanism wrench, inserting its two prongs into the corresponding wrench slots on top of the elevating screw sleeve bushing. Then unscrew the latter to a point where the elevating knob can be easily rotated, but the fit between the elevating screw and the elevating screw sleeve bushing must be a rigid one. If this procedure hasn't the desired effect look for:

2. A bent elevating screw and replace same. If no new one is available and repair is urgent, remove the elevating screw from the mechanism by unscrewing it from the elevating screw sleeve bushing. Put it on a wooden block and with a rawhide hammer straighten it as well as possible. It is impossible thus to do away entirely with binding of the elevating screw, but the elevating knob usually again can be rotated which will cause the elevating screw to move up and down, as desired.

Note: The elevating screw stop retaining screw must be unscrewed from the bottom of the elevating screw before it is possible to unscrew the latter all the way from the elevating screw sleeve bushing.

3. Use a fine file or stone to remove burrs on any part of the elevating mechanism. Be careful not to take off too much metal.

Too much clearance between the elevating screw and the elevating screw sleeve bushing may be eliminated by:

1. Screwing the elevating screw sleeve bushing into the elevating screw sleeve until proper clearance between the elevating screw and the elevating screw sleeve bushing is obtained.

2. Replace a worn elevating screw, elevating screw sleeve and elevating screw sleeve bushing, whichever part or parts may be worn.

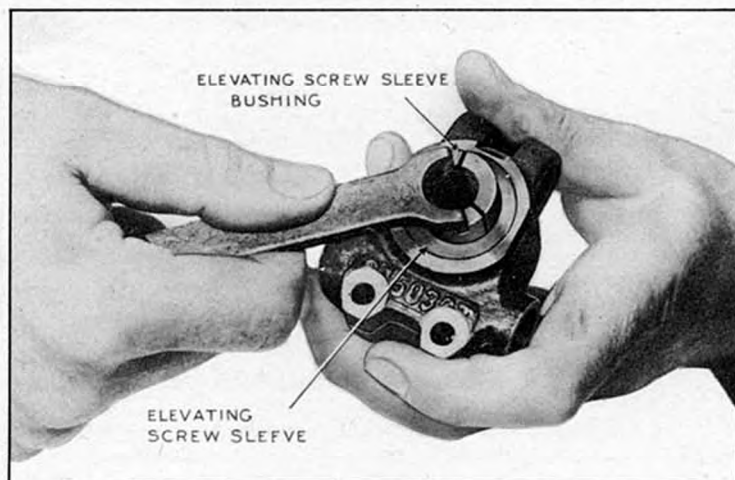


Figure 17. -Screwing elevating screw sleeve bushing into the elevating screw sleeve with the elevating mechanism wrench.

MALFUNCTIONS OF THE CRADLE PINTLE CLAMPING SCREW ASSEMBLY AND THE PINTLE CLAMPING BLOCK

The malfunctions caused by the above named assembly and pintle clamping block, working together as a group in the pintle socket, are:

1. Cradle pintle cannot be clamped to a fixed position.
2. Cradle pintle cannot be removed from the pintle socket.
3. Binding of the cradle pintle in traverse.
4. Binding of the cradle pintle clamping screw which prevents actuating the pintle clamping block by screwing or unscrewing the cradle pintle clamping screw into or from the pintle socket.

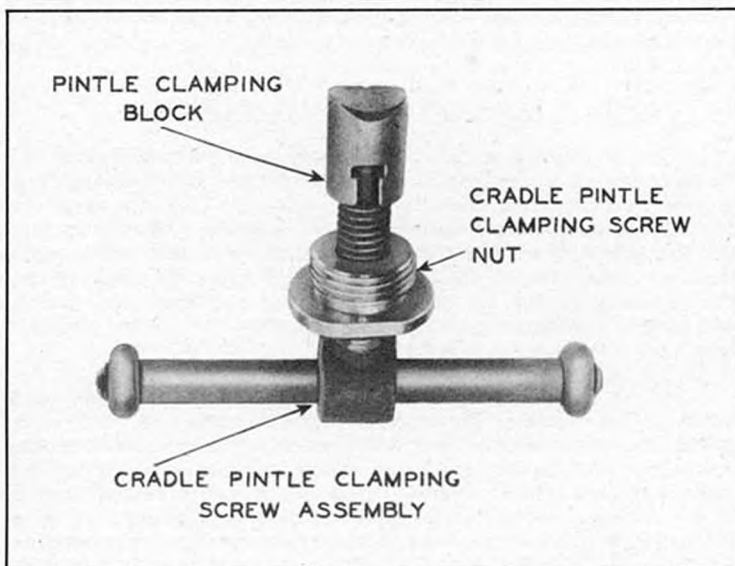


Figure 18. -Cradle pintle clamping screw assembly with pintle clamping block attached to it.

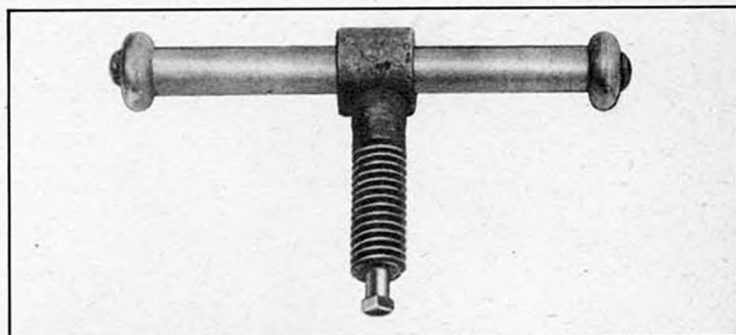


Figure 19. -Cradle pintle clamping screw assembly.

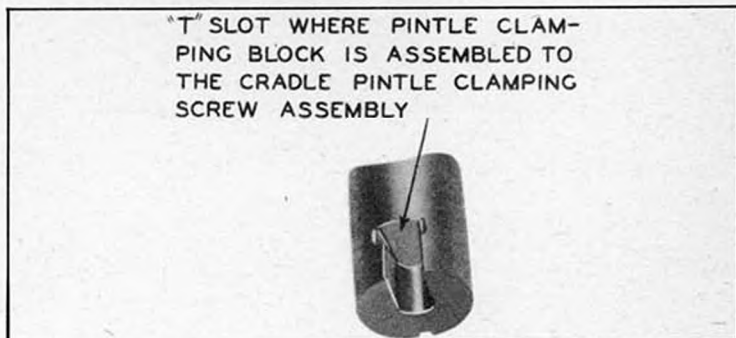


Figure 20. -Pintle clamping block (upper side).

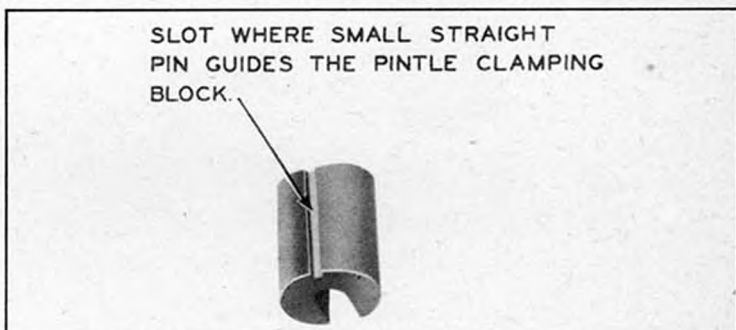


Figure 21. -Pintle clamping block (lower side).

If cradle pintle cannot be clamped to a fixed position due to a worn pintle clamping block or a missing or sheared off straight pin which properly positions the pintle clamping block, proceed as follows:

Unscrew the cradle pintle clamping screw until resistance other than that caused by unscrewing it is felt. Then lift the cradle pintle from the pintle socket. Insert a long punch into the forward inside part of the pintle socket, place it on top of the straight pin which secures the cradle pintle clamping screw nut to the pintle socket, and with a hammer drive out that straight pin. Then unscrew the cradle pintle clamping screw nut from the pintle socket. Then remove the cradle pintle clamping screw assembly with the pintle clamping block, attached to the bottom of the cradle pintle clamping screw, by pulling out on the handle. Replace the pintle clamping block if worn. If it isn't worn look for the small straight pin protruding on the bottom of that part of the pintle socket where the pintle clamping block has been removed from. If that pin is not there the pintle clamping block was not properly positioned so that its entire lower surface could engage the corresponding groove on the lower part of the cradle pintle when the cradle pintle clamping screw is screwed inward.

After the pintle clamping block or the straight pin has been replaced assemble the parts as follows:

Screw the cradle pintle clamping screw nut about two thirds of the way up on the cradle pintle clamping screw. This prevents shearing the pintle clamping block off the cradle pintle clamping screw when the cradle pintle clamping screw nut is screwed into the socket.

Note: The cradle pintle clamping screw nut and a straight pin properly position and secure the cradle pintle clamping screw assembly,

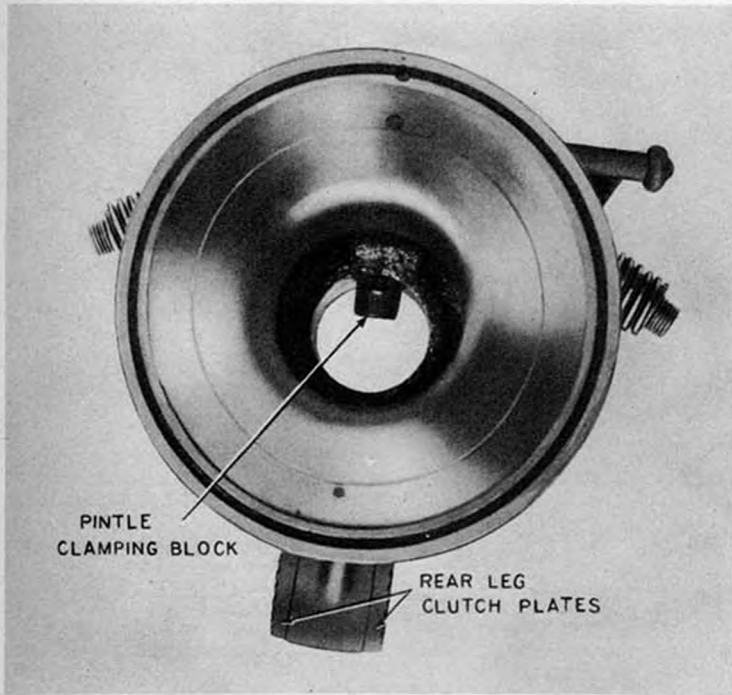


Figure 22. -Inside of pintle socket assembly with cradle pintle clamping screw assembly and pintle clamping block screwed in.

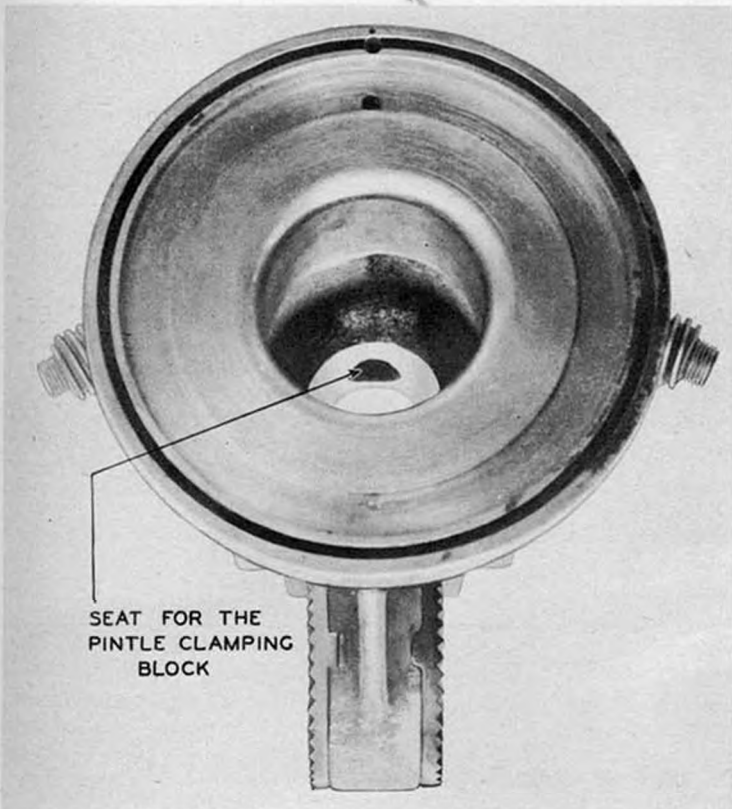


Figure 23. -Inside of pintle socket assembly with cradle pintle clamping screw assembly and pintle clamping.

with the pintle clamping block, into the pintle socket assembly.

Then replace the cradle pintle clamping screw assembly with the pintle clamping block into its housing in the pintle socket so that the recess cut on the lower side of the pintle clamping block guides over the small straight pin, thereby properly positioning the pintle clamping block. Then screw the cradle pintle clamping screw nut into its seat in the pintle socket and secure it in place by the straight pin.

(Continued on page 206)

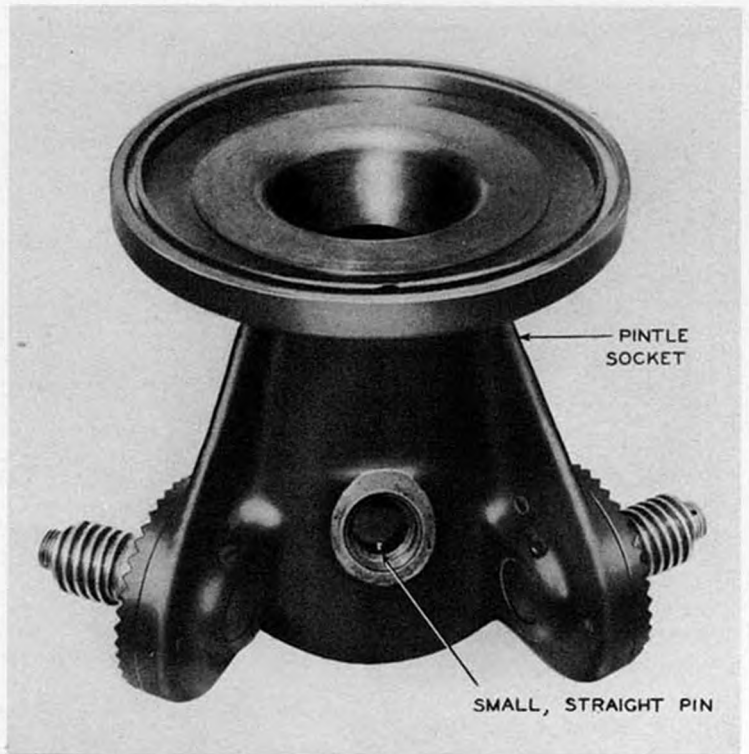


Figure 24. -Showing small straight pin in pintle socket assembly which guides and therefore properly positions the pintle clamping block. That small pin fits into the lower recess cut on the bottom of the pintle clamping block. (Figure 21.)

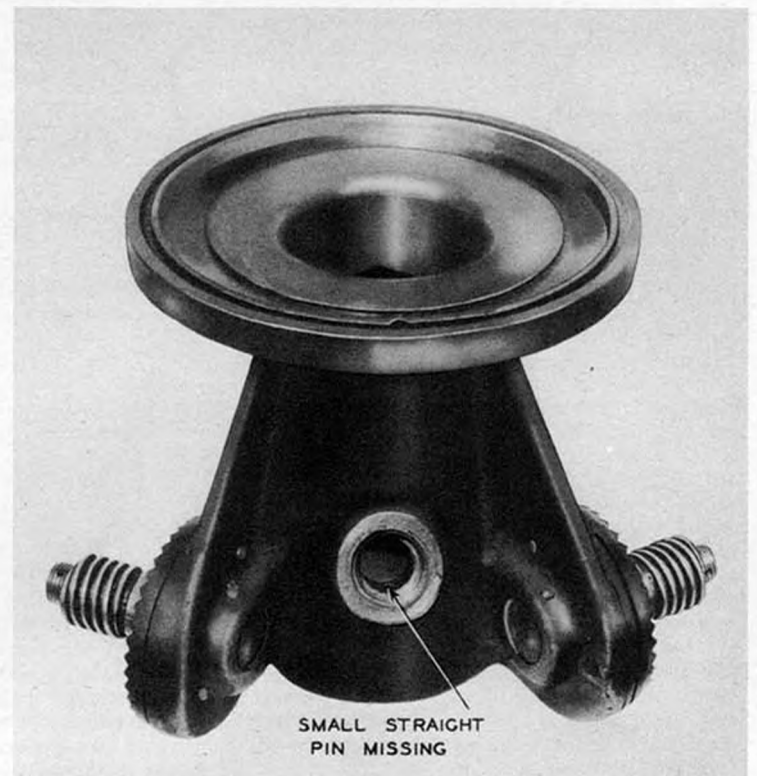


Figure 25. -Showing pintle socket assembly with small straight pin missing. This allows the pintle clamping block to rotate when screwing or unscrewing the cradle pintle clamping screw into or from the socket, which condition in turn prevents proper engagement of the cradle pintle and makes it impossible to clamp the cradle pintle to a fixed position. If that small straight pin does not show in the socket use a small punch and hammer and drive it from the outside of the pintle socket inward until it protrudes about 1/8 inch. If it is missing replace with a new one. To find its recess on the socket remove the paint immediately below the cradle pintle clamping screw nut on the outside of the pintle socket.

ARTILLERY



Conducted by W. C. Minshaw, Capt., Ord. Dept.

INSPECTION AND ADJUSTMENT OF THE 155mm RECOIL MECHANISM, M3, ON THE 155mm GUN CARRIAGE, M1

by

C. C. KEITH

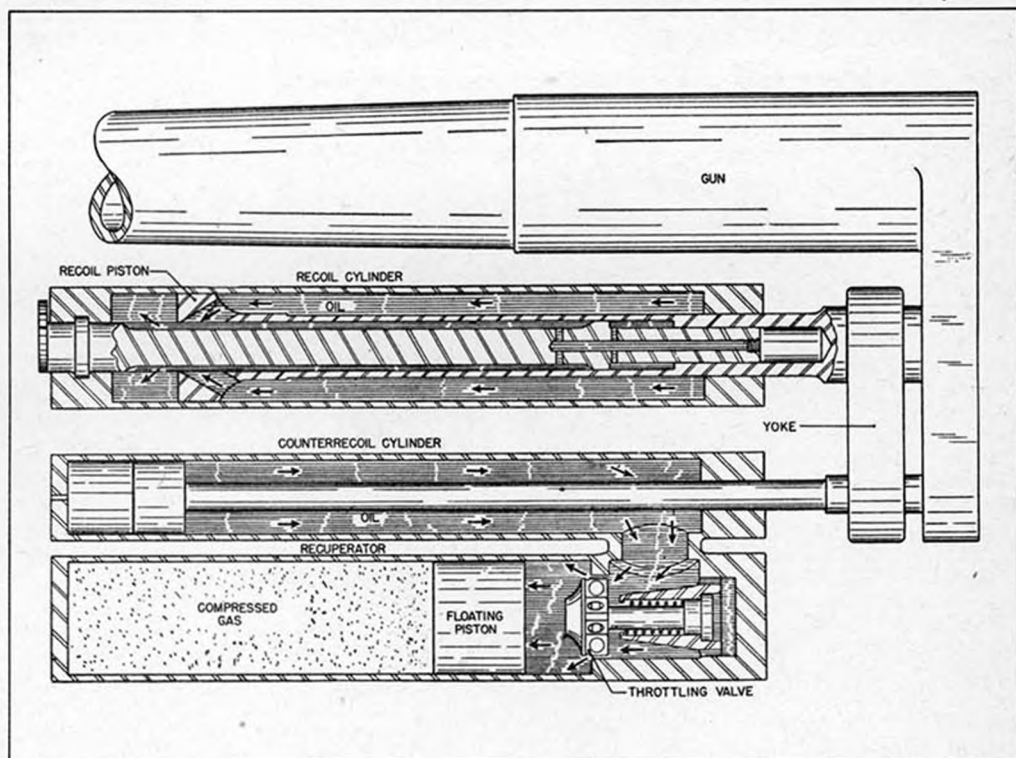
M.Sgt., Ord. Dept.

The 155mm Gun recoil mechanism, M3, is the variable recoil type and has two independent systems consisting of the RECOIL SYSTEM assembled in the recoil cylinder (Plate "A"), and the RECUPERATOR and COUNTERRECOIL SYSTEM assembled in the cylinders shown on (Plate "B").

The recoil and counterrecoil systems absorb the recoiling energy of the gun after it has been fired. The recuperator system returns, and holds the gun in battery. The RECOIL BUFFER, (Plate "A" (7)) absorbs the last portion of the recuperator action to prevent damage to the weapon due to the sudden stopping of the forward moving of the recoiling parts.

ACTION IN RECOIL. - The energy developed in firing causes the gun to recoil and thereby pull the recoil rod (Plate "A" (1)) assembled with the piston (2) and fastened to the gun at (3), and the counterrecoil rod (Plate "B" (1)) assembled with the counterrecoil piston (2) and fastened to the gun at (3) to the rear. This action forces the recoil oil in space (4) in the recoil cylinder (Plate "A") into space (6) through orifices in the piston at (5) which are opened to variable length and depth by grooves in the stationary control rod (12) as it telescopes within the recoil rod. The oil forced through the orifices is throttled, dissipating a great portion of the energy and controlling the length of recoil. At the same time the oil in the counterrecoil cylinder in space (4) (Plate "B") is forced through the communicating hole (5) into the regulator (8) of the recuperator cylinder. This forces open the regulator valve (6) and causes the oil to push the floating piston (7) forward, thereby compressing the nitrogen in space (9). The throttling of the oil, compressing of the nitrogen, and friction of the moving parts gradually bring the gun to rest.

ACTION IN COUNTERRECOIL. - At the end of recoil the increased nitrogen pressure in the recuperator cylinder immediately starts the floating piston, and the oil in rear of it, in the



Recoil Mechanism -- Schematic Diagram

opposite direction. This action closes the regulator valve (Plate "B" (6)) and forces the oil through the counterrecoil controlling holes (10) in the valve into the regulator and through hole (5) into the counterrecoil cylinder, pushing the counterrecoil piston forward, thus returning the gun into battery. In the recoil cylinder, (Plate "A") the oil returns from space (6) through the orifices (5) into space (4) on the return of the gun into battery position.

ACTION OF THE BUFFER. - A spear head buffer (Plate "A" (7)) on the end of the control rod, and equipped with throttling grooves, absorbs the last portion of the recuperator action. On entering the buffer chamber (8) in the rear end of the recoil rod the buffer forces the oil, accumulated during recoil, by way of the throttling grooves through orifice (9) and holes (10) into

the throttling grooves of the control rod, and thence into space (4) and thereby easing the forward movement of the recoiling parts into battery position.

ACTION OF OIL INDEX. - The oil index (Plate "B" (15)) indicates the amount of reserve oil in the recuperator and counter-recoil cylinders. The oil index is actuated by the oil index rod (16) which contacts the floating piston. When this index extends less than 5 m/m (0.20 inch) beyond the face of the cylinder head there is an insufficient amount of reserve oil in the system.

REPLENISHER ACTION. - The recoil replenisher (Plate "C"), attached to the left side of the cradle, serves as a reservoir for excess oil due to expansion by increased atmospheric temperature or heat developed by firing, and

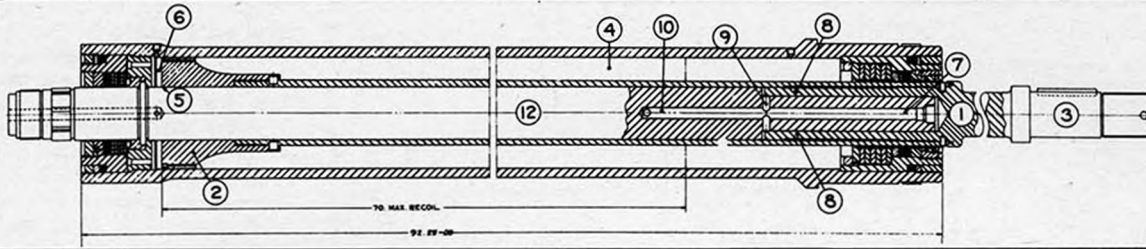


Plate A
RECOIL SYSTEM

fills the void due to contraction of the oil at low temperatures. When the recoil piston moves toward the rear, during recoil, a void is produced in the recoil cylinder. A portion of the oil in the replenisher is forced into this void by the spring loaded piston, B187255, (Plate "C") through a small copper tube connecting the replenisher cylinder and the recoil cylinder, B159318, (Plate "D"). On the return of the gun to battery position

(g) Condition of the gun slides and cradle ways.

The efficient functioning of the mechanism depends upon:

OIL RESERVE AND MALFUNCTION OF OIL INDEX. - The oil reserve is a term applied to that portion of the oil which normally separates the floating piston from the regulator. The compressed nitrogen acts to put pressure on the oil only as long as there is oil between the regulator and floating piston. After the floating piston and the regulator come in contact further movement of the floating piston is pre-

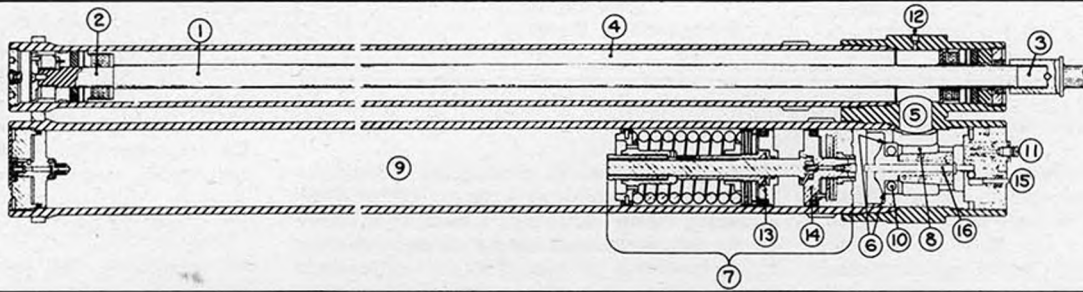


Plate B
RECUPERATOR AND COUNTERRECOIL SYSTEM

this oil is forced back into the replenisher against the action of the spring loaded piston. A filling and drain hole is provided for adding to or withdrawing oil from the replenisher, B155851, (Plate "C").

