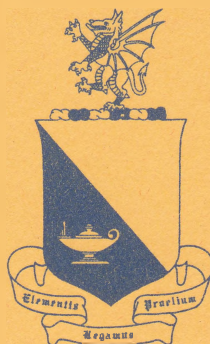


CHEMICAL WEAPONS
AND
AMMUNITION

THE CHEMICAL WARFARE SCHOOL
Book 3



THE CHEMICAL WARFARE SCHOOL
EDGEWOOD ARSENAL, MARYLAND

11570

CONTENTS

Chapter I Chemical Grenades

II Candles

III Chemical Cylinders

IV Livens Projectors

V Chemical Mortars

VI Chemical Munitions used by Artillery

VII Chemical Weapons used by the Air Corps

VIII The Technique of Firing Chemical Agents

(These Chapters are revised from time to time and when revised the revisions should be substituted to complete the text.)

CHAPTER I
CHEMICAL GRENADES

(This chapter supersedes Chap. I, Book 3, Aug.-36)

	Paragraphs
SECTION I - General	1-3
II - Standard Chemical Grenades	4-6
III - Limited Standard Chemical Grenades	7-10

SECTION I

GENERAL

	Paragraph
General	1
Classification	2
Identification Markings	3

1. GENERAL. - a. A chemical grenade is a missile filled with a chemical agent, dispersed by an ignition or exploding device, and thrown by hand or projected from a rifle or some sort of special projector.

b. Chemical grenades are used in three widely different fields - war, peacetime training, and civil disturbances. They are intended for use by the individual soldier and in war their principal application is to clear shelters, to screen, or to demoralize. Chemical grenades are of great value in the peacetime training of troops in smoke and simulated gas situations. They are extremely effective when employed in connection with civil disturbances.

c. Chemical grenades are manufactured by the Ordnance Department but are filled by the Chemical Warfare Service; they are then returned to the Ordnance Department for storage and issuance.

2. CLASSIFICATION. - Chemical grenades are primarily classified according to method of projection, as hand grenades and rifle grenades. All chemical grenades now listed as standard are hand grenades and are constructed for releasing the chemical agent by nonexplosive combustion initiated by an ignition device.

3. IDENTIFICATION. - a. Grenades in common with all chemical munitions are identified by three distinct systems of markings stenciled or painted over the blue-grey waterproofing enamel of each grenade as follows:

(1) By Symbol Designation - in yellow or red letters the code designation of the specific chemical agent; e.g., HC in yellow (hexachlorethane mixture) and CN in red (chloracetophenone).

(2) By Colored Bands - around the central portion of the grenade body. Yellow designates smoke and red designates irritant gas.

(3) By the Words - SMOKE or GAS stenciled in yellow or red, respectively.

b. The lot number is also stenciled on the grenade in yellow or red. This lot number is of great value in the investigation of munitions which may exhibit defects in the field.

SECTION II

STANDARD CHEMICAL GRENADES

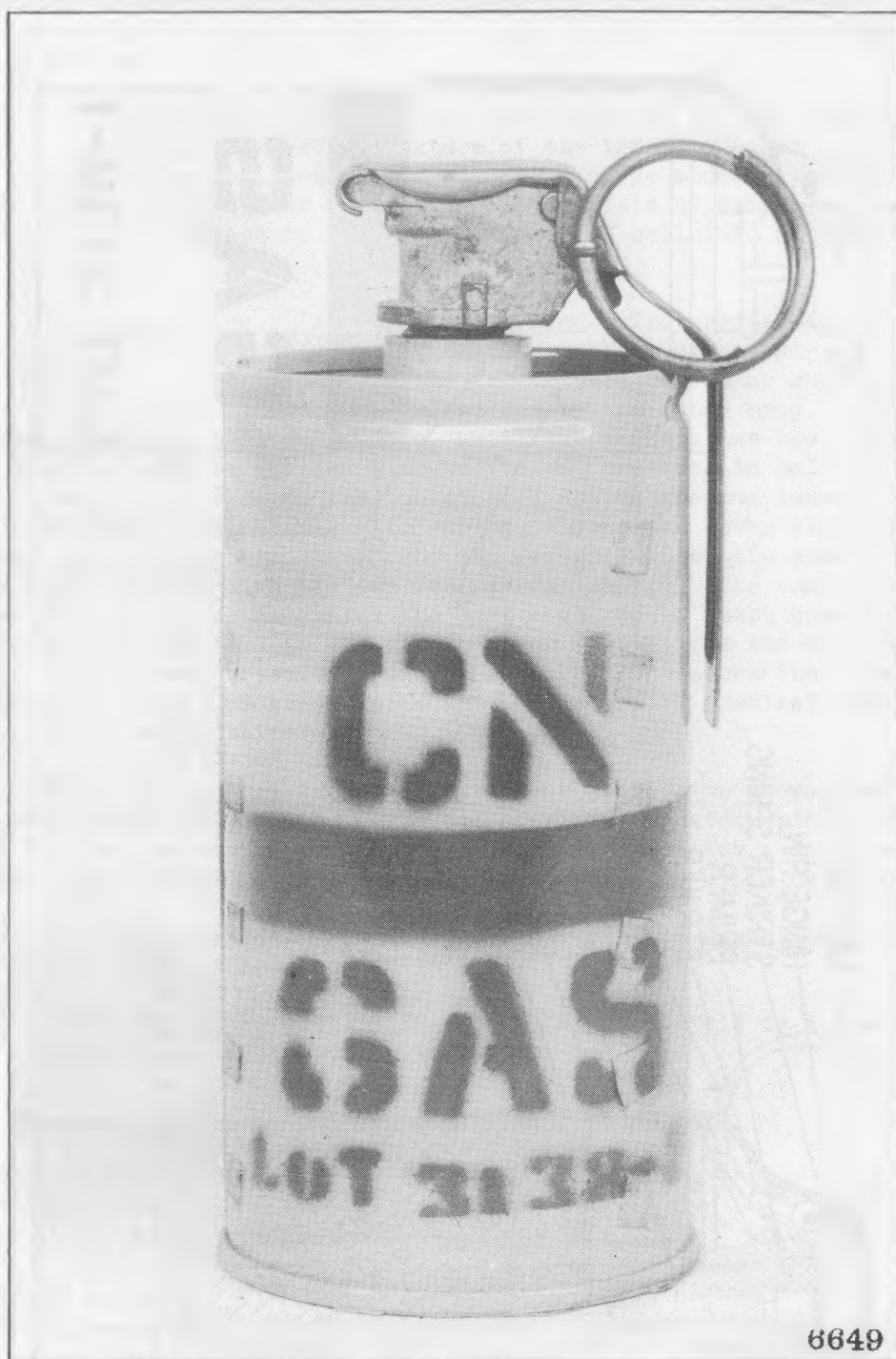
	Paragraph
General	4
Grenade, Hand, Gas, Irritant, CN-DM, M6	5
Grenade, Hand, Gas, Irritant, CN, M7	6
Grenade, Hand, Smoke, HC, M8	7

4. GENERAL. - a. The chemical grenades now listed as standard are hand munitions. These may be either thrown by hand to function at a distance as a grenade or placed upon the ground to function as a candle. When thrown by hand the maximum range is about 35 yards, depending on the ability of the individual. They are also suitable for use with fast-moving vehicles such as armored cars or tanks. When so employed they may be either thrown by hand or distributed by means of improvised dropping tubes.

b. General Description. (See Plates 1 and 2 - all standard chemical hand grenades conform in design except as to markings). - The grenade consists of the container, igniting fuze, and filling.

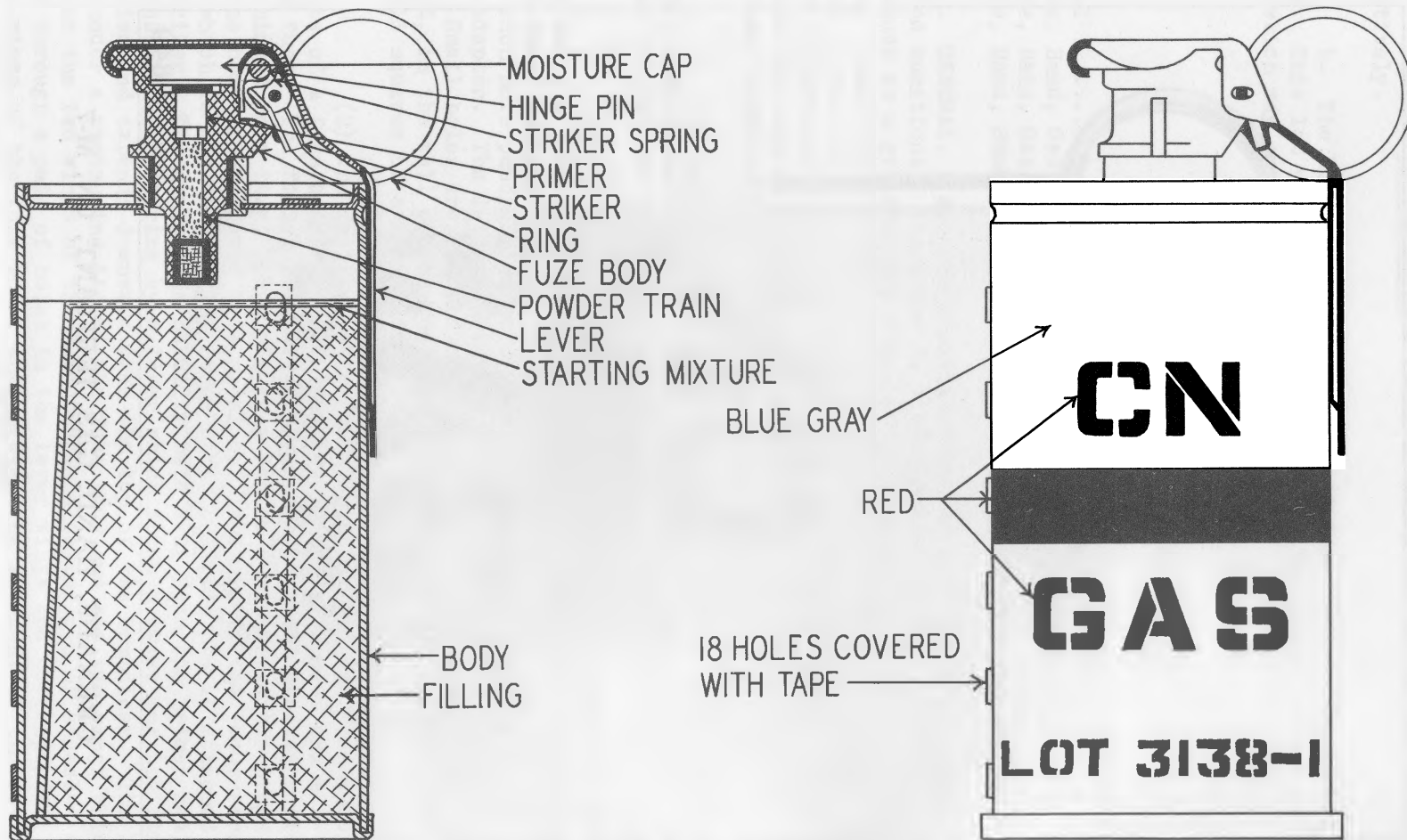
(1) The container is a tin cylinder 2-3/8 inches in diameter and 4-1/2 inches high. Two thin disks are crimped and soldered to the wall, forming the top and bottom of the container. The top has a 3/4-inch hole punched in its center into which is inserted and soldered an adapter. The latter is internally threaded to take the igniting fuze. Small holes are punched in the top of the body around the adapter, and, in the wall of the container body. These are normally sealed by small squares of adhesive tape.

(2) The igniting fuze (Hand Grenade Igniting Fuze M200) consists of a fuze body which carries the firing mechanism and a 2-second fuse. The firing mechanism consists of a steel striker horizontally hinged on a steel hinge pin in a recess between the two wings of the fuze body and actuated by a steel coil spring, of the "mouse-trap" type, which is attached to the hinge pin. A firing pin is attached to the striker. The striker is normally held away from the primer against the tension of the spring by a lever which forms a cover for the firing mechanism and extends downward over the top of the container. The lever hooks under a protruding lip of the fuze body and has two wings which fit over the two wings of the fuze body. A cotter pin of annealed steel passes through a pair of holes in the lever wings and corresponding holes in the wings of the fuze body, thus preventing movement of the lever with consequent functioning of the striker. This pin forms the safety device for the firing mechanism. The ignition system consists of a



GRENADA, HAND, GAS, IRRITANT, CN, M-7

HAND GRENADE IGNITING FUZE M200



GRENADE, HAND, GAS, IRRITANT, CN, M-7

primer of fulminate of mercury and a 2-second powder train contained in an extension of the fuze body, the base of which is sealed with a thin lead disk.

(3) The filling consists of the charge and the starter charge. The charge is a solid mixture of the irritant agent and smokeless powder with a small amount of magnesium oxide added. The starter charge is placed on top of the charge and consists of army black powder, grade A7, held in place by a binder composed of celluloid dissolved in acetone.

c. Operation. (1) Throwing by hand. The grenade is held in the hand with the end containing the fuze assembly uppermost and the lever extending into the palm at the "V" between the thumb and first finger. The safety pin is then pulled out by the other hand. After the safety pin has been pulled and, until the grenade has been thrown, the container must be gripped with sufficient pressure to hold the lever firmly against the side of the container. As the grenade leaves the hand the striker, actuated by its spring, throws the lever clear and strikes the primer. The flash from the primer ignites the powder train which in 2 seconds' time ignites the starter charge. The combustion of the starter charge generates the heat required to start combustion of the smokeless powder in the charge which volatilizes the chemical agent. The pressure resulting from the combustion forces the adhesive tape from the small emission holes and the vaporized chemical agent escapes from the container.

(2) To fire as a candle. Place grenade on ground and hold the lever firmly in position while withdrawing the safety pin. When ready to fire, release lever and move rapidly upwind for a distance of 5 yards. The functioning is the same as given under c. (1) above.

d. The grenades are issued by the Ordnance Department, packed with fuzes assembled thereto, 25 in a box.

5. GRENADE, HAND, GAS, IRRITANT, CN-DM, M6. - This is a chemical hand grenade of the fast-burning type.

Description

Weight Filled: 1 pound (approximately).
 Shape: Cylindrical.
 Color: Blue-grey.
 Safety Device: Safety pin.
 Igniter: Hand Grenade Igniting Fuze M200 (2-second delay).
 Filling: CN-DM burning mixture approximately 10 ounces (a mixture of chloracetophenone, diphenylaminechlorarsine, smokeless powder, and magnesium oxide). A thin layer of starter charge is placed on top of the charge. Each 10 ounces of the charge contains 4 ounces of CN-DM, the remaining 6 ounces being smokeless powder, et cetera. The 4 ounces of CN-DM in the grenade is a 50% mixture,

2 ounces of CN and 2 ounces of DM.
 Identification: Red letters CN-DM.
 Red word - GAS.
 One red band.
 Lot number, words and letters in red.

Characteristics
 of Cloud: Blue-grey to yellow in color, with a pungent fruit-
 like odor. The odor of smokeless powder gases
 is also apparent. The cloud has an immediate
 lacrimatory and nauseating effect on unprotected
 personnel and usually causes sneezing.

Time of Burning: 25-40 seconds (comes to full volume in about 5 sec-
 onds after ignition). A small stream of vapor con-
 tinues some 10 or 15 seconds longer.

6. GRENADE, HAND, GAS, IRRITANT, CN, M7. - (See Plates 1 and 2).
 This is a chemical hand grenade of the fast-burning type; except for the
 charge, it is identical with the M6 grenade.

Description

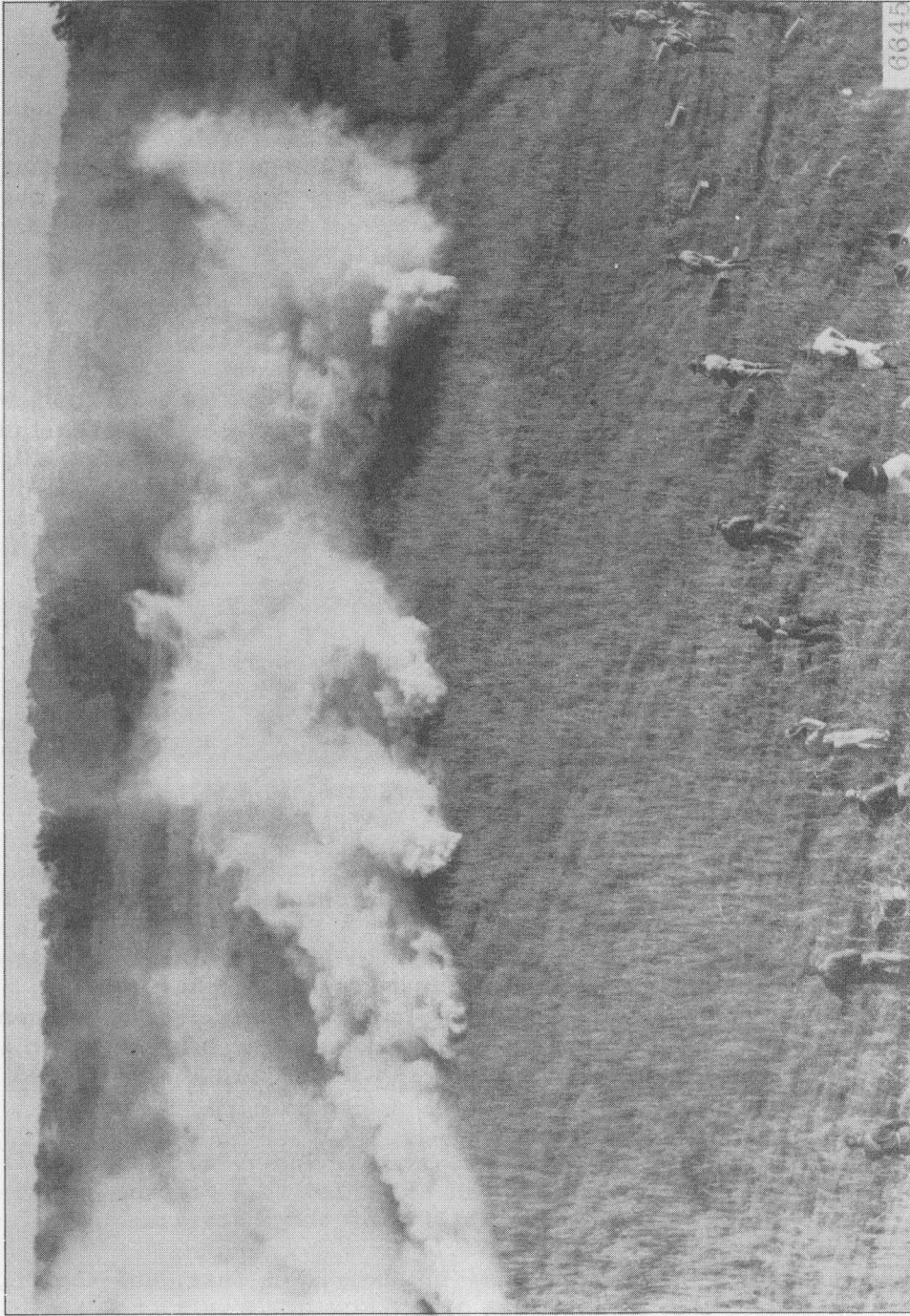
Weight Filled: 1 pound (approximately).
 Shape: Cylindrical.
 Color: Blue-grey.
 Safety Device: Safety pin.
 Igniter: Hand Grenade Igniting Fuze M200 (2-second delay).
 Filling: CN burning mixture, approximately 10 ounces (mixture
 of chloracetophenone, smokeless powder, and magnesium
 oxide). A thin layer of starter charge placed on top
 of the charge. Each 10 ounces of the charge contains
 4 ounces of CN, the remaining 6 ounces being smoke-
 less powder.

Identification: Red letters - CN.
 Red word - GAS.
 One red band.
 Lot number, words, and letters in red.

Characteristics
 of Cloud: White to blue-grey to colorless vapor having a fruit-
 like pungent odor. An immediate lacrimatory effect
 on unprotected personnel. Nontoxic except in ex-
 tremely high concentrations. Practically no obscur-
 ing effect.

Time of Burning: 25-40 seconds (comes to full volume within 5 seconds
 after igniting). A small stream of vapor continues
 some 10 or 15 seconds longer.

7. GRENADE, HAND, SMOKE, HC, M8. - This grenade is standard for
 use by the Air Corps only. This grenade is identical in design with the
 standard chemical grenades except that holes are punched in the top only
 and not in the side of the body, and the method of loading is such that
 the burning area of the HC smoke mixture is considerably less than in
 the fast-burning grenades. The size of the burning area determines
 whether a grenade is "fast" or "slow".



6645

GAS CLOUD FROM CN-DM GRENADES

PLATE 3

Description

Weight Filled: 1.75 pounds (approximately).
 Shape: Cylindrical.
 Color: Blue-grey.
 Safety Device: Safety pin.
 Igniter: Hand Grenade Igniting Fuze M200 (a 2-second delay).
 Filling: HC smoke mixture - 18.75 ounces (mixture of hexachlorethane, powdered zinc, ammonium perchlorate, and ammonium chloride. Starter charge and fast-burning mixture (about 2 ounces) are placed on top of the charge.

Identification: Yellow letters - HC.
 Yellow word - SMOKE.
 One yellow band.
 Lot number, words, and letters in yellow.

Characteristics of Cloud: Dense, white, nontoxic smoke of great obscuring power. Under normal conditions the screen established by one grenade is effective at a distance of 100 yards downwind.

Time of Burning: 3 minutes (10-15 seconds are required to reach full volume of smoke emission).

SECTION III

LIMITED STANDARD CHEMICAL GRENADES

	Paragraph
Status	8
Grenade, Hand, Gas, Irritant, CN, Mk. V	9
Grenade, Rifle, Gas, Irritant, Mk. II	10

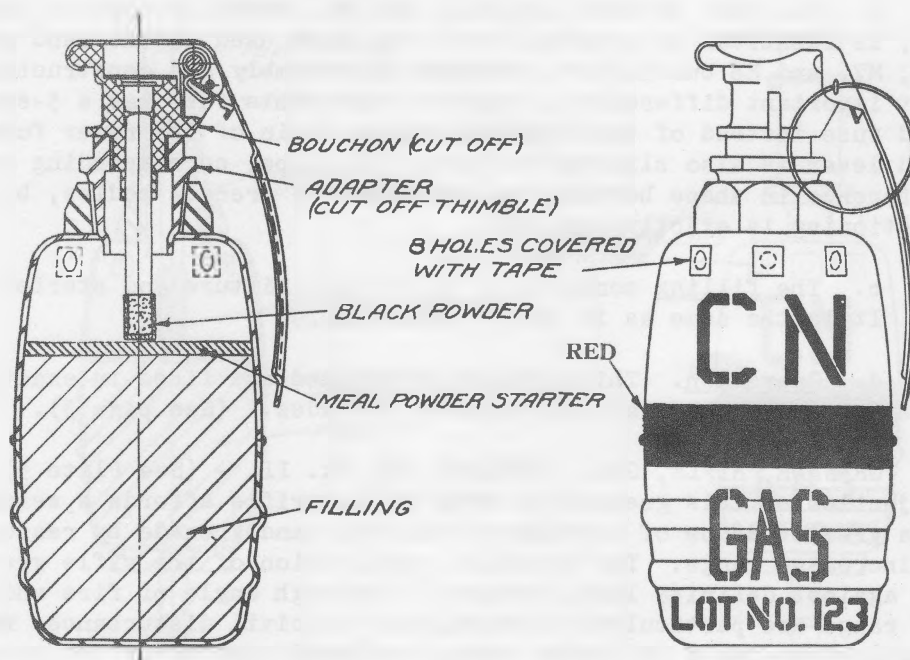
8. STATUS. - Certain chemical grenades formerly classified as standard, but which are no longer being manufactured, are available for issue until the present stocks are exhausted. Such grenades are classified as limited standard, and comprise at the present time two irritant gas CN grenades, one of these being a hand grenade and the other a rifle grenade. Both are slow-burning grenades. The old ordnance nomenclature "Mk." is used for these grenades instead of the "M" which is used for the standard grenades inasmuch as the description "Mk." was used when these grenades were developed.

9. GRENADE, HAND, GAS, IRRITANT, CN, Mk. V. - (See Plate 4). - This is a slow-burning grenade; it can be hurled to a distance of 35-40 yards, depending upon the throwing ability of the individual.

It consists of three parts: the body, the fuze, and the filling.

a. The body consists of the container, the bushing, and the thimble.

(1) The container is barrel shaped and is made in two



GRENADE, HAND, GAS, IRRITANT, CN, Mk V

cup-shaped sections of thin-drawn sheet steel which are welded together. Eight small holes for the emission of gases are punched around the upper part of the body just below the shoulder. These are sealed with small squares of adhesive tape. The outer surface is weather-proofed by a coating of enamel.

(2) The bushing is a flat steel nut welded to the container at its top to serve as a means of attachment for the thimble.

(3) The thimble is a steel well tube cut off and open at the lower end and threaded on the outside at the upper end so that it can be screwed into the bushing and is threaded on the inside at the top to take the fuze.

b. The hand grenade igniting fuze M7, which is used on this grenade, is identical in principle with the fuze used on the hand grenades M6, M7, and M8 but differs somewhat in assembly and construction. The most important difference is the fact that this fuze has a 5-second Bickford fuse instead of the 2-second powder train of the newer fuzes. The hand lever is also slightly different in shape, corresponding to the difference in shape between the two types of grenade bodies, but the functioning is exactly the same.

c. The filling consists of CN burning mixture and starter charge. It is the same as in the M7 grenade.

d. Operation. This grenade is handled and fired in exactly the same manner as the standard chemical grenades. (See page 3).

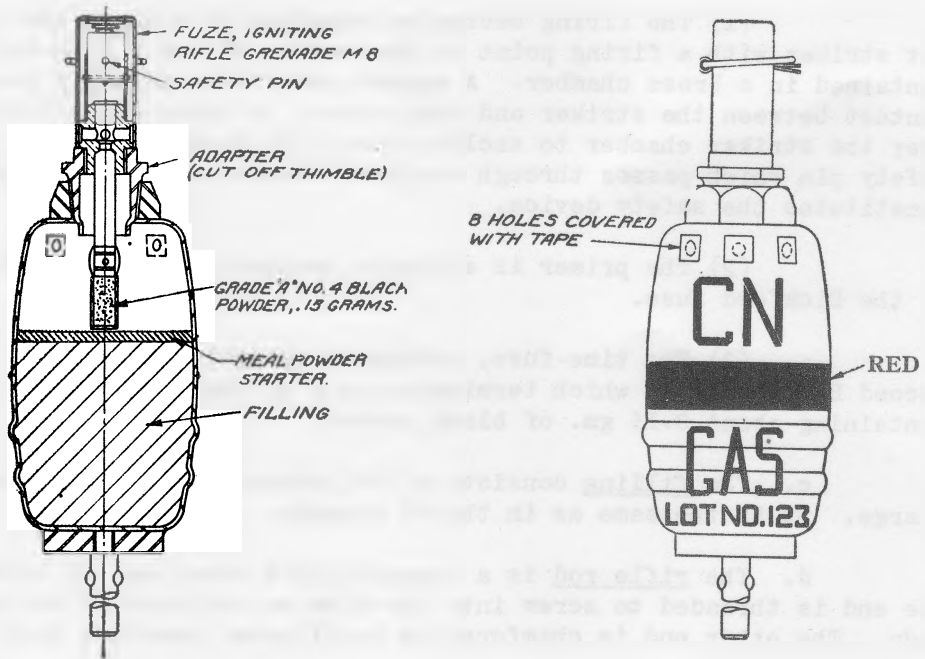
10. GRENADE, RIFLE, GAS, IRRITANT, CN, Mk. II. - (See Plate 5). The projection of this grenade by means of the rifle affords a weapon having a greater scope of usefulness than the hand grenade by reason of the increased range. The principal application of the rifle grenade is against definite local targets. The high angle of fire and greater range are particularly advantageous in civil disturbances when it is desired to reach defiladed areas, enclosed spaces, or the rear of mobs, and when mobs cannot be approached from the upwind side.

The chemical rifle grenade is screwed onto a copper-plated steel rod which is inserted into the bore of the rifle. It is projected by means of a special blank cartridge.

The range is controlled by the angle of elevation as indicated in the following table and is influenced by the speed and direction of the wind at the time of firing:

<u>Elevation</u> (Degrees)	<u>Range (approx.)</u> (Yards)
15	185
25	235
45	265

NOTE: W.D. Circular No. 27, 1928 prohibits the firing of rifle gre-



GRENADE, RIFLE, GAS, IRRITANT, CN, Mk II

nades from rifles of Springfield Armory manufacture bearing serial numbers less than 800,000 and those of Rock Island Arsenal manufacture having numbers less than 285,507.

This grenade consists of five parts: the body; the fuze; the filling; the rifle rod; and the cartridge.

a. The body, including the bushing and thimble, is identical in design with the hand grenade Mk. V except that a small steel disk is soldered to the bottom, drilled, and threaded to take the threaded end of the rifle rod.

b. The rifle grenade igniting fuze M8 consists of a firing mechanism, a primer, and a time-fuse, matchhead assembly in one unit.

(1) The firing mechanism consists of a brass inertia pellet striker with a firing point in the center of the bottom surface and contained in a brass chamber. A copper shear wire normally prevents contact between the striker and the primer. A brass cover fits snugly over the striker chamber to exclude dirt. It is held in place by a safety pin which passes through striker, striker chamber and cover, and constitutes the safety device.

(2) The primer is a simple percussion cap at the upper end of the Bickford fuse.

(3) The time-fuse, matchhead assembly includes an 8.3-second Bickford fuse which terminates in a cylindrical shaped lead tube containing about 0.15 gm. of black powder.

c. The filling consists of CN burning mixture and starter charge. It is the same as in the M7 grenade.

d. The rifle rod is a copper-plated steel rod 15 inches long. One end is threaded to screw into the disk on the base of the grenade body. The other end is chamfered to facilitate insertion into the barrel.

e. The cartridge is a .30 cal. special blank cartridge employed in the rifle as the grenade propellant.

f. Operation. When the safety pin and cover have been removed and the grenade is ready to fire, the shear wire alone prevents contact between striker and primer. Upon discharge of the rifle, the forward movement of the grenade and inertia of the striker cause the shear wire to be cut and the striker to explode the primer. The flash from the primer ignites the fuse which, after 8.3 seconds, flashes the matchhead. This in turn ignites the starter charge and main charge.

CHAPTER II

CANDLES

(This chapter supersedes Chap. II, Book 3, Aug.-36)

SECTION		Paragraphs
I	- General	1-2
II	- Candles, Gas, Irritant	3
III	- Smoke Pots	4-5
IV	- Limited Standard Candles	6-8

SECTION I

GENERAL

	Paragraph
Development of Smoke Candles	1
Tactical Uses	2

1. DEVELOPMENT OF SMOKE CANDLES. - The development of candles for the production of obscuring smokes and irritant gases grew out of a demand for a small munition which could be carried and employed by individuals. Moreover, a munition was desired that would produce an extensive cloud or fog on the ground to overcome the disadvantages inherent in smoke produced by detonation - as from shell - a considerable portion of which is initially blown high into the air. The several smoke candles which were developed during the war have been superseded by more efficient candles, including lacrimatory and irritant candles.

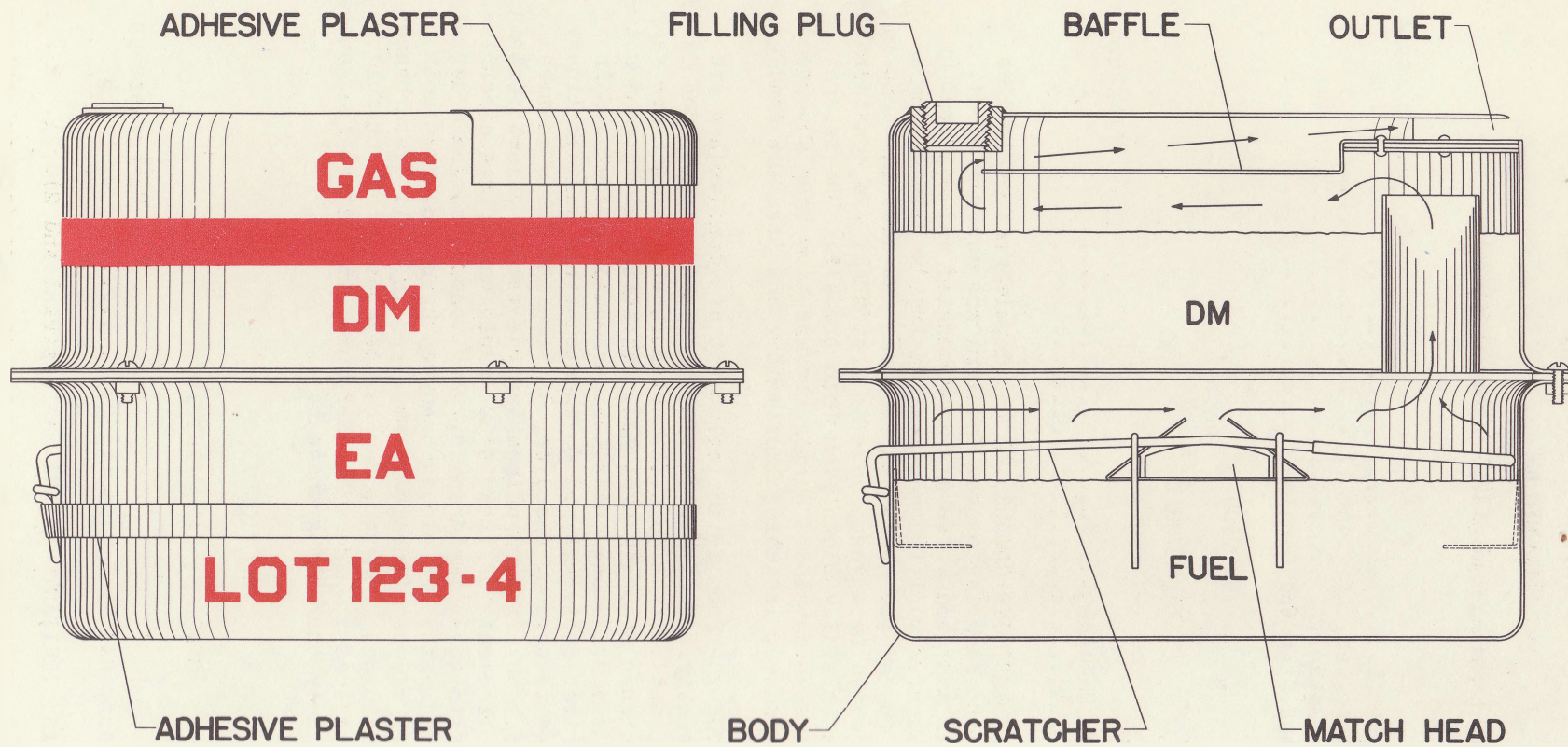
2. TACTICAL USES. - From a tactical point of view candles are munitions of opportunity. Their successful use is dependent upon favorable wind, weather, and terrain conditions. However, candles are very efficient munitions when properly employed, and afford advantages not possessed by other means. Smoke candles or grenades may be used in screening flanks, river crossings, or movements within our own lines. They may be employed to screen, disguise, or simulate other chemical attacks, or to draw enemy fire on unimportant or remote objects within our own lines. Emplacements of these smoke munitions, fired electrically, may be employed to cover withdrawals. Irritant smokes have certain advantages possessed by the gas clouds produced by cylinders. Both candles and grenades may be effectively employed in civil disturbances and in peacetime training. However, the candle does not reach full volume as quickly as does the grenade; therefore, it has not the general usefulness in riot duty that the grenade has.

SECTION II

CANDLES, GAS, IRRITANT

	Paragraph
Candle, Gas, Irritant, DM, MI	3

3. CANDLE, GAS, IRRITANT, DM, MI. - (See Plates 1 and 2). a. The



DM IRRITANT GAS CANDLE MI



CANDLE, GAS, IRRITANT, DM, MI

DM candle is the only candle now listed as standard. It differs fundamentally from the smoke candles designed for screening in that it is intended for harassing effect rather than for obscuring purposes. This candle, as a weapon, may be considered as a convenient substitute for the portable chemical cylinder within the limitations of its chemical filling. Large clouds are easily produced which possess the advantages of extensiveness, pervasiveness, and duration of cylinder gas clouds. When employing the DM candle greater safety and a smaller expenditure of effort results than with the cylinder operation. In addition the irritant smokes are difficult to protect against, having the power to penetrate an otherwise efficient gas mask unless constructed with a special smoke filter. The DM candle is a very effective weapon when properly employed but, like the portable chemical cylinder, its use is dependent upon favorable wind and weather conditions. It shares an additional disadvantage with cylinders in that the concentration of the cloud is greatest at the point of emission, i.e., in or close to our own lines where it is least desired.

b. Description. The DM irritant candle consists of two cylindrical compartments of sheet steel 7 inches diameter by 2-7/8 inches high, placed one above the other, and bolted together on an external flange with an asbestos gasket in between. It is painted blue-grey.