VARIABLE RECOIL FUNCTION. - The variable recoil mechanism controls the length of recoil required for various elevations of the gun. As the gun is elevated or depressed the position of the valve turning rod pin is changed in the cam groove of the valve turning cam (Figure 3). This change of position of the valve turning rod pin rotates the valve turning rod cam with the gear toothed segment attached, which in turn meshes with the gear toothed segment attached to the control rod of the recoil cylinder. This action turns the control rod, thereby controlling the opening of the oil passage grooves in the control rod. The relative positions of the oil passages in the control rod at 0 elevation and at 65 degrees elevation of the gun, as controlled by the variable recoil mechanism, are shown on Plates F-1 & F-2.

INSPECTION AND ADJUSTMENT

For the proper field maintenance of the 155mm gun recoil mechanism, M3, Ordnance Maintenance companies may dismount, disassemble, repair, and reassemble any part of the replenisher, the counterrecoil cylinder front head, the oil filling and drain valve housings and parts, and the oil index packing. It is absolutely forbidden to remove any other cylinder head or stuffing boxes. Thoroughly trained mechanics only should be permitted to work on the recoil mechanism.

The recoil mechanism is inspected for:

- Oil leakage.
- Proper functioning of oil index.
- Leakage of nitrogen.
- Serviceability of the replenisher.
- Pressure of the compressed nitrogen.
- Friction of the various packings.

(a) The proper "oil reserve" which is indicated by and the position of the replenisher piston.

(b) Proper friction of the recoiling parts and the proper nitrogen pressures which are checked by the manometer test.

LEAKAGE OF OIL. - Remove the filling and drain plugs and examine for leakage of oil around the valves. Remove the counterrecoil cylinder front head and check for leakage around the counterrecoil piston. Examine the face of

vented, so pressure on the oil will drop to zero. In amount, a full oil reserve constitutes the volume corresponding to the distance the oil index travels between its extremes of movement, + 70 strokes of battery pump. This volume is one quart.

If the oil index is binding an incorrect indication of the amount of reserve oil will be given. If the gun is fired with an incorrect amount of reserve oil damage to the mechanism may result. Therefore, particular attention must be given to the functioning of the oil index packing. Binding of the oil index packing usually causes the oil index to fail on the out stroke. To remedy this failure, first try loosening the

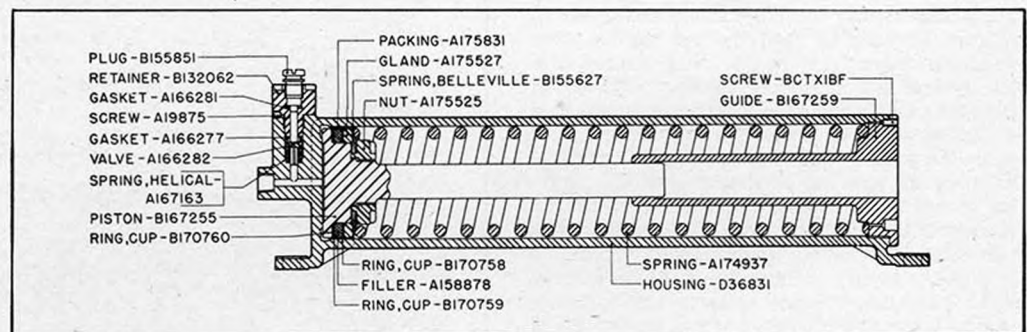


Plate C
REPLENISHER

the counterrecoil cylinder rear head and the oil index. Check each end of recoil cylinder and each end of the replenisher cylinder for excessive leakage. Piston and stuffing box packings normally pass a small amount of oil which assures lubrication. A leak at any packing which does not exceed three drops per minute, immediately after firing, is not considered serious. A leak at any packing of an inactive mechanism should not, however, exceed one drop in two minutes.

follower B155406 (Plate "E"). In the event that an excessive amount of oil leakage occurs due to unscrewing the follower it will be necessary to disassemble the oil index assembly and replace the packing A15898 (Plate "E"). If the malfunction is excessive oil leakage, and not binding, try tightening the follower with the oil index follower wrench. Hold the wrench firmly and squarely against the follower to avoid damaging the slots. If the leakage does not stop, renew the packing. To renew the oil index

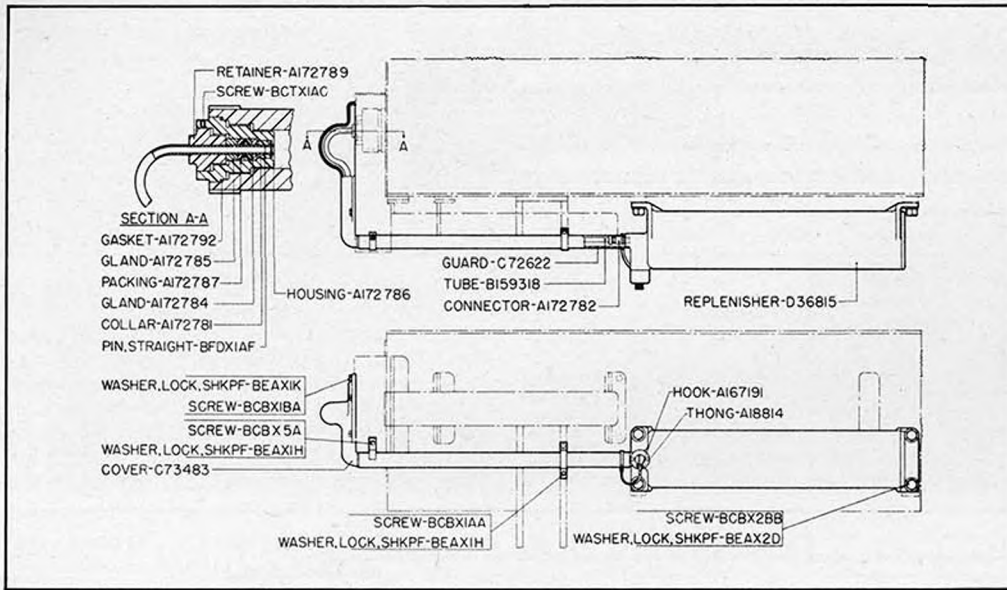


Plate D
REPLENISHER AND CONNECTIONS

packing first drain the reserve oil from the mechanism. This relieves the pressure from the inside and MUST be done prior to disassembly of the oil index assembly. To release the reserve oil, remove the filling and drain plug B155851 (Plate "E") and screw in the oil release A1001 (Figure 1). As the oil release pushes in the one way valve A166282 oil will spurt out. Catch this oil in a container. (If the oil index were functioning correctly it would recede beyond the face of the cylinder as the oil is drained). After the reserve oil has been drained from the cylinder remove the oil release A1001 and in its place insert adapter B158805 (Figure 1). Attach the oil filling line to the adapter, leaving the connection loose for the purpose of purging the line of air. Slowly pump oil into the line from the battery pump and tighten the connection between the line and the adapter when air bubbles disappear from the connection. Remove the oil index follower (Figure 2), using the special wrench provided for that purpose. With the oil filling line of the battery pump connected as described above, and shown in (Figure 2) pump oil into the mechanism. The pressure exerted by the oil being pumped into the system will force the packing outward. In case the packing comes only partially out and then sticks to where an excessive pressure is built up by the pump it will be necessary to insert the follower and push the packing inward. By pushing the packing backward and forward in this manner little difficulty should be experienced in removing it. The oil index assembly consists of three belleville springs B155902, the packing A15898, two glands enclosing the packing A166286, and the follower B155406. The belleville springs are forced out by the pressure and should be examined for cracks. Assemble new packing and reassemble as shown in (Plate "E"). Pull the follower up tight. Pump in reserve oil to test for proper functioning of the index, and for leakage. If any defects in the oil index mechanism cannot be corrected by this method the recoil mechanism should be sent to an arsenal, or some other designated repair base, for repair.

REPLENISHER. - The normal position of the replenisher piston when the gun is ready for firing is 150mm (5.9 inch) measured from the rear face of the replenisher cylinder. This position indicates a full recoil cylinder and suf-

ficient reserve in the replenisher. When the replenisher piston is at a point 100mm (3.93 inches) or less from the rear face of the cylinder oil should be removed before firing, and if the piston measures 200mm (7.87 inches) or more from the rear face of the cylinder oil must be added. To check the operation of the replenisher piston insert a scale in the opening of the replenisher piston guide and against the replenisher piston, then release the oil from the replenisher by means of the oil release, A1001, screwed into the filling and drain valve, B155851, (Plate "C"). If a smooth movement of the piston takes place the mechanism is working satisfactorily. The rubber packing of the replenisher piston A175831 (Plate "C") deteriorates with age. The rubber swells and increases the friction of the piston to

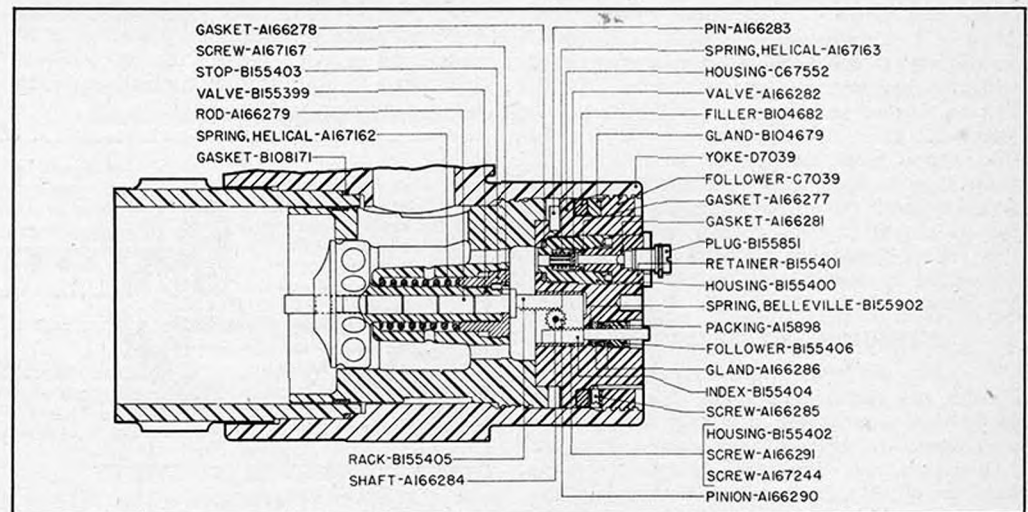


Plate E
REcuperator CYLINDER REAR HEAD

where the piston binds and makes the mechanism inoperative. In the event this happens it will be necessary to remove the piston from the cylinder and renew the packing. Figure 4 shows the mechanism being disassembled. A special wrench is used to disassemble the filling and drain valve assembly, while the replenisher piston extractor is being utilized to relieve the tension of the spring. These tools are part of the special repair chest furnished to maintain this materiel.

Figure 5 shows the disassembled parts. Figure 4 is not intended to illustrate the correct method of relieving the tension of the spring; rather, it is merely to point out that there is a special tool for this purpose. The thin replenisher cylinder wall is often damaged by lifting slings. Slings, if used, should be so placed that they will not bear directly on the cylinder wall. The cylinder wall should never be struck to jar the piston when it is stuck. After any repairs to the replenisher piston the recoil system should be filled and allowed to stand for ten hours, if time will permit, after which the guide and spring will be removed to note the amount of oil which has passed the piston. Clear oil indicates a leak and requires adjustment of the packing.

MANOMETER TEST. - See Figure 1 for tools used). (a) The purpose of a manometer test is to:

- (1) Obtain the nitrogen pressure.
- (2) Obtain the friction of the floating piston.
- (3) Determine the combined friction of the counterrecoil piston, counterrecoil piston rod stuffing box, and recoil rod stuffing box.

(b) Procedure to make test:

(1) With the gun in battery at 0 elevation, remove the filling and drain plug from the replenisher. Insert the filling and drain valve release (A1001) and draw off the oil in the replenisher. Remove the filling and drain valve release.

(2) Remove the filling and drain plug on the recuperator rear head. Insert the filling and drain valve release, after assembling it to the adapter B105455, and drain off the reserve oil. The flow of oil will stop when the oil index shows below the surface of the cylinder head.

(3) Remove the counterrecoil cylinder front head, (Figure 6), attach the jack screw C7336, and by its means (Figure 7) move the piston rod approximately 4 inches to the rear. If the gun is mounted on the cradle it will be disconnected from the recoil mechanism by removing the nuts from the recoil and counterrecoil rods, after it has been forced out of battery this 4 inches. Examine exposed rods for corrosion, rust, scratches, etc. and clean with

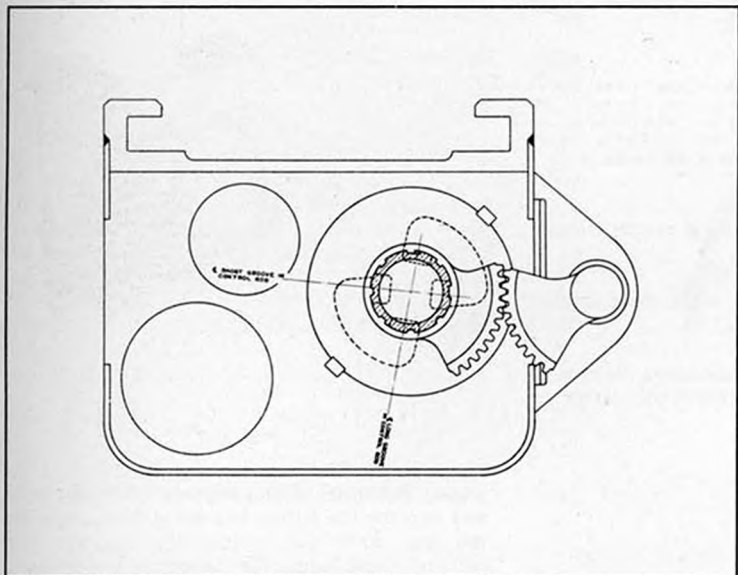


Plate F1
VARIABLE RECOIL MECHANISM - 0° ELEVATION

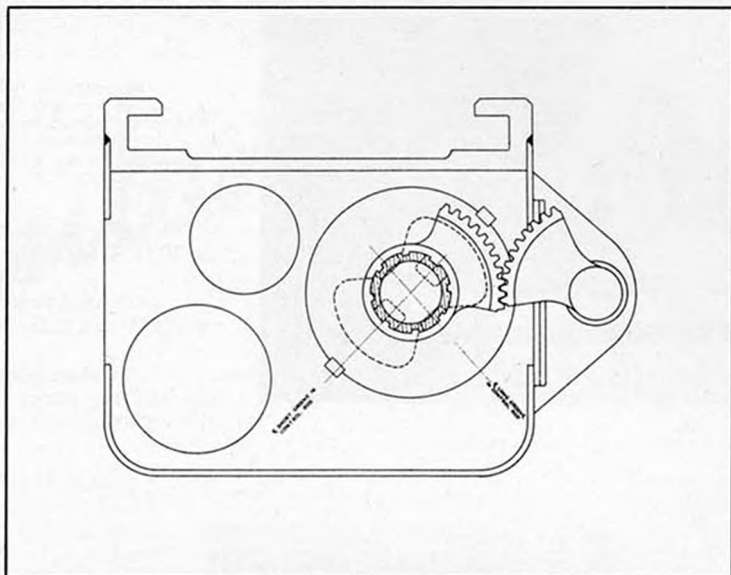


Plate F2
VARIABLE RECOIL MECHANISM - 65° ELEVATION

crocus cloth.

(4) Attach the pressure gage C6385 to the end of the adapter B105455, leaving this connection slightly loose for purging. Assemble the connection A141612 to the pressure gage, and the oil filling line of the pump to the connection. (Figure 8) Pump slowly to "purge" the line and tighten all connections.

(5) Back out the jack screw. Pump slowly and move both rods forward taking the gage reading while the rods are between 3 and 4 inches out, and in motion. This reading represents the combined friction of the recoil rod stuffing box, counterrecoil piston and counter-

recoil rod stuffing box. Obtain three uniform gage readings.

(6) Continue to pump slowly until the rods are in battery position and the oil index stops moving outward (5mm beyond the face of the head) and take the gage reading. This reading represents the nitrogen pressure (AP) plus the floating piston friction (F).

(7) Loosen the oil filling line at the gage sufficiently to allow the oil to escape by drops. Observe the gage hand as the pressure decreases and record the reading as the gage hand becomes stationary. This reading represents the nitrogen pressure (AP) minus the floating piston friction (F).

(8) The gas pressure in the mechanism is one half the sum of the high and low readings, viz:

$$AP \text{ equals } \frac{(AP \text{ plus } F) \text{ plus } (AP \text{ minus } F)}{2}$$

EXAMPLE

Let AP represent the nitrogen pressure, and F represent the floating piston friction.

Gage reading as found in par 6 --- 1895.7 lbs per sq in
 Gage reading as found in par 7 --- 1711.1 lbs per sq in
 Add these readings together --- 3606.8 lbs per sq in
 Then divide by 2 --- 1803.4 lbs per sq in
 (The final figure represents the nitrogen pressure in the mechanism.)



Fig. 1 -- Tools for Manometer Test.

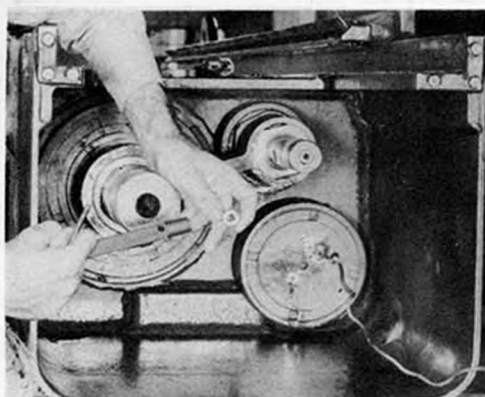


Figure 2

EXAMPLE

Gage reading as found in par 6 --- 1895.7 lbs per sq in
 Gage reading as found in par 7 --- 1711.1 lbs per sq in
 Subtract the low from the high reading --- 184.6 lbs per sq in
 Then divide the answer by 2 --- 92.3 lbs per sq in
 (The final figure represents the friction of the floating piston)

(10) The desired floating piston friction is 70 to 90 lbs per sq in.

Satisfactory friction of the floating piston is 70 to 170 lbs per sq in.

Desired friction of combined friction of the stuffing boxes and counterrecoil piston is 110 to 200 lbs per sq in.

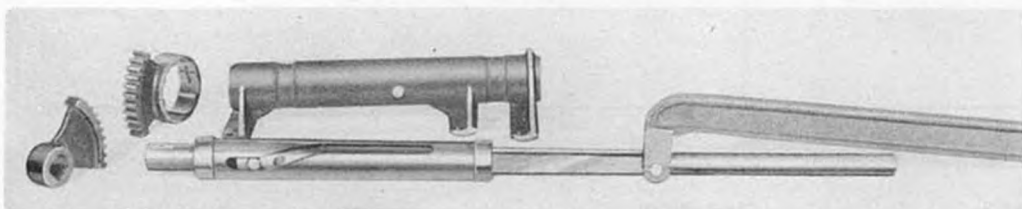


Figure 3

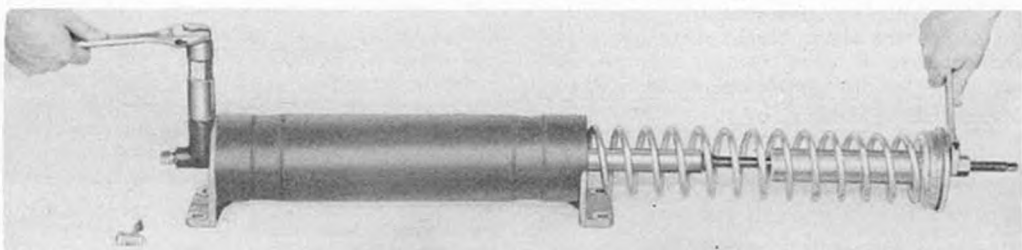


Figure 4

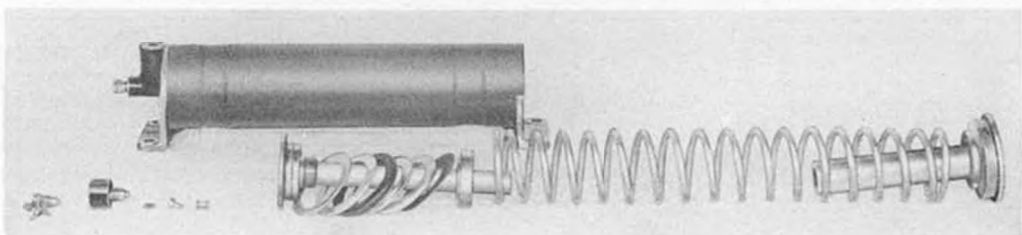


Figure 5

(9) The floating piston friction is one half the difference between the high and low readings, viz:

$$F \text{ equals } \frac{(AP \text{ plus } F) \text{ minus } (AP \text{ minus } F)}{2}$$



Figure 6

Satisfactory friction of combined stuffing boxes and counterrecoil piston is 110 to 425 lbs per sq in.

(11) The initial air pressure of the mechanism is 1820 lbs per sq in at 70 degrees Fahrenheit. The allowable limit for a serviceable mechanism is plus or minus 100 lbs per sq in.

The correct pressure for any temperature may be found by referring to the table at the right, showing variations of pressures with changes in temperature.

RESTORING MECHANISM TO NORMAL.

(1) Remove the oil line connection, allowing the reserve oil to drain. Remove adapter, B105455, and filling and drain valve release, A1001. Screw adapter, B158805, into the filling and drain hole and attach the oil line, leaving the connection loose. "Purge" the line of air and tighten the connection. Then apply 100 full strokes of the pump to force into the mechanism approxi-



Figure 7

mately one quart of oil. Remove all connections and replace the filling and drain plug. Remove the jack screw and replace the counterrecoil cylinder front head. (2) Assemble the adapter, B158805, with the oil filling line to the filling and drain hole of the replenisher and force in oil until the end of the piston is 5.9 in. from the rear face of the replenisher cylinder. This constitutes the reserve for the recoil cylinder. Remove the connections and replace the drain plug.

The pressure-temperature table used in this article is from letter, Rock Island Arsenal, dated May 8, 1942. For further detailed information concerning this materiel consult Technical Manuals 9-350 and 9-1350.

Temperature Centigrade	Temperature Fahrenheit	Pressure Kg per sq cm	Pressure Lbs sq in
-15	5	113	1599
-10	14	115	1630
-5	23	117	1660
0	32	119	1691
5	41	121	1721
10	50	123	1752
15	59	125	1782
20	68	127	1813
25	77	129	1843
30	86	132	1874
35	95	134	1904
40	104	137	1935
45	113	139	1965
50	122	141	1996
55	131	143	2026
60	140	145	2057

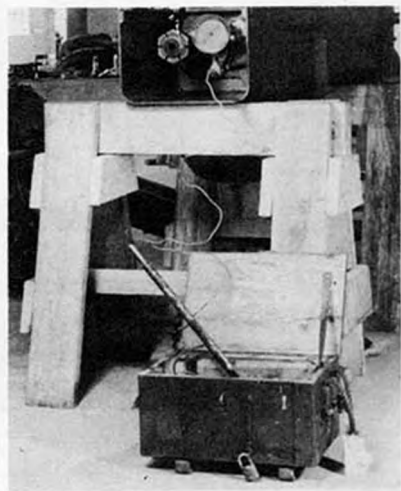
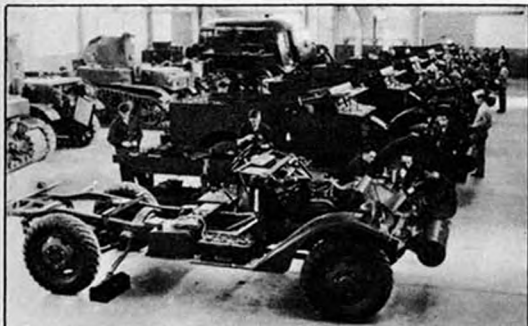


Figure 8



Automotive

Conducted by:
J. W. WINSLOW,
M. Sgt., Ord. Dept.

FUELS AND LUBRICANTS

by W. J. SEVERINGHAUS, 1st Lt., Ord. Dept.

In the past year the types of petroleum derivatives supplied to the field forces have been altered radically. Efforts have been made to simplify the schedule of supplies. The problems involved in discarding several types of lubricants in favor of one type which must serve for the several are not easily solved. Much has been accomplished. The results concern everyone who is in any way connected with properly maintaining our equipment.

New specifications have been made for almost every part of the schedule: gasoline, Diesel fuel, engine oil, gear oil and grease. I will point out for each part the specifications which most concern the use of that part, the significance of the specifications, and the actual use of the part in vehicle operations.

GASOLINE

For all gasoline powered motor equipment, except that powered by radial aircraft engines, and some air-cooled engines requiring clear (unleaded) gasoline, the Q. M. General procures two gasolines. These two correspond reasonably to the "regular" and "premium" grades offered to the public. A 72 octane number fuel is the regular grade. An 80 octane number fuel is the premium grade. While it is desirable to supply all units with the 80 octane fuel, economy dictates that 72 octane be used except for critical phases of operation. This is not a money economy. It is an economy necessary because of limited supply of materials. At present time all transport vehicles in the U. S. will be supplied with the 72 octane fuel. Where storage facilities permit, the 80 octane fuel is supplied for combat vehicles. Units, both transport and combat, in overseas operation will be supplied with 80 octane fuel. This distribution insures that the wrong grade of gasoline will not be used under conditions where it might cause loss of life and equipment. The 72 octane fuel may be used where engines are not called upon to give maximum power at all speeds. In combat, maximum power conditions can only be met with the 80 octane fuel. To use the 72 octane fuel would cause such severe detonation as to damage the engine.