The lower compartment contains a 3-1/4 pound cake of smokeless powder which is used as fuel to supply heat and hot gases to sweep over the surface of the DM. Mounted on the cake is an ignition device consisting of a matchhead and a red phosphorus-coated pull wire. The matchhead is crimped into a zinc cup set in the center of the surface of the cake and held in place by anchor posts which pierce the cup and are embedded in the cake. The tops of the anchor posts are loops and serve as guides for the pull wire. The coated portion of the wire normally lies to one side of the matchhead. The uncoated portion extends outward through a hole in the side of the compartment where it terminates in a loop. The loop is bent down against the side of the compartment and is held in place and protected by a wide covering of adhesive tape.

A circular flue 1 inch in diameter and 2 inches long placed close to the compartment wall is the only communication between bottom and top compartments.

The upper compartment contains a 2-pound cake of DM (diphenylaminechlorarsine). Above the cake is a metal baffle or deflector which causes the heated gases from the burning powder to traverse the upper surface of the DM cake before finding exit into the chamber formed by, and above, the baffle. The smoke vapors leave the candle through an annular slot in the wall of the upper compartment just below the top cover. The slot is normally covered by adhesive tape to exclude dirt and moisture.

c. In Operation. The DM candle utilizes the principle of steam distillation to disperse the agent, as DM decomposes on ordinary distillation. It is therefore necessary to cause the agent to vaporize at a temperature lower than its normal boiling point. This is accom-

plished by passing the hot gases from the burning smokeless powder through the flue into the upper compartment and across the surface of the DM as it is being heated. The vapor is carried above the baffle, and through the slot into the air where it quickly cools and condenses to form a smoke. The complete candle weighs 9-1/4 pounds.

d. Directions for Use. Remove tapes from the exit slot and wire loop of the pull wire. When ready to fire, place candle on the ground in an upright position with gas exit pointing downwind. Hold candle firmly to the ground, straighten wire loop to a horizontal position, and pull out quickly until it stops. A hissing sound indicates ignition has taken place. In case of failure on first trial, push the wire back to its original position and again pull. Immediately after ignition, move at least five yards upwind of the candle. DM candles are not fired electrically.

e. Characteristics of Cloud. DM candles produce a heavy canary-yellow cloud with a "smoky" odor, having an immediate irritating action on unprotected personnel. The physiological effects are manifested in sneezing and coughing followed by nausea and a feeling of both physical and mental depression. Although rapidly incapacitating, the effects of DM are not fatal except under most extreme concentrations. DM smoke has a slight corrosive action on metals, rusting iron and steel and tarnishing bronze and brass.

The candle burns 2 to 4 minutes.

DM smoke is a particulate cloud having a decided ability to penetrate a gas mask canister lacking an adequate filter.

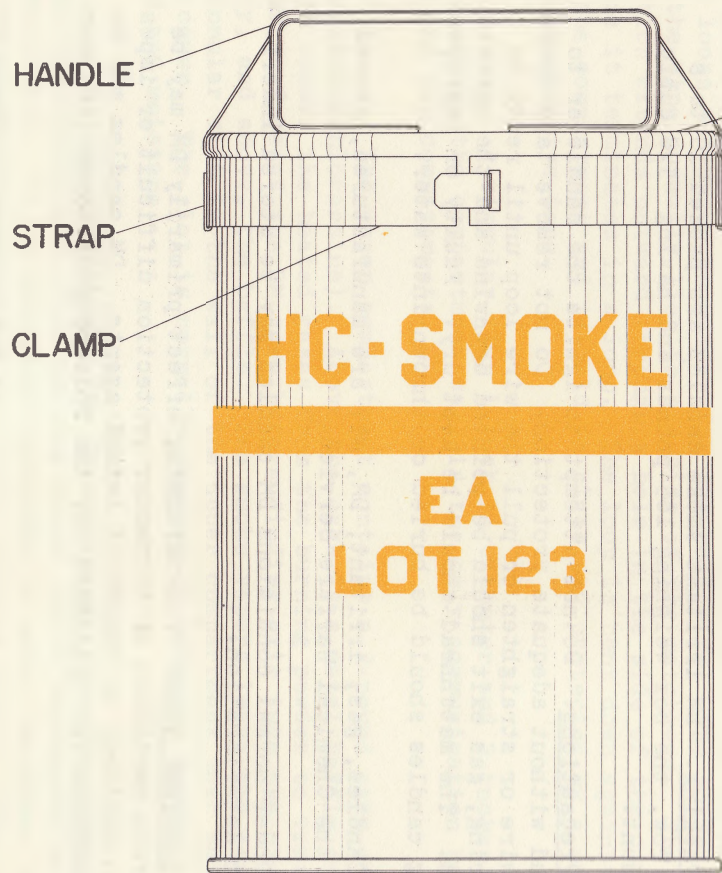
f. Packing. DM irritant smoke candles are packed 10 to a box in double row, the box weighing 165 pounds and having 5.8 cubic feet displacement.

g. Precautions. Do not attempt to ignite the candle or to enter the cloud without adequate protection. Do not remove tape covering the pull wire or straighten or pull the wire loop until ready to use. When firing, gas exit should be pointed downwind and the operator located upwind. The matchhead should be kept dry. Faulty or improperly functioning candles should be buried or thrown into water.

h. Candles, gas, irritant, DM, MI, are manufactured, stored, and issued by the Chemical Warfare Service.

Under normal conditions DM candles may be stored indefinitely without deterioration.

i. Tactical Uses. For harassing effect primarily DM may be used to penetrate canisters or to render protection difficult or impossible prior to delivery on target of lethal agents. DM candles may be used as a substitute for cylinders for the releasing of large irritant-smoke clouds.



ADHESIVE
PLASTER

SCRATCHER
ENVELOPE

SCRATCH
BLOCK

STARTER
MIXTURE

BODY

SMOKE
MIXTURE

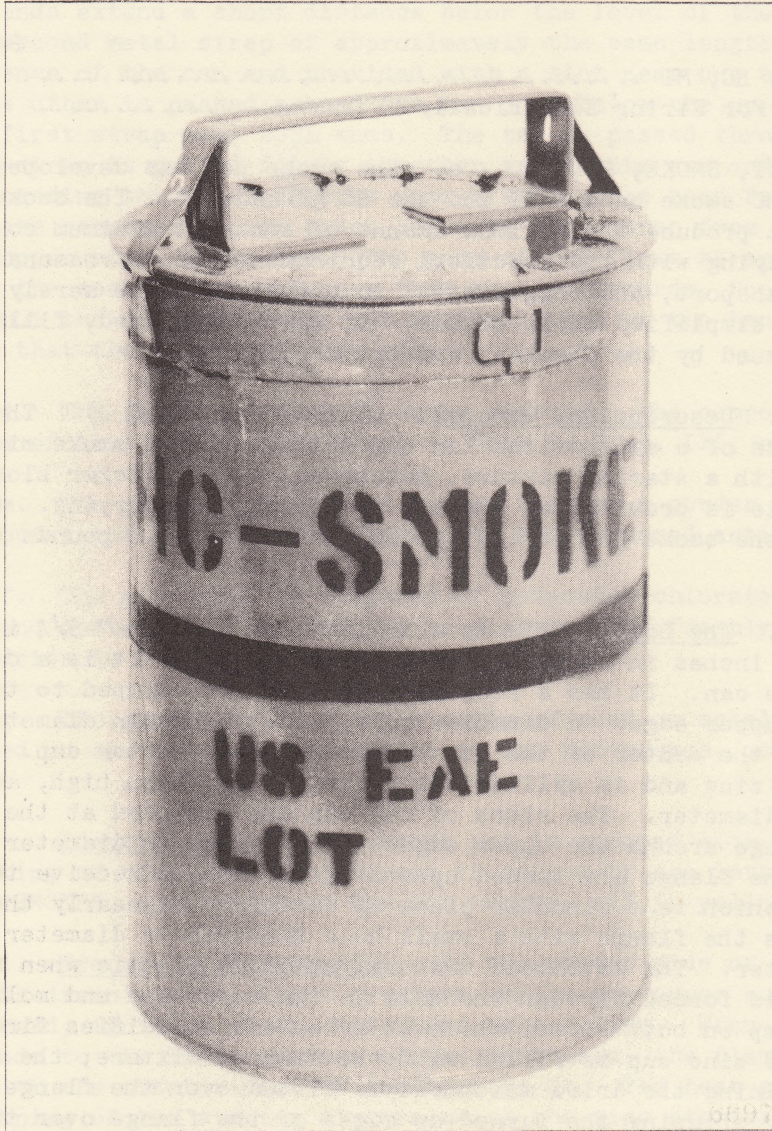
COVER

TOP

MATCH
HEAD
COVER

MATCH
HEAD
MIXTURE

HC SMOKE POT



POT, SMOKE, HC MI

j. Identification. The DM candle is marked in red with the letters "DM", with one red band, and with the words "GAS IRRITANT".

SECTION III

SMOKE POTS

	Paragraph
Pot, Smoke, HC, MI	4
Directions for Firing Electrically	5

4. POT, SMOKE, HC, MI. - a. The smoke pot was developed to replace the HC smoke candle MI and the HC grenade M8. The smoke pot is designed to produce the maximum amount of smoke at minimum cost while still complying with the practical requirements as to reasonable size, ease of transport, and ruggedness. In principle it is merely an enlarged and simplified smoke candle. It is manufactured, filled, stored, and issued by the Chemical Warfare Service.

b. Description, General. (See Plates 3 and 4). The HC smoke pot consists of a cylindrical tin can filled with HC smoke mixture and equipped with a starter mixture, matchhead, and scratcher block. A metal handle is provided at the top to facilitate carrying. The total weight of the smoke pot is 14.3 pounds, of which 12.5 pounds is smoke mixture.

c. The Body. This is a cylindrical tin can 7-3/4 inches high and 5-5/16 inches in diameter, with crimped seams. It is a commercial-type grease can. It has a recessed top which is crimped to the side along the upper edge. A circular hole 2-1/8 inches in diameter is punched in the center of the top to receive the starter cup. This cup is made of zinc and is cylindrical in shape, 3/4 inch high, and 1-1/8 inches in diameter. The sides of the cup are extended at the top to form a flange around the upper edge 2-5/16 inches in diameter. The edges of the flange are turned upwards 9/64 inch to receive the matchhead disk which is a circular piece of cardboard of nearly the same diameter as the flange with a small hole 1/4 inch in diameter punched in the center. The matchhead mixture, which is plastic when freshly prepared, is forced through the hole in the cardboard and molded into a small lump on both sides, where it dries and solidifies firmly in place. The zinc cup is filled with the starter mixture; the matchhead disk containing the dried matchhead is fitted over the flange and held in place by crimping the turned-up edges of the flange over the cardboard. When thus assembled, the matchhead is directly over and in close contact with the starter mixture.

Prior to this assembling, the can is filled with the HC smoke mixture which is pressed firmly into place, leaving a small cylindrical hollow space in the center of the top surface of the press cake into which the zinc starter cup fits. The recessed top assembly is covered by a circular metal cover which fits into the recess. A metal handle is soldered to the top of the cover. Between the cover and the recessed top there is placed a scratcher block to be used in igniting the matchhead. To prevent the scratcher block from coming in

contact with the matchhead before use it is placed in a small manila envelope and, as an additional precaution, a strip of manila paper is placed over the matchhead. The seam between the cover and the side of the can is sealed with adhesive tape. Finally, the cover with its handle is held firmly in place as follows: A metal strap is passed over the top of the handle and down on opposite sides of the can so that the ends extend a short distance below the level of the cover surface. A second metal strap of approximately the same length as the circumference of the can and provided with a slot near one end and a tab at the other is passed around the can just below the upper edge and over the first strap near both ends. The tab is passed through the slot, the strap is pulled firmly together around the can and held in place by bending the tab backwards upon itself. The bead formed by crimping the recessed top in place prevents this strap from slipping over the upper edge of the can. The ends of the first strap projecting below the second strap are now bent sharply upwards, forming hooks. Thus the complete smoke pot may be lifted by the handle with no danger that the cover may come off.

d. The filling is the HC smoke mixture. The composition and properties of this mixture are given in Book 2, Chap. III, par. 14.

e. The starter mixture is in the form of a powder and is composed of potassium perchlorate, zinc dust, and powdered antimony.

f. The matchhead is composed of potassium chlorate, antimony sulfide, and dextrine. This mixture is plastic when freshly prepared but soon dries to a solid mass.

g. The scratcher block is a strip of wood or metal which has been coated on one side with a mixture of red phosphorus, dextrine, and sand.

h. Identification. The smoke pot is sprayed with a water-proof coating of blue-grey lacquer and is marked by the letters "HC", the word "SMOKE", one band, and the lot number, all in yellow.

i. Process of Functioning. If the coated side of the scratcher block is drawn with a slight pressure across the upper surface of the matchhead, ignition of the matchhead takes place. When this ignition spreads to the lower surface of the matchhead, the flame comes in contact with the starter mixture and ignites it. The heat generated by the burning of the starter mixture melts the zinc starter cup and the still burning starter mixture comes in contact with and ignites the HC smoke mixture. Then the evolution of HC smoke commences. The amount of smoke produced during the first 20 seconds is comparatively small. The average burning time is 6-1/2 minutes.

j. Characteristics of Cloud. The HC smoke pot forms a dense, greyish white, nonirritant smoke of high obscuring value.

k. Directions for Use. Straighten the tab of the metal strap

around the can, remove the tab from the slot, and remove the entire strap. Remove the other metal strap that passes over the handle. Remove the adhesive tape and metal cover. Take out the envelope containing the scratcher block and remove the strip of manila paper from over the matchhead. Remove the scratcher block from the manila envelope. Set the smoke pot in proper position on the ground. Hold the coated side of the scratcher block in direct contact with the matchhead and draw this scratcher block across the surface of the matchhead at the same time applying gentle pressure with the fingers. If ignition fails, repeat the process pressing somewhat harder with the fingers so as to increase the friction. The position of the smoke pot on the ground may be varied according to the rate of burning desired. If the smoke pot is set upon its base the burning time will probably vary between the average and the maximum. Laying it on its side, on the other hand, tends to speed up the rate of burning.

l. Packing. HC smoke pots are packed six to a box, upright, and in a single layer. The packed box weighs about 96 pounds, with a displacement of 1.7 cubic feet.

m. Precaution. The smoke pot should stand storage indefinitely under proper conditions. The chemical components are sensitive to moisture, but this will cause no trouble unless the covers are opened or the smoke pots stored under such extremely moist conditions that the cans are rusted through. After opening the cover of a smoke pot the matchhead must be kept dry until used. Faulty or improperly functioning smoke pots should be buried or thrown into water.

n. Tactical Uses. HC smoke pots may be used generally for purposes indicated in the opening paragraphs of this chapter.

5. DIRECTIONS FOR FIRING ELECTRICALLY. - a. To fire the HC smoke pot electrically. Remove the cover, withdraw the matchhead, and insert the open end of an electric squib into the matchhead hole and tape it securely in this position; or a squib may be taped to the smoke pot so that the flash will be communicated directly to the matchhead instead of the starter mixture.

b. In wiring connect the squib wires of not more than 20 smoke pots in one electrical series, and connect the free ends of the first and last squibs to a lead wire from the terminals of the exploder (i.e., machine, blasting, 100 cap.) using wire, firing, L.P. or its equivalent for lead wire. Fire by operating the exploder in the usual manner. For training purposes, when exploders are not available, smoke pots may be fired by connecting the lead wires to an automobile battery. With the latter method best results will be obtained by wiring the smoke pots in parallel.

c. Precautions. The circuit should be tested by means of a circuit detector before firing to make certain that the circuit is intact. The metal cover should be laid in place over the squib and matchhead to exclude moisture, but should not be forced into position as it might damage the squib or cut the wires. Under no circumstances use detonators or blasting caps in place of squibs.

NOTE: An electric squib is a small paraffined paper tube containing a small quantity of black powder. It is ignited by means of an electrical current carried by two 4-ft. or 6-ft. wires. When ignited it produces a flash. An electric detonator is a small copper tube containing a charge of fulminate of mercury. It carries wires similar to those of a squib.

SECTION IV

LIMITED STANDARD CANDLES

	Paragraph
Status	6
Candles, Lacrimatory, CN, Slow, MI	7
Candle, Smoke, HC, MI	8

6. STATUS. - Certain candles formerly listed as standard have been reclassified as limited standard since the discontinuance of their manufacture. Such munitions will continue to be issued until the present stocks are exhausted. The candles described in the subsequent paragraphs are now designated as limited standard and have been taken over by the Ordnance Department for storage and issue.

7. CANDLES, LACRIMATORY, CN, SLOW, MI. - (See Plates 5 and 6).
 a. Description. This candle is a tear-producing munition. It consists of a cylindrical container of tin 4 inches in diameter and 2-3/4 inches high. A disk of tin plate is crimped in place about 1/8 inch below the upper edge of the container forming a depressed case cover. A 7/8-inch hole is punched in the center as an outlet for the gases, and a 1/4-inch hole is on one side for the matchhead. A small scratcher block is taped in place opposite the matchhead. The candle is provided with a removable cover sealed with adhesive tape. The candle weighs 1.3 pounds and is painted blue-grey. It burns for about 2 minutes.

b. The filling is a solid mixture of chloracetophenone, smokeless powder, and magnesium oxide, weighing 12 ounces. On top of it is a thin layer of starter mixture composed of meal powder, ferrous sulphide, and iron oxide, bound by a mixture of nitrocellulose and acetone.

c. Identification. This candle is identified by means of the letters "GAS CN" and a 1/2-inch band around the candle, all in red.

d. Directions for Use. Remove sealing tape and the cover. Remove scratcher block. Place candle on the ground and draw the coated side of the scratcher block across the matchhead. Evolution of CN commences in three seconds.

The CN candle may be fired in groups electrically, as described in par. 5. In this case the electric squib is taped to the candle in such a manner that the open end lies against the matchhead.

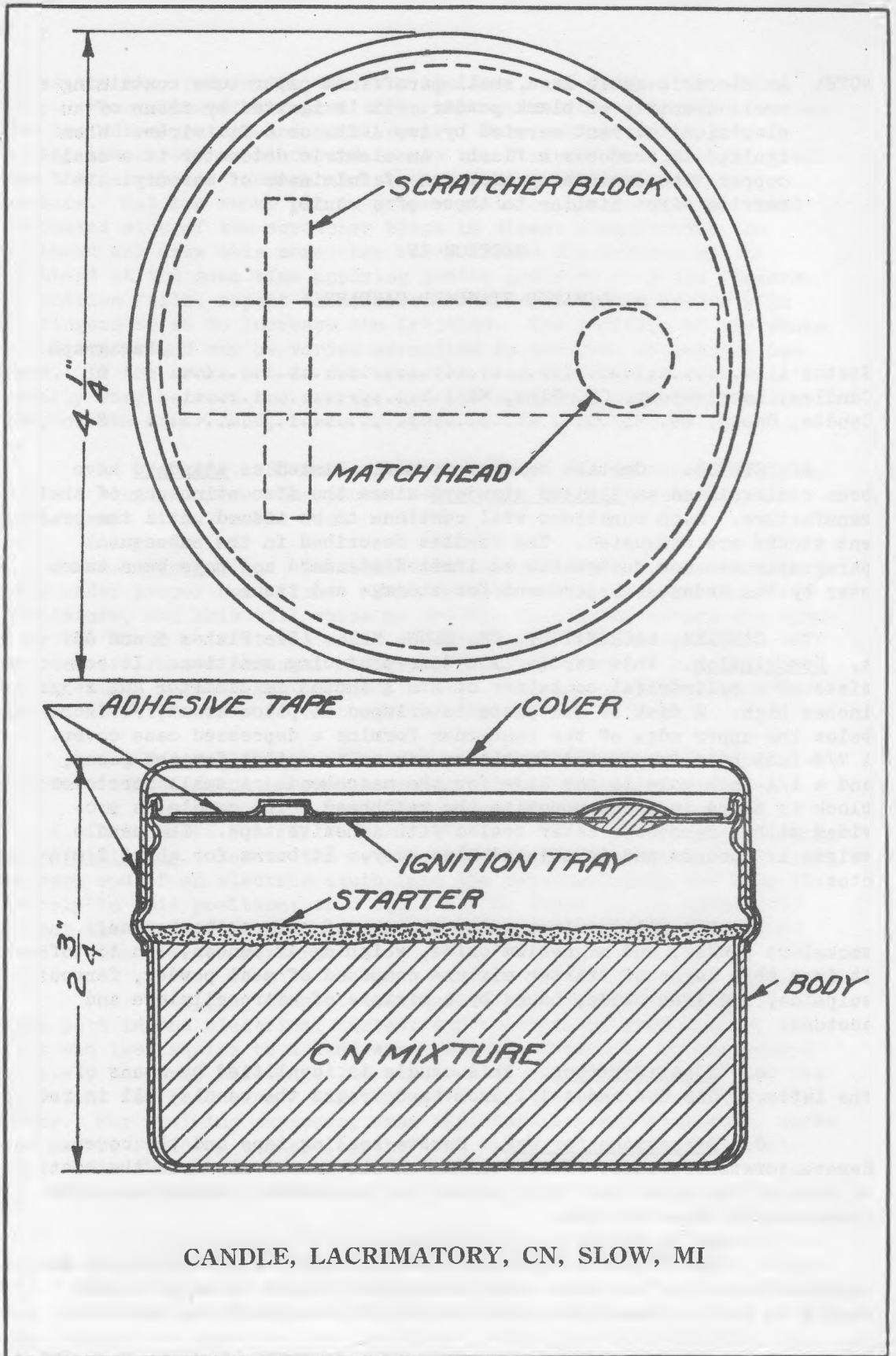


PLATE 5



CANDLE, LACRIMATORY, CN, SLOW, MI

Should the candle burst into flame upon ignition, extinguish the flame by striking the orifice quickly with any light pliable object, such as a leafy branch.

e. Characteristics of Cloud. The CN candle emits a white to blue-grey cloud to colorless vapor having a fruit-like pungent odor and an immediate lacrimatory effect on unprotected personnel. It is incapacitating but is nontoxic except in extremely high concentrations. The vapor has very little obscuring effect.

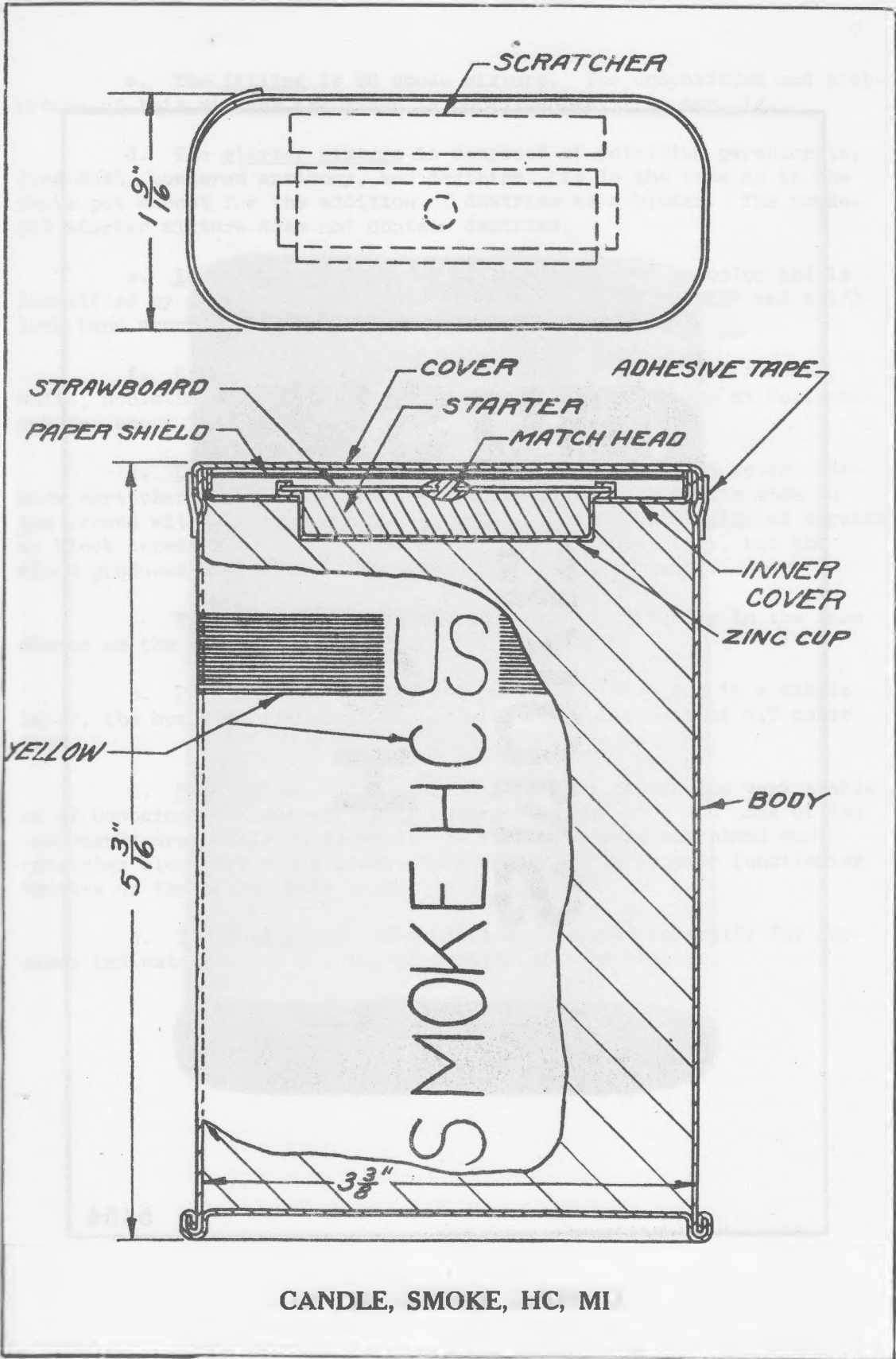
f. Packing. CN candles are packed 25 to the box in one layer. Weight 45 pounds; displacement 1.1 cubic feet.

g. Precautions. The matchhead must be kept dry until ignited. The smokeless powder of the CN mixture is known to deteriorate at high temperatures but does not constitute an explosive hazard because of the retarding effect of the chloracetophenone. The CN candle, nevertheless, should be kept in cool, dry storage. Improperly functioning candles should be buried or thrown into water.

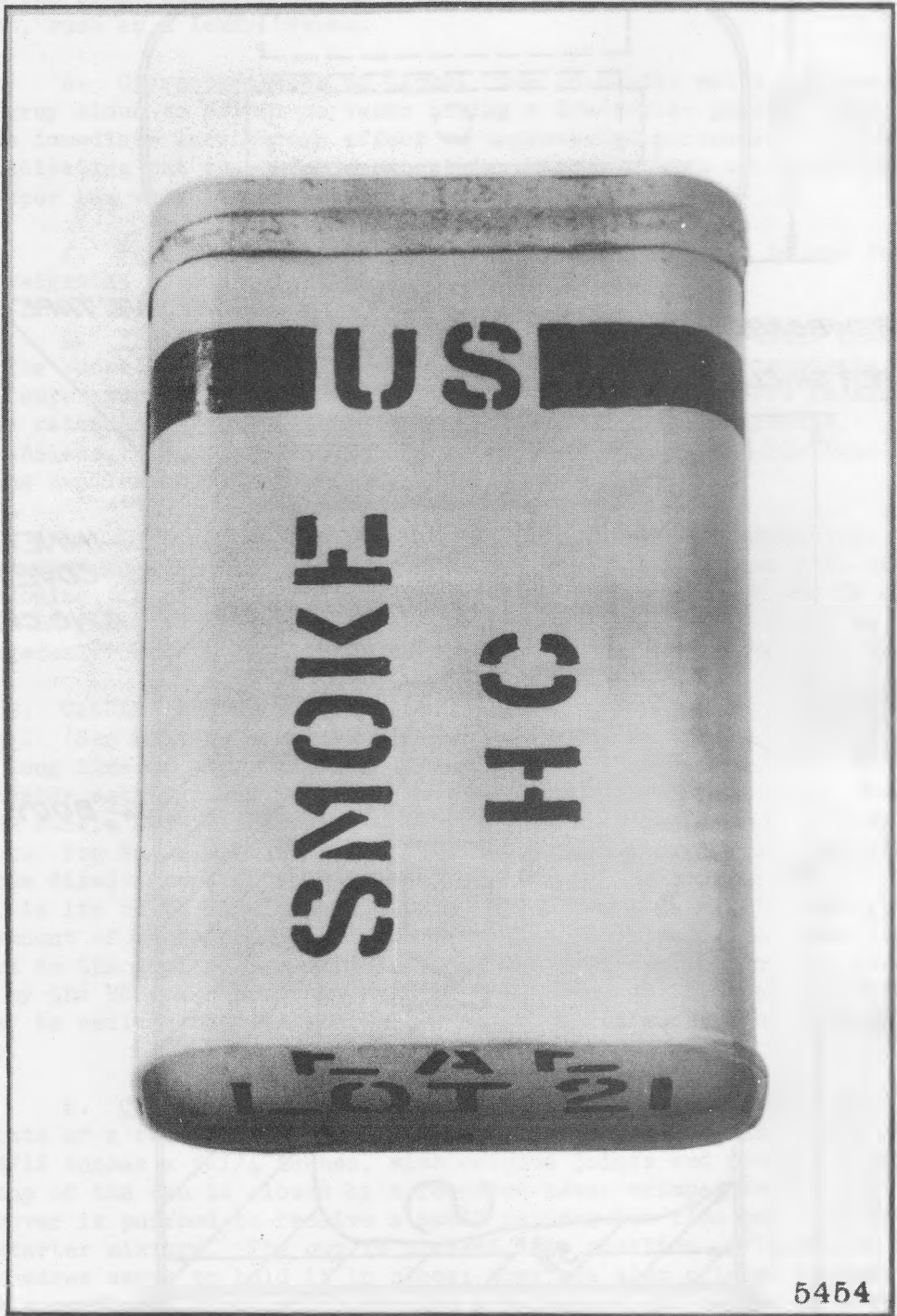
h. Tactical Uses. The CN candle is a harassing munition. It may be used to advantage against mobs but, due to its slower rate of functioning, is not as effective for this purpose as either the CN or the CN-DM grenade. The candle, being an effective irritant, can be advantageously used in peacetime training for simulating lethal war gases.

8. CANDLE, SMOKE, HC, MI. - a. Candle, Smoke, HC, MI (Hexachlorethane). (See Plates 7 and 8). The HC smoke candle is the final result of a long line of experimentation which aimed at the development of a thoroughly satisfactory smoke candle. It is smaller and lighter than the old BM candle and is shaped so as to fit conveniently into a soldier's pocket. The smoke mixture is stable, homogeneous, and solid throughout. The one disadvantage of this candle, just as in the case of the HC grenade, is its cost. A single candle costs 90 cents, which is high for the amount of smoke produced. The HC candle has, therefore, been transferred to the limited standard list and has been replaced on the standard list by the HC smoke pot. In case of war, however, it is possible that it may be reclassified as standard because of its convenient size and shape.

b. Construction. (See Plates 7 and 8). The HC smoke candle consists of a rectangular tin can, resembling a tobacco can, 1-1/2 inches x 3-5/16 inches x 5-1/4 inches, with crimped joints and rounded corners. The top of the can is closed by a recessed cover crimped to the sides. The cover is punched to receive a small rectangular zinc cup containing the starter mixture. The cup is pressed into position. Flanges on its upper edges serve to hold it in place; they are also crimped to hold in place a cardboard strip which carries a matchhead and serves as a cover for the starter mixture. A loose scratcher block is placed in the upper recess and is separated from the matchhead by a piece of paper. The can is closed by a removable cover sealed by adhesive tape. The candle weighs approximately 2 pounds and is weatherproofed by a coating of lacquer.



CANDLE, SMOKE, HC, MI



CANDLE, SMOKE, HC, MI

c. The filling is HC smoke mixture. The composition and properties of this mixture are given in Book 2, Chap. III, par. 14.

d. The starter mixture is composed of potassium perchlorate, zinc dust, powdered antimony, and dextrine. It is the same as in the smoke pot except for the addition of dextrine as a binder. The smoke-pot starter mixture does not contain dextrine.

e. Identification. The candle is blue-grey in color and is identified by means of the letters "HC" and the word "SMOKE" and a 1/2-inch band around the candle, all in yellow.

f. Characteristics of Cloud. The HC candle forms a dense, white, nonlethal smoke of great obscuring value. It burns at full volume for about 3 minutes.

g. Directions for Use. Remove adhesive tape and cover. Remove scratcher block and paper separator. Lay candle on its side on the ground with the top pointing downwind. Draw treated side of scratcher block across matchhead. The candle ignites immediately, but the cloud produced during the first 10 to 20 seconds is small.

The HC smoke candle may be fired electrically in the same manner as the smoke pot. (See par. 5).

h. Packing. HC candles are packed 25 to a box in a single layer, the box weighing about 60 lb. with a displacement of 0.7 cubic feet.

i. Precautions. The chemicals in this candle are very stable as it contains no electrolytes to undergo dissociation and none of the components are liable to decompose on storage. Keep matchhead and scratcher block dry until used. Bury faulty or improperly functioning candles or throw them into water.

j. Tactical Uses. HC candles may be used generally for purposes indicated in the opening paragraphs of this chapter.

CHAPTER III

CHEMICAL CYLINDERS

(This chapter supersedes Chap. III, Bk. 3, May-37)

	Paragraphs
SECTION I - General	1-5
II - The Portable Chemical Cylinder	6-9
III - Agents Used in Cylinders	10-13
IV - Flame Throwers	14-16

SECTION I

GENERAL

	Paragraph
Definition	1
Early Cloud-Gas Attacks	2
Value of Cloud Gas	3
Tactical Uses	4
Present Status of Cylinders	5

1. DEFINITION. - "Chemical cylinder" is the name given generally to any of the various containers used for the handling and transportation of chemicals in the liquid state, and also applies specifically to containers used as weapons for the release of gas in quantity, and employed in the cloud form of attack.

2. EARLY CLOUD-GAS ATTACKS. - The cylinder cloud-gas attack was the first method employed during the World War for the projection of warfare gases in appreciable quantities. Extensive clouds of chlorine, phosgene, or combinations of these were released on wide fronts. Transported by the wind, these clouds were carried over targets, enveloping them in a continuous pervading blanket of gas, flowing into depressions, dugouts and shelters, and often penetrating to a considerable depth within enemy territory.

For nearly a year after the first gas attack of the World War in April, 1915, cloud gas was the most deadly form of chemical attack, but it gradually became less effective as the efficiency of gas masks increased, and as collective experience and vigilance minimized the element of surprise.

The first cylinders used were approximately 4 feet long and when filled weighed about 140 pounds. They were installed in groups of four in pits dug under front-line parapets, in the firing step, or bottom of the trench, along an extended front. Each group was connected by rubber hoses to a four-way connection having a single outlet pipe. This extended over the parapet about 8 feet. When weather and tactical conditions were favorable, the nozzles were opened simultaneously all along the line; the contents of the cylinders were discharged and the cloud formed in a few seconds.

To install these cylinders with requisite secrecy and in sufficient numbers to carry out a cloud-gas attack of any size, required considerable care, preparation, and a vast amount of labor. To install 150 cylinders required troops to carry up 14 tons of material, plus the labor of installation. Until fired, these installations were a source of danger to troops because of the possibility of premature release of the gas by enemy shell fire.

Although relegated to a position of minor importance during the last part of the war, cylinders were effectively employed by the British in the latter part of 1918. In these instances the disadvantages previously indicated were removed by massing cylinders on flat cars, moving the trains rapidly forward and releasing the gas by electrical detonation.