Field cook stoves, blowtorches and small air-cooled engines (such as used on small gasoline driven battery chargers) operate with less trouble on unleaded gasoline. To supply this demand a filtering unit has been designed to remove the lead from leaded gasoline. The supply points for these filter units have not been disclosed to date.

Motor Fuel - 72 octane is procured under U. S. Army Specifications No. 2 - 114.

Motor Fuel (All-Purpose) is procured under U. S. Army Specification No. 2-103A. (This is 80 octane.)

For the "Continental" radial gasoline light tank engine an 87 octane fuel is required. For the "Wright" radial gasoline medium tank engine a 91 octane fuel is required. Reports indicate that supplies of the 87 octane are available to tank outfits in the field, but that 91 octane fuel is sometimes not supplied.

DIESEL FUEL

Diesel fuel is supplied in three classes A, B, and X. The three classes differ in octane number, volatility and pour point as is shown in the table.

Class	A	B	X
Cetane Number	50	47	45
Volatility (Relative)	Lowest	Intermediate	Highest
Pour Point (max)	+ 10° F	- 20° F.	- 40° F.
How Climate Affects Use	For Hot Climate	For Temperate Climate	For Cold Climate

The contractor is responsible for the delivery of the proper class of fuel. Deliveries are made in accordance with a rather lengthy geographic and seasonal distribution table.

Oil, Fuel, Diesel for High-Speed Automotive-Type Diesel Engines is procured under U. S. Army Specification No. 2-201B.

ENGINE OIL

The most radical change has occurred in the engine oil supplied. This is evident in two outstanding ways: (1) there are now only three SAE grades (10, 30, 50) and (2) All engine oil supplied is now of the heavy duty type containing "detergent" or "cleansing" additives.

Authority for using the proper SAE grade is found in the TM or manufacturers manual or War Department Lubrication Guide for each vehicle. But, with few exceptions, for gasoline In-Line engines operating at temperatures below 32 degrees F, SAE 10 engine oil is used. For gasoline in-line engines at temperatures above 32 degrees F, SAE 30 engine oil is used.

For most in-line Diesel engines SAE 30 engine oil is the proper grade. Again the authority indicated above should be consulted.

For all radial engines, Wright and Continental (gasoline) and Guiberson (Diesel) SAE 50 engine oil will be used. (See also "gear oils" for lubrication of tank transmissions). This will take the place of the old Navy Symbol 1100 and 1120 (SAE 50 and SAE 80, aircraft grade 100 and 120) oils previously used in radial engines in tanks.

Introduction of detergent oils will cause some engine failures unless the change-over is accomplished with due care. The action of the detergent oil is to clean out sludge and other crankcase and oil system deposits. Every Armyman charged with servicing engines should become familiar with Training Circular No. 32, May 22, 1942 "Instructions on the Use of Improved Lubricants." The procedure outlined in this circular will insure against failure of an engine during change-over due to action of personnel not acquainted with the properties of the new oils. This article cannot cover the subject thoroughly but for the benefit of those units receiving the new oils before obtaining TC 32, the following is included.

(1) New engines may be serviced with new oil of the proper SAE grade and no further attention is required other than normal oil changes.

(2) The care necessary in making the change-over on engines already in service increases with the amount of sludge and deposits which have accumulated in the engine. In general the following steps are followed:

- a. Drain engine of old oil while hot.
- b. Remove filter element and replace with new element.

c. Fill one-half (1/2) with the new oil and run at fast idle for one-half (1/2) hour. Watch oil pressure gage continually.

d. Drain.

e. Inspect filter element. If sludged, replace.

f. Repeat flushing, running, inspecting until the unit appears clean.

g. During the 1st 100 miles of road operation the oil pressure must be watched continuously. At the end of the 1st 100 miles, drain, check filter element and replace if necessary.

The oil pressure must be watched because sludge may become dislodged and shut off the oil supply. If at any time the oil pressure drops below normal (gradually or rapidly) the engine must be stopped and cleaned by hand until the obstruction is removed.

The new oils supplied by different contractors may be mixed with-out any danger. Old stocks of oil may be mixed with new oils. Such mixing will reduce the effectiveness of the new oils.

Oil, engine, lubricating, all purposes, is procured under U. S. Army Specification No. 2-104A.

Field forces will be supplied with 1-qt., 5-qt. and 5-gallon cans. Permanent stations, where danger of contamination is lower, will get engine oil in standard drums.

GEAR LUBRICANT

Another radical change has taken place in lubricants for gears. Now all enclosed gears (except tank transmission) are lubricated with one type of gear oil. It is available in three SAE grades, 80, 90, and 80-140. Most gearing requires either the 80, or 90 grades. The 80-140 is available in small quantities and will be supplied only to such parts of the Army as operate under extreme climatic conditions of heat and cold. The new gear lubricant is quite like the common "Mild Hypoid Type," but will also handle hypoid axles. It has extreme pressure qualities due to special additives in the oil. Further information regarding the new gear lube may be found in WD TC 32.

Lubricant gear, Universal, is procured under Federal Specification No. VV-L-761. For most camps and stations in the U. S. only the grades SAE 80, and SAE 90 will be supplied. Grade SAE 80-140 will probably be supplied only to overseas units.

IMPORTANT. - Tank transmissions are lubricated with Oil, Engine, Lubricating, all purpose, SAE Grade 50. Universal gear lubricant will not be used in tank transmissions.

All gear oil is supplied in 25-pound pails. Permanent stations will continue to receive gear oils in standard drums, inasmuch as the danger of contamination is lower than in combat areas.

GREASES

There are now five (5) greases in the Schedule of Supplies.

Grade	Consistency at Room Temp.	Use	Nomenclature	
0	Softest	For winter all grease requirements except water pump and wheel bearing	Grease, general purpose No. 0 U.S.A. Spec. 2-106	
1	Greases are listed in order of increasing hardness	For summer all grease requirements except WP and WB	Grease, general purpose No. 1 U.S.A. Spec. 2-107	
2		Wheel Bearings under all temp. below 90° F.	Grease, general purpose No. 2 U.S.A. Spec. 2-108	
Heavy Duty Wheel Bearing No. 3		For use under extreme temp. conditions (continuously over 90°)	Grease, wheel bearing heavy duty, No. 3 U.S.A. specification 2-110	
Water Pump No. 4		Hardest	Water pumps.	Grease, water pump, hard, No. 4, U.S.A. Specification, 2-109

All greases, except water pump grease, are available in 25-pound pails. Water pump grease is supplied in 1-pound tins.

MISCELLANEOUS

Lubrication of other items at all temperatures:

- Generator and starting motor — engine oil
- Fan and distributor — engine oil
- Oil bath air cleaner — engine oil
- Brake fluid — ISO, Delco 9, Puritan, or Lockheed 21
- Shock absorber fluid, light — Delco
- Shock absorber fluid, heavy — Houdaille
- Motorcycle chains — engine oil
- Vacuum booster cylinders — engine oil, SAE 10 for all seasons
- Hydraulic dump hoists — engine oil, SAE 10 for all seasons
- Speedometer drive cables — Grease, general purpose Nos. 0, or 1.

These recent developments render obsolete the table of "Automotive Lubricants" in THE ORDNANCE SERGEANT for June 1942 (see page 505). The new table is given below.

- Oil, engine, lubricating, all purpose SAE 10
- SAE 30
- SAE 50
- Lubricant, gear, Universal SAE 80
- SAE 90
- SAE 80-140
- Grease, general purpose No. 0
- Grease, general purpose No. 1
- Grease, general purpose No. 2
- Grease, wheel bearing, heavy duty No. 3
- Grease, water pump No. 4

WE WERE WRONG, BUT IT WON'T HURT YOU

(A Correction)

In the center of page 510, June issue of THE ORDNANCE SERGEANT, the following statement may be found, sad to say:

"For instance, a battery with an S. G. reading of 1.250 will freeze at about 65 degrees F. below zero, whereas a battery that is as low as 1.175 will freeze at about 12 degrees F. above zero".

This statement is obviously wrong. The above paragraph should read:

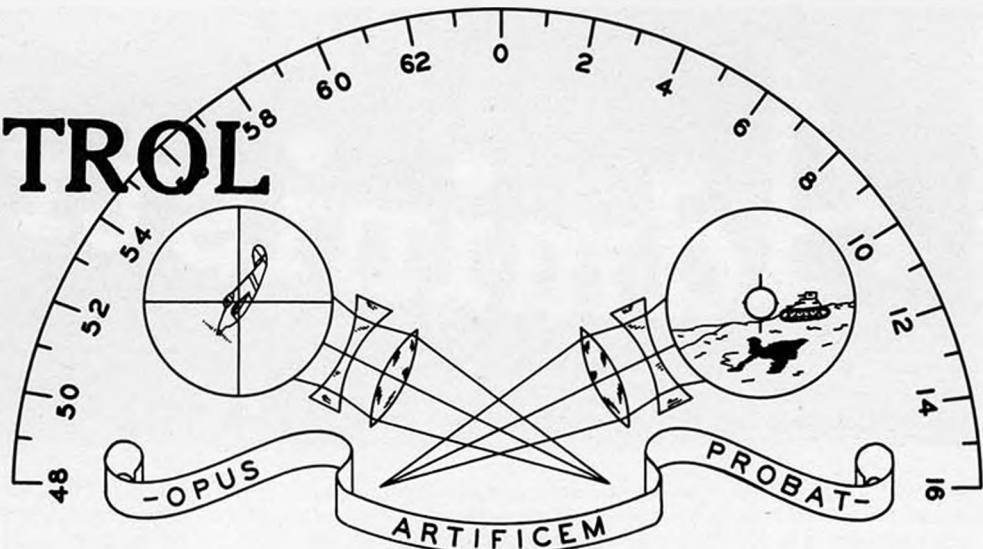
"For instance, a battery with an S. G. reading of 1.250 will freeze at about 65 degrees F. below zero, whereas a battery that is as low as 1.175 will freeze at about 4 degrees F. below zero."

ORDNANCE FIELD SERVICE TECHNICAL BULLETINS

Elsewhere in this issue you will find tentative or preliminary texts of Ordnance Field Service Technical Bulletins which are scheduled for distribution at a later date. This important information will appear in later issues, as will frequent advance texts of Field Service Modification Work Orders. This information is OFFICIAL and is published in this magazine in an effort to obtain the widest possible distribution in advance of the normal distribution to the field, which is often unavoidably delayed under present conditions.

FIRE CONTROL

Conducted by:
R. L. JOHNSON,
Captain, Ord. Dept.



INSPECTING AND REPAIRING GENERATORS FOR ISSUE

by C. S. IRESON, 2nd Lt., Ord. Dept.

This article deals with the inspection and preparation of generating units, and their gasoline engines, for issue to the using service. The generators to be referred to are those which are used with anti-aircraft fire control systems. When these generators are issued to the using units they must be fully equipped and in excellent mechanical condition. It is the responsibility of the Ordnance Department to see that these requirements are met prior to issue.

Both new machines and reconditioned machines are handled by the Ordnance Department. The procedures of inspecting them and preparing them for issue are almost identical.

Certain preparatory steps must be taken before attempting to start the engine. One of the first of these steps is to prepare the six volt storage battery used to start the engine. The batteries of all new machines are shipped dry, without electrolyte, but with the plates partly charged.

Fill them with an electrolyte made by mixing sulphuric acid with distilled water. In mixing the electrolyte, always pour the acid into the water. NEVER POUR WATER INTO THE ACID, AS THIS IS VERY DANGEROUS. Use only glass or hard rubber containers for mixing the acid and water.

Before attempting to prepare the electrolyte, read the instructions on the tag attached to the battery by the manufacturer. Follow these instructions very carefully. They specify the specific gravity of the electrolyte to be used and the method of application.

In case the instruction tag has been misplaced, use the following procedure in preparing the battery for use.

Mix the acid and water to a specific gravity of 1.300 (when cold). One part by volume of acid to two and three-fourths parts water will make a solution with a specific gravity of 1.280 to 1.300 at atmospheric temperature. In tropical climate the specific gravity will be slightly lower.

When sulphuric acid is mixed with water the temperature of the solution rises very rapidly. Allow the solution to cool before filling the battery. The temperature of the electrolyte, when used to fill the battery, must not be lower than 60 deg. F; or higher than 90 deg. F.

After the battery has been filled allow it to stand for 8 to 16 hours before charging it. If during this period, the level of the electrolyte falls, restore it by adding distilled water. The level of the electrolyte should always be from 1/4 to 3/8 of an inch above the plates of the battery.

It is considered good practice to completely discharge a new battery at a slow rate and then to recharge it to full charge at an equally slow rate, (approximately 4 to 6 amperes.)

The available time, however, may not permit this to be done. If so, charge the battery until the specific gravity of the electrolyte does not continue to rise. The battery should then be fully charged with a specific gravity of 1.290 to 1.300. If the specific gravity is not within these limits, drain the electrolyte from the battery into a glass or rubber container. Adjust the specific gravity to 1.300 by adding sulphuric acid to increase it or by adding distilled water to decrease it. Refill the battery with the corrected electrolyte.

Where a used battery, or one that has been filled with electrolyte, is found in the generator, it is first tested with both a hydrometer and a cell tester to ascertain its condition. Should it be found partially or wholly discharged, it must be recharged and again tested before reinstallation in the generator.

After installing either a new or used battery be sure and clean the top and terminals thoroughly. Coat the terminals with a light coat of vaseline or light grease. This will prevent corrosion.

Lubrication is a most important item and cannot be overemphasized. Fill the crankcase until the gauge stick shows "full", with a good grade of motor oil meeting government specifications. The capacity of the M4 generator engine is 2 quarts; the M5 - 4 quarts; and the M7 - 7 quarts. An extra quart, however, must be added to each of these crankcases, since the oil filter consumes one quart. The climate will determine the viscosity of the oil to be used.

Use Oil, engine, SAE 30 when the minimum anticipated temperature is not lower than plus 32° F, and oil, engine, SAE 10° for temperature from plus 32° F. to minus 10° F. When the temperature is below minus 10° F. it may be necessary to dilute the crankcase oil with 10% gasoline or kerosene, or 15% diesel fuel. Care must be exercised to maintain the diluent at this ratio since it will be partly driven off during operation.

Some generators are shipped with a very light oil, known as "break-in oil", in the crankcase. A unit having "break-in oil" in the crankcase must not be run more than ten hours before changing the oil to the viscosity indicated in the previous paragraph.

Should it be found, in the case of a reconditioned machine, that oil is already in the crankcase, the quantity and quality should be observed; and likewise the condition of the oil filter. Drain the dirty or discolored oil from the crankcase, flush with a small quantity of SAE 10 oil, and then refill with oil of the proper grade and viscosity. Clean the filter of any dirt or sludge that may be found in the bottom of the case and renew the filler if of the renewable type; if of the non-renewable type, wash with gasoline before replacing. Always add an extra quart of oil for the filter when it has been cleaned.

(Continued on page 207)



Conducted by: J. E. Dempsey, 1st Lt., Ord. Dept.

FURLOUGHS, DELAYS ENROUTE, AND PASSES

BY
HOWARD B. SCHOR
S. Sgt., Ord. Dept.

Since periods of cessation from routine work for the purpose of travel, healthful recreation, and diversion are essential for the efficiency of persons in the military service furloughs are granted. Normally the War Department encourages the taking of furloughs, but today due to wartime emergencies this privilege has been curtailed although certainly not eliminated.

Except in cases of extreme emergency and upon return from outside the United States furloughs will be confined to periods not in excess of fifteen days at any one time. (WD Circular No. 79, dated March 17, 1942). Post, camp and station commanders and regimental and separate battalion commanders and higher commanders may grant furloughs to enlisted men under their control on the basis of thirty days a year and may delegate this authority to grant furloughs to such of their subordinates as they may designate. Furloughs for enlisted men serving outside the continental limits of the United States will be prescribed and regulated by department commanders, the commanding general, United States troops in Alaska and commanders of detached forces. (WD Circular No. 133, 1940).

Furloughs may not be granted while organizations are on maneuvers or to individuals who are undergoing training in replacement training centers and officer candidate schools except that emergency furloughs may be authorized at any time (WD Circular No. 200, 1941). Enlisted men undergoing treatment for an infectious, contagious or venereal disease will not be granted furloughs except in case of urgent necessity. An officer authorized to grant furloughs may temporarily restrict or suspend the granting of such to any part or to all of the enlisted men under his control whenever in his opinion circumstances render such restriction or suspension desirable. The number of enlisted men on furlough from any command will not exceed fifteen (15) percent of the enlisted strength except under exceptional circumstances. During periods immediately following maneuvers or similar specialized training periods and during the Christmas holidays, fifty (50) percent of the individuals in an organization may be authorized furloughs at any one time. (WD Circular No. 200, 1941). It should be understood that a furlough is a privilege which may or may not be granted as military necessities may dictate. It is not a right which may be demanded by any enlisted man.

Many enlisted men, due to their lack of understanding of the computation of furlough time, have come back from furloughs twenty-four (24) hours before the actual end of their furlough. The guiding rule to follow is that the day on which an enlisted man starts his furlough is a day of absence and he will receive the ration allowance for that day; and the day

of return is a day of duty, regardless of the hour of return, and his organization will receive the ration allowance for that day. For example, an enlisted man granted a furlough for ten days from September 1 to September 10, inclusive, is due to return on September 11 before midnight. In the above example the enlisted man would receive a check for furlough rations allowance for ten days. The money value of this furlough ration is published annually in a War Department Circular. The furlough ration figure for 1942 is \$0.44 per ration. For ten days the enlisted man would receive a check from the local finance officer amounting to \$4.40. If the furlough is overstayed this ration allowance is forfeited.

ORIGINAL FURLOUGH
(See AR 615-27)

TO WHOM IT MAY CONCERN:

Pursuant to authority given in AR 615-27 a FURLOUGH is hereby granted to
(Give full reference to orders or other authority)

Fellows, Joseph T. 6608224 Cpl. 150th Ord. Co. (MM)
(Last name) (First name) (Middle Initial) (Army serial number) (Grade) (Company, Regiment, and unit or activity)

for 10 days *from Sept. 1, 1942, *~~to~~ Sept. 10, 1942
(First day of absence) (Last day of absence)

He is authorized to visit Chicago, Ill. He will report for duty on or before Sept. 11, 1942
(Organization and station, or military station nearest point of departure from the United States) (Day due to return)

Place Ft. Blank, Ill.
(Organization and station, or military station nearest point of departure from the United States)

Date Aug. 30, 1942

Roger Bacon
ROGER BACON
Capt., 99th Inf.
Adjutant, ~~Company~~

MEMORANDA FROM PERSONNEL OFFICER
MEMORANDA FROM ~~COMPANY COMMANDER~~

This soldier was last paid in full to include Aug. 31, 1942. *~~He has been informed that the Government will not pay hospital or medical expenses incurred by a soldier while on furlough. (Act of Congress of March 2, 1933.)~~

He will be included in the ration account of his organization to include Aug. 31, 1942

Previous furloughs in current enlistment: None

Soldier's age 24 years; height 5 feet 9 inches; build medium; eyes green; hair blond;

complexion fair; signature *Joseph T. Fellows*; address on furlough 619 S. Beach St., Chicago, Ill.

He has been informed that the Government will not pay hospital or medical expenses incurred by a soldier while on furlough. (Act of Congress of March 2, 1933.)

Harold B. Sundry
HAROLD B. SUNDRY
Capt., Ordn. Dept.
Personnel O., ~~Company~~

THIS SPACE WILL BE USED FOR REFERENCE TO HIGHER AUTHORITY, WHEN NECESSARY, AND FOR THE ACTION OF SUCH AUTHORITY THEREON
(When so referred the certifies above will not be completed until approval below is returned)

W. D., A. G. O. Form No. 31
March 1, 1933 *Strike out words not applicable. 8-1942

Figure 1

The form used for the granting of furloughs is W. D., A. G. O. Form No. 31, the furlough certificate. This form is filled out in duplicate by the personnel officer of the next higher administrative unit for approval and signature by the officer empowered to grant the furlough. The authority under which a furlough is granted will be cited on the certificate. This will usually be a quotation of Army Regulations 615-275; but if the

furlough is in excess of the time so authorized the certificate must be accompanied by a copy of the order or other authority under which it was granted. The period of a furlough must be stated in the certificate over the signature of the officer granting the furlough. Only the original copy of the furlough certificate will be signed.

The certificate on the back of W. D., A.G.O. Form No. 31 at the bottom titled "Certificate of Soldier's immediate commanding officer as to his return from furlough" is the one upon which the furlough ration allowance is paid. This is signed by the enlisted man's company commander upon the man's return.

The other two certificates are filled out only in the case of enlisted men on furlough from a station beyond the continental limits of the United States.

The original of the furlough certificate is given to the enlisted man when going on his furlough. Upon his return from furlough both the signed original copy and the unsigned duplicate are sent to the personnel officer who after making the proper entries on page 6 of the man's service record (furlough section) will forward these copies to the finance officer of the post or command. The finance officer will use these as a voucher for which he will pay the man his commutation of rations for the time of the furlough.

The government will not pay hospital or medical expenses incurred by a soldier while on furlough. This statement on the certificate refers only to payments for treatment by civilian agencies such as private medical treatment by the family doctor or by a civilian hospital as contrasted with medical care by an army hospital. If an enlisted man is in a civilian

If, however, an enlisted man is taken to an army hospital while on furlough, the following would happen: The commanding officer of the hospital, after looking at the man's furlough certificate, would notify the man's company commander, who would suspend the man's furlough while he remained in the army hospital. The soldier would be carried on his company's morning report as "absent sick" for the period he was in the army hospital. Upon date of release from the hospital, the commanding officer would again notify the soldier's company commander and he, in turn, would continue the man's furlough, and the date the man was to return to duty would be changed accordingly. The soldier would then be carried on the morning report as on furlough. The commanding officer of the hospital would make the necessary notation on the enlisted man's furlough certificate and the man would continue on his furlough.

An officer empowered to grant a furlough may extend a furlough already granted to an enlisted man under his command. However, the entire period thus covered by the extended furlough may not exceed the maximum period for which the officer had authority to grant a furlough originally.

An enlisted man may not leave the continental limits of the United States on furlough unless specific authority has been granted for him to do so and that fact noted on the furlough certificate as a separate entry. Limits prescribed will be stated on the certificate and if these are exceeded the furlough may be cancelled and the soldier arrested. Furloughs to visit foreign countries are granted subject to such passport regulations as may be in force.

The granting of a furlough to return to the U. S. from foreign service to an enlisted man is controlled by the commanding general of the department or task force in which the man is serving. Such a furlough takes effect the day after the day the soldier reaches the United States; and the date of his return to duty is the date upon which he reports for duty at the military post nearest the port of debarkation to his overseas station. For example, Fort Slocum, N. Y. would be such a point for men based in Iceland or Ireland. The two certificates on the back of the furlough certificate at the top would be filled in upon the soldier's arrival in the United States coming from his home station, and when he returned to the station nearest his point of departure for his home station overseas.

Enlisted men on furlough will not take with them their arms and equipment. However, enlisted men returning to the United States for furlough will be authorized to take with them certain specified articles of clothing and equipment.

When an enlisted man requests payment during furlough he will be paid on a separate consolidated payroll (W. D. Form No. 366) or on an individual voucher (W. D. Form No. 337), his accounts being stated in full with the additional remark: "Enlisted man on furlough; desires payment by check mailed to(designated address)".

DELAYS ENROUTE

Enlisted men desiring to delay enroute while traveling under official orders may be granted such delays by the officer authorized to grant furloughs. A formal furlough certificate is not accomplished in such cases, the authority for delay enroute being incorporated in the orders under which the man is traveling. Such delays are chargeable to furlough time and entered in the man's service record accordingly.

PASSES

An officer authorized to grant furloughs may grant passes to men under his control for a period not greater than three (3) days but he cannot authorize visits to places at a considerable distance from the station of the organization. "Considerable" may be interpreted to mean a distance from 50 miles to 350 miles. In case of injury or sickness the same rules that apply to furloughs apply here also. Passes are usually of such size that they may be carried in one's wallet. Passes vary in form and wording according to the whims of the officer authorized to grant them.

CERTIFICATE AS TO DATE OF ARRIVAL WITHIN CONTINENTAL LIMITS OF U. S. AND SUBSISTENCE FURNISHED EN ROUTE.

The quartermaster or agent of an Army transport or other military transportation, the purveyor of a naval vessel, or purser of a commercial vessel, upon which a soldier is en route to the United States for furlough, will certify below as to date of arrival within the continental limits of the United States, and as to subsistence furnished en route.

I certify that subsistence was furnished the soldier named in this certificate of furlough from _____ 19____, to _____ 19____, both dates inclusive, on _____ (Date of arrival in U. S.) _____, which arrived at _____ on _____ 19____.

(Signature) _____
(Grade and other official designation) _____

CERTIFICATE AS TO DATE OF ARRIVAL AT AND DEPARTURE FROM MILITARY STATIONS, EN ROUTE FROM FURLOUGH.

In returning from furlough to a station beyond the continental limits of the United States the soldier will report to the military station nearest the point of departure from the United States. The date of his arrival at and departure from such station will be noted below, with a statement of subsistence furnished. When transportation or commutation of rations is furnished the soldier returning from furlough, notation will be made below.

I certify that the soldier named herein reported for duty at this station on _____ 19____. *was released from _____ 19____, to _____ 19____; *was furnished *commutation of rations *transportation to _____ He left this station pursuant to _____ on _____ 19____.

(Signature) _____
(Grade, etc.) _____

CERTIFICATE OF SOLDIER'S IMMEDIATE COMMANDING OFFICER AS TO HIS RETURN FROM FURLOUGH.

Commutation of rations will be paid the soldier for the inclusive dates of the beginning and end of his furlough. The soldier's organization is not entitled to draw rations for him within such inclusive dates.

This soldier reported for duty *as required by this furlough certificate, on Sept. 11 1942 and will be included in the ration account of his organization beginning with the day following the end of the period for which he has received rations in kind or commutation thereof.

William G. Burtz
WILLIAM G. BURTZ
(Signature)
Capt., Ord. Dept.
(Grade, etc.)
Station Ft. Blank, Ill. Commanding 150th Ord. Co. (M)

*Ratios not words not applicable.

Subvoucher No. _____ to Voucher No. _____
Account of _____ at _____ 19____
dated _____ 19____ for \$ _____
Signature _____
Distributing Officer _____
Signature of _____
received by man in cash on _____ 19____

Figure 2

hospital when his furlough time runs out and his commanding officer has been notified of his whereabouts and finds through investigation by the Red Cross that such a condition is so, he will be carried on his company's morning report as "absent sick". Upon release from the civilian hospital he will return to his company for duty.

Remember those changes of address. They are important if you want to get THE ORDNANCE SERGEANT regularly.

Upon receipt of these three copies in the transportation office, a clerk will make up a bill of lading in five copies, the original copy, a white War Department Quartermaster Government Bill of Lading, Standard Form No. 1058, three copies of the memorandum bill of lading, the yellow form No. 1058a, and one copy of the shipping order, 1058b, the salmon colored form. First, the number printed on the original copy is typed on the remaining four copies in the same space, after the letters "WQ". After the words "War Department" on the line designated by the words "Bill To", write FINANCE OFFICER, Washington, D. C. On the line below, insert the procurement authority shown on the memorandum shipping ticket. "Transportation Office" and the address of the office is placed on the line following as the issuing office. The name and title of the issuing officer is indicated on the next line below, such as "John J. Jones, Capt., Ordnance Dept.", with the date appearing at the end of the same line over the portion designated for the information. Opposite the words "Received from", the same information that was shown on the preceding line is repeated, "Capt. John J. Jones, Transportation Officer", because it is the Transportation Officer at a post, camp, or station who turns the shipment over to the common carrier. The agent of the common carrier has no dealings with the Ordnance Property Officer except in the case of express shipments which are delivered directly to the Ordnance Property Officer at the designation. However, in this case, it is still the Transportation Officer who turns the shipment over to the common carrier at the shipping point. In the event that the Transportation Officer had given a partially completed bill of lading to some other party to make a shipment at government expense, the name and designation of this person would appear opposite the words "Received from" as this line indicates the individual actually turning the items over to the common carrier. An example of this would be when the manufacturer shipped items to a depot subject to acceptance by the army at the destination. A Transportation Officer would be the issuing officer, and the manufacturer would be the consignor. In the normal course of shipping between stations, it is the

is located is the "Shipping Point". The destination will be the place where the shipment will be returned over to the Transportation Officer by the last common carrier to handle the shipment. This may be the post, camp, or station, or the nearest town to the post on the line of the last common carrier at which the Transportation Officer will receive the shipment. In the event that there are two cities or towns of the same name in the state, the name of the county will be placed on this line as additional information to specifically determine the destination. The "consignee", or person whom the common carrier will contact when the shipment arrives, will be the Transportation Officer in the case of freight shipments. If the shipment is to travel by express, the name of the ultimate consignee, or person who is to finally receive the articles shipped, is inserted in this place. In the shipment of Ordnance materiel, this would be the Ordnance Property Officer as the shipment would be delivered directly to his warehouse. If the shipment is to be sent by boat outside of the continental limits of the United States, the consignee will be the Port Transportation Officer located at the point at which the shipment will be placed in the hold of the boat. After the word "via", the route or lines over which the shipment is to travel is indicated by inserting the initials of the names of the commercial carriers in the sequence in which they will receive and deliver the shipment to subsequent carriers. Owing to the fact that the government is allowed reduced rates for shipments of public property traveling over land grant lines, it is essential to route the shipment over as many miles of these land grant lines as possible to secure the lowest possible cost of transportation. This information can be obtained from the Finance Circular, F-3, 6-1-31. Most of the express companies allow reduced rates for express shipments traveling over land grant lines so it is necessary to route express shipments also. However, one of the pur-

WAR DEPARTMENT
Q. M. C. FORM NO. 484
REVISED FEB. 3, 1935

SHIPPING TICKET

CONSIGNOR'S VOL. No. _____
CONSIGNEE'S VOL. No. _____
NUMBER OF SHEETS _____

CONSIGNOR: ORDNANCE PROPERTY OFFICER, Camp Grant, Illinois

DATE SHIPPED OR DELIVERED: July 26, 1942

SHIP TO: ORDNANCE PROPERTY OFFICER, Fort Sheridan, Illinois

AUTHORITY OR REG. NO. Radiogram, 6th CAOO, Dated 7/25/42, File No. 474
TRANSPORTATION COST OF \$ 3.50 CHARGEABLE TO P.A. No. 53 ORD 6001 P3030 A0525-3

QUANTITY	STOCK NO.	ARTICLE	UNIT	UNIT COST	TOTAL COST
6		GROUP B-1 RIFLE, U. S., cal. .30, M1905.	ea.		
6		PISTOL, automatic, cal. .45, M1911.	ea.		
6		GROUP B-3 SLING, gun, M1907 (leather)	ea.		
6		GROUP B-6 HOLSTER, pistol, M1916 (leather)	ea.		
XXXX COMPLETE SHIPMENT XXXX					

Shipped by EXPRESS
Via: REA
Route: C, B, & Q
B/L #: WQ 268741
No. of Pkgs: 3 Pkgs.
Pkg. #s: 1-3
Total Wgt: 95 lbs.
Authority for Express Shipment
Radiogram, 6th CAOO, Dated 7/25/42 File #. 474

(SAMPLE COPY OF A SHIPPING TICKET TO TRANSFER ACCOUNTABILITY)

ARTICLES LISTED IN COLUMN "ORDERED" HAVE BEEN RECEIVED UNLESS OTHERWISE NOTED IN COLUMN "SHIPPED."

(NAME) (RANK) (ORGANIZATION)

UNITED STATES OF AMERICA

No. WQ-268741

Bill to WAR DEPARTMENT, FINANCE OFFICER, Washington, D.C.
(Department or Establishment and Bureau or Service)
53 ORD 6001 P3030 A0525-3
(Appropriation (chargeable))
Transportation Office, Camp Grant, Illinois
(Shipping office)

GOVERNMENT BILL OF LADING
MEMORANDUM COPY
Received from Capt. JOHN J. JONES, Transportation Officer, (Consignor)
by the Railway Express Agency (Office of Transportation Interest) the public property hereinafter described, in apparent good order and condition (contents and value unknown), to be forwarded subject to conditions stated on the reverse hereof, from Camp Grant, Illinois (Shipping point) to Fort Sheridan, Illinois (Destination)
by the add company and connecting lines, there to be delivered in like good order and condition to ORDNANCE PROPERTY OFFICER, Fort Sheridan, Illinois (Consignee)
via C, B, & Q RR (Route (journey only when some substantial interest of the Government is subserved thereby))

MARKS	NUMBERS ON PACKAGES	DESCRIPTION OF ARTICLES (Observe strictly carrier's freight classification. Avoid trade or technical names)	WEIGHTS*
DOMESTIC	1-2	2-boxes Small Arms Pkg. #1 60 lbs. #2 20	80 lbs.
For: ORDNANCE PROPERTY OFFICER, Fort Sheridan, Illinois.	3	1-box Small Arms Accessories- #3 15	15 lbs 95 lbs

EXPRESS
Pick-up service at origin _____ was _____ by the Government.
(Size car ordered) _____ ft. Size car furnished _____ ft. Date furnished _____ Initials _____ Car No. _____
(To be filled in by general office receiving account)

RAILWAY EXPRESS AGENCY
(Name of transportation company)
Radiogram, 6th CAOO, Dated 7/25/42 7/26/42, 19 Per _____ (Agent)

CERTIFICATE OF ISSUING OFFICER
(To be filled out when the bill of lading is used for use by contractor in tracking shipment)
Contract No. _____ of Purchase Order No. _____, dated _____, 19____
(F. O. B. point method in contract) (Shipping office)
CARRIER'S RIGHTS TO SHIPPING CHARGES NOT AFFECTED BY FACTS SET OUT IN THIS CERTIFICATE

MEMORANDUM COPY

Delivery service at destination was _____ by the Government.

* Show also value measurement for shipments via common carrier in cases where required.
10-1941 † Furnish this information in case of outland shipments only.
U.S. GOVERNMENT PRINTING OFFICE

function of the Transportation Officer to turn the shipments over to the common carrier. The name of the common carrier who receives the packages at the shipping point is placed after the words "by the". The location of the shipping point appears next such as, Fort Sheridan, Illinois, or, in the event that the items are taken to the nearest available freight station, the name of the city or town and state in which the freight station

poses of sending items by express is to save time, and circuitous routing would defeat the purpose if carried to an extreme. For this reason, great care should be used in planning the route. The information as to rates and routes can be found in the applicable freight rate tariff which is obtained from the common carrier.

Under the "marks" column, the word "DOMESTIC" should be shown for shipments traveling within the continental limits of the United States. If the shipment is to travel by boat, the word "EXPORT" is substituted for "DOMESTIC". The mode of shipment will also be designated, such as, (Continued on page 208)



Conducted by: F. P. Bingert, T. Sgt., Ord. Dept.

THE STORY OF TOOLMAKING AND PRECISION WORK

by

WARREN GREENE OGDEN, JR.
2nd Lt., Ord. Dept.

THE EARLY TOOL BUILDERS

Tools have played a highly important part in the history of civilization. Without tools and the ability to use them, men were indeed but a "poor, bare, forked animal," - worse clothed than the birds, worse housed than the beaver, worse fed than the jackal. "Weak in himself," says Carlyle, and of small stature, he stands on a basis, at most for the flattest - soled, of some half square foot, insecurely enough; has to straddle out his legs, lest the very wind supplant him. Feeblest of bipeds! Three quintals are a crushing load for him; the steer of the meadow tosses him aloft like a waste rag. Nevertheless he can use tools, can devise tools: with these the granite mountain melts into light dust before him; he kneads glowing iron as if it were soft paste; seas are his smooth highway, winds and fire his unwearied steeds. Nowhere do you find him without tools: without tools he is nothing; with tools he is all."

History takes good care of soldiers, statesmen and authors. It is even kind to engineers like Watt, Fulton and Stephenson, who have conspicuously and directly affected society at large. But little is known, even among mechanics, of the men whose work was mainly within the engineering profession, and who served other engineers rather than the general public. The lives and the personalities of men like Maudslay, Nasmyth and Eli Whitney, can hardly fail of interest to the mechanic of today. They were busy men and modest, whose records are mainly in iron and steel, and in mechanical devices which are used daily with little thought of their origin.

In following the history of English and American tool builders, the query arises as to whether there might not have been important contributions to tool building from other countries. Others have contributed to some degree, but practically all of the creative work in tool building has been done in these two countries. Although the French were pioneers in many mechanical improvements, they have always shown an aptitude for refinements and ingenious novelties rather than for commercial production on a large scale. They have influenced other nations more through their ideas than through their machinery. The Swiss are clever artisans, particularly in fine work, but they have excelled in personal skill, operating on a small scale, rather than in manufacturing. Germany has, under the Empire, developed splendid mechanics, but the principal

machine tools had taken shape before 1870, when the Empire began. The history of English and American tool building therefore, covers substantially the entire history of the art.

Well informed persons are aware of the part which machinery in general has had on modern industrial life. But the profound influence which machine tools have had in that development is scarcely realized, even by tool builders themselves.

It is well to glance for a moment at the problems which were involved in building the first steam engine. Watt had been working for several years on the steam engine when the idea of the separate condenser came to him on that famous Sunday afternoon walk on the Glasgow Green, in the spring of 1765, and to use his own words, "in the course of one or two days the invention was thus far (that is, as a pumping engine) complete in my mind." He was a skilled instrument maker and his first small model was fairly successful, but when he undertook "the practice of mechanics in great," his skill and all the skill of those about him was incapable of boring satisfactorily a cylinder 6 inches in diameter and 2 feet long; and he had finally to resort to one which was hammered. For ten weary years he struggled to realize his plans in a full sized engine, unable to find either the workmen or the tools which could make it a commercial success. His chief difficulty lay in keeping the piston tight. He "wrapped it around with cork, oiled rags, tow, old felt hats, paper and other things, but still there were open spaces left, sufficient to let the air in and the steam out." Small wonder! for we find him complaining that in an 18 - inch diameter cylinder, "at the worst place the long diameter exceeded the short by three-eighths of an inch". When Smeaton first saw the engine he reported to the Society of Engineers that "neither the tools nor the workmen existed that could manufacture so complex a machine with sufficient precision."

Fortunately, in 1774, John Wilkinson, of Bersham, hit upon the idea, which had escaped both Smeaton and Watt, of making a heavy boring bar, running it clear thru the cylinder and giving it a fixed support at each end. The superiority of this arrangement was at once manifest, and in 1776 Boulton wrote that "Mr. Wilkinson has bored us several cylinders almost without error; that of 50 inches diameter, which we have put up at Tipton, does not err the thickness of an old shilling in any part."

The importance to Boulton & Watt of the timely aid of Wilkinson's boring machine can hardly be overestimated. It made the steam engine a commercial success, and was probably the first metal-working tool capable of doing large, heavy work with anything like present-day accuracy.

We hardly realize the crudity of the tools available in the eighteenth century. In all machinery the principal members were of wood, as that could be worked by the hand tools then in use. The fastenings and smaller parts only were of metal, and consisted of castings and forgings fitted by hand. There were some lathes of the very simplest type. Most of them were "pole" lathes, operated by a cord reaching from a foot treadle, around the work itself, and up to a pole or wooden spring attached to the ceiling. The work rotated alternately forward and backward, and was caught with a hand tool each time as it came forward. Such lathes were

almost useless for metal cutting, as they lacked both the necessary power and a holding device strong enough and accurate enough to guide a tool. There were a few rude drilling and boring machines, but no planing machines, either for wood or metal. The tool equipment of the machinist or "millwright", as he was called, consisted chiefly of a hammer, chisel and file. The only measuring devices were calipers and a wooden rule, with occasional reference perhaps to "the thickness of an old shilling," as above. Hand forging was probably as good as or better than that of today. Foundry work had come up to at least the needs of the time. But the appliances for cutting metal were little better than those of the middle ages.

Such was the mechanical equipment in 1775; practically what it had been for generations. By 1850 it was substantially that of today. In fact, most of this change came in one generation, from about 1800 to 1840. Since that time there have been many improvements and refinements, but the general principles remain little changed. With so wonderful a transformation in so short a time, several questions arise almost inevitably: Where did this development take place, why was it so rapid, and who brought it about?

The first question is fairly simple. England and America produced the modern machine tool. In the period mentioned, England developed most of the general machine tools of the present day; the boring machine, engine lathe, planer, shaper, the steam hammer and standard taps and dies. Somewhat later, but partially coincident with this, America developed the use of commercial limit gauges, and the interchangeable system of manufacture.

To the second question as to why this development when once begun should have been so rapid, there are probably two answers. First, an entirely new demand for accurate tools arose during these years, springing from the inventions of Arkwright, Whitney, Watt, Fulton, Stephenson and others. The textile industries, the steam engine, railways, and the scores of industries they called into being, all called for better and stronger means of production. While the rapidity of the development was due partly to the pressure of this demand, a second element, that of cumulative experience, was present and can be clearly traced.

The third question as to who brought this change about is not so simple. It is not easy to assign the credit of an invention. Mere priority of suggestion or even of experiment seems hardly sufficient. Nearly every great improvement has been invented independently by a number of men, sometimes almost simultaneously, but often in widely separated times and places. Of these, the man who made it a success is usually found to have united to the element of invention a superior mechanical skill. He is the one who first embodies the invention in such proportions and mechanical design as to make it commercially available, and from him its permanent influence spreads. The chief credit is due to him because he impressed it on the world.

Joseph Bramah may not be entitled to take rank as a first class inventor, though he was a most prolific one; but, as the founder of a school from which proceeded some of the most distinguished mechanics of our time, he is entitled to a prominent place among the men who had a direct influence on tool building. Bramah was a Yorkshire farmer's boy, born in 1748. Due to an accident which made him lame, he learned the cabinet maker's trade, went to London, and, in the course of his work which took him into the well-to-do houses about town, he made his first successful invention - the modern water closet. He patented it in 1778 and it continues to this day in substantially the same form.

We next find Bramah turning his attention to the invention of a lock that should surpass all others then known. After much study and many experiments, he contrived a lock which was one of the most successful ever invented. For many years it had the reputation of being absolutely unpickable. Confident of this, Bramah placed a large padlock on a board outside his shop window in Piccadilly and posted beneath it the following notice: "The artist who can make an instrument that will pick or open this lock shall receive two hundred guineas the moment it is produced."

Many tried to open it. In one attempt made in 1817, a clever mechanic named Russel spent a week on it and gave it up in despair. In 1851 Alfred C. Hobbs, an American, mastered it and won the money. He spent sixteen days and an actual working time of fifty-one hours, in doing it. Hobbs had unmolested access to it for days with any tools he could bring or devise; and though he finally opened it, a lock probably sixty years old which could stand such an assault for fifty-one hours was secure for all ordinary purposes.

This article is the first of a series which will continue in forthcoming issues of THE ORDNANCE SERGEANT.

When Bramah began manufacturing the locks he found almost immediately that they called for a better quality of workmanship than was available, with even the best manual skill about him. A series of machine tools had to be devised if they were to be made in the quantities and of the quality desired. He turned first to an old German who had the reputation of being the most ingenious workman in London; but while he, with Bramah, saw the need, he could not meet it. One of his shopmates, however, suggested a young man at the Woolwich Arsenal named Henry Maudslay, then only eighteen years old.

Bramah sent for him and Maudslay soon became his right-hand man, and was made superintendent of the works at nineteen. The work of these two men in developing the tools needed laid the foundation for the standard metal-cutting tools of today. The most important improvement was the slide rest.

Bramah died in 1814, at the age of sixty-six. He gave the world some great and valuable devices and paved the way for others. His influence on modern tools can probably never be accurately judged, but Sniles' tribute to him is as true today as when it was written, two generations ago:

"From his shops at Pimlico came Henry Maudslay, Joseph Clement, and many more first-class mechanics, who carried the mechanical arts to still higher perfection, and gave an impulse to mechanical engineering the effects of which are still felt in every branch of industry."

Maudslay remained with Bramah for eight years, during which time the two laid the foundation for many of the modern machine tools, more especially the slide-rest and screw-cutting lathe. He left the shop in Pimlico in 1797 and with a single helper started a little blacksmithing and jobbing shop on his own account near Wells and Oxford streets in London.

It is in connection with the slide-rest and screw cutting lathe that Maudslay is best known. Too much value cannot be placed on the slide-rest and its combination with a lead screw, operated by change gears. It is used in some form in almost every machine tool and is one of the great inventions of history. Many men were working at the problem of generating an accurate screw thread. The use of dies was quite well known, but their design and workmanship was of the crudest order and their product of the same character; and they were inadequate for the making of any large threads. A few years prior to 1800 he made a machine for originating screws and from this time until the present day improvement in the accuracy of screws has been brought about chiefly by beginning with the best screw available as a lead screw and cutting others from it by devices which corrected its errors.

Maudslay's work on the screw thread was not confined to the lathe. He improved the system of taps and dies whereby they were made to cut the threads instead of squeezing them up. He made the first move toward systematizing the thread sizes. He established for his own use definite standard pitches. Many copies of these threads found their way to other shops and influenced the construction of similar tools elsewhere.

Maudslay's record, as left behind him in steel and iron, would give him a secure place in engineering history, but his influence as a trainer of men is quite as great. Clement, Roberts, Whitworth and Nasmyth worked for him, and all showed throughout their lives, in a marked way his influence upon them. Other workmen, whose names are not so prominent, spread into the various shops of England the methods and standards of Maudslay & Field and made English tool builders the leaders of the world for fifty years.



Conducted by: W. G. Sylvester, Capt., Ord. Dept.

PROCESS CHART FOR ELECTRIC ARC WELDING

BASE METAL OR ALLOY	WELDING PROCESS	POLARITY	WELDING ELECTRODE		PREHEATING REQUIRED	
			MATERIAL	TYPE		
<u>IRON</u>						
1. Wrought iron	M.A.W.	Reverse	Mild Steel	*Shielded arc	No	
	C.A.W.	Straight	Mild Steel	Use a flux	No	
	M.A.B.	Reverse	Bronze	Shielded Arc	No	
2. Low carbon iron	M.A.W.	Reverse	Mild steel	Shielded Arc	No	
<u>CARBON STEELS</u>						
1. Low carbon (Up to 0.30% C)	M.A.W.	Straight	Mild steel	Bare or light coated	Up to 300°F.	
	M.A.W.	Reverse	Mild steel	Shielded arc	Up to 300°F.	
	C.A.W.	Straight	Mild steel	Use a flux	Up to 300°F.	
	M.A.B.	Reverse	Bronze	Shielded arc	Up to 300°F.	
2. Medium carbon (0.30 to 0.50% C)	M.A.W.	Reverse	High strength steel or 25-20 or modified 18-8 stainless steel	Shielded arc	300-500°F.	
	M.A.W.	Reverse	Mild steel	Shielded arc		
3. High carbon (0.50 to 0.90% C)	M.A.W. (a)	Reverse	High strength steel or 25-20 or modified 18-8 stainless steel	Shielded arc	500-800°F.	
	M.A.W.	Reverse	Mild steel	Shielded arc		
4. Tool steel (0.80 to 1.50% C)	M.A.W.	Reverse	High strength steel or 25-20 or modified 18-8 stainless steel	Shielded arc	Up to 800°F.	
	M.A.W.	Reverse	Mild steel	Shielded arc	Up to 1000°F.	
<u>CAST STEELS</u>						
1. Plain carbon (Up to 0.25% C)	M.A.W.	Reverse	Mild steel	Shielded arc	200°F.	
	M.A.B.	Reverse	Bronze	Shielded arc	200°F.	
2. High manganese (12% Mn)	M.A.W.	Reverse	Weld with 25-20 stainless steel and surface with nickel manganese	Shielded arc	No	
	To build up sections.	Reverse	Nickel manganese	Shielded arc	No preheat. Quench and peen weld.	
3. Other alloys	M.A.W.	Reverse	Mild steel	Shielded arc	In some cases	
<u>CAST IRONS</u>						
1. Gray cast iron (Machineable welds)	M.A.W.	Reverse	Monel, 18-8 stainless steel or mild steel	Shielded arc	700-800°F. or no preheating but peen weld	
	M.A.W.	Straight	Cast iron	Shielded arc		
	M.A.B.	Reverse	Bronze	Shielded arc		
	C.A.B.	Straight	Bronze	Shielded arc		
2. Malleable iron (machineable welds)	M.A.W.	Reverse	Monel, 18-8 stainless steel or mild steel	Shielded arc	700-800°F. Anneal weld	
	M.A.W.	Straight	Cast iron	Shielded arc		
	M.A.B.	Reverse	Bronze	Shielded arc		
	C.A.B.	Straight	Bronze	Shielded arc		
3. Alloy cast irons			(Same as gray cast iron)		Up to 500°F.	
<u>LOW ALLOY HIGH TENSILE STEELS</u>						
General		M.A.W. (b)	Reverse	Same as base metal; or high strength or mild steel or 25-20 stainless steel	Shielded arc	Yes
1. Nickel alloy steel (3-3½% Ni) (Up to .25% C)	M.A.W.	Reverse	Nickel alloy or 25-20 stainless steel	Shielded arc	No preheat Slow cool 300-600°F. Slow cool	
	M.A.W.	Reverse	Nickel alloy or 25-20 stainless steel	Shielded arc		
2. Nickel copper alloy steels	M.A.W.	Reverse	Nickel alloy or 25-20 stainless steel	Shielded arc	250-300°F.	
3. Manganese Molybdenum alloy steels	M.A.W.	Reverse	Carbon Molybdenum or special electrode	Shielded arc	250-300°F.	