3. THE VALUE OF CLOUD GAS. - The value of cloud gas lies in the fact that high concentrations of chemical agents in vapor form can, with little or no warning, be made to cover any desired front. In a steady favorable wind, it is practicable to launch a cloud covering a front of a mile or more and in such a high concentration as to pervade the entire area and penetrate inferior or defective masks. Under favorable conditions, clouds have proved lethal after traveling six to eight miles from the point of release.

The principal limitations in the use of cylinders are meteorological conditions and the quantities that can be transported to the point of release.

4. TACTICAL USES OF CYLINDERS. - a. Cylinders are used with nonpersistent agents for casualty effect only. The limit of effectiveness and range are governed by the number of cylinders used on a given front (i.e., density). Cylinders reach their greatest utility in stabilized warfare, or in the initial phases of attack in mobile warfare. Open warfare and rapid movement will limit the use of cylinders; in the initial phases of an attack there will be frequent opportunities for employing them. For training or demonstration purposes, cylinders may also be used with smoke or nontoxic agents to simulate the presence of casualty-producing agents.

b. Flat or gently sloping terrain is best suited to cloud-gas attack. Gullies and intersecting valleys act as flues and may divert the travel of a cloud in a direction different from that of the prevailing wind. When a cloud approaches clumps of trees or woods from an open space, they tend to break it up or cause it to rise or be deflected. On the other hand if the cloud succeeds in entering the woods or if it was originally released therein the tendency of the woods is to increase the persistency by retarding the rate of travel. A low velocity wind (3 or 4 miles per hour) will carry a cloud of high concentration intact up a gentle slope.

5. PRESENT STATUS OF CYLINDERS. - The limitations of the older heavy cylinder (emplacement type) led to the development of a light, one-man, portable cylinder of high chemical efficiency. Such a weapon now constitutes part of the offensive equipment of chemical troops.

Although a weapon of opportunity, the potentiality of cloud-gas warfare is still sufficiently great to warrant consideration. Therefore, the cylinder has been continued as a standard chemical weapon.

SECTION II

THE PORTABLE CHEMICAL CYLINDER

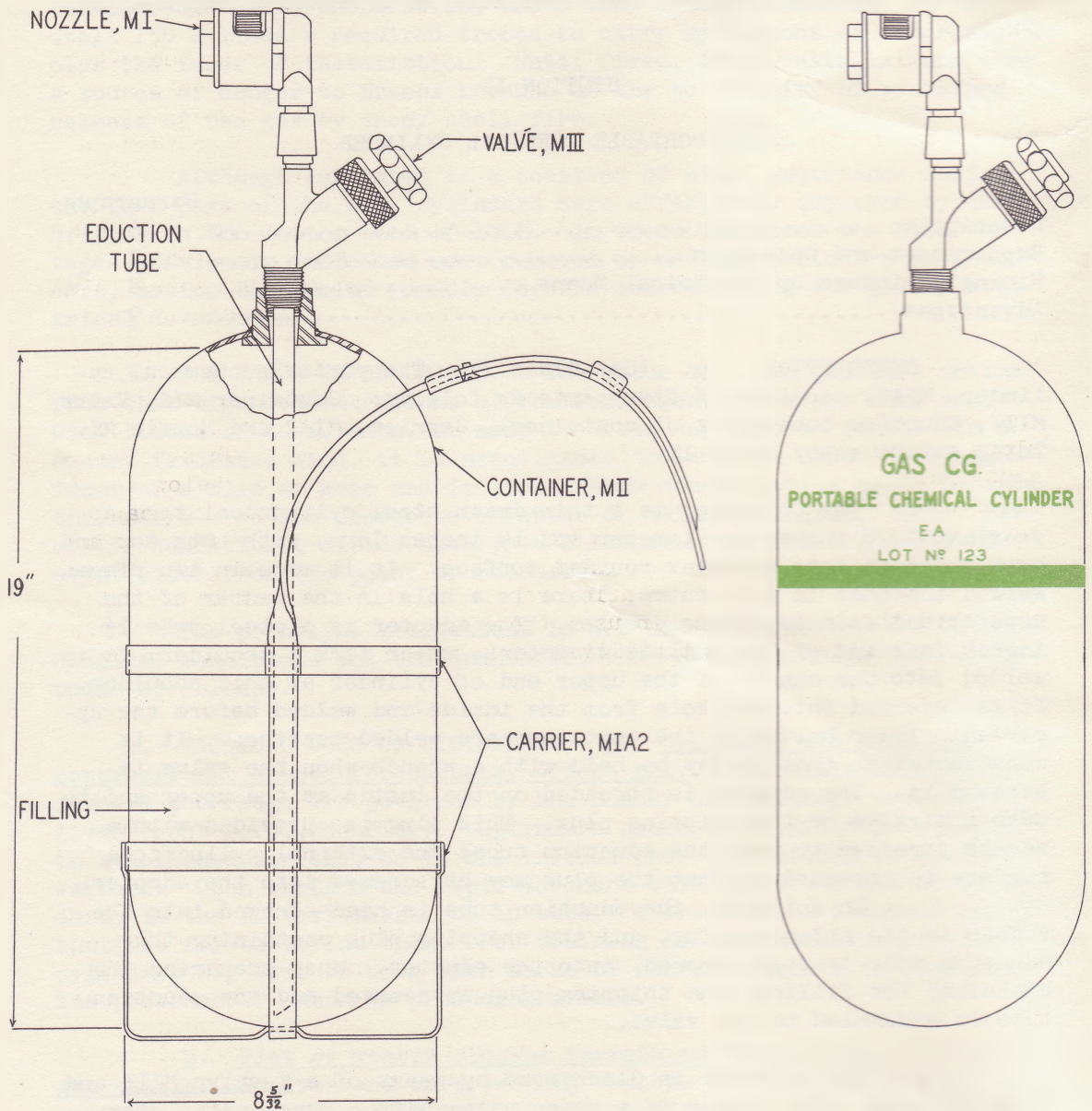
	Paragraph
Description	6
Emplacement and Operation	7
Firing Cylinders by Electrical Means	8
Advantages	9

6. DESCRIPTION. - a. (See Plate 1). The portable chemical cylinder, MIA2, consists of five parts as follows: Container MII, Valve MIII, Eduction tube (part of container), Carrier, MIA2 and Nozzle MI. Total weight empty is 20 lb.

b. The Container is a thin drawn-steel cylindrical tank approximately 8 inches in diameter and 19 inches long, with both top and bottom formed into a convex rounded surface. It is made in two pieces, welded together in the center; there is a hole in the center of the upper piece to receive the adapter. The adapter is a steel tube $1\frac{1}{2}$ inches long and of two outside diameters, which form a shoulder. It is welded into the center of the upper end of cylinder at this shoulder. It is inserted into the hole from the inside and welded before the upper and lower halves of the container are welded together. It is constructed so that it may be held with a wrench when the valve is screwed in. The adapter is threaded on the inside at the upper end to take the valve or the shipping plug. This plug is provided with a recess threaded to take the eduction tube; the external cylindrical surface is threaded so that the plug may be screwed into the adapter.

In shipping, the eduction tube is hand-screwed into the recess in the shipping plug, and the shipping plug containing the eduction tube is then screwed into the adapter. When preparing the container for filling, the shipping plug is removed and the eduction tube is assembled to the valve.

c. The cylinder is discharged by means of a Y-valve MIII and eduction tube. The former is a brass valve with a monel-metal stem, set at an angle to the axis of the eduction tube and outlet pipe. The outlet pipe is a part of the Y-valve and is normally closed by a screw cap. The lower end of the valve carries a pipe thread by which it is screwed into the adapter of the container, and is tapped to receive the threaded end of the eduction tube. The eduction tube is a 3/8-inch iron pipe, which is screwed into the valve and terminates close to the bottom of the container. One end is threaded externally to screw into the bottom of the valve and the other end is cut off at an angle of 45° to insure discharge. This tube enables the contents of the container to be discharged as a liquid so that the bulk of the



PORTABLE CHEMICAL CYLINDER, MIA2
(WITH NOZZLE AND FIRING DEVICE)

vaporization and consequent cooling takes place outside the cylinder. This principle is comparable to that of the seltzer bottle and permits rapid discharge of the cylinder.

d. The Carrier MIA2 consists of a steel rack with hooks to fit over one's shoulders, (see Plate 1). The ends of the hooks are pointed to facilitate suspension of the cylinder on a parapet wall. The hooks are furnished with leather guards which ease the burden on the shoulders. The carrier makes it possible to stand the cylinder.

e. The Nozzle MI. (1) This brass nozzle, which is attached to the threaded end of the outlet tube of the Y-valve by means of a reducing fitting, is designed to minimize the loud hissing noise which is characteristic of escaping gas under pressure. Incidentally, the nozzle permits the rapid release of gas (i.e., constriction of the nozzle by frost formation, due to the cooling effect of vaporization).

(2) It consists essentially of a cylindrical chamber, in the wall of which ten parallel vertical slots have been cut. These slots are internally covered by several layers of fine-mesh steel-wire gauze held in place by a circular retainer. The inlet is below the slots and is practically tangent to one of the end slots. The cap-cover carries a projection which extends nearly to the bottom of the chamber, thereby insuring a high-velocity swirl in the chamber. Surrounding the chamber is a movable brass band which serves to exclude dirt from the slots. When in use, the band is turned so that an opening in it registers with the slots. It is held in this position by a spring catch.

(3) This nozzle is used only with agents that are true gases.

f. The cylinder weighs about 55 pounds when filled with 32 pounds of phosgene and 3 pounds of CO_2 . The chemical efficiency of the cylinder with this filling is 57%.

7. EMPLACEMENT AND OPERATION. - a. Cylinders are emplaced for firing usually in a row or series of rows running at right angles to the direction of the wind. The number of cylinders required and the proper distance between each cylinder vary according to the range and may be determined by consulting Reference Data, Table 11. When the emplacement is on the surface of the natural terrain the cylinders may be placed upright. However, it is customary to tilt them forward so that they rest on the pointed ends of the carrier hooks. When fired from a trench or parapet they are suspended upright from the top of the front wall by the pointed hooks of the carriers.

b. The emplaced cylinders may be fired either individually by hand or simultaneously by electrical means. To fire them by hand it is only necessary to open the valve quickly to the fullest extent. The valve should be "cracked" with a wrench a few moments in advance of firing the emplacement. For this purpose the hand wheel of the valve is provided with a hexagonal shoulder immediately above the valve handle. The method of firing electrically is described in para-

graph 8.

c. The cylinder operates on a pressure principle similar to that of the seltzer bottle. At the time of filling, liquefied gas is drawn from bulk containers and run into the cylinders, leaving an adequate "void" or empty space above the liquid. The valve MIII, with the eduction tube assembled to it, is screwed into the threaded opening of the container and the valve closed.

d. The high vapor pressure of the liquefied gas within the container of the cylinder, results in the building up of considerable pressure in the void above the liquid. The amount of pressure within the cylinder at any moment is that of the gas pressure in the void which depends upon the particular gas or gases inclosed and the temperature. The accumulated pressure is exerted against the surface of the liquid as well as against the container walls.

e. When the cap is removed from the outlet and the valve is opened, the liquid in the container is forced up through the eduction tube and out through the valve and nozzle by the pressure of the gas (vaporized liquid) above the liquid in the container. As the void increases the pressure of the gas decreases, which allows more of the liquid in the container to vaporize. This results in a continuous expulsion of the liquid content of the container until the liquid level in the container drops below the end of the eduction tube, when only gas will come out of the container. The expansion of the gas in the container results in the absorption of heat both from the walls of the container and the liquid in the container with a consequent lowering of their temperature. The evaporation or further transformation of liquid into gas also lowers the temperature of the liquid, but not enough to prevent the development of sufficient pressure in the container to expel the liquid, except in very cold weather. When projected into the atmosphere, where the pressure is much less than that within the container, the agent can no longer maintain its liquid state and immediately vaporizes. The conversion of the liquid into gas requires much heat, which must be drawn from the surrounding atmosphere and the container. The extreme cooling effect thus produced often results in the formation of frost and ice on and in the nozzle, which might result in constriction and stoppage of the flow in a poorly designed nozzle or if the valve were not fully opened.

f. From the foregoing considerations, it will be evident that, from the viewpoint of operation, the cylinder functions best on warm days, or when artificially warmed; and conversely does not function so well in very cold weather.

g. When a chemical agent is used which does not have a sufficiently high vapor pressure to expel it from the cylinder, such as phosgene, the necessary pressure approximately 200 pounds, may be obtained either by replacing a certain amount of the liquid by liquid chlorine or by forcing sufficient CO₂ gas into the cylinder.

8. FIRING CYLINDERS BY ELECTRICAL MEANS. - The latest device for firing cylinders electrically has not yet been standardized, but en-

gineering tests have been completed. This device consists of a Grinnell automatic sprinkler head without the deflector and with the heat-collecting cup that is built around the fusible metal link, filled with pyrotechnic material. An electric squib is inserted in a slot cut in the top of the cup. When fired by an exploder, the squib ignites the pyrotechnic mixture and the heat generated by the burning of this mixture melts the fusible link. This allows the gas pressure within the container to force its way out through the modified sprinkler head.

Cylinders equipped with this type of device permit the emplacement and release of large quantities of gas in a single operation.

9. ADVANTAGES. - The portable cylinder is the most mobile of chemical weapons for the weight of chemical contained.

It has the highest chemical efficiency of any weapon at present authorized (i.e., ratio of the weight of chemical contained, to the weight of the filled container).

By its use, advantage may be taken of meteorological conditions temporarily favorable.

It avoids much of the noise and work of installation of the older emplacement type cylinder which was likely to give warning of an attack.

It reduces the danger to our own troops of loaded cylinders remaining some time in the front line, subject to rupture by enemy shell fire.

It permits the simultaneous firing of any desired number of cylinders, when equipped for electrical firing, with a minimum of operators.

SECTION III

AGENTS USED IN CYLINDERS

	Paragraph
Prerequisite Characteristics of Cylinder Gases	10
Agents Used in Cylinders	11
Use of Solid or Liquid Agents	12
Wind Limits	13

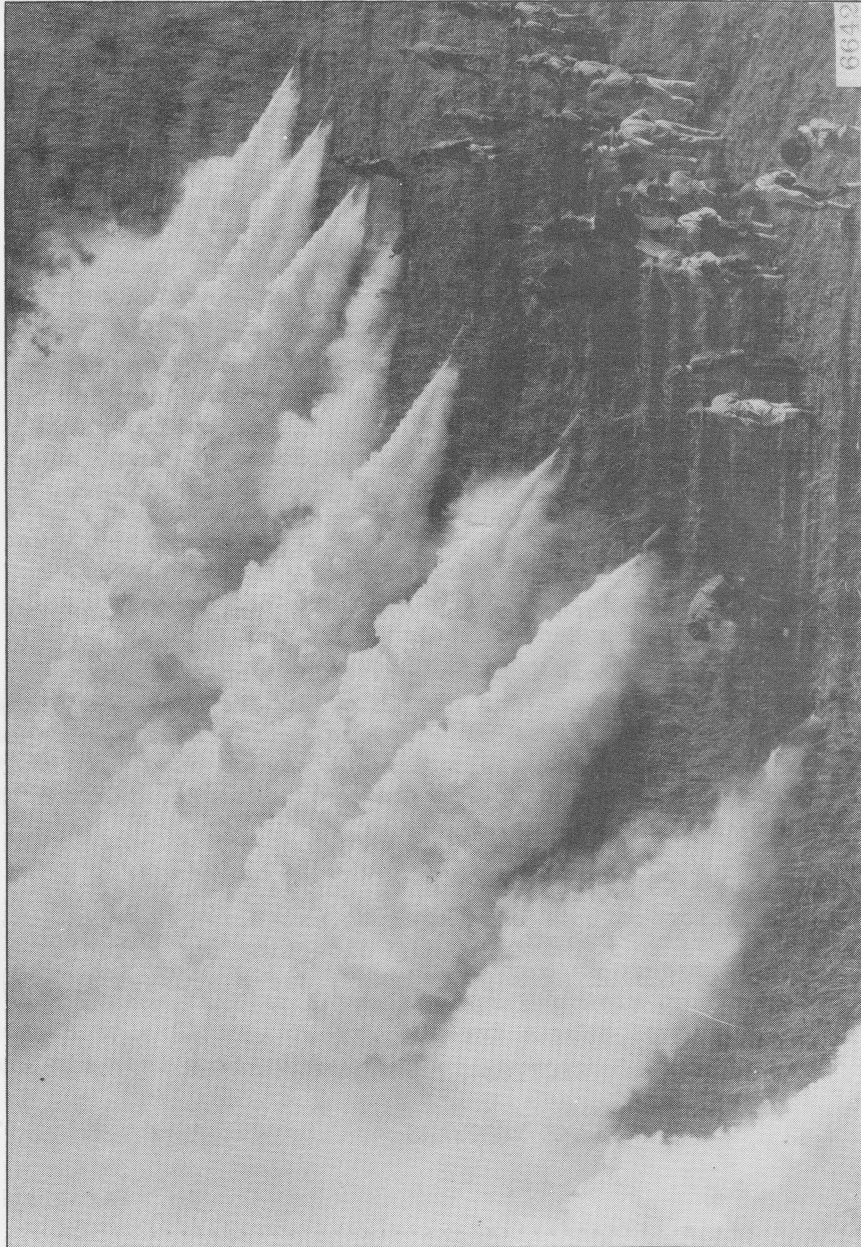
10. PREREQUISITE CHARACTERISTICS OF CYLINDER GASES. - To be employed in cylinders for cloud-gas attacks, a gas must possess the following properties:

a. It must be highly toxic and rapid in action in fairly low concentrations.



PORTABLE CHLORINE CYLINDERS IN OPERATION

PLATE 2



**SMOKE RELEASED FROM PORTABLE CHEMICAL CYLINDERS
TO SHOW CLOUD FORMATIONS**

PLATE 3

b. It must be heavier than air so that it will stay on the ground.

c. It must have a high vapor pressure (low boiling point) so that it will not only vaporize readily at ordinary temperatures but also to such an extent that the pressure developed within the container will be sufficient to expel the unvaporized chemical agent. An agent that is incapable of acting as its own expellant may be mixed with CO₂ or some other gas of high vapor pressure to overcome this deficiency; but such added expellants dilute toxic concentrations to the extent used, and do not have any effect upon the vaporization of the liberated chemical agent.

d. It must be obtainable in large quantities under war conditions.