BASE METAL OR ALLOY	WELDING PROCESS	POLARITY	WELDING ELECTRODE		PREHEATING REQUIRED
			MATERIAL	TYPE	
4. Carbon molybdenum alloy steels (.10 to 20% C) (.20 to .30% C)	M.A.W.	Straight or reverse	Carbon molybdenum	Shielded arc	300-400°F.
	M.A.W.	Straight or reverse	Carbon molybdenum	Shielded arc	400-500°F. Slow cool
5. Nickel chromium alloy steels (1-3½% Ni) (Up to .20% C) (.20 to .55% C) (High alloy content)	M.A.W.	Reverse	Same as base metal or 25-20 Stainless steel	Shielded arc	200-300°F. Slow cool
	M.A.W.	Reverse	Same as base metal or 25-20 stainless steel	Shielded arc	600-800°F. Slow cool
	M.A.W.	Reverse	Same as base metal or 25-20 stainless steel	Shielded arc	900-1000°F. Slow cool.
6. Chrome-Molybdenum alloy steels	M.A.W.	Straight or reverse	Chrome Molybdenum or carbon Molybdenum	Shielded arc	300-800°F. Slow cool
	C.A.W.	Straight	Same as base metal	Use a flux	300-800°F. Slow cool
7. Chromium Alloy steels	M.A.W.	Reverse	Same as base metal or 25-20 or 18-8 stainless steels.	Shielded arc	300-800°F.
8. Chromium Vanadium alloy steels	M.A.W.	Reverse	Chrome Molybdenum or Carbon Molybdenum	Shielded arc	200-800°F.
9. Manganese Alloy steels (1.6 - 1.9% Mn)	M.A.W.	Reverse	Carbon Molybdenum or mild steel	Shielded arc	300-800°F.
<u>STAINLESS STEELS</u>					
1. Chromium alloys (12-28% Cr) (Stainless Irons)	M.A.W.	Reverse	25-20 or Columbium bearing 18-8 stainless steel	Shielded arc	No
2. Chromium Nickel Alloys	M.A.W.	Reverse	25-20 or Columbium bearing 18-8 stainless steel	Shielded arc	No
<u>COPPER AND COPPER ALLOYS</u>					
1. Deoxidized Copper	M.A.W.	Reverse	Deoxidized Copper Phosphor Bronze or Silicon copper	Shielded arc	500-800°F.
	C.A.W.	Straight	Deoxidized Copper Phosphor Bronze or Silicon copper	Use a flux	500-800°F.
2. Commercial Bronze and low brass	M.A.W.	Reverse	Phosphor Bronze or Silicon copper	Shielded arc	200-300°F.
	C.A.W.	Straight	Phosphor Bronze or Silicon copper	Use a flux	200-300°F.
3. Spring, admiralty and yellow brass	C.A.W.	Straight	Phosphor Bronze	Use a flux	200-300°F.
4. Muntz Metal, Tobin Bronze, Naval Bronze, Manganese Bronze	C.A.W.	Straight	Phosphor Bronze	Use a flux	200-300°F.
5. Nickel Silver	M.A.W.	Reverse	High Nickel Alloy	Shielded Arc	300-500°F.
	C.A.B.	Straight	Phosphor Bronze or Silicon Copper	Use a flux	300-500°F.
6. Phosphor Bronze.	M.A.W.	Reverse	Phosphor Bronze	Shielded arc	200-300°F.
	C.A.W.	Straight	Phosphor Bronze	Use a flux	200-300°F.
7. Aluminum Bronze	M.A.W.	Reverse	Aluminum Bronze or Phosphor Bronze	Shielded arc	200-300°F.
	C.A.W.	Straight	Aluminum Bronze or Phosphor Bronze	Use of flux (Optional)	200-300°F.
8. Beryllium Copper	C.A.W.	Straight	Beryllium Copper	Use of flux (Optional)	500-800°F.
<u>ALUMINUM AND ALUMINUM ALLOYS</u>					
1. Pure aluminum (2S)	M.A.W.	Reverse	Pure aluminum or 95% aluminum 5% silicon electrode	Shielded arc	500-800°F.
	C.A.W.	Straight	Pure aluminum or 95% aluminum 5% silicon electrode	Flux coated	500-800°F.
2. Aluminum alloys (General)	M.A.W.	Reverse	95% aluminum 5% silicon electrode	Shielded arc	500-800°F.
	C.A.W.	Straight	95% aluminum 5% silicon electrode	Flux coated	500-800°F.
3. Aluminum Manganese Alloy (3S)	M.A.W.	Reverse	95% aluminum 5% silicon electrode	Shielded arc	500-800°F.
	C.A.W.	Straight	95% aluminum 5% Silicon electrode	Flux coated	500-800°F.
4. Aluminum Magnesium Chromium Alloy (52S)	M.A.W.	Reverse	95% aluminum 5% silicon electrode	Shielded Arc	500-800°F.
	C.A.W.	Straight	95% aluminum 5% silicon electrode	Flux coated	500-800°F.
5. Aluminum Magnesium Manganese Alloy (4S)	M.A.W.	Reverse	95% aluminum 5% silicon electrode	Shielded Arc	500-800°F.
	C.A.W.	Straight	95% aluminum 5% silicon electrode	Flux coated	500-800°F.
6. Aluminum Silicon Magnesium Alloys (52S) (53S)	M.A.W.	Reverse	95% aluminum 5% silicon electrode	Shielded Arc	Up to 400°F
	C.A.W.	Straight	95% aluminum 5% silicon electrode	Flux coated	Up to 400°F
7. Aluminum Copper Magnesium Manganese Alloys Duraluminum (17S) (24S)			Arc Welding not recommended.		
8. Aluminum Clad			Arc Welding not recommended.		
<u>NICKEL AND NICKEL ALLOYS</u>					
1. Nickel	M.A.W.	Reverse	Nickel	Shielded Arc	200-300°F.
	C.A.W.	Straight	Nickel	Lightly flux coated	200-300°F.

BASE METAL OR ALLOY	WELDING PROCESS	POLARITY	WELDING ELECTRODE		PREHEATING REQUIRES
			MATERIAL	TYPE	
2. Monel (67% Ni 29% Cu)	M.A.W.	Reverse	Monel	Shielded Arc Lightly flux coated	200-300°F.
	C.A.W.	Straight	Monel		
3. Inconel (79% Ni 13% Cr 6% Fe)	M.A.W.	Reverse	Same as base metal	Shielded arc	200-300°F.

LEAD

Lead cannot be arc welded.

MAGNESIUM ALLOYS

Arc Welding not recommended.

KEY

* Shielded arc type electrodes are heavy coated and usually require reverse polarity, however, manufacturer's recommendations specify the preferred polarity for special electrodes, which may differ with the polarity recommended above in some cases.

(a) Stress relieve by heating 1200 to 1450°F. for one hour per inch of thickness and cool slowly.

(b) A large number and variety of low alloy high tensile steels are used in Ordnance construction. In arc welding these steels, certain special precautions are required such as preheating before welding, use of special electrodes, and a postheating treatment. In general, where good corrosion resistance is required or when the welded joint is to be heat treated after welding, electrodes having the same composition or properties as the base metal are used. Where these steels are in the heat treated condition, it is recommended that the filler metal used should be of the austenitic type such as, 25% Chromium 12% Nickel, 25% Chromium 20% Nickel or 18% Chromium 8% Nickel stainless steel, in order

to obtain good weld metal properties. Some of these stainless steel electrodes have Columbium or other alloying elements added to retain their stainless properties after welding.

An example of this is the so-called modified 18-8 stainless steel electrode which contains small percentages of either manganese or molybdenum. Electrodes of this type may be used in place of the 25-20 type of electrode in any of the welding processes for which 25-20 electrode are specified. Usually no preheating is required in welding with these electrodes.

- M.A.W. - Metallic Arc Welding
- C.A.W. - Carbon Arc Welding
- M.A.B. - Metallic Arc Brazing
- C.A.B. - Carbon Arc Brazing

PROCESS CHART FOR OXYACETYLENE WELDING

BASE METAL OR ALLOY	WELDING PROCESS	FLAME ADJUSTMENT	WELDING ROD	FLUX REQUIRED	PREHEATING REQUIRED
<u>Iron</u>					
1. Wrought Iron	F.W.	Neutral	Low Carbon or High Strength Steel	No	No
	B.W.	Sl. Oxidizing	Bronze	Brazing	No
2. Low Carbon Iron	F.W.	Neutral	Low Carbon Steel	No	No
	B.W.	Sl. Oxidizing	Bronze	Brazing	No
<u>Carbon Steels</u>					
1. Low Carbon (Up to .30% C) (Up to .30% C)	F.W.	Neutral	Low Carbon Steel	No	No
	B.W.	Sl. Oxidizing	Bronze	Brazing	No
2. Medium Carbon (.30% to .50% C)	F.W.	Neutral to Sl. Carburizing	Low Carbon or High Strength Steel	No	300-500°F.
	B.W.	Sl. Oxidizing	Bronze	Brazing	200-400°F.
3. High Carbon (.50% to .90% C)	F.W.	Carburizing	High Carbon Steel	No	500-800°F.
	B.W.	Sl. Oxidizing	Bronze	Brazing	300-500°F.
4. Tool Steel (.80% to 1.50% C)	F.W.	Carburizing	Drill Rod	Some C.I. Flux	Up to 1000°F.
	B.W.	Sl. Oxidizing	Bronze	Brazing	500-600°F.
<u>Cast Steels</u>					
1. Plain Carbon (Up to .25% C)	F.W.	Neutral	Low Carbon Steel	No	200°F.
	B.W.	Sl. Oxidizing	Bronze	Brazing	200°F.
2. High Manganese (12% Mn)	F.W.	Sl. Carburizing	Nickel Mang. Steel	Wrap rod with al. wire	No
3. Other Alloys	F.W.	Sl. Oxidizing	Bronze	Brazing	No
	B.W.	Neutral to Sl. Carburizing	Same as Base Metal	No	In some cases
<u>Cast Irons</u>					
1. Gray Cast Iron	F.W.	Neutral	Cast Iron	Cast Iron Flux	700-800°F.
	B.W.	Sl. Oxidizing	Bronze	Flux Brazing	Locally to 500°F.
2. Malleable Iron	F.W.(a)	Neutral	White Cast Iron	Cast Iron Flux	700-800
	B.W.	Sl. Oxidizing	Bronze	Brazing	Locally to 500°F.
3. Alloy Cast Irons	F.W.	Neutral	Same as base Metal or cast iron	Cast Iron Flux	500-1000
	B.W.	Sl. Oxidizing	Bronze	Brazing	Locally to 500°F.
<u>Low Alloy High Tensile Steels (General)</u>					
	F.W.	Neutral to Sl. Carburizing	Same as base metal or high strength steel	No	Yes
1. Nickel Alloy Steel (3-3½% Ni.) (Up to .25% C) (more than .25% C)	F.W.	Neutral to Sl. Carburizing	"	No	No preheat Slow cool
	F.W.	Neutral to Sl. Carburizing	"	No	300-600°F. Slow cool

BASE METAL OR ALLOY	WELDING PROCESS	FLAME ADJUSTMENT	WELDING ROD	FLUX REQUIRED	PREHEATING REQUIRED
2. Nickel Copper Alloy Steels	F.W.	Neutral to Sl. Carburizing	"	No	250-300°F.
3. Manganese Molybdenum Alloy Steels	F.W.	Neutral to Sl. Carburizing	"	No	250-300°F.
4. Carbon Molybdenum (.10 to .20% C)	F.W.	Neutral to Sl. Carburizing	Carbon Molybdenum or high strength rod	No	300-400°F.
(.20 to .30% C)	F.W.	"	"	No	400-500 slow cool
5. Nickel Chromium Alloy Steels (Up to .20% C)	F.W.	"	Same as base metal or high strength rod	No	200-300° slow cool
(.20 to 55% C)	F.W.	"	"	No	600-800°F. slow cool
(high alloy content)	F.W.	"	"	No	900-1100 slow cool
6. Chrome Molybdenum Alloy Steels	F.W.	"	"	No	300-800°F. slow cool
7. Chromium Alloy Steels	F.W.	"	"	No	300-800°F.
8. Chromium Vanadium Alloy Steels	F.W.	"	"	No	200-800°F.
9. Manganese Alloy Steels (1.6 -1.9% Mn.)	F.W.	"	"	No	300-800°F.
<u>Stainless Steels</u>					
1. Chromium Alloys (12-20% Cr) (Stainless Irons)	F.W.	Neutral	Same as base metal or (18-8) stainless	Stainless	No
2. Chromium Nickel Alloys	F.W.	Neutral to Sl. Carburizing	(18-8) stainless steel	Stainless	No
<u>Copper and Copper Alloys</u>					
1. Deoxidized Copper	F.W. B.W.	Neutral Sl. Oxidizing	Deoxidized Copper Bronze	No Brazing	500-800° 400-600°
2. Commercial Bronze and low brass	F.W. B.W.	Oxidizing Sl. Oxidizing	Same as base metal or Bronze	Brazing Brazing	200-300° 200-300°
3. Spring, Admiralty, and yellow brass	F.W.	Oxidizing	Same as base metal or Bronze	Brazing	200-300°
4. Muntz Metal, Tobin Bronze, Naval Brass, Manganese Bronze	F.W.	Oxidizing	Bronze	Brazing	200-300°
5. Nickel Silver	F.W.	Neutral	Nickel Silver	Brazing	200-300°
6. Phosphor Bronze	F.W. B.W.	Neutral Neutral or Sl. Oxidizing	Bronze Bronze	Brazing Brazing	300-500° 200-300°
7. Aluminum Bronze	F.W.	Sl. Carburizing	Aluminum Bronze	Brazing	200-300°
8. Beryllium Copper	Oxyacetylene welding or brazing not recommended, use silver solder and flux.				
<u>Aluminum and Aluminum Alloys</u>					
1. Pure Aluminum (2S)	F.W.	Neutral	Pure Aluminum	Aluminum	500-800°F.
2. Aluminum Alloys (General)	F.W.	Neutral	Same as base Metal or 95% Aluminum, 5% Silicon rod.	Aluminum	500-800°F.
3. Aluminum Manganese Alloy (3S)	F.W.	Neutral	Pure Aluminum	Aluminum	500-800°F.
4. Aluminum Magnesium Chromium Alloy (52S)	F.W.	Neutral	95% Aluminum 5% Silicon rod	Aluminum	500-800°F.
5. Aluminum Magnesium Manganese Alloy (4S)	F.W.	Neutral	95% Aluminum 5% Silicon Rod	Aluminum	500-800°F.
6. Aluminum Silicon Magnesium Alloy (51S) (53S)	F.W.(b)	Neutral	95% Aluminum 5% Silicon Rod	Aluminum	Up to 400°F.
7. Aluminum-Copper-Magnesium Manganese Alloy (Duraluminum) (17S) (24S)	Welding not recommended.				
8. Aluminum Clad	Welding not recommended.				
<u>Nickel and Nickel Alloys</u>					
1. Nickel	F.W. B.W.	Carburizing Sl. Oxidizing	Nickel Bronze	No Brazing	200-300°F 200-300°F
2. Monel (67% Ni 29% Cu)	F.W. B.W.	Carburizing Sl. Oxidizing	Monel Bronze	Brazing Brazing	200-300°F 200-300°F
3. Inconel (79% Ni 13% Cr 6% Fe)	F.W. B.W.	Carburizing Sl. Oxidizing	Inconel Bronze	Brazing Brazing	200-300°F 200-300°F

(Continued on page 210)



FORGING

Conducted by: W. G. Sylvester, Capt., Ord. Dept.

Forge Welding is by far the oldest welding process for joining metal pieces or parts. It consists of heating the ends of the metal parts in a forge fire, in which coal, coke, or charcoal is used as a fuel. The ends to be joined are heated until the surface of the metal becomes plastic. When this condition is reached the parts are quickly superimposed and the weld is made either by pressure or by quick, sharp hammering blows. The hammering may be done either by hand or by machine and the force of the hammering or pressure is governed largely by the size and mass of the pieces or parts being joined. In this process the surfaces to be joined must be free from foreign matter, and in some cases, a flux is used (usually a sand or borax sprinkled on the surfaces to be joined just before the metal reaches the welding temperature) to remove oxide scale and dirt. The flux spreads over the hot metal and forms a protective coating which prevents further oxidation by keeping out the air. It also lowers the melting point of the scale making it fluid so that it can be squeezed out of the weld when it is hammered.

Hand forge welding is no longer used extensively, because of the great development of oxyacetylene and electric arc welding.

With the development of suitable machinery the speed with which the manual smith's weld could be made, as well as the size of the parts to be welded, was greatly increased. Through this process of machine forge welding, long seams in lap or butt welded pipe can be made and the quality of the weld is such as to make its location almost impossible of detection. This process requires the use of a gas flame or other suitable heating method to bring the metal edges to the fusion temperature. The pressure is applied by mechanical rolls to press the plastic edges together while the parts to be welded are forced between rolls along the line of welding.

Principles of Forge Welding

In order to weld steel or wrought iron by the forge welding process, the ends of the metal parts should be heated to a white heat (approximately 2500° F.) in which state the metal is extremely plastic and capable of being welded by means of pressure or blows. It is essential when heating the parts to be welded that the heat be applied uniformly and at a soaking heat. Extremely rapid heating will cause uneven expansion of the metal, starting internal cracks. This is especially dangerous when heating high carbon and high alloy steels. To avoid internal cracking in these steels the parts should be preheated slowly to temperatures between 1200° and 1400° F. before placing them in the hottest portion of the forge fire.

Metal parts that have been overheated or burned will produce welds that contain oxide inclusions, voids or blowholes, and the grain structure of the metal itself will be coarse.

Forge welding at temperatures below the plastic range will result in incomplete welding at the joint, and therefore lowered strength.

In order to properly cleanse the metal parts of oxides and other foreign matter a flux is used. The most common fluxes are clean silica sand, borax, and a mixture of equal parts of borax and fine iron filings. The latter is very satisfactory as a general purpose flux being particularly applicable for forge welding of steels. The borax has a comparatively low fusion point and spreads out over the "scarfed" steel surface to form a protecting film. It also lowers the melting point of oxides already formed, thus enabling them to be squeezed out in the forge welding operation. This is particularly important in forge-welding high carbon steels. The iron filings serve as a guide to proper welding temperatures in that they fuse on the surface when the proper welding heat has been attained.

FORGE WELDING

No flux is necessary when welding low carbon steel or wrought iron as it is possible to melt the oxides without burning or melting the metal.

Special Precautions in Forge Welding

It is important to upset the ends of the parts to be welded before shaping the "scarfs" in order to provide some excess metal at the joint for mechanical working during and after welding.

The "scarfed" surfaces should be well rounded so that contact and the initial stages of welding will occur at the center of the mating surfaces. The curved surfaces will enable the liquid oxides and other foreign matter to be forced out during the forge welding operation.

The "scarfed" ends should be placed face down in the fire and care should be taken to avoid both prolonged heating at the proper welding temperature as well as overheating.

The welding operations should be performed rapidly so that all welding will progress before the oxides solidify and before the metal cools below a welding heat.

All blows struck should be uniform to work the metal evenly and to avoid internal strains.

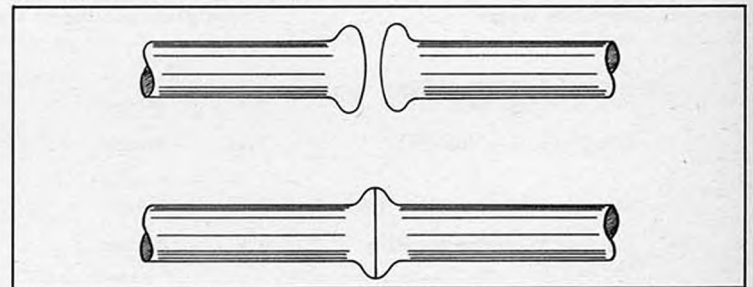


Fig. 1. -- Butt Weld -- Ends Upset

Factors Affecting the Properties of a Forge Weld

The following factors materially affect the quality of the joint produced by forge welding:

1. The skill of the welder.
2. The weldability of the material.
3. The quality of the fuel used — sulphur and ash are detrimental to good welding.
4. The quantity of flux used and the method and time of application.
5. The temperature and uniformity of heat distribution in the parts to be welded.
6. The type of fire used.
7. Impurities in the joint — oxides, slag, and fuel ash trapped in between the scarfed faces of the joint.
8. Force of hammer blows.
9. Method of working the parts being welded.

Basic Joint Types used in Forge Welding

Butt Welds: There are two methods commonly used for preparing edges of stock for butt welding. The first of these consists of upsetting and rounding the ends of the stock slightly as shown in Figure 1. The second method used consists of grinding a land and bevel on the ends of the parts to be welded so as to produce an included angle of from 30° to 45° as shown in Figure 2.

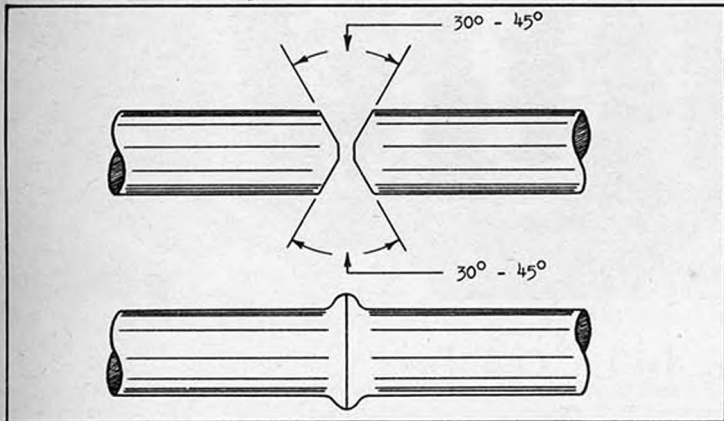


Fig. 2. -- Butt Weld -- Ends Ground

In joints prepared by either method, the weld is first effected at the center and is caused to progress outward by repeated hammer blows on the ends of the stock. This progressive welding action causes slag, oxides and other foreign matter to be worked out of the joint, thus producing sound welds.

The hot plastic metal upon being forced together produces a ring of excess metal at the joint when the weld is completed. This excess metal should be hammered back with the hammer and swages to obtain the outside dimensions of the original parts.

Lap Welds

The joint is prepared for lap welding by upsetting and beveling the ends of the stock as shown in Figure 3. The pieces are placed in the fire with the scarfed faces down and allowed to heat uniformly. When a bright red heat is obtained the parts are removed from the fire and the scarfed faces are dipped in flux composed of equal parts of borax and fine iron filings or chips. They are again returned to the fire, face down and heated until the flux and iron chips are thoroughly melted on the

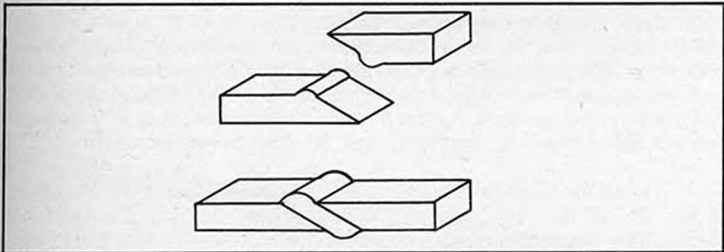


Fig. 3. -- Lap Weld

scarfed faces and the proper welding temperature is reached. At this point the parts are removed from the fire and tapped on the horn of the anvil to remove adhering scale dirt and other foreign matter. The scarfed faces are then quickly superimposed on the anvil and the weld completed by striking with the hammer. The principal difficulty experienced in making this type of weld is in handling and properly aligning the pieces.

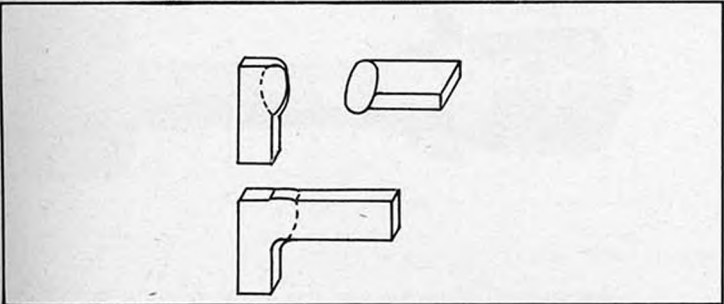


Fig. 4. -- Corner or Angle Weld

Corner or Angle Welds

This type of weld is used to join two pieces located at right angles to each other as shown in Figure 4. The edges should be upset and scarfed as shown and the welding procedure outlined for making lap weld should be used. In order to avoid burning off the thin edges and corners, they should be turned up out of the fire until the heavier mass of metal at the joint is heated to the proper welding temperature. Prior to removing the pieces for the welding operation these thin edges are turned down for an instant to insure uniform heating throughout.

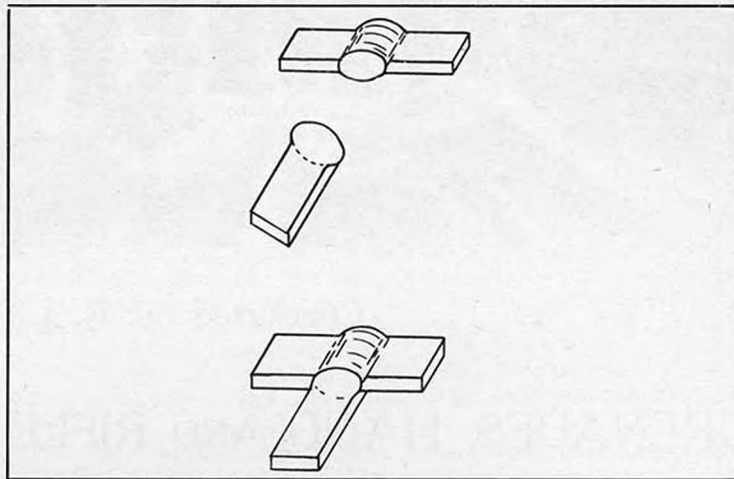


Fig. 5. -- "T" Weld

Tee Welds

This type of joint is used to produce a "T"-shaped section by joining two pieces as shown in Figure 5. The center section of the cross piece and the end of the piece forming the leg of the "T" are prepared by upsetting and scarfing in a manner similar to that used in preparing a joint for corner or angle welds. Extreme care is necessary when making this type of weld to insure uniform heating at the center of the cross piece without burning the thinner edges.