11. AGENTS USED IN CYLINDERS. - a. Nonpersistent agents only are used in cylinders. Although chlorine, phosgene, chlorpicrin and other gases were employed singly and in combination during the World War, it is now considered that the most efficient filling for cylinders is phosgene with the minimum of liquid carbon dioxide or chlorine necessary to provide the required pressure for expelling the mixture. With 8% by weight of CO₂, this phosgene mixture produces a positive uniform discharge over a wide range of temperatures, in a minimum of time.

b. Agents now standard for the cylinder include CG and FS.

12. USE OF LIQUID OR SOLID AGENTS. - Liquid agents or solid agents in solution may be adapted for use in cylinders by the addition of CO₂ as an expellant, and the use of a special spray nozzle. These adaptations are not suitable as war fillings, but may be used for demonstration, training, or mob-control purposes. For example, CNB and FS are suitable for use in this manner.

13. WIND LIMITS. - As the successful use of gas is largely dependent on wind conditions, it is essential to establish certain rules governing the use of gas in relation to the direction and velocity of the wind. Wind limits, including map diagrams, are discussed in Book 4, Chapter II.

SECTION IV

FLAME THROWERS

	Paragraph
General	14
German Flame Throwers	15
Allied Flame Throwers	16

14. GENERAL. - During the World War much was heard about the appearance on the battlefield of a horrible offensive weapon introduced by the Germans which wrought havoc by projecting a blazing tongue of fire at a helpless victim. These "Flammenwerfers" or Flame Throwers were used against the British in 1915, and at first were rather suc-

cessful, but they were abandoned as soon as their limitations were learned.

15. GERMAN FLAME THROWERS. - Two general types were used, i.e., portable and large. Both consisted essentially of two tanks, one containing nitrogen under high pressure, the other filled with a highly inflammable mixture of oils. These tanks communicated with a flexible hose, special release valve, nozzle and ignition device. When the valve was opened, a jet of atomized oil shot through the nozzle, and ignited as it was projected into the air. The portable flame thrower had a range of 14 to 17 yards; the duration of the flame was less than one minute. In the case of the larger apparatus, the range was from 33 to 40 yards and the duration from one to two minutes. These were limiting factors. Others were to be found in the great weight of these cumbersome weapons, and the fact that the stream could not be directed downward because of the convection currents which rose from the intense heat, resulting in an upward-curling flame. Reasonable protection could be had by lying face downward against the front wall of the trench. Although some casualties were caused among green or isolated troops, the chief effect was demoralization.

On the other hand, the troops operating these weapons were placed in a most disadvantageous position. When the flame throwers ceased discharging after a minute or two the soldiers were left practically unprotected and helpless, and they were exposed to enemy rifle and machine-gun fire at very short range. If they were carrying the portable apparatus on their backs, they could not even run, owing to its weight and to the difficulty of getting rid of it quickly.

It is interesting to note that the limitations of this weapon were recognized by the Germans, in that the flammenwerfer units were composed largely of refractory or penal men, whose death or capture was of little importance.

16. ALLIED FLAME THROWERS. - The Allies also designed a flame thrower in reprisal for the German apparatus. It was quite different in design and was not a true flame thrower inasmuch as it did not actually project a flame, but instead squirted a jet of burning liquid. It was lighter in weight and probably more efficient than the German true flame thrower, but was almost equally limited in its use and was soon discarded.

CHAPTER IV

LIVENS PROJECTORS

(This chapter supersedes Chap. IV, Book 3, Sept.-36)

	Paragraphs
SECTION I - General	1-4
II - Description	5-13
III - Operation	14-35

SECTION I

GENERAL

	Paragraph
Introduction	1
Characteristics	2
Value as a Weapon	3
Tactical Uses	4

1. INTRODUCTION. - a. The Livens projector is a crude mortar designed to project large quantities of chemical agents and produce high concentrations on important targets within a limited range.

b. Projectors are installed in the ground and fired electrically in batteries of 25, any number of batteries being fired in unison. The British are credited with having installed 6000 projectors in a single emplacement area of which 4500 were fired; at another time 2500 were simultaneously fired into Lens.

2. CHARACTERISTICS. - a. Range. The maximum range is 1450 yards with the present propellant. Range is controlled solely by the weight of powder charge used.

b. High Angle of Fire. The projector is fired at a constant angle of elevation of 45 degrees. This high-angle fire permits firing from a trench or behind cover as well as the engaging of targets that are defiladed.

c. Efficiency. A battery of projectors fires but one shell per projector per installation, but after firing the projectors may be salvaged when practicable, installed elsewhere, and refired. The large shell capacity permits the more rapid delivery of a chemical agent on a target, and with greater surprise than is obtainable by any other weapon, providing secrecy of installation is maintained.

d. Mobility. The projector is a weapon of limited mobility. It requires the transportation of about 225 lb. of material for each individual projector installed; but the component parts are capable of being carried considerable distances by hand. Livens projector material is transported from the rear areas by truck as far forward as the tactical situation or cover permits; beyond this point it must be carried by hand.

e. For ranges between 1000 and 1450 yards the range probable error will be 40 yards and the deflection probable error will be 30 yards. Due to the dispersion of one battery, no targets less than 320 yards in depth x 240 yards in width can be covered efficiently. Tactically it is best to rarely engage smaller targets than 500 x 500 yards.

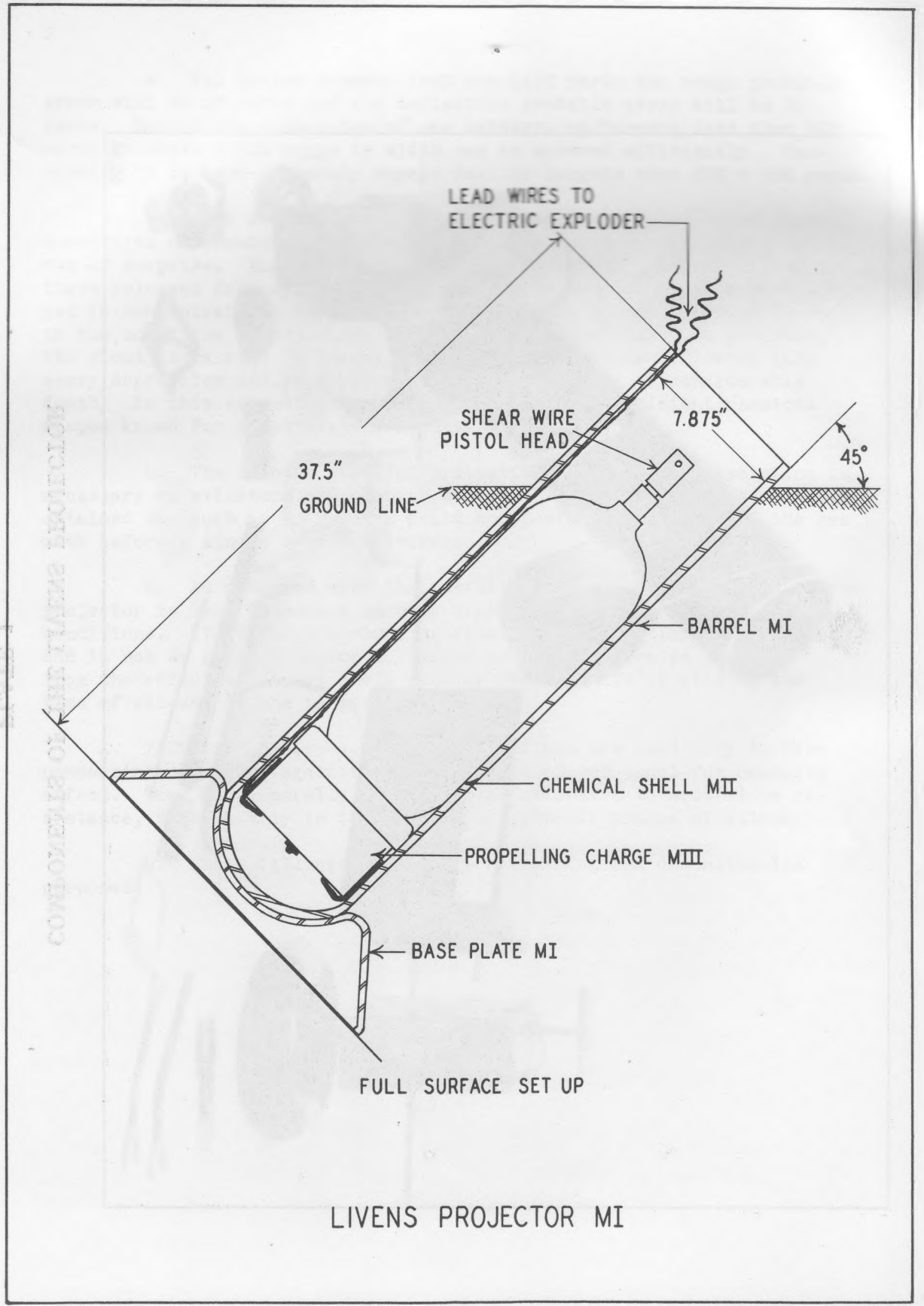
3. VALUE AS A WEAPON. - a. By means of Livens projectors large quantities of chemical agents may be released on a target with a maximum of surprise. Huge clouds, comparable in behavior and effect to those released from cylinders, can be made to envelop an extensive target in concentrations so great as to search out the slightest defects in the condition or adjustment of protective apparatus. In addition, the cloud is carried by the wind as a prevailing blanket flowing into every depression and penetrating territory downwind to considerable depth. In this respect the projector is the most efficient chemical weapon known for nonpersistent agents.

b. The highest state of protective training and discipline is necessary to withstand a projector attack. The concentrations usually obtained are such as to require rapid and perfect adjustment of the gas mask before a single breath is taken.

c. As compared with the portable chemical cylinder, the Livens projector is less dependent upon favorable wind, weather, and terrain conditions. It produces a cloud of greater concentration on the target and is not so great a source of danger to friendly troops - either from the effect of direct shell fire or from a shift of wind at the time of release on the target.

4. TACTICAL USES. - a. Livens projectors are used only to fire nonpersistent agents against concentrations of personnel for casualty effect. They are generally useful on the offensive to neutralize resistance, particularly in the initial or jump-off phases of attack.

b. Smoke fillings are used for training and demonstration purposes.



SECTION II

DESCRIPTION

	Paragraph
Component Parts	5
The Projector	6
The Shell MII & MIIA1	7
The Fuze MI	8
The Burster Tube MI	9
Functioning of the Bursting Mechanism	10
The Propelling Charge MIII	11
Fillings for Livens Projector Shell	12
The Accessories Set MI	13

5. COMPONENT PARTS. - (See Plate 1). The component parts of the Livens projector complete comprise - the projector, the shell, the fuze and burster tube, the propelling charge, the fillings and the accessories set.

6. THE PROJECTOR MI. - (See Plates 1 and 2). a. The projector consists of the barrel, muzzle cover, and the baseplate.

b. The Barrel MI is a smooth-bore tube made of 3/8-inch steel of approximately 8 inches inside diameter, open at one end, rounded and spun over at the other. It is 2 feet 9 inches long and weighs 110 pounds.

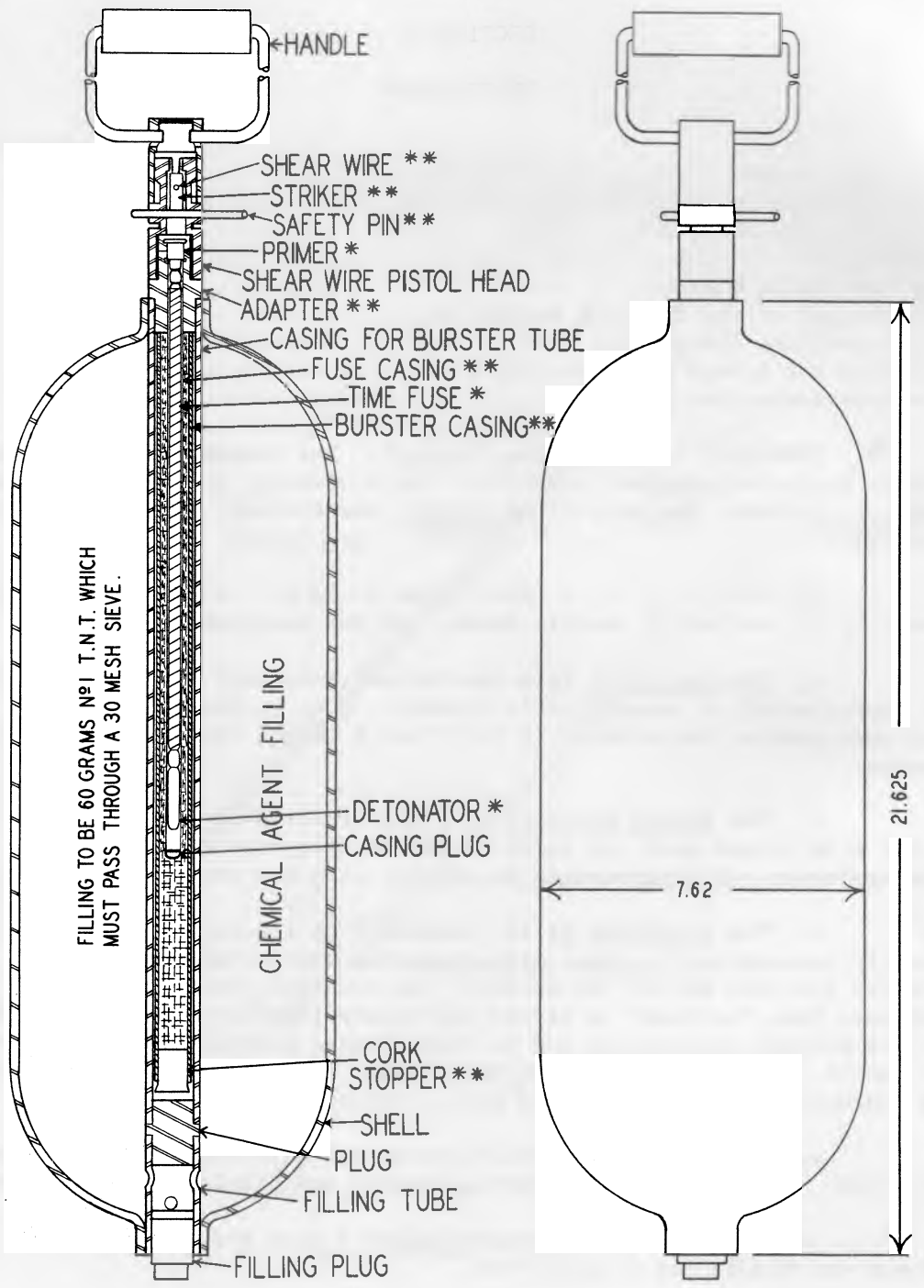
c. The Muzzle Cover MI is a cap of olive-drab canvas, provided with a draw cord, by which it may be tied over the open end of the projector. Its purpose is to exclude rain and dirt.

d. The Baseplate MI is pressed from 1/4-inch steel. It is roughly rectangular in shape with a rounded depression in the center to receive the butt end of the barrel. The vertical sides are parallel and have been flattened to permit the closer installation of projectors in the battery emplacement and to form flanges to distribute the force of recoil. The baseplate has a rope handle and weighs 30 pounds. It is approximately 19 inches long and 12 inches wide.

e. Packing. (1) Barrels are packed with muzzle covers, one to a box. The packed box weighs 140 pounds and displaces 3 cubic feet.

(2) The baseplates are packed 5 to a box, weighing 185 pounds and displacing 5 cubic feet.

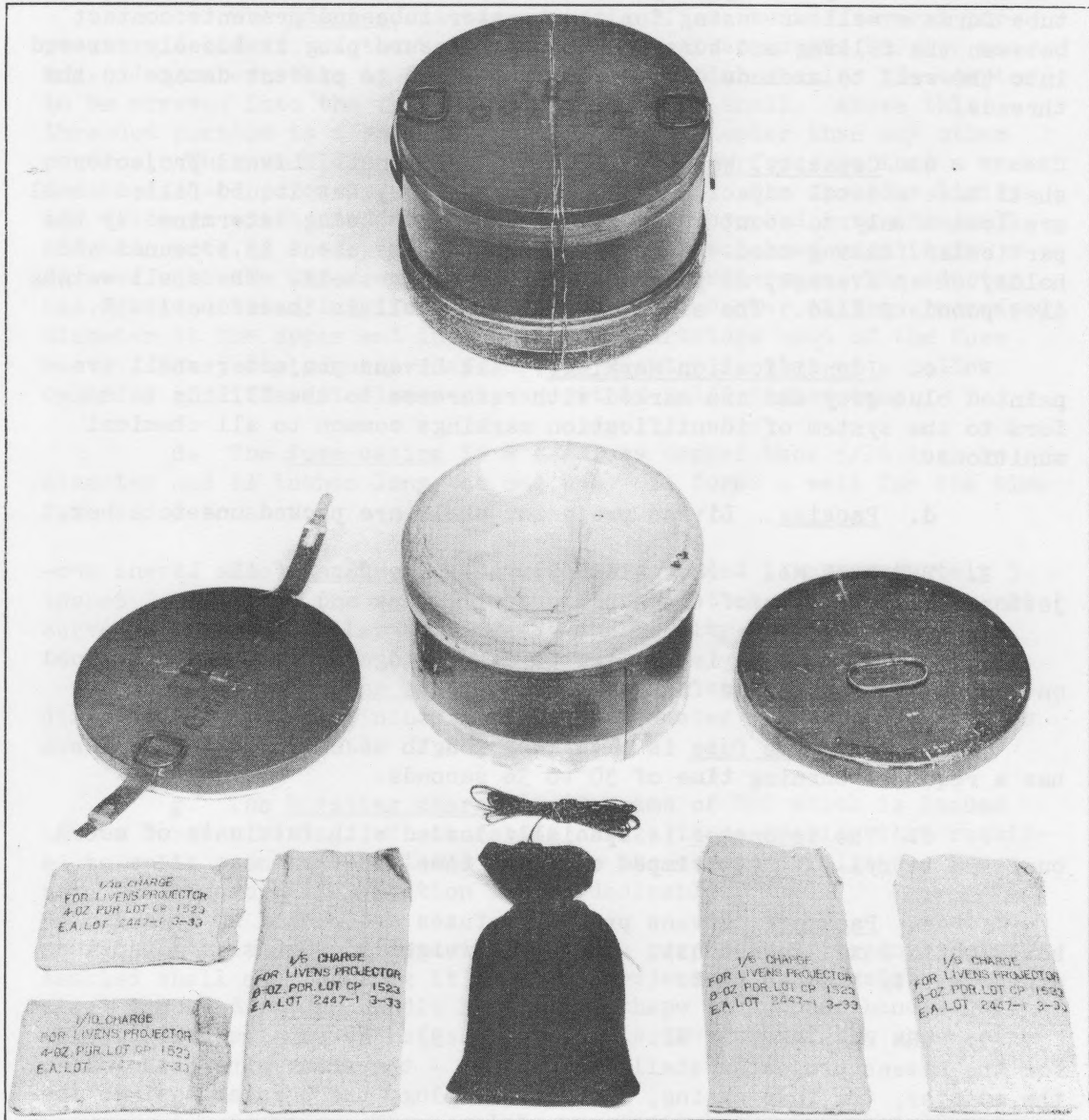
7. THE SHELL MII AND MIIA1. - (See Plate 3). a. The shell body is approximately 21-1/2 inches long and 7-1/2 inches outside diameter and made of steel pipe. The open ends are swaged in but not completely closed, leaving a hole in the center. A tube is run through the axis of the shell, welded to the shell body at the openings to form a gas-tight joint, and the ends of the tube are threaded internally. (This



* FUZE MI CONSISTS OF PRIMER, TIME FUSE AND DETONATOR

** BURSTER TUBE MI

SHELL, LIVENS PROJECTOR, MII



COMPONENTS OF THE LIVENS PROJECTOR
PROPELLING CHARGE MIII

tube consists of two sections, each welded to one end of a steel plug which is about 2 inches from one end of the assembled tube). Several holes are bored through the walls of the tube through which the liquid fillings enter the shell. After filling, a steel plug is screwed into the end resulting in a gastight joint. The other end of the central tube forms a well or casing for the burster tube and prevents contact between the filling and burster tube. A closure plug is loosely screwed into the well to exclude dirt and moisture and to prevent damage to the threads.

b. Capacity, Weight, Chemical Efficiency. Livens projector shell have a total capacity of 716 cubic inches, but liquid-filled shell are loaded only to about 90% volume, the "void" being determined by the particular filling used. The empty shell weighs about 33.5 pounds and holds, on an average, 28 pounds of phosgene per shell. The shell weighs 61.5 pounds filled. The efficiency of the shell is therefore 45.5%.

c. Identification Markings. All Livens projector shell are painted blue-grey and are marked with reference to the filling to conform to the system of identification markings common to all chemical munitions.

d. Packing. Livens projector shell are packed one to a box.

8. THE FUZE MI. - (See Plate 3). a. The fuze of the Livens projector shell consists of the - primer, time fuse and detonator.

b. The primer is carried in a cartridge head which is crimped onto one end of the time fuse.

c. The time fuse is a 12-inch length of Bickford fuse which has a required burning time of 30 to 36 seconds.

d. The detonator is specially loaded with fulminate of mercury and tetryl. It is crimped onto the time fuse.

e. Packing. Livens projector fuzes are packed 20 to a tin box, 10 tin boxes to a chest. The chest weighs 35 pounds and displaces approximately 1 cubic foot.

9. THE BURSTER TUBE MI. - (See Plate 3). a. The burster tube for the Livens projector shell consists of - the shear-wire pistol head, the adapter, the fuse casing, the annular plug, the burster casing, the bursting charge and the handle.

b. The shear-wire pistol head is made of heavy galvanized metal and looks somewhat like a short section of pipe. The lower end is threaded internally so that it can be screwed onto the end of the adapter. Inside the pistol head and above the threads is placed the striker which is an inertia pellet with a small point on its lower surface. This striker is normally suspended in place by a copper shear wire. A double-pronged safety pin passes through holes in the head just above the screw threads and prevents downward movement of the striker. The upper end of the head is threaded externally to take the

protective cap. This cap is a cylindrical tube of the same size as the pistol head proper and acts as a protection for the shear wire. There are two holes, 180 degrees apart, in the sides of the cap near the upper end designed to receive a detachable handle.

c. The adapter, as its name signifies, serves several purposes as follows: On the bottom portion is attached the burster casing. Just above this is a threaded section which enables the adapter to be screwed into the threaded opening of the shell. Above this threaded portion is a shoulder of a greater diameter than any other portion. This shoulder has two parallel flat surfaces so that a wrench may be used to screw it tightly into the shell. The shoulder limits the distance which the burster casing can be inserted into the shell and also acts as a stop for the shear-wire pistol head when it is screwed onto the upper end of the adapter. Furthermore, the adapter has a hole drilled longitudinally through the center with an increased diameter at the upper end into which the cartridge head of the fuze seats. Thus, the general shape of the adapter is that of a hollow cylinder of different diameters, and it is 2-1/2 inches long.

d. The fuse casing is a seamless copper tube 5/16 inch in diameter and 14 inches long, at one end. It forms a well for the time fuse and detonator.

e. The annular plug is made of wood and is approximately 3 inches long and of the same diameter as the bottom of the adapter. It serves as a space filler to increase the density of loading.

f. The burster casing is a seamless steel tube 7/8 inch in diameter and about 17 inches long. The diameter is such that it fits over the bottom diameter of the adapter.

g. The bursting charge is 65 grams of TNT which is loaded into a burster casing. The bursting charge is no heavier than required to split open the shell and disperse the chemical filling. Excessive bursting or fragmentation is not desirable.

h. A handle is provided for the purpose of carrying the assembled shell and lowering it into the projector. It consists of a steel loop and wooden handle similar in shape to a spade handle. It is attached by means of holes in the protective cap of the shear-wire pistol head.

i. Packing. The complete burster tubes are packed 10 per chest, in cradles of two layers of five each. Ten handles are packed in a small compartment in one end. The chest weighs approximately 35 pounds and displaces 1 cubic foot.

10. FUNCTIONING OF THE BURSTING MECHANISM. - When the safety pin has been pulled and the projector is fired, the force of set-back causes the striker to cut the shear wire and the striker point to hit the primer causing it to function. The Bickford fuse is thus ignited and,

in 30 to 36 seconds, flashes the detonator which in turn explodes the TNT bursting charge. The safety pin is never withdrawn until just prior to the time the projector is to be fired.

11. THE PROPELLING CHARGE MIII. - (See Plate 4). a. The Livens projector propellant is a variable charge of smokeless powder designed to be ignited electrically.

b. The charge can is a cylindrical tin-plate can 7-5/8 inches in diameter and about 4-1/2 inches in depth. The lower cover has two metal straps that hook through two eyes soldered to the body and has two one-finger loop handles. On the top of the container is a steel stamping which is soldered to the upper rim. This plate has a central depression to take the lower end of the projector shell. When the charge is fired this plate acts as a gas check, its flanged sides expanding against the walls of the barrel. The wires from the charge pass outward through a hole at the edge of the gas check. They are normally coiled in the depression when packed. A wire bail is provided in the gas check to permit lowering the charge into the barrel. A top cover is also provided. The bottom and top covers are held in place by nailless strapping and the cover joints are moisture proofed by adhesive tape. The over-all size of container with gas check complete is about 7-3/4 inches in diameter and approximately 5-1/2 inches in depth.

c. The full propelling charge consists of a base charge (in red bag); two 1/10-charge bags containing 4 ounces of .50 caliber smokeless powder; and three 1/5-charge bags containing 8 ounces of .50 caliber smokeless powder.

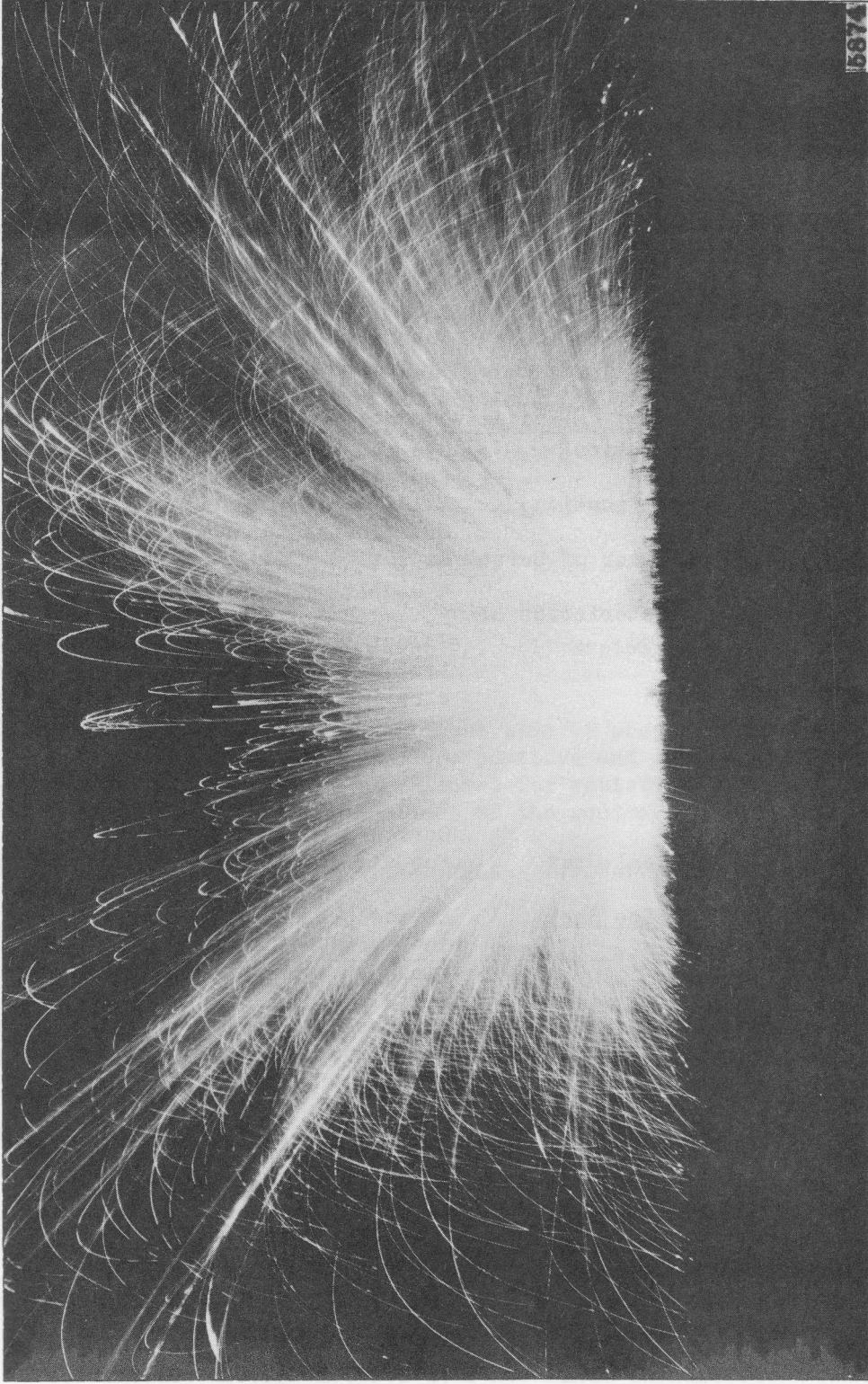
The base charge consists of 8 ounces of .50 caliber smokeless powder in the red base-charge bag and an igniter bag filled with 10 ounces of glazed grade A. No. 4 Army black powder. An electric squib is in the center of the igniter bag and is completely surrounded by the powder; the wires from the squib are stitched to both sides of the bag near the point of closure. This igniter bag is placed in the base-charge bag where it is surrounded by the 8 ounces of .50 caliber smokeless powder.

The complete propelling charge is placed in the charge container as shown in Plate 7.

d. Packing. The propelling charges are packed complete, four to a box, weighing 55 pounds and displacing 1-1/2 cubic feet.

12. FILLINGS FOR LIVENS PROJECTOR SHELL. - a. General. During the World War four distinct types of fillings were used in projector shell, namely, gas, smoke, incendiary, and high explosive. The Livens projector proved particularly suitable for the projection of nonpersistent casualty agents due to the high initial concentration obtained on the target.

b. Standard fillings for projectors are at present limited to CG and FS. FM is a substitute standard filling.



BURST FROM ONE LIVENS PROJECTOR SHELL
LOADED WITH WHITE PHOSPHORUS

PLATE 5

- (1) Shell MII or MIIA1, FS or FM Filling.
 Description See par. 7.
 Filling FS or FM smoke. 28 pounds.
 Identification Letters "SMOKE-FS" or "SMOKE-FM" in yellow on body. One yellow band around body.
 Character of Burst Explosion muffled. Minimum fragmentation.
 Characteristics of Cloud White, dense, acid, nontoxic smoke of great obscuring power. Obscuring effect increases with humidity in atmosphere.
 Tactical Uses None. This filling is used for training or in demonstration only.
- (2) Shell MII or MIIA1, CG Filling.
 Description See par. 7.
 Filling Phosgene in liquid form. 28 pounds.
 Identification Letters "GAS-CG" on body in green. One green band around body.
 Character of Burst Explosion muffled. Minimum fragmentation.
 Characteristics of Cloud Colorless, highly toxic, nonpersistent gas with a characteristic penetrating odor resembling mouldy hay or green corn. Is a lung irritant and has a delayed physiological action. Cloud first appears as a mist which quickly disappears. Corrodes metals.
 Tactical Uses For casualty effect. Nonpersistent.
- (3) Practice Shell Livens projector shell, rendered inert and filled to weight with sand, are used in training.

13. THE ACCESSORIES SET MI. - The accessories necessary to lay, emplace, wire, test, and fire a battery of Livens projectors comprise the following:

a. For Laying the Battery. (1) Aiming Stakes. These are oak-wood rods 7/8 inch square and not less than 5 feet in length, painted red and white in alternate stripes. They are pointed at one end.

(2) Compass, Prismatic, Engineers.

(3) Measuring Tape. This is a 100-foot steel tape used to lay out the emplacement.

(4) Tracing Tape. This is a white twilled cotton tape 1 inch wide. It comes in 100-foot rolls and is used for marking projector emplacements.

b. For Digging the Emplacement. (1) Picks and Spades.

(2) Clinometer.

c. For Wiring the Battery. (1) Friction tape is used to wrap splices or joints in the lead wire and propelling charge wires to prevent short circuits or corrosion of the joints, which would result in an increase of resistance with possible malfunctioning.

(2) Lead Wire. This is flexible, twisted-pair firing wire, each wire consisting of 7 strands of copper wire, rubber insulated, braided with cotton, and weatherproofed. This wire is furnished in 1000-foot coils weighing 38 pounds.

(3) Lead-wire Reel. This is an open wooden box housing a reel operated by a steel crank, the long end of the crank serving as a spindle for the reel. Capacity of reel, 1000 feet of lead wire. Weight filled, 50 pounds; displacement, 1.5 cubic feet.

(4) Pliers. These are 8-inch combination cutting pliers.

d. For Testing the Circuit. (1) Circuit Detector, Engineers, or Circuit Detector (Commercial).

e. For Firing the Battery. (1) Exploder, Magneto, 100 cap commercial type.

NOTE: For use in the field not more than 25 projectors are fired from a single exploder to insure positive and certain operation, a factor of safety being allowed for resistance of joints and a variation in the resistance of the squibs.

f. For Testing the Exploder. (1) Rheostat for Testing Exploder.

g. For the Preparation of Ammunition. (1) Wrench.

SECTION III

OPERATION

	Paragraph
General	14
Aiming Points	15
Laying the Battery	16
Range	17
Range Table	18
Lateral Adjustment	19
Effect of Winds	20
The Emplacement	21
Methods of Emplacing a Battery	22
Preparation of Ammunition	23
Assembling the Complete Round	24
Loading the Battery	25
Wiring the Battery	26
Camouflaging the Emplacement Area	27
Firing the Battery	28
Misfires	29
Shorts	30
Duds	31
Procedure after Firing	32
Safety Precautions	33
Wind and Safety Limits	34
Drill with Livens Projectors	35

14. GENERAL. - In the employment of Livens projectors the entire emplacement area consisting of any number of batteries may be assigned to a single target. This target may be a woods, a village, a center of resistance, or other areas heavily occupied by enemy personnel. If the target is large the individual batteries or groups may be assigned to cover separate portions of it, each group having a definite aiming point, in order to secure the proper distribution of the agent. These considerations, together with the necessity of separating the several batteries of the emplacement in order to minimize damage from enemy shell fire, require that each battery be individually aligned to register on the target.

15. AIMING POINTS. - For purposes of aiming, targets are considered as small targets, line targets, or area targets.

a. Small Targets. The Livens projector has a probable error in range of approximately 40 yards and a probable error in deflection of approximately 30 yards when fired at ranges upward of 1000 yards. The shell from projectors laid on a common aiming point will impact over an area about 320 yards deep and 240 yards wide. Targets not exceeding these dimensions may be considered as small targets, and all projectors firing on such should be laid on a central aiming point.

b. Line Targets. Targets with a greater frontage than 240 yards and not exceeding 320 yards in depth are considered as line targets. For such areas an additional aiming point for each 200 yards of

frontage should be allowed.

c. Area Targets. Targets with a greater frontage than 240 yards and a greater depth than 320 yards are considered as area targets. When firing on such areas additional aiming points should be used for each additional 200 yards of width and for each additional 250 yards in depth. In determining the required concentration for any of the above targets the number of squares (100 yards x 100 yards) within the area should first be computed. Projectors equivalent to the number of squares times the required number of projectiles per square should then be emplaced.

16. LAYING THE BATTERY. - The considerations governing the determination of direction of fire for Livens projectors and the specific methods used are identical with those of the 4.2-inch chemical mortar.

17. RANGE. - The range of the Livens projector is entirely controlled by the amount of propelling charge used, as the projector is invariably fired at constant angle (45 degrees). The charge can be packed with a maximum charge corresponding to the extreme range. Shorter ranges are obtained by using less powder.

18. RANGE TABLE. - The following range table for Livens projectors is for use with the propelling charge MIII.

TENTATIVE RANGE TABLE

LIVENS PROJECTOR

Charge	:	Range
oz.	:	yd.
24	:	910-1010
28	:	1020-1120
32	:	1130-1230
36	:	1240-1340
40	:	1350-1450

19. LATERAL ADJUSTMENT. - As the battery of Livens projectors is dug in and fired only once from a single emplacement, no lateral adjustment is possible.