Jump Welds

This type of weld is used to join a stem to a flat plate as shown in Figure 6. The flat plate is scarfed by producing a small round indentation

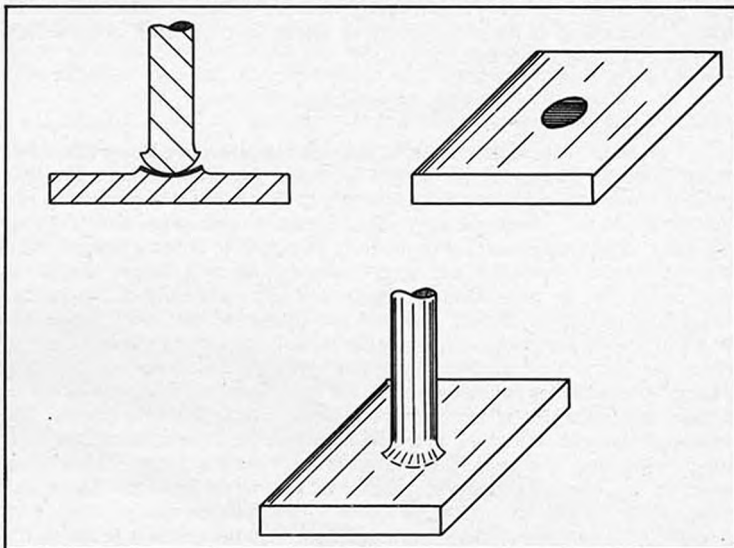
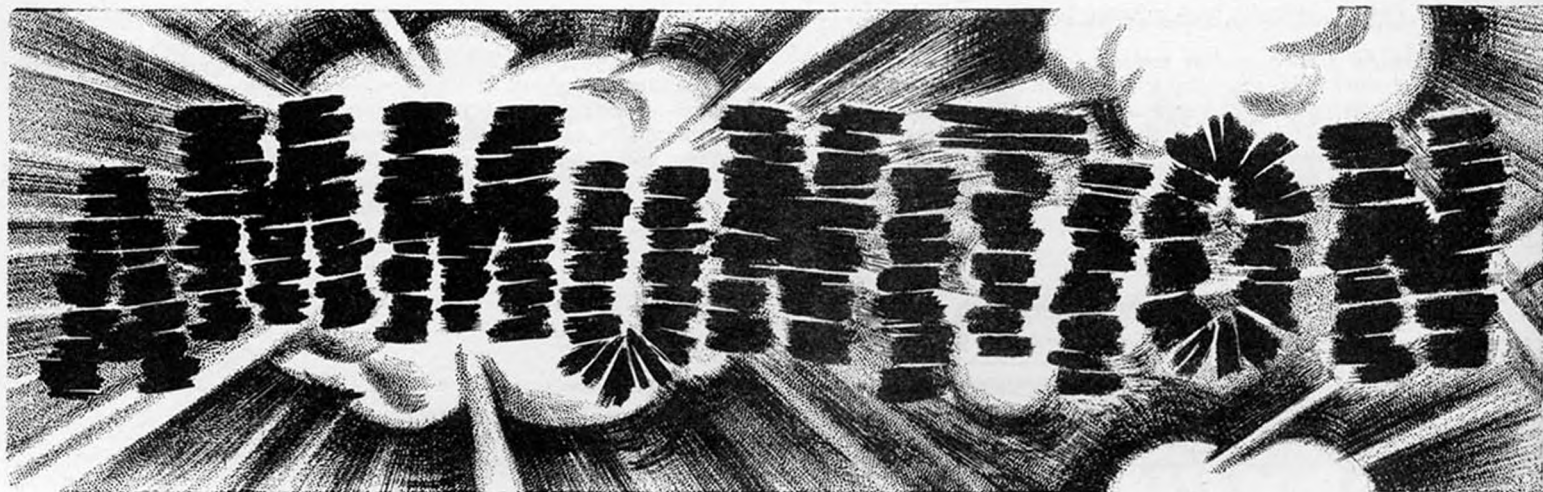


Fig. 6. -- Jump Weld

and the end of the stem is upset and rounded. The upset section of the stem should be formed so as to allow a tapered clearance space between it and the edges of the hole in the plate. This is necessary in order to avoid having slag and oxide inclusions in the weld. The stem is welded by striking the top of the stem with a hammer and the flange is dressed down and welded to the plate by using a set hammer or fuller.

(Continued on page 209)



Conducted by: R. J. Russo, 1st Lt., Ord. Dept.

GRENADES, HAND AND RIFLE

by W. L. PARKER
M.Sgt., Ord. Dept.

General. - Grenades have been of great importance in wars of the past and are of equal importance in the present conflict. Usually we think of the present war only as one of fast movement, paying little or no attention to the days and weeks of stubborn fighting necessary to consolidate the ground gained by tank and armored column advances. Close combat still exists and it is here that the grenade is called upon to perform its mission. Most of us are familiar with those grenades which are and have been standard items of issue for the past few years. However, very few of us are familiar with recently developed grenades, such as the new rifle grenades, or the offensive grenade which has been out of service for a number of years. The following is a brief review of the more common types and an addition of that information which is available pertaining to more recent developments. Detailed information as to the functioning of these ammunition items is purposely omitted due to their confidential nature.

HAND GRENADES

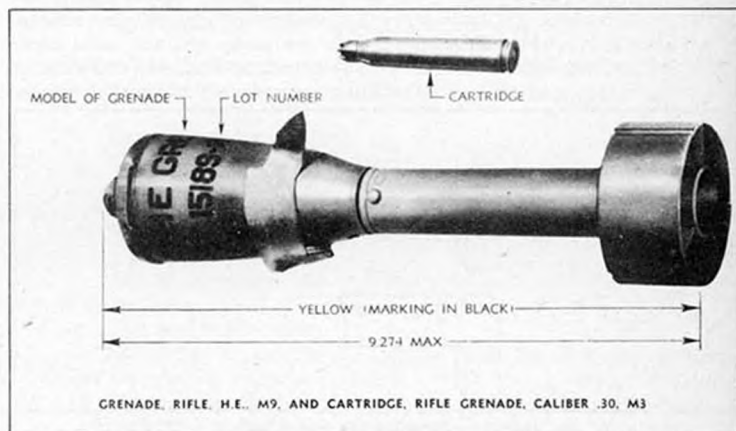
General. - Hand grenades, as the name implies, are those grenades designed to be thrown at the target by hand. At present there are five general types of hand grenades in service: fragmentation grenades, offensive grenades, chemical grenades, practice grenades, and training grenades. The fragmentation grenade is designed to burst a few seconds after it has left the hand and upon bursting, throw a large number of fragments over an area having a radius of approximately thirty yards. These fragments are of such size and are propelled with such force that they will kill or seriously wound any personnel not under protective cover within the thirty yard radius. Fragmentation grenades are termed "defensive" grenades due to the necessity for the person throwing the grenade to have sufficient cover for protection from the flying fragments. Offensive grenades are nothing more than a cardboard container filled with a high explosive charge and fuzed with a detonating fuze. The killing power of the offensive grenade is entirely dependent upon the flame and blast set up by the explosion, as there is no fragmentation from this grenade. The effective killing radius of the offensive grenade is normally four or five yards from the point of burst. These grenades are termed "offensive" grenades because protective cover is not necessary for their use. Chemical grenades are used to quell riots and to lay smoke screens; in some cases the smoke grenade is used as a signal by airplanes in distress. Practice grenades are used to give troops practice in the proper use of grenades. They contain only a small charge of black powder to lend realism to the practice and as a spotting charge to determine the point of burst. Training grenades are used to teach troops to throw grenades. They are entirely inert, usually being a solid cast iron body.

Fragmentation Grenade Mk. II. - The fragmentation hand grenade

body is made of cast iron. It is about the same size and shape of a large lemon and is designed to fit comfortably in the hand. The outside surface is deeply serrated, horizontally and vertically, to assist in forming uniform fragments of effective size when the grenade explodes. The fuze, M10A1, is screwed into the top of the grenade body, its lever extends across the top of the fuze and down the side of the grenade body. The lever is held down by the hand after the safety pin is pulled, when thrown the lever flies off and the firing pin is released. The same principle applies to all of our hand grenade fuzes. The explosive filler, bursting charge, is of E.C. blank fire powder. This is a commercial type of semi-colloided nitrocellulose, granulated into small shot-like grains. It is generally pink or yellow in color and is associated with the words "blank fire" in that its principal use has been for loading blank ammunition for small arms weapons. The loaded fragmentation grenade is painted yellow for identification.

Offensive Hand Grenade Mk. III. - The offensive grenade body is of cylindrical cardboard with metal ends. Fragmentation is not desired in the offensive grenade, hence the use of very light material as a container. The upper end of the grenade body is made of lead antimony and forms a means of holding the fuze. The body is colored yellow and is marked with the necessary data for identification and is then dipped in paraffin to make it waterproof. The bursting charge of this grenade is TNT, approximately one-quarter pound. The use of TNT as a bursting charge makes the use of a detonating fuze necessary. This type of detonating fuze is not safe to store, ship, or handle when assembled to the high explosive filled grenade and must therefore be shipped separately from the loaded grenade body. A wooden fuze hole plug is inserted to prevent the entrance of moisture, dirt, or other foreign material.

Offensive Hand Grenade Mk. IIIA1. - This grenade is a modification of the Mk. III and was designed to supersede the Mk. III mentioned above. The construction of the two are essentially the same, however, the Mk. IIIA1 is slightly larger and contains approximately one-half pound of TNT. The M6A2 detonating fuze is used with this grenade and must be shipped separately from the loaded grenade bodies.



GRENADE, RIFLE, H.E. M9, AND CARTRIDGE, RIFLE GRENADE, CALIBER .30, M3

Gas Grenades M6 and M7. - These two grenades are identical except for the chemical filler; the M6 contains CN-DM, and the M7 contains CN. The body is cylindrical in shape and is made of tin plate. The top is made of heavier gage metal than the sides and the bottom in order to support the fuze adapter which is attached to the center of the top by crimping. All other joints of the body are crimped or soldered. The body contains twenty-four perforations; eighteen in the sides in three equally spaced rows, and six in the top. All of the holes are covered with small squares of adhesive tape to prevent the entrance of moisture or dirt. When the grenade functions these patches are burned or blown off and the gas escapes through the vents. The filler is of the proper chemicals, CN-DM in the M6 and CN in the M7, mixed with a finely granulated smokeless powder and a binder. Three tapered metal cores, each covering a vertical row of vents in the body, are left extending down into the filler during the loading operation. After the charge is pressed in, the three tapered cores are removed leaving a tapered vertical groove in the filler opposite each vertical row of vents. A starting mixture is poured in on top of the chemical composition and allowed to flow down the sides into the grooves in order to insure rapid and uniform ignition of the filler. The M200A1 igniting fuze is used with these grenades. The grenade will function in approximately one and three-quarter seconds after the lever has been released. Gas grenades are painted gray with red stenciling for identification.

Smoke Grenade M8. - The M8 smoke grenade is practically the same as the M6 and M7 gas grenades. The metal container is of the same size but there are only four vents for the smoke cloud to escape through, these are all located on the top. The filler is of HC, a smoke producing chemical. The fuze used is the M200A1. The grenade body is painted gray with yellow stenciling for identification.

Practice Grenade Mk. II. - The practice grenade is made from the empty body of the Mk. II. It is equipped with a service fuze and has a small quantity of black powder to give off a smoke puff when the grenade functions. The body of this grenade is painted blue for identification.

Training Grenade Mk. IA1. - The training grenade is used for practice in throwing. The body and fuze are cast into one piece and a safety ring is added to give practice in the proper preparation of the grenade for throwing.

Packing of Hand Grenades. - The present standard packing of grenades, except the Mk. IIIA1 Offensive grenade, is one per individual fiber container, twenty-five containers per wooden packing box. Some grenades may yet be found in service in the older type packing such as ten per metal lined box or twenty-five per metal lined box.

RIFLE GRENADES

General. - A few years ago the rifle grenade went out of service, however, we find a new rifle grenade with which the rifleman may combat tanks and other armored vehicles coming into existence. We have

adopted a high explosive rifle grenade for combat use and a practice rifle grenade for training purposes.

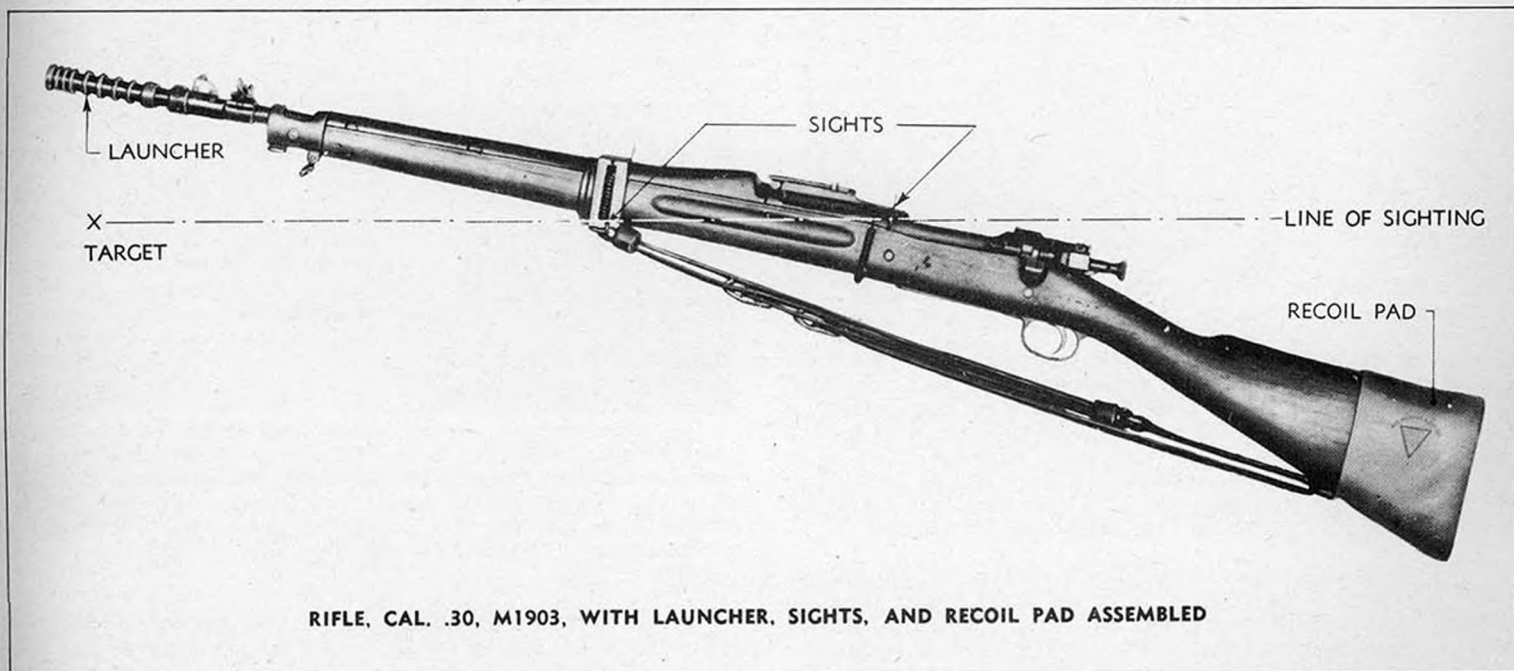
H.E. Rifle Grenade, M9. - This is a high explosive rifle grenade which was designed to be fired, by use of a grenade launcher, from the M1903 or the M1917 service rifles. In outward appearance this grenade resembles the 60-mm mortar shell; this resemblance is very general and mentioned only as a comparison. The body of the grenade is very blunt at the front and tapers toward the base in a curve. The fin assembly is attached to the base of the body to make the grenade stable in flight. The front of the body is cut square and is closed by a light thin metal cup. This thin cup holds the base of the firing pin by means of a simple shear wire. The firing pin extends through the body to a point about two-thirds of the distance from the nose to the rear of the body. Upon impact with the target the thin metal nose is crushed and the firing pin is driven into the detonator thus starting the explosion. The detonator is located at the base and inside of the body of the grenade. The firing pin is prevented from reaching the detonator during handling by a safety pin which is inserted from the side of the grenade body. Just prior to firing the safety pin must be removed; a ring is provided to facilitate the removal of the pin. The fin assembly consists of a metal tube four and one-half inches long. The rear of the tube is open and has the fins extending from it; the front of the tube is attached to a threaded plug which screws into the grenade body. A small set-screw locks the fin assembly in place after it has been screwed into the grenade body. The three fins are of light material and are so made that they form a circle around the rear of the tube. The entire length of the grenade with the fins in place is approximately nine inches. The grenade is painted yellow and stenciled in black.

Anti-Tank Rifle Grenade M9A1. - This grenade is the same as the HE M9 except that the nomenclature has been changed from HE to AT and a safety wire has replaced the safety pin.

Practice Rifle Grenade M11. - This grenade is of the same size and shape as the M9 and is used for practice firing where it is not desirable to use an explosive grenade. It is entirely inert and spare fin assemblies and cartridges are issued so that the grenade body may be re-used a number of times. The body of the grenade is painted blue and stenciled in white.

Cartridge Rifle Grenade M2. - The cartridge to be used when firing the above grenades is blank loaded but must not be confused with caliber .30 blank ammunition. The cartridge case is of the standard caliber .30 size and is readily identified by a pressed cannellure just forward of the shoulder and by the mouth of the case being indented so that it is closed and formed into a star shape. The length of the cartridge case is approximately two and one half inches. The pressed cannellure forms a seat for the closing wad which is secured in the neck of the case by a water-proofing compound after loading. A five and one-half grain primer is used. Before loading the propellant charge five grains of loose black powder are placed in the case and then fifty-six grains of propellant charge are loaded

(Continued on page 209)





Conducted by: Glenn H. Staley, 1st Lt., Ord. Dept.

AVIATION ORDNANCE REORGANIZATION

During the past six months, such great strides forward have been taken by the fledgling Aviation Ordnance and such revolutionary changes have evolved from an effort to keep pace with a tremendously expanding Air Force, that a survey of its present status should prove both revealing and challenging to the Aviation Ordnance veteran.

It should be taken into consideration that any reference to a "present status" is intended to refer to the status as it existed or was contemplated on July 1, 1942. There can be no assurance that the exigencies of war will not require further and more drastic changes in all echelons to satisfy the vacillating requirements of modern combat. With that qualification in mind, perhaps it would be well to review Army Air Force organization a bit in order to understand the relationship between it and Aviation Ordnance.

Neglecting the higher echelons of command, those policy-forming divisions of the Army Air Forces with which the average Aviation Ordnance man is not concerned, let us direct our attention to the breakdown of a typical Air Force. We learn that for the purpose of facilitating the handling of problems varied in nature, each Air Force has been subdivided into four (4) specific commands. These have been most recently called the Bomber Command, the Fighter Command, the Ground-Air Support Command, and the Service Command. As in the past, ordnance sections of a few officers and enlisted men act in the capacity of technical advisors and special staff officers of the command. Within each type command, the normal breakdown into Groups and Squadrons has not materially changed. True, the Tables of Organization would indicate that the old Headquarters Squadron of the Group has gone and that the headquarters has been superimposed upon one of the combat squadrons. Equally true is the fact that these same tables have provided for additional planes in the squadrons visualizing, perhaps, a hard hitting, faster moving unit in a Group not too earth-bound by time consuming administrative details. However, the greater change seems to have been with respect to the attached Aviation Ordnance units which, of course, is of more vital interest to us. It is the purpose of this article to set forth some of those changes for examination and comment.

First of all, it may be stated as a general policy, that Aviation Ordnance appears to be pointed towards a closer contact and more intimate fusion with the Air Forces. The old Ordnance Companies, Aviation (Bombardment and Pursuit) with six (6) officers and one hundred eighty-one (181) enlisted men and five (5) officers and eighty-three (83)

enlisted men respectively, set up to render ordnance service to corresponding type Groups have been ordered inactivated and in their places, ordnance sections will operate as an integral part of the squadron. Patterned after the familiar airdrome platoons which they are replacing, these sections will vary in size according to the type of squadron of which each becomes a part. For example, the ordnance section of a heavy bomber squadron is composed of one (1) officer and twenty-nine (29) enlisted men including a section chief and two assistants, one clerk, one auto mechanic, four armorers, nineteen munitions workers and one chauffeur.

The ordnance section of a medium bombardment squadron has one (1) officer and twenty (20) enlisted men of whom one is section chief, two are assistant section chiefs, one clerk, one auto mechanic, three armorers, eleven munitions workers and one chauffeur.

The ordnance section of a light bombardment squadron is composed of one (1) officer and eighteen (18) enlisted men distributed as follows: one section chief, two assistant section chiefs, one clerk, one auto mechanic, four armorers, and nine munitions workers.

The ordnance section of a dive bomber squadron totals one (1) officer and twenty-seven (27) enlisted men. They include a section chief and his two assistants, one clerk, one auto mechanic, five armorers, and seventeen munitions workers.

The ordnance section of a fighter squadron, whether it is a single engine or two-engine fighter, is made up of one (1) officer and fifteen (15) enlisted men. They are assigned duties as follows: one section chief, four armorers, one of whom is also

qualified as a clerk, and ten munitions workers, one of whom acts as assistant section chief.

It has probably already become apparent that the new ordnance sections are considerably smaller than the corresponding airdrome platoons that were formerly associated with the squadrons. Of course, it is to be expected that the complete subordination of the new ordnance section to the administration, jurisdiction and control of the squadron commander will obviate the necessity for certain personnel of the old airdrome platoon.

At the date of this writing (July 1, 1942), no changes have been announced in the case of the Ordnance Company, Aviation (Air Base)

(Continued on page 210)

IMPORTANT!

Newly activated Ordnance Sections of Bombardment and Fighter Squadrons cannot expect to receive THE ORDNANCE SERGEANT until they request that it be sent to them. If you are transferred or reassigned to one of these Sections make it your business to have your unit placed on the mailing list of THE ORDNANCE SERGEANT.

Because of the contemplated inactivation of Ordnance Companies, Aviation (Bombardment and Pursuit), and the coincident assignment of their personnel to the new sections mentioned above, it is expected that almost all of these companies will be removed from the mailing list of THE ORDNANCE SERGEANT. If your organization is not to be inactivated it WILL be necessary for your company commander to so advise THE ORDNANCE SERGEANT in writing. If this is not done your organization will be removed from the mailing list effective with the November issue. But don't wait until November. You might forget about it later.

ORDNANCE TRAINING ACTIVITIES



Conducted by: G. D. Meixel, 1st Lieut., Ord. Dept.

Secretary, The Ordnance School

THE BOMB DISPOSAL SCHOOL

"So you're in Bomb Disposal. Well, it was nice knowing you alive". Such seems to be the general idea that has grown up regarding the Bomb Disposal School; but we who belong to the unit beg to differ. We know that the unit has a new and potentially dangerous mission; but we feel that the knowledge and training given us through the school will enable us to successfully carry out any and all assigned tasks. In fact, the only fault we have to find is that the mission we have been assigned gives us no chance to get a shot at the enemy in person.

In the Army of the United States, the disposal of unexploded shells, bomb, and other missiles had always been a function of the Engineer Corps; and had been accomplished by simply blowing up the missile in question where it lay. Since the action of all previous wars was confined to areas very close to the front lines, this system worked very well in the past; but the development of large scale aerial bombardment directed against industries, utilities, transportation lines, and the general public made it necessary to handle unexploded aerial bombs in such a way that further damage would be avoided and civilian morale would not be adversely affected. With this new concept of bomb disposal operations in mind, the War Department transferred the responsibility for the disposal of all unexploded bombs, shells, and other missiles from the Engineer Corps to the Ordnance Department just prior to the entrance of the United States into the war.

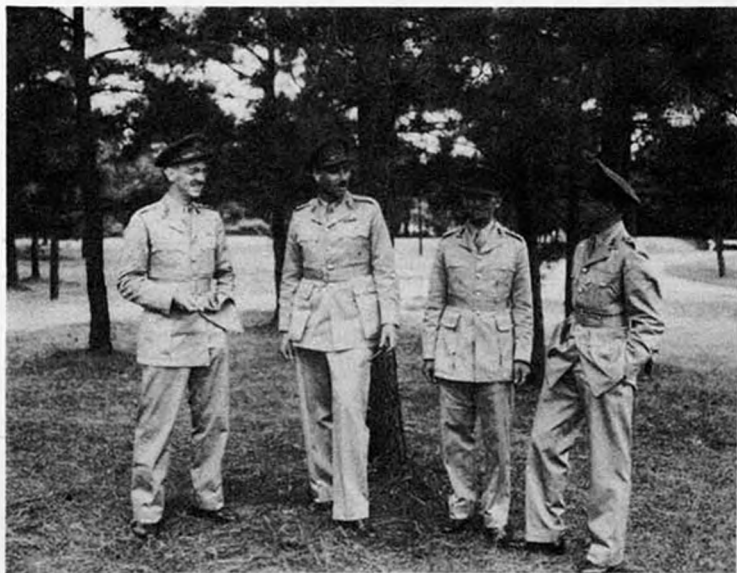


Lt. Col. Kane and Major Walker observing Bomb Disposal operations in England.

Fortunately, through the foresight of Brigadier General J. S. Hatcher, Commanding General of the Ordnance Training Center, preliminary studies of the bomb disposal problem had already been made by Lt. Col. T. J. Kane and Major G. B. Jarrett; and on the basis of these preliminary studies the Bomb Disposal School was activated at Aberdeen at the beginning of the present year with Lt. Col. T. J. Kane as Commandant, Major W. C. DeBill as Assistant Commandant, and Major H. M. Walker as Director of Training. Thus, at the start of the present year,

the Bomb Disposal School was little more than an idea; with fewer than ten officers and enlisted men assigned to the task of developing the idea into a force of trained men ready and able to handle all bomb disposal operations not only in this country, but in any part of the world where American troops might operate in the future.

The tangible assets of the new unit consisted solely of the officers and men assigned, for there was no background of knowledge of the problems to be met or how to meet them. The solution to the problem lay in England, where a major problem of bomb disposal had been encountered and successfully dealt with. A mission headed by Lt. Col. T. J. Kane and Major H. M. Walker went to England to study the problem under actual field conditions; and a group of British officers and enlisted men was brought to this country to assist in the training of the first classes of the

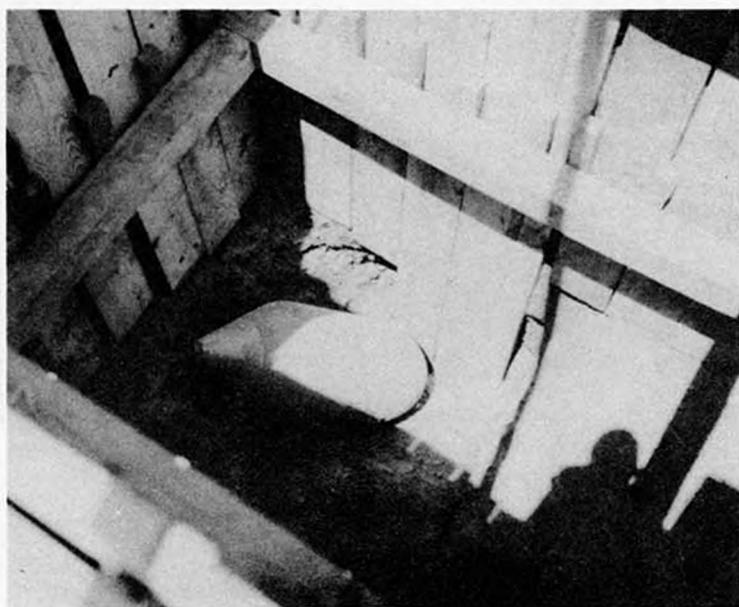


Officers of the British Bomb Disposal mission. Left to right -- Capt. Sharman, Col. Yates, Capt. Hudson, Capt. Draper.

new school. The officers of the British group were Colonel Geoffrey Yates, and Captains J. P. Hudson, T. H. Sharman, and J. W. Draper; all officers with outstanding records in bomb disposal operations in England. The English also brought with them a complete line of the equipment they had developed to deal with unexploded bombs; and the first classes were organized on the basis of English methods and equipment.

The first officers' class started February 17, 1942; and since then five classes have been graduated with the sixth and seventh classes now in training. The course has changed considerably from the original instruction due to the addition of new knowledge of enemy bombs and the development of new techniques by the Research section of the school. The officers' course includes instruction in types of bombs and fuses, bomb

reconnaissance, evacuation and safety distances, protective measures, care and use of bomb disposal equipment, and methods of making bombs safe.



Bomb Disposal field work. Bomb has just been uncovered in bottom of shaft.

The first enlisted men's class started on April 8, 1942; and the men of the first two enlisted classes are now serving as instructors for the current classes and as technicians handling the equipment of the school. The third class of enlisted men received a "blitz" course and was immediately assigned to field duty. The fourth and fifth classes of enlisted men have also completed their courses, and are now attached to provisional companies. Approximately 200 enlisted men have completed their training and over 400 are now in various stages of training. Instruction includes recognition of bomb types, care and use of equipment, bomb reconnaissance, excavation of unexploded bombs, field rigging, and basic military training. Special emphasis is placed on safety rules and protective measures, so that any task assigned may be successfully carried out with minimum risk. And while we are on the subject of safety measures, let's cease considering bomb disposal units as "suicide squads". It just isn't so. In England, where bomb disposal has been a problem of major proportions, the actual casualty rate has been as low or lower in B. D. units as in any branch of the British armed forces. Further, it must be remembered that in making this record the British Bomb Disposal units started from scratch and learned their work the hard way, by experience; and that they have given us a tremendous advantage by placing their hard-won knowledge completely at our disposal. So, let's forget the "suicide squad" idea.



Bomb Disposal field work. Bomb has just been hoisted out of shaft.

To date, only one unit has been sent to field duty; but another is now ready and within a short time there will be sufficient men trained to activate several more units; and finally to establish an orderly flow of completely trained units to the field to accompany all forces of the United States wherever they may be sent. Several officers have been sent on special missions; and the officers trained to date include a number of Corps Area staff officers who are now acting as liaison officers for Bomb Disposal at the various Corps Area Headquarters.

The school cooperates in the training of civilian air raid wardens in bomb reconnaissance, safety and evacuation measures in areas where unexploded bombs fall, and coordination of civilian defense organizations with B. D. units. Several thousand civilian air raid wardens have already received this training from Bomb Disposal School instructors, and B. D. officers are now in the field continuing to cooperate with this phase of the work.

The progress of the Bomb Disposal School has been on display several times in exhibitions for a number of notable visitors including Major General L. H. Campbell, Jr., Chief of Ordnance; Major General Charles T. Harris, Assistant Chief of Ordnance; Major General R. H. Dewing, C. B., D.S.O., M.C. Acting Commander, British Army Staff, Washington, D. C.; Brigadier General J. S. Hatcher, Commanding General, O.T.C.; Brigadier General R. W. Case, Commanding General, A.P.G.; Brigadier General B. W. Simpson, Commanding General, O.R.T.C.; Brigadier E. R. Blood, M. C., Chief of Procurement, British Army Staff, Washington, D. C.; Colonel W. P. O'Brien, Administrative Section, Service of Supply, Washington, D. C.; Brig. Gen. H. R. Kutz, Chief of Field Service; Colonel C. W. Reed, Chief of Military Personnel and Training, Colonel W. B. Hardigg, Commanding Officer, Proving Center, A.P.G.; Colonel G. G. Eddy, Chief Proof Officer, Proving Center, A.P.G.; Lt. Col. L. A. Codd, Executive Officer, Office of the Chief of Ordnance and Lt. Colonel H. J. Conway, Executive Officer, O.T.C. On these occasions, the complete story of bomb disposal was presented in field exhibits showing the organization and equipment of a Bomb Disposal Company, the problems to be met in bomb disposal work, and all methods and equipment both old and new used to accomplish the mission of the Bomb Disposal School. The new methods brought out by the Research Section in their portion of the display were of especial interest as showing how American ingenuity is steadily improving old methods and devising new means to meet new problems as they arise.



The first Bomb Disposal unit entraining for field duty.

Thus, under the able direction of Lt. Col. T. J. Kane, the school has grown from the original small group of officers and enlisted men to a completely self-contained unit with its own headquarters, supply, research and intelligence sections, a department of advanced training handling all officers' classes and classes for enlisted technicians, and a department of basic training handling the primary training of enlisted men. The school has recently been assigned a new area, complete with all necessary buildings and equipment to make the school a self-contained unit of the Ordnance Training Center, and a training range for field problems. On the training range, various sizes of aerial bombs are dropped from planes; and all phases of bomb disposal operations are thus

carried out under as close to actual field conditions as is possible. With this new equipment and training range, bomb disposal training will be greatly accelerated; and new units will be activated at regular intervals to be stationed with American troops wherever operations are being carried on, ready and able to successfully carry out their mission, the SAFE disposal of unexploded bombs and shells of all types.

ORDNANCE TRAINING METHODS

By: P. J. Phillips, Major, Ord. Dept.
Director of Training Methods, The Ordnance School

PART V

DEMONSTRATIONS

A demonstration is an accurate portrayal of a subject or procedure to be taught. A well-planned and carefully presented demonstration is one of the most effective methods of instruction in basic, technical, tactical, and logistical subjects. The demonstration is based on the fact that seeing an object or procedure usually makes a more rapid and lasting impression on the mind than the other senses produce. A demonstration is always preceded by a thorough explanation of the work to be demonstrated and therefore is not a distinct and separate method of instruction. Demonstrations used in conjunction with other methods of instruction add to the instructional value of the other methods.

A demonstration demands considerable preparation on the part of those concerned with its execution. Preparation includes a careful study of the subject, complete plans based on the result of each study, and, finally, repeated rehearsals by all personnel involved in the demonstration. The demonstration should not only convey to the student a clear and accurate picture of the subject or procedure, but also set up a standard of excellence which he or his group must attain. It should arouse admiration in those for whose benefit it is given and should stimulate a desire to emulate it.

The many time-consuming factors in demonstrations, preparation, and rehearsal of the necessary troops, time required to set up facilities and equipment, time lost in taking the group to and from observation points, are all eliminated by the use of training films. In planning instruction, FM 21-8 should be consulted, and full use made of the available training films for demonstration purposes.

PREPARING FOR A DEMONSTRATION

The first requirement for any presentation, if it is to be worth the time it takes to give, is that it must occur at a time when an actual need is present and when its value is fully appreciated by the learner. Next to this requirement comes the necessity for careful planning of the performance. If the demonstration is to be a job operation, go through the performance beforehand, making an analysis of each move and step as you go. A written list of these steps will serve further to guide the future demonstration. Skilled specialists perform many of their acts so frequently that they are seldom conscious of all the factors that make the act a skillful one. Many movements and procedures have reached the stage of habit, so that consciousness of their existence is no longer required. In fact, the more skilled the worker, the less apt he is to realize the detailed nature of his accomplishment. The reader may prove the validity of this statement by first listing the steps and important points in some skill which he possesses to a high degree. Then perform the skill, listing, as you proceed, each teaching point. Compare the two and note the omissions in the first list. It is interesting to discover how few people can describe or write out directions for tying a four-in-hand tie without actually performing the act and carefully studying the sequence.

A few trials or experiments will convince the instructor that careful thought must be given to the preparation of an effective demonstration. In addition to the operation analysis already explained, the instructor should:

- (1) Anticipate those steps which may cause the greatest difficulty, and provide, or have ready, some form of supplemental instruction to clarify the point.
- (2) Have all materials and equipment needed for the demonstration at hand and within easy reach.

- (3) Be sure that everything works as planned, testing it in advance to be sure.

- (4) Go through the demonstration as a rehearsal before the actual presentation.

- (5) Remove all possible distractions before the demonstration begins, e.g., unnecessary noise, glare, unused equipment, etc.

- (6) List on paper the points you want to get across.

- (7) Plan short demonstrations. Two short demonstrations with an intervening period of application are better than a longer single presentation.

Well-prepared demonstrations assure consistently good presentations and reduce student error and individual instruction to the minimum, thus making for high teaching efficiency.

SUGGESTIONS FOR IMPROVING THE DEMONSTRATION

Even a well-planned demonstration cannot realize its full value unless well presented. Just as in all other phases of teaching, there is technique in making a good demonstration. Some of the main points are:

- (1) Do the performance yourself in a most skillful manner; so well, in fact, that it will incite wonder and admiration for your ability. Avoid the danger, however, of overawing the student to the point of discouragement or of creating an impression that you are "showing off".

- (2) Explain each step as you perform it, telling why as well as how whenever it can be done without going into a lengthy discussion.

- (3) Be sure that every one can see, because the worth of a demonstration is measured by its visual appeal.

Use large objects, equipment, and drawings.

See that glare from light sources and shiny surfaces is avoided; the light source should be invisible whenever possible and always outside the line of vision.

Hold your work up where all can get a good view.

Stand at the side of your work, particularly when it is on the board back of you.

Be sure that you have sufficient illumination on the demonstration.

- (4) Support your demonstration with pictures, charts, diagrams, models, slides, movies, and printed instruction material. These aids will help in interpreting your demonstration for individual students. They clarify obscure points, provide material for continued study, and serve to emphasize important points. Visual aids are just as valuable in a demonstration as they are in any other method of presentation.

- (5) Question the students as the demonstration progresses. This serves as a guide to their thinking, stimulates their attention, and checks the effectiveness of your instruction. If some point in the presentation doesn't "get over", the best time to clarify it is immediately, while the "stage is all set". Remember that all the subsequent portion of the presentation may be lost for want of a better understanding of the first part.

- (6) Have all students see the demonstration from the angle in which they will see it when they do it themselves. A teacher facing a group actually reverses his motions with respect to the learner. In certain cases such as the demonstration of the tying of a knot, arranging objects in a definite form, using a rule, etc., this reversed procedure becomes more confusing than helpful.

- (7) Have only one thing going on at a time. While explaining as one goes along is good practice, there is danger that merely talking continuously will in itself become a counterattraction which divides the interest. The magician makes great use of the art of counterattraction. Converge, or focus, attention on the one thing you are doing; do not disperse it by side shows or mental byways.

- (8) Speak clearly and distinctly, but not necessarily loudly. Speak deliberately but not without animation. Above all avoid a monotone. Express as much interest in what's going on as if you yourself were doing

or seeing it for the first time. Incredible as it may seem, an instructor's attitude reflects itself noticeably in the students' reactions.

(9) Keep the demonstration short. Two important factors operate against long presentations:

The interest span for the average person rapidly approaches a limit after twenty minutes.

The ability to retain that which is seen and heard has decided limits, after which the effectiveness of instruction drops off rapidly.

(10) If students are grouped around the instructor, let him take time at the start to see that the short fellow is in a front line position and the taller ones at the back. Form a large enough circle so that all can see without crowding or climbing on top of chairs, boxes, equipment, or even one another. Physical discomfort is as much a distraction as noise, so see that everyone is as comfortable as circumstances permit.

(11) Frequently, at the beginning of a demonstration, it is wise to go through the entire performance with the same speed and skill one would use on the job, as a means of giving the learner an over-all glimpse of what you are trying to accomplish. A slower performance, accompanied by explanation and discussion, could then follow as the means of getting the detailed information across.

(12) Make sure that in slowing down your performance for demonstration purposes you do not lose the technique employed in performing at the usual rate.

The demonstration can be used to advantage in several ways in meeting the instructional problems. While its most common use is that of transmitting new instruction in formal lesson presentation, it can also be employed to:

This is the fifth and last of a series of articles published for the benefit of individuals who may be assigned as instructors within their own organizations. A complete study of this subject may be found in a text of The Ordnance School, OS 9-41, "Manual for Ordnance Instructors".

(1) Present work procedures when the background experience of the group is insufficient to help them interpret oral or written directions for new work.

(2) To establish, by example, standards for workmanship.

(3) To arouse interest and furnish an incentive for further accomplishment.

(4) To provide a basis for understanding and appreciation of the related processes not essentially required in the job.

The field of technical duties is so broad that it is impracticable to give illustrations of the use this method in teaching them; however, it may be applied to nearly all technical subjects with profit and with a saving of time.

In tactical training, demonstrations usually show the movement and functioning of groups of individuals or units in combat. Since most tactical exercises are intricate and complex, demonstrations for the instruction of enlisted men should be limited to those by the company and smaller units. Demonstrations of tactical exercises by units larger than the company are generally used only in the instruction of officers.



MACHINE GUN TRIPOD

(Continued from page 179)

If the cradle pintle cannot be removed from the pintle socket it indicates that either the cradle pintle clamping screw is badly bent, which prevents unscrewing same from the pintle socket, which condition in turn keeps the pintle clamping block engaged with the groove on the lower part of the cradle pintle, or the pintle clamping block has been shorn off the lower part of the cradle pintle clamping screw. This malfunction of these particular parts of the tripod is caused by forcefully unscrewing the cradle pintle clamping screw all the way from the socket by personnel

ignorant of the construction and assembly of the parts involved. It has been formerly stated that the straight pin and the cradle pintle clamping screw nut must be removed first in order to remove the cradle pintle clamping block from the pintle socket. In order to avoid trouble and save time this rule must be adhered to. Also keep in mind to stop unscrewing the cradle pintle clamping screw as soon as resistance other than that caused by unscrewing it is felt.

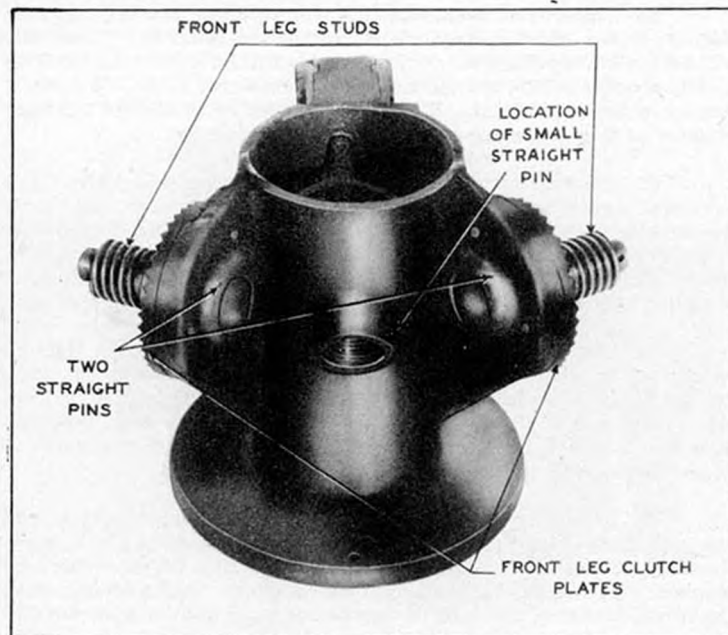


Figure 26. -Location of seat for the small straight pin which properly positions the pintle clamping block.

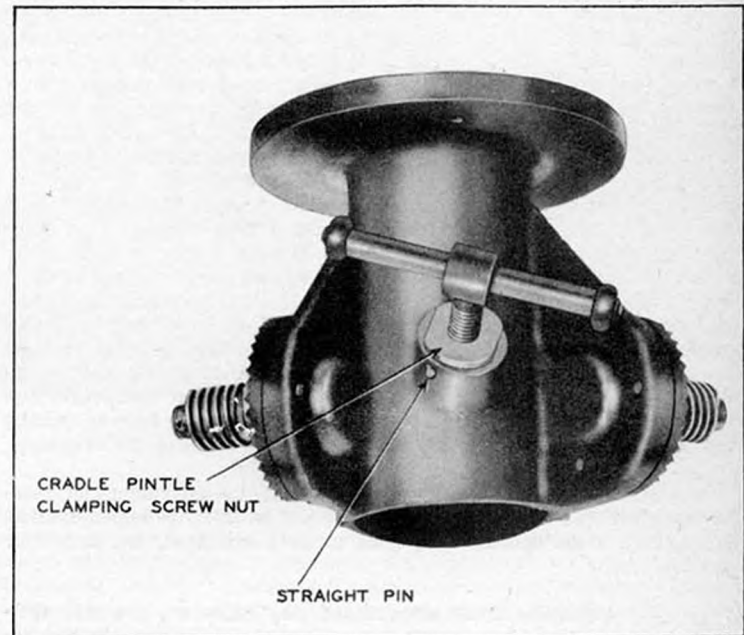


Figure 27. - Location of cradle pintle clamping screw nut, and straight pin which secures the former in place.

If a bent cradle pintle clamping screw caused the trouble try to straighten it with a rawhide hammer and unscrew it just far enough to allow removal of the cradle pintle from the pintle socket. Figure 27 shows the parts and location of same, to be removed before the cradle pintle clamping screw with the pintle clamping block can be removed without causing trouble.

If the pintle clamping block is shorn off and seated against the cradle pintle it locks the latter into the pintle socket and cannot be removed until the pintle clamping block clears completely the inside of the cradle pintle. To accomplish this the cradle pintle clamping screw must be forcefully unscrewed from the pintle socket, thereby ruining the threads and the straight pin which normally secures the cradle pintle screw nut in place. Then remove the pintle clamping block by turning the pintle socket upside down or using a strong wire with a small hook to insert it in the T slot on the pintle clamping block (upper side, Figure 20) and pull it out.

Another procedure is to drill the straight pin out with the electric drill press which will save the cradle pintle clamping screw nut. Then remove the pintle clamping block as outlined above, and replace parts.

Binding of the cradle pintle in traversing same in the pintle socket is usually caused by a bent, burred or rusty cradle pintle clamping screw. Replace a badly bent cradle pintle clamping screw. If it is only slightly bent a couple of light taps with a rawhide hammer will straighten it but it will never function as smoothly as a new one. The cradle pintle clamping screw should always be lightly oiled.



GENERATORS

(Continued from page 187)

The crankcase is never filled above the "full" mark on the gauge stick. To do so would cause an excessive amount of oil to be thrown against the cylinder wall, resulting in oil pumping, smoking, excessive carbon deposits, and fouled spark plugs.

Grease cups are next. Fill all grease cups on the main generator and exciter bearings with #0 lubricating grease. Give the caps of the cups two or three turns clockwise to force grease to the bearings. The bearings of the battery charging generator, and the starter, require a few drops of same grade oil being used in crankcase, also the joints in the connecting links between the throttle arm and the governor need a few drops of the same oil. To lubricate the engine fan remove the plug located in the fan hub and squirt into the shaft engine oil until the oil runs out at the end of the shaft and drips off. Replace the plug.

The water pumps on the M4, M5 and M7 generators all require a special water pump grease. This grease is listed as; grease, water pump, hard #4 - USA specification #2-209. Check the grease cups to see that this grease is actually present, and at the same time give the caps a turn clockwise to force some of the grease to the pump bearings.

The distributor shafts are lubricated by an oil or grease cup. In either case they must be inspected and lubricated.

The following chart may be used as a guide to proper lubrication of the generator unit.

PART	FREQUENCY	LUBRICANT	QUANTITY AND APPLICATION
Crankcase	Change after 50 hours of operation add as needed	Engine oil Above 32° F. use SAE 30 Below 32° F. use SAE 10	Fill through filler and breather tube. Check quantity by bayonet gauge.
Water pump	50 hours of operation	Grease-water pump #4	Few drops, refill cup when empty
Battery Charging Gen.	Every 50 hrs. operation	Oil, engine (same as crankcase)	Few drops in oil cups.
Distributor	"	Engine oil for cup Grease, General Purpose #0 for grease cups	Few drops in cup 1 turn. Fill when empty.

PART	FREQUENCY	LUBRICANT	QUANTITY AND APPLICATION
Starter	Every 50 hrs. opera.	Engine Oil (Same as crankcase)	Few drops in front bearing cup.
Fan	"	Engine Oil (Same as Crankcase)	Remove plug and fill until oil drips from shaft.
Breaker Cam	Semi-Annually	Grease, General Purpose #0 SAE #10 Engine oil	Wipe cam lightly One drop on breaker cam pivot pin.
Governor	Every 50 hrs. operation	Engine Oil SAE #10	Few drops on Joints in linkage
A.C. Generator	"	Grease, General Purpose #0	One turn - Fill cup when empty
Exciter Bearing (M-7 Gen. only)	"	Grease, General Purpose #0	One turn - fill cup when empty

Commutators) and slip rings) Do not lubricate under any circumstances.

Automatic Choke) Do not lubricate under any circumstances.

Fill the cooling system of the engine and inspect its condition. In tropical or temperate climates the system will be filled with clean water; in a frigid climate an anti-freeze solution such as alcohol, Prestone, etc., must be used. Charts are published by the manufacturer showing how much anti-freeze to use to protect the system at various temperatures. Always refer to this chart when preparing a generating unit for issue.

If such charts are not available, the following charts may be used as a guide.

FREEZING POINT	PINTS TO RADIATOR		
	ETHYLENE, GLYCOL, PRESTONE	GLYCERINE	DENATURATED ALCOHOL
M-4 Generating Unit			
10° F.	2	4	2½
0° F.	2½	5½	3
-10° F.	3	6	3½
-20° F.	3½	7	4
-30° F.	4	8	5
-40° F.	4½		5½
-50° F.	4½		6
-60° F.	5		6½
-70° F.	5		
M-5 Generating Unit			
10 F.	2¼	5	3
0 F.	2-3/4	7	3-3/4
-10 F.	3-3/4	7½	4-1/2
-20 F.	4-1/2	8	5
-30 F.	5		6¼
-40 F.	5-3/4		7
-50 F.	5-3/4		7½
-60 F.	6-1/4		8¼
-70 F.	6-1/4		
M-7 Generating Unit			
10 F.	18	36	22½
0 F.	22½	49½	27
-10 F.	27	54	31½
-20 F.	31½	63	36
-30 F.	36	72	45
-40 F.	40½		49½
-50 F.	40½		54
-60 F.	45		58½
-70 F.	45		

Special attention should be devoted to the condition of the radiator. If it is found to be dirty or clogged with sludge, it must be disconnected from the engine and both the water jacket of the engine and the radiator blown out with a combination of air and water until clean. The cooling system may also be cleaned by a solution furnished by the Q.M., known as "Chemical Cleaner & Inhibitor for cooling systems - or by a solution of 1/2# washing soda and 1 quart of kerosene to a gallon of water. A coat-

ing of rust, oil or sludge on the surface of the tubes lowers the rate at which heat from the engine is dissipated into the atmosphere. After filling the radiator inspect the drain plugs, valves and connecting hose for leaks. Even a small leak will soon drain the entire system and may result in almost irreparable damage.

The capacity of the M4 generator radiator is 1 gallon; the M5 - 5 quarts; and the M7 - 9 gallons. Before attempting to fill a radiator be sure the drain valves are closed.

There are always four sets of carbon brushes to be inspected on any of the A.C. generators driven by gasoline engines. They are the battery charging generator brushes, starter brushes, D. C. exciter brushes and the main A.C. generator brushes. An inspection of these brushes includes the condition of the brushes themselves, the spring tension on the brushes, and the condition of the commutator or slip rings upon which the brushes ride. Brushes showing excessive wear are replaced, and the new brushes sanded in to fit the surfaces on which they are to ride. Often the condition of the commutator or slip ring causes excessive wear of the brushes. A commutator or slip ring showing signs of being burred or rough should be dressed down with 00 sandpaper while the unit is running. In case they show pitted places or roughness after light sanding, the rotor will have to be removed and placed in a lathe where the rings on the commutator may be turned to a true smooth surface.

All of these engines are equipped with an air filter for the carburetor intake. The M4 has a metal wool screen filter. Remove it from the carburetor, wash it in a suitable solvent, and then dip in a medium grade motor oil and replace. The M5 and M7 units have a filter of the oil bath type. To clean, first remove, drain the oil, wash the screen in a suitable solvent, replace, and fill the oil reservoir with medium weight oil.

Two rubber compound belts will be found on these engines; the fan belt, and either an exciter drive belt or a battery charging generator belt. Inspect them for wear and tension. They are of the V type and do not require too much tension. Adjust the longer belts until they will deflect about one inch when grasped near the center. The shorter belts will have less deflection.

Having completed the above preparatory steps turn the engine over several times with the hand crank to see that it is free of binding. Start the engine with the starter, and after allowing it to warm up bring it to full, normal, operating speed. During this time check the oil pressure, water temperature, and general sound of the unit. The oil pressure of the M4 and M5, at 1200 R.P.M., should be between 15 and 20 pounds per square inch and the M7 approximately 25 pounds at 1200 R.P.M. At lower speeds the pressure will be less. An oil pressure gage is located on the panels of all models.

If the oil pressure fails to build up, cut the engine off at once - serious damage will be done to the engine if allowed to run without proper oil pressure.

After the engine has warmed up raise the voltage on the main generator to its normal value. Connect a full rated load to the generator terminals by using resistance of some suitable type. Allow this load to remain on long enough to test the performance of the generator under full load. The unit should take its rated load without excessive heating or strain. Note the speed of the unit to check the action of the governor. The drop in speed from "no load" to "full load" should not reduce the frequency more than two cycles. Note the temperature of the cooling system as indicated by the temperature gauge on the generator panel. The operating temperature under full load in temperate climates is normally between 140 degrees F. and 180 degrees F.

There is a D.C. ammeter on the panel of all generators to indicate the charging or discharging rate of the battery. Adjust the third brush (current brush) of the battery charging generator until the ammeter shows a charging rate between 6 and 10 amperes when the engine is running at full rated speed. Too high a charging rate is detrimental to the battery.

Special attention should be given to the general sound of the machine while under load, and also without a load. Any indication of the unit exerting a straining effect or effort to carry the load, or any abnormal noises at all, should be investigated, and if defects exist they should be corrected. It may be the result of poor ignition timing, sluggish governor, excess carbon, fouled plugs, lack of lubrication or any one of many other possible defects.

The preparation and inspection of the mechanical condition com-

pleted, next check the accessory list of equipment to be furnished with the generating unit. The manufacturer furnishes, with each new unit, a list of all tools and spare parts. If such a list is not available secure one or refer to the appropriate manual for the model under inspection. These manuals usually contain a similar list. Replace any missing tools or spare tools before issuing the generating unit to the using service.

If the above instructions are followed carefully and conscientiously few complaints will be received from the using service in regard to the condition of generators issued.



BILL OF LADING

(Continued from page 191)

FREIGHT, or EXPRESS. Also appearing in this column is the title and address of the ultimate consignee. If the shipment was to be made by freight to the Ordnance Property Officer at Fort Sheridan, Illinois, the consignee in the heading of the bill of lading would be the Transportation Officer, Fort Sheridan, Illinois, and the ultimate consignee would be shown in the "Marks" column "FOR: ORDNANCE PROPERTY OFFICER, Fort Sheridan, Illinois". The "Numbers on Packages" column and the "Number and Kind of Packages" column will contain the same information in the same manner as it appeared on the memorandum shipping ticket. In the "Description of Articles" column, the nomenclature for the items in the shipment will be that of the common carrier which differs from the SNL nomenclature. Rifles, pistols, etc. are referred to as Small Arms; gun slings, holsters, etc. become Small Arms Accessories; field glasses and other fire control instruments with lenses are known as Optical Instruments; and pyrotechnics are called Fireworks. This nomenclature is found in the common carriers' classification index. Also, this index indicates the class in which the items will be placed which in turn determines the rate or cost of transportation in sending the shipment between the shipping point and destination. In the event that items of different classes are attached to make one unit, the entire unit will be assigned the class of the part which is of the highest class by itself. An example of this would be the shipment of a tank upon which the weapons are attached. A tank travels fifth class while a weapon is considered first class. Because the weapons are attached, the entire unit will be shipped first class, and therefore at the highest rate. Should the weapons be detached, separate bills of lading would be made out, and the weapons will take first class, and the tanks, fifth class. In making a shipment which includes items of different classes, a separate bill of lading must be made out for each class. Therefore, even though the weapons travel in transit on the same car as the tank, two bills of lading are necessary to make the shipment.

The individual weights of packages along with the number of each package are included on the right hand side of the description of articles column of the bill of lading. The total weight of items of each nomenclature is set down in the "Weight" column of the bill of lading.

Pick up and delivery service refers to the transportation of the shipment or freight car between the freight terminal and the warehouse or siding. At some camps, there are government engines which haul the cars on the spur track from the railroad siding to the camp. At others, the railroad will furnish the engine to haul the cars. Less than carload lots may be taken to or hauled from the freight terminal of the common carrier by government trucks, or the common carrier may furnish this pick up and delivery service. If the freight rate exceeds a certain amount, the common carrier sometimes furnishes this service free of charge. Therefore, this service should be considered by the Transportation Officer. To record the service furnished by the common carrier, the notation is placed on the bill of lading in such a manner that the words not applicable can be marked out and the Disbursement Officer, Transportation Division, Finance Office in Washington, D. C. can use the information in checking the bill submitted by the last common carrier for the transportation charges. Routing instructions can be obtained from the Quartermaster General which gives the information as to the facilities and services available at every camp in the United States.

When the five copies of the bill of lading have been prepared, the following information should be placed on the memorandum shipping ticket: mode of transportation; routing; bill of lading number; total weight of shipment; number of packages; package numbers; railroad car numbers and the seal numbers that appear on the seals on the doors of the freight

cars. One copy of the memorandum shipping ticket is signed by the Transportation Officer and returned to the Ordnance Property Officer.

Two of the memorandum copies of the bill of lading are stamped, one, "Property Shipped", the other "Property Received". All the copies of the bill of lading are signed by the common carrier's agent except the Property Received copy. When the agent signs, Army Regulations specify that he should sign his full name with middle initial instead of using only initials as is the practice in signing commercial bills of lading. The common carrier keeps the salmon colored shipping order, and returns the other three copies to the Transportation Officer. The yellow copy, which has not been stamped, referred to as the "Unstamped Copy", is sent to the Finance Officer in Washington, D. C. The "Property Shipped" copy is retained by the Transportation Officer and filed along with a copy of the memorandum shipping ticket. The original copy and the "Property Received" copy, along with one copy of the Memorandum Shipping Ticket, are sent in separate envelopes to the Transportation Officer at the destination. Upon receipt of the Property Received copy, the consignee Transportation Officer will send it to the ultimate consignee who will place a certificate on the reverse side to the effect that the public property described on the bill of lading, in apparent good order and condition, has been received, except as noted. The Ordnance Property Officer will insert the weight of the shipment as received, the date, and sign his name. In the event that items are damaged or short, it is noted on the bill of lading as a means of informing interested parties who would be concerned in rectifying the error. The Ordnance Property Officer then returns the Property Received copy of the bill of lading to the Transportation Officer consignee who uses it as an authority to accomplish the original bill of lading. The original is then turned over to the common carrier who delivered the shipment, and the Property Received copy is filed along with a copy of the memorandum shipping ticket by the Transportation Officer consignee.

In order that the Transportation Officer at the shipping point will know that the transaction is complete, the Transportation Officer at the destination notifies him on W.D.Q.M.C. Form No. 214, Acknowledgment of Receipt of Property Shipped. When the Transportation Officer consignee receives this form, he will file it with the Property Shipped copy of the bill of lading, and his retained copy of the bill of lading, and his retained copy of the memorandum shipping ticket for reference in the event that any inquiry should be received at a later date concerning this shipment.

The form used in this article to transfer responsibility for the shipment to the Transportation Officer from the Ordnance Property Officer was the Memorandum Shipping Ticket. Tally-Outs are often used to list the items for shipment instead of preparing the list on the Memorandum Shipping Tickets. At other places, three additional copies of the shipping ticket to transfer accountability are prepared, and when the additional necessary information is placed upon them, they are used as memorandum shipping tickets. The form used makes little difference as long as it meets all the necessary requirements. The Memorandum Shipping Ticket as described herein will meet those requirements.



FORGE WELDING

(Continued from page 199)

Split Welds

There are two general methods used to prepare edges of pieces to make split welds. Figure 7 shown the joint type used for light sections while the edge preparation shown in Figure 8a is used on heavier sections.

The face of the scarf is sometimes roughened to prevent slipping as shown in Figure 8b.

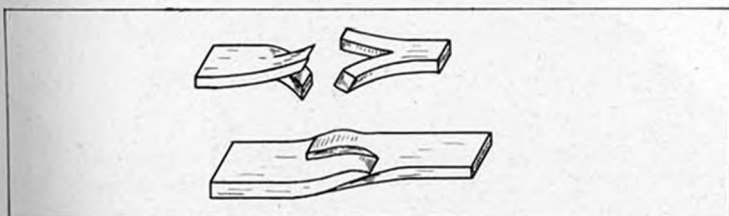


Fig. 7. -- Split Weld -- Light Sections

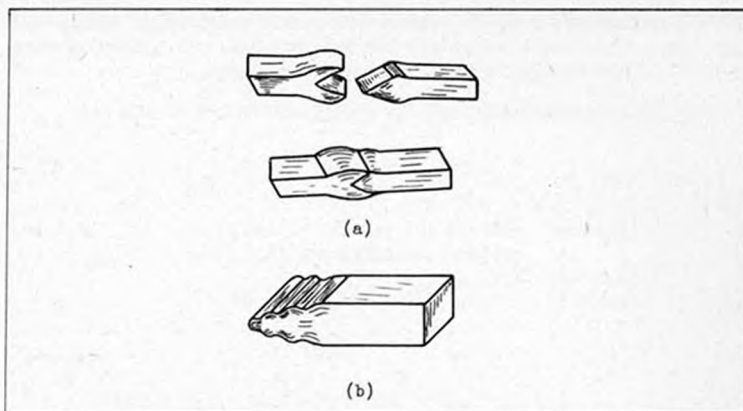


Fig. 8. -- Split Weld -- Heavy Sections

Each of the basic types of joints discussed are modified when welding pieces which are non-uniform in cross section in order to prevent overheating and burning of the lighter edges while obtaining a uniform welding heat throughout the sections to be welded.

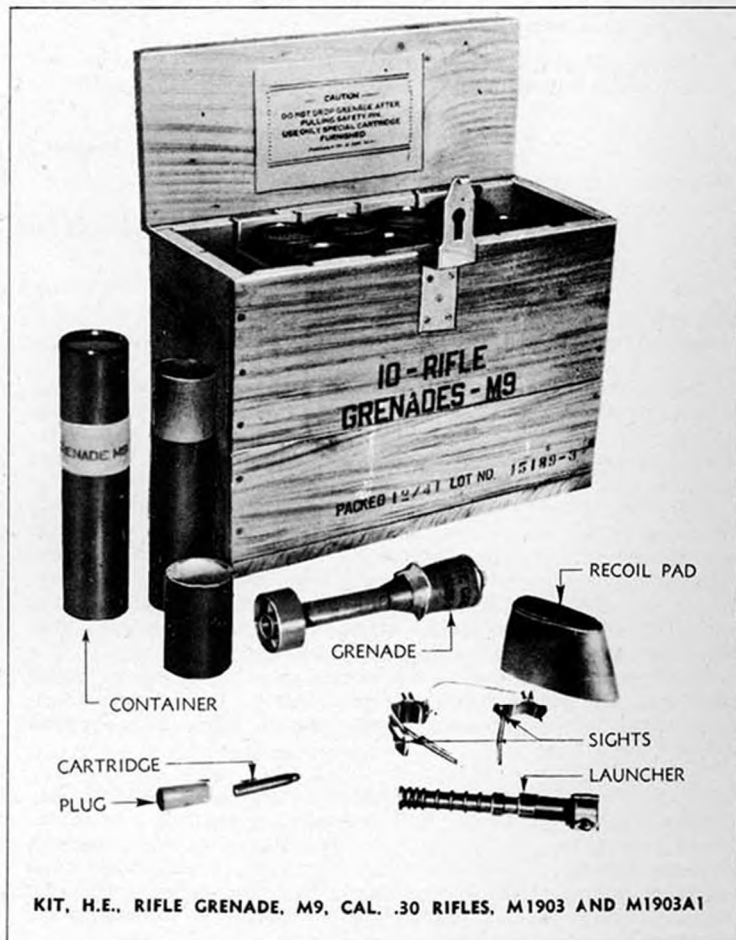


GRENADES

(Continued from page 201)

into the case. This loading gives the M9 grenade a velocity of 180 feet per second measured at five and one half feet from the launcher. For bulk shipment these cartridges are packed in cartons of twenty-rounds each, 100 cartons (2000 rounds) per metal lined wooden packing box.

Cartridge Rifle Grenade M3. - This cartridge is exactly the same as the M2 except that it has a propellant charge of fifty-one grains which gives the grenade a velocity of approximately 165 feet per second at five and one half feet from the launcher.



Rifle Grenade Kits. - For convenience of supply, handling, and use those components necessary for the firing of rifle grenades were assembled into standard kits containing the following:

- 10 Rifle Grenades
- 10 Cartridges
- 1 Launcher - (M1 for use with the M1903 rifle)
(M3 for use with the M1917 rifle)
- 1 Launcher Sight
- 1 Recoil Pad

When packed in these kits the cartridge, contained in a cellophane envelope was placed in the empty part of the fin assembly and held there by a wooden plug. These kits are no longer a standard method of packing; only the grenades and cartridges being supplied as ammunition items of issue. The present standard method of packing is in boxes of 10 grenades and 11 cartridges, the cartridges are no longer placed in the tail but are packed in the space vacated by the launcher, sights, and recoil pad.

Note. - There are two grenades under development at present which resemble the M9 and M11 respectively but are larger, these are the M10 A. T. and the M13 Practice. Further information is not available at present. These grenades will probably be fired from a projector using a shotgun type blank loaded cartridge as a propelling charge.



PROCESS CHART FOR OXYACETYLENE WELDING

(Continued from page 197)

BASE METAL OR ALLOY	WELDING PROCESS	FLAME ADJUSTMENT	WELDING ROD	FLUX REQUIRED	PREHEATING REQUIRED
Lead	F.W.	Neutral to Sl. Carburizing	Lead	Soldering Acid	No
Magnesium Alloys (c)	F.W.	Sl. Carburizing	Same as base metal	Special Flux	500-600°F
White Metal	F.W.	Carburizing	White metal	No	No

NOTES

(a) Welded as white cast iron only and should be followed by malleablizing treatment. Fusion welding is not recommended for malleable iron.

(b) Heat treat (51S) and (53S) after welding. Properties of (17S) and (24S) alloys cannot be restored by heat treatment after welding.

(c) Welding is not recommended on some magnesium alloys.

* Preferred Method.

F.W. Fusion Welding
B.W. Bronze Welding

In general, in welding low alloy high tensile steels, it is recommended that the filler metal used should be of the same composition as the base metal to obtain good corrosion resistance at the welded joint.

In welding low alloy high tensile steels in the heat treated condition it is recommended that the filler metal used should be of the austenitic type such as, the 18% chromium 8% nickel stainless steel welding rod.

In all cases where the low alloy high tensile steels are to be heat treated after welding the filler metals used should be of the same composition as the base metal or other suitable high strength welding rod.



AVIATION ORDNANCE REORGANIZATION

(Continued from page 202)

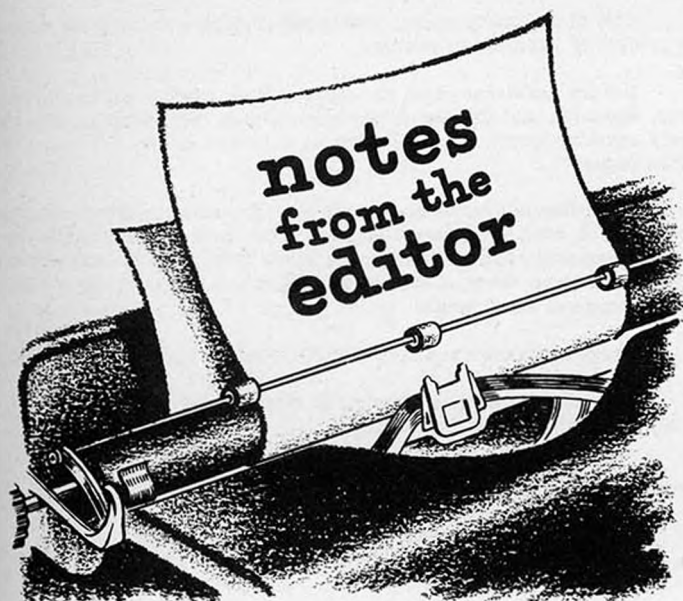
and it is to be assumed that it occupies its normal place as the hub of ordnance activities at an Air Base or a Service Center as it is now called.

Cause for some confusion recently has been the Ordnance Company, Aviation (Air Base) Special, which now has an enlisted strength of twenty (20) men. Correspondence with men in the field indicates that these companies, probably temporary in nature, have been operating at Air Depots doing armament work exclusively on the planes which go through the depot. Not concerning themselves with the problem of ammunition supply or anything but the furnishing of competent armorers to check and repair the armament of every plane before it leaves the depot, this company is similar to and may become the recently organized Ordnance Company, Aviation (Air Depot) which has a T/O strength of two (2) officers and twenty (20) enlisted men. These companies are going to answer a vital need of field Air Depots where damaged planes are sent for repair. The smoothest operating aircraft in the world are of little avail in combat if their guns are not functioning just as smoothly. The Ordnance Company, Aviation (Air Depot) will assure a double check on a powerful machine of war.

One of the newest Aviation Ordnance companies is the Ordnance Company, Aviation (Service). This company does not have a stabilized table of organization. Some cases have been reported of companies with a strength of 83 men where others had over 1000. Usually broken into detachments approximating 35 men, these companies are stationed at the various Air Corps training schools for the purpose of furnishing the ordnance service required there.

Undoubtedly many of these changes seem a far cry from Aviation Ordnance in its infancy and time alone may hold the answer as to the feasibility of each individual innovation. Let it suffice to be said that only by continued and increased cooperation between Air Force and Ordnance personnel alike may a combat team be moulded sufficient to cope with the task which lies ahead.





HEADQUARTERS
41ST ORDNANCE BATTALION (M&S)
Fort Jay, New York

July 14, 1942

SUBJECT: Automotive

TO : Editor, THE ORDNANCE SERGEANT, Aberdeen Proving
Ground, Maryland.

Inclosed find articles pertaining to Automotive Maintenance. If this is in line with your policy in creating a department whereby those in the Field may exchange ideas on maintenance procedures, a policy which I strongly advocate, I would then like to submit some of my experiences regarding automotive maintenance that I gained through personal research in the field.

ALEXANDER HUSOS
Captain, 41st Ordnance Battalion, (M&S)
Automotive Officer

INTERCHANGEABILITY OF PARTS

During the course of maintenance on motorized equipment, parts have been found to fit more than one type of vehicle. For various reasons at times this condition, of interchangeability of parts, has prevented undue tieup of a vehicle. At present there is no information available as to the number of parts that are interchangeable. This necessitates personal research in regards to the number of parts that may be interchangeable, making notations in the parts books also keeping a list of the parts that are common to more than one type of vehicle. Until such time as printed information will be available, the course mentioned here is recommended for use by units, adding to their efficiency in the maintenance of motorized equipment.

TIRES

Some of the tires on vehicles now in use by organizations have a mark on the outside of the tire indicating the balance point of the tire. This "balanced point" is indicated by tire manufacturers by a red dot, blue dot, yellow dot, etc. Still others will stamp a warning sign to place valve stem opposite dot or arrow. The valve stem of the inner tube must be placed opposite this indicated point.

PREVENTION OF CORROSION AT THE BATTERY POST

The practice of applying grease or vaseline to cover the battery post and battery cable terminal to prevent corrosion has to some extent been abused. In some instances, the grease or vaseline has been applied excessively, the excess grease having a tendency to soften the sealing compound on top of the battery thereby causing possible leakage of the electrolyte. The application of grease to prevent corrosion must be applied moderately.

Button your lip and save a ship.

Soldier, if you're packing your barracks bag one of these days and suspect that you'll soon be walking up a gangplank, make certain that relatives and friends have your correct overseas mailing address so letters will reach you without unnecessary delay.

Before you move out of camp you probably will be given an Army Post Office number as well as instructions to send your mail in care of the Postmaster of a certain city. If you don't receive an APO number be sure and ask for one. The APO number should appear on every piece of mail addressed to you until you are notified otherwise.

Suppose your APO number is 100 and you are a Private named Jones. Around your neck hangs identification number 1234560 and you're in Company A of the 999th Infantry. The commanding officer has sent out a bulletin which says that from now on your correct address will include your name, grade and serial number; organization; APO number, and mail should be sent to you in care of the Postmaster at San Francisco.

Then before you leave camp, let the folks at home know that your mail should be addressed like this:

Pvt. John J. Jones, 1234560
Co. A, 999th Inf.
APO 100
c/o Postmaster
San Francisco, California

Every time you write a letter be sure and include a complete military address, since some of your friends may have forgotten the correct way to reach you by mail.

During the course of your journey you may be assigned temporary quarters for several days. Don't write home to change your address.

IN SPITE OF REGULATIONS TO THE CONTRARY, ONCE IN A WHILE A SOLDIER DECIDES TO PASS ON THE ADDRESS OF ONE OF THESE TEMPORARY STATIONS; HE THINKS MAIL WILL REACH HIM QUICKER IF HE FORGETS HIS APO NUMBER AND GIVES THE NAME OF HIS STATION. HE'S WRONG ON TWO COUNTS. FIRST, HE IS DISOBEDIENT; AND SECOND, EVEN THOUGH HIS MAIL MAY BE CORRECTLY ADDRESSED ACCORDING TO CIVILIAN STANDARDS, IN CERTAIN AREAS ALL MILITARY MAIL BEARING NO APO NUMBER MUST BE SET ASIDE FOR DIRECTORY SERVICE, WHICH MAY DELAY IT AS LONG AS 48 HOURS.

Disregarding an APO number may result in even longer delays than that. If the soldier and his unit have left that temporary station and a new group has arrived, the mail has to be re-serviced, the neglected APO number looked up, and the organization checked for ultimate destination. In the meantime, a boat carrying correctly addressed mail to this same outfit may have started on its way.

Getting mail to soldiers overseas is a big job. It's getting bigger every day. Yet, today, mail is arriving at many of the major warfronts more frequently than it did those same destinations in peace time. Remember, soldier the letters which arrive quickest are those which are properly addressed.

Orchids were on order recently for fifteen enlisted men of the Bermuda Base Command.

They are the men behind the men behind the guns - members of the B.B.C.'s Ordnance Detachment, who added another laurel to their imposing list of accomplishments.

The detachment ended its first thirteen months without one arrest by civil or military authorities to mar its records.

Commenting on this, General Strong wrote to Capt. Arthur Byrne:

"The records of Bermuda Base Command, U. S. Army fail to

disclose a single instance where an enlisted man of your organization has been reported for any infraction of regulations at a recent inspection of your barracks and shop installations, a most praiseworthy state of organization and systematic arrangement was noted. The finest of old Regular Army standards were maintained."

In a large way responsible for this achievement is the campaign-seasoned, indefatigable Arthur W. Byrne, Captain and commanding officer of the unit, a veteran of twenty-eight years of service. Captain Byrne, who rose from the ranks, has seen service in Hawaii, the Philippines, Panama, France, the Mexican border and widely-scattered points in the States.

Captain Byrne, in organizing the unit here in April, 1942, was assisted in no small measure by T/Sgt. E. M. Jackson, candy-haired veteran of 17 years who, as ranking non-com, is "boss" of the Ordnance warehouse. Like the majority of his men, Sgt. Jackson is a Pennsylvanian.

The unit has three Staff Sergeants, Arthur W. Loucks, J. S. Stryjewski, and John O. Graham.

HEADQUARTERS FOURTH AIR FORCE
OFFICE OF THE ORDNANCE OFFICER
San Francisco, California

Editor
THE ORDNANCE SERGEANT
The Ordnance School
Aberdeen Proving Ground
Aberdeen, Maryland

July 14, 1942

Dear Sir:

The enclosed photostatic sketch is being forwarded in the hope that it will be of interest to all Ordnance Sergeants.

This fixture for removing oil buffer filler screws, caliber .50 machine gun oil buffer is made up of seven parts as follows:

1. Frame -- The frame is a piece of strap metal approximately 6" long, bent as shown in the sketch. The top is drilled for the 1/2" adjusting nut and threaded with a 32 thread as the filler screw has that thread. The bottom has a recess cut to fit around the oil buffer piston rod.

2. Adjusting nut -- The adjusting nut is made of 1/2" round stock with 1/2" nut sweated to the top with a 32 thread. A larger thread can be used on the frame and adjusting nut if equipment for cutting a 32 thread is not available.

3. Screw driver -- The screw driver is made from 3/8" drill rod

Two of the line sergeants are brothers, Ronze and Anthony Gengo, who preferred Bermuda to parting.

Not the least-known of the organization is Sgt. Dauvin, native of Sugny, Belgium, and darling of society circles. Sgt. Dauvin, who can repair anything from a wrist watch to a broken heart, has taken out citizen papers.

In Ordnance every man has his job. Ammunition experts are Sgt. Joseph Grebe and Corp Howard Haines. The truck-tractor department is in the competent hands of Sergeants Harry Meverley and Andy Stefanov while Sgt. Anthony Gengo, Corp. Steve Adkins and Corp. Woodrow Modlin are in charge of small arms.

Sergeant Graham and Corporal Gillespie are in charge of artillery.

Sergeant Sullivan, machinist, is temporarily on detached service at the New York Port of Embarkation.

-- The B.B.C. (Bermuda Base Command) News



and shaped as shown in sketch.

4. Wrench -- The wrench is a piece 1/4" x 1/2" and must be made in the shape of a square cornered U. It must extend to the front of the fixture 1-3/4".

5. Filler piece -- The filler piece is welded in the front side of fixture which centers the oil buffer filler screw with the screw driver.

6. & 7. Handle -- The handle is made of 1/2" square stock and is drilled to receive the top end of the screw driver which protrudes through the adjusting nut 1/2". It is then drilled from the side half way through with a 1/2" drill, the other half with a 7/32 drill and then tapped with a 1/4" standard tap. A 1/4" standard thread screw is used to bind the handle to the screw driver.

Operation of Fixture --

Place the oil buffer in the fixture, turn the adjusting nut until the screw driver is seated firmly in the screw driver slot of the filler screw. If the 32 thread is used, turn the handle and adjusting nut at the same time to remove the filler screw. If a larger thread is used, the handle is turned alone 1/4 turn, then loosen the adjusting nut and repeat.

Very truly yours,

CHAUNCEY PERRY
Master Sergeant
Ordnance Department