20. EFFECT OF WINDS. - Because of the high trajectory, long time of flight, tumbling, and size of the projector shell, winds exert considerable influence on range and deflection. Lateral winds cause lateral deflection; head winds decrease range while following winds tend to increase range. High-velocity winds, when they do not preclude projector operations, should be compensated for by increasing concentrations fired on the target area. In actual practice, however, it is seldom possible to make any allowances for wind conditions inasmuch as conditions prevailing at the time of emplacement of the battery may be very different when the battery is fired.

21. THE EMPLACEMENT. - a. Location of Emplacement Areas. The following general considerations govern the location of an emplacement area:

(1) It should be located as far forward as the tactical situation permits; in the front line or, preferably, just behind it. But in no case should the distance from the emplacement to the front line exceed 50% of the range.

(2) The position should be concealed from aerial and land observation and fire and should be accessible by routes of approach affording maximum cover and concealment of the nature of the operation.

(3) It should be so located with reference to friendly troops as to: Minimize the number of troops to be withdrawn from the danger zones between emplacement and target.

b. Distribution of Batteries in the Emplacement Area. (1) Projectors are generally installed in batteries of 25 each. The following considerations govern the distribution within the emplacement area.

(2) Path of Fire. Each battery position must be so situated as to permit a path of fire unobstructed by trees, embankments or construction while affording maximum cover. This is facilitated by the high angle of fire of the weapon.

(3) Type of Terrain. The nature of the terrain may determine and fix the location of a battery so as to allow little or no latitude in the choice of a position. Ease of camouflage should be considered whenever possible.

(4) Character of Soil. The emplacement trench should be prepared in favorable soil whenever possible. A dry firm soil is required for best results. The deficiencies of loose, wet, or sandy soil should be corrected by reinforcement under the baseplates.

(5) Reduction of Hazard from Enemy Shell Fire. The several batteries of an emplacement should be sufficiently separated as to reduce considerably the effectiveness of enemy shell fire. This is important, especially for large shoots which must be prepared well in advance of the time of the operation.

22. METHODS OF EMPLACING A BATTERY OF PROJECTORS. - There are two methods of emplacing a battery of projectors, as follows:

a. Full Surface Set-up. (See Plate 2).

(1) When Used. This method must be used when the soil is loose or very porous, soft or wet, or very sandy, that is, whenever the soil will not afford rigid backing for the baseplate. This method is also often used in good soil if the battery is to be set up more than six hours prior to firing.

(2) Constructing the Trench. The line of aim having been staked out, the site of the trench is cleared and leveled and a stake is driven into the ground on the line of aim to mark its intersection with the emplacement line.

(3) Aligning the Trench. (a) An emplacement line is then marked off at right angles to the line of aim, running through the stake. This is done either by some simple geometrical method or by the "right-triangle method" as follows:

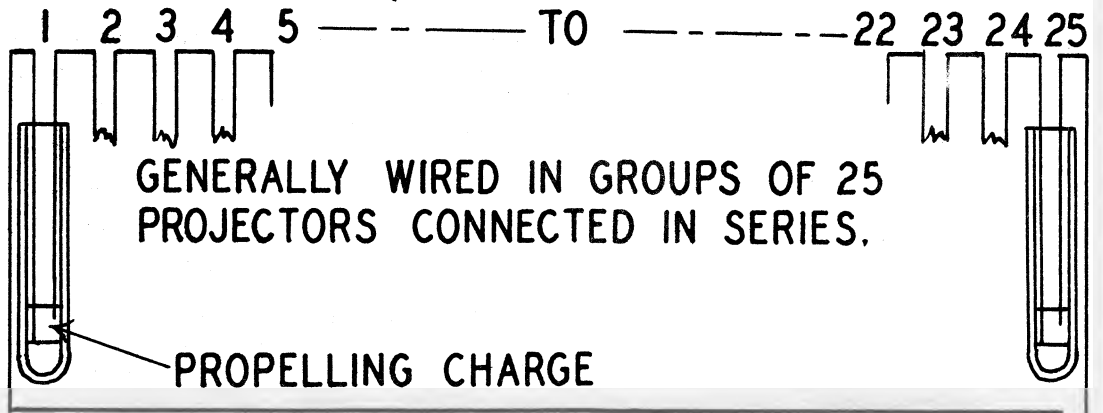
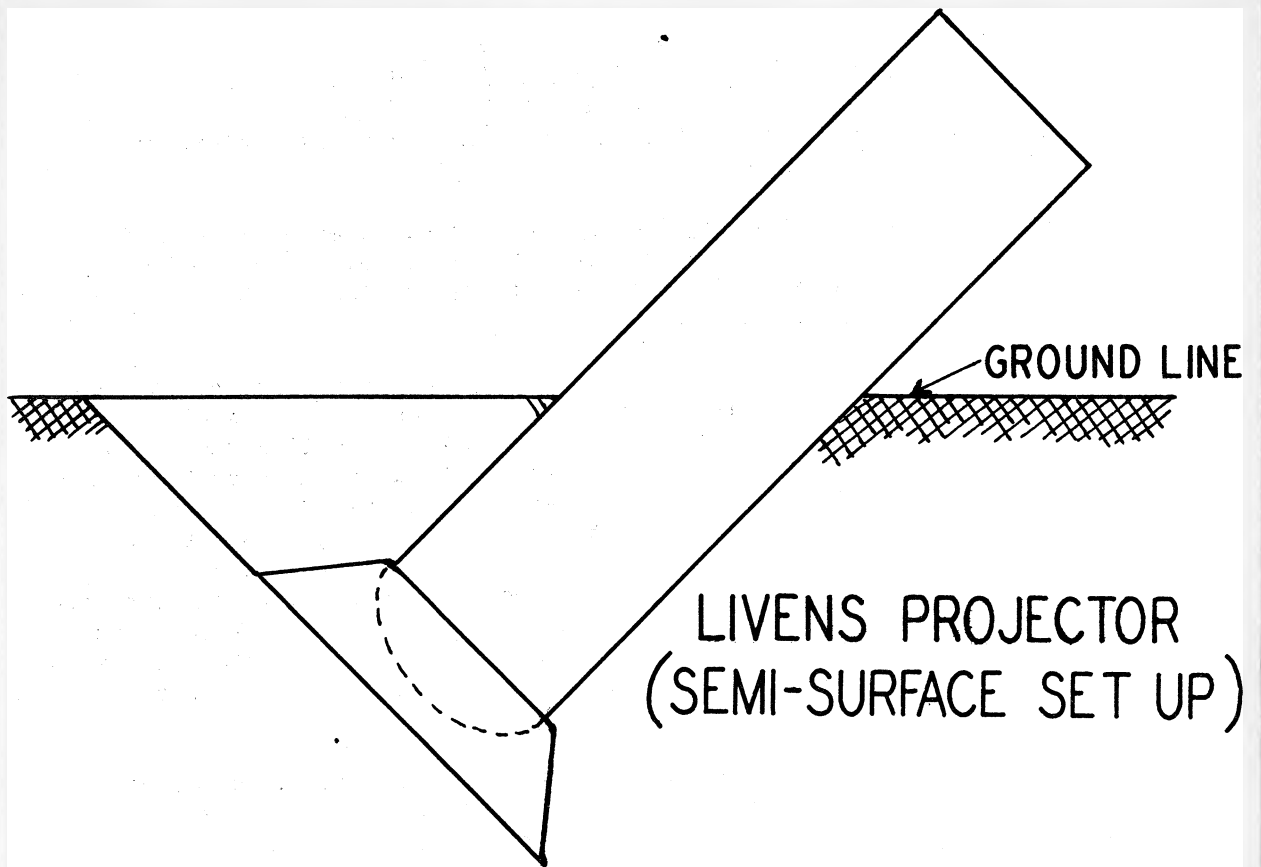
(b) The stake driven at the center of the proposed emplacement is called the zero stake. Another stake driven exactly 20 feet in front, in line of aim of the zero stake, is called the 20-foot stake. The zero end of a nonelastic tape is held on the "zero" stake and the 40-foot mark on the tape is placed at the "20-foot" stake. While the tape is securely held in this manner it is grasped at the 15-foot mark and drawn taut to one side of the line of aim. A stake is then driven at the 15-foot mark. The tape is then moved to the opposite side and similarly drawn taut. A second stake is then driven at this new location of the 15-foot mark. A line joining the two stakes, drawn at the 15-foot mark, is perpendicular to the line of aim at the emplacement line or zero stake.

(c) The emplacement line thus determined is marked with white tape. A trench, 4 feet wide, is then marked out using the same tape, allowing about 12 inches in length per projector.

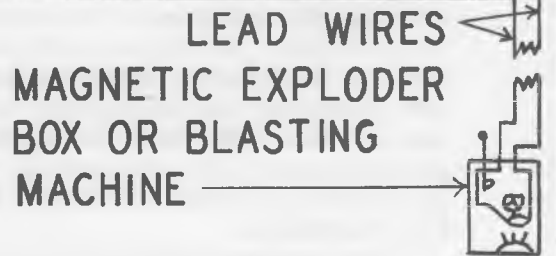
(4) Digging the Trench. A V-shaped trench is then dug whose front and rear walls are inclined at an angle of 45 degrees from the horizontal. When this has been done, level the front and rear walls and undercut the bottom of the front wall to accommodate the lower lip of the baseplate so that the rim of the cupped depression of the baseplate is tangent to the front wall. Then, when the baseplate rests against the rear wall, the barrel rests almost its entire length against the forward slope. For further details see T.R. 415-35.

(5) Alignment of the Projectors. (a) The center or "sighting" projector and its baseplate are set approximately in line with the line of aim. From a position in the rear of the emplacement the sighting projector is aligned with the aiming stakes, care being taken that both muzzle and base of the barrel are bisected by the plane of fire. The remaining projectors are alternately set up one by one on either side of the center projector and carefully made parallel to it. The flat sides of the baseplates are placed together to economize trench space. The individual projectors ordinarily are not sighted; but the end projectors are frequently "toed-in" slightly to prevent too great dispersion on small targets. After alignment the projectors are checked for elevation.

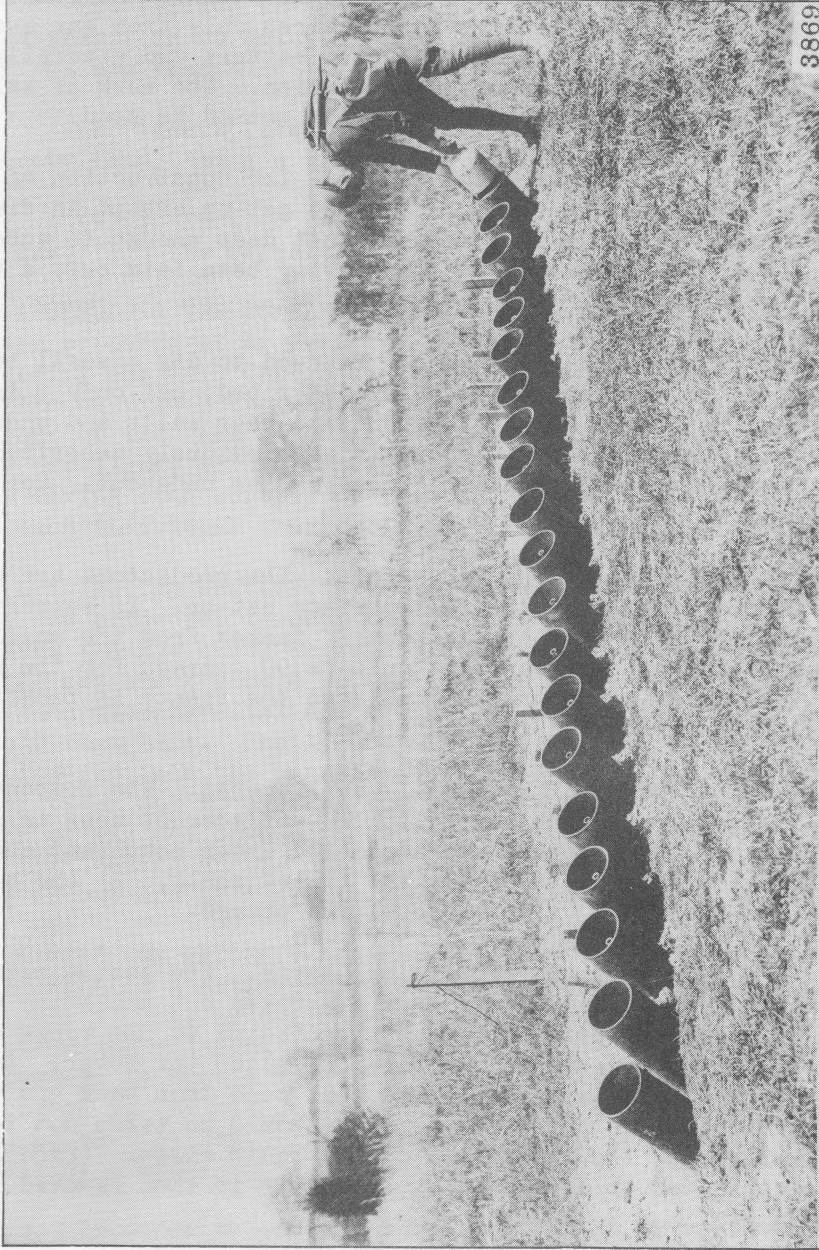
(b) When the alignment has been completed the earth from the excavation is back-filled and tamped down around the baseplates and between the barrels, taking care not to change the alignment. Muz-



GENERALLY WIRED IN GROUPS OF 25 PROJECTORS CONNECTED IN SERIES.



METHOD OF WIRING PROJECTORS



**LOADING A BATTERY OF LIVENS PROJECTORS
(Semi-surface Set-up)**

PLATE 7

zle covers are then put on.

c. Semi-surface Set-up. (See Plates 6 and 7). (1) When used. This method should be used whenever soil conditions and ease of concealment permit. (Within these limitations it is invariably used when projectors are to be fired shortly after installation). As compared with the full surface set-up, this method requires only from one-quarter to one-fifth the time necessary to emplace a battery and generally facilitates night operations - the normal situation. The work of salvage after firing is also facilitated when this method is used.

(2) Constructing the Trench. The construction of the trench is identical with that of the full surface set-up except in dimension, the semi-surface being shallow and dug just deep enough to accommodate the baseplates. The emplacement line having been laid out, a trench 2 feet wide is marked out.

(3) Digging the Trench. Proceed to dig a small trench down the length of the emplacement as above described, but only 8 inches deep. When this has been done level the front and rear walls and undercut the front wall to accommodate the baseplate as previously described. If supports are used the vertical wall need not be undercut. For further details see T.R. 415-35.

(4) Aligning the Projectors. The projectors are aligned just as is done when using the full surface set-up. If supports are used they should hold the barrel about 8 inches from the muzzle. The angle between support and barrel should be 90 degrees for the most rigid mounting. When the alignment is completed the trench is backfilled and the installation rechecked for elevation.

23. PREPARATION OF AMMUNITION. - a. General. The components of the complete round are transported to the emplacement area in separate boxes. They are there opened and assembled under competent supervision. The complete round consists of (1) the filled shell, (2) the burster tube, (3) the fuze, and (4) the propelling charge.

b. To Prepare the Propelling Charge. The bottom cover of the charge can is removed and powder bags are taken out until the amount of charge, including the base charge, corresponding to the range desired as computed from the range tables remains. Replace the cover. Insert the tin straps into the metal eyes of the can, bend them back and flatten them against the sides of the can. Care should be taken not to injure the squib or scrape the insulation of the squib wires. (Excess powder should be collected or destroyed). The cover is then removed from the gas-check.

c. To Assemble the Shell. (1) Open individual boxes.

(2) Remove closure plug from shell.

(3) Unscrew shear-wire pistol head from adapter.

(4) Assemble the fuze to the burster tube by inserting the

detonator and time fuse through the hole in the adapter into the fuse casing until the cartridge head seats in the adapter, being careful not to twist, jar, hammer, or otherwise force a fuse that cannot be inserted easily by hand.

(5) Replace shear-wire pistol head, being careful not to strike the primer in so doing. Screw down tightly and carefully by hand - do not use wrench.

(6) Insert fused burster tube into the shell and screw it into place by hand, using a wrench for the final tightening.

(7) No further preparation is necessary, and the shell is ready to insert in the barrel.

24. ASSEMBLING THE COMPLETE ROUND. - The shell and propelling charges are prepared at or near the battery position while the projectors are being dug in. Charge cans are placed in a row immediately in front of the muzzles. The shell, fuze ends outward, are placed in a row in front of the cans allowing a narrow aisle between rows. After carefully uncoiling, straightening, and separating the squib wires (the ends having been scraped of insulation if not already cleaned and tinned), each individual charge can is tested with the circuit detector.

25. LOADING THE BATTERY. - If the circuit is intact the can is lowered into the projector through the muzzle by means of the wire bail which leaves the gas check uppermost. The exit of the squib wires through the gas check should be against the upper surface of the bore, they are then made parallel and are bent over the upper rim of the muzzle to hold them taut. Shell, beginning at either end of the battery, are then lowered into the barrels (see Plate 10), fuze ends uppermost, care being taken not to disturb the insulation of the squib wires. The handle may or may not be used in this operation. The various operations in the loading of the battery should proceed in regular order, beginning at one end of the battery and working through to the other.

26. WIRING THE BATTERY. - (See Plate 6). a. The individual propelling charges in a battery are connected together in one electrical series. This is done by splicing one wire from a propelling charge to one wire from the adjacent propelling charge and continuing thus throughout the battery in such a way that the current flows from the end propelling charge to the next, from that to the next, et cetera, to the other end of the battery. This leaves only two free wires, one on each end propelling charge.

b. In order to prevent short circuiting by splices coming in contact with metal or moisture, small stakes are driven vertically into the ground between the barrels and the spliced wires wound around them in such a manner as to keep them off the ground.

c. If the battery is not to be fired the same day it is emplaced, all spliced joints should be well taped with friction tape to

prevent an increase in resistance through corrosion as well as to afford better insulation.

d. The lead wire should be tested before being connected to the battery circuit. When the wiring has been completed the circuit of the battery as a whole is tested by connecting the exploder ends of the lead wire with the circuit detector. If the circuit is defective the trouble may be remedied by going over the splicing. If this does not clear the circuit something is wrong with the wiring directly connected to the squibs, and the defect may be localized by testing half the circuit. If intact, the remaining half contains the fault. By a similar method the individual projector causing the trouble is sought out and the defect remedied. Retest the complete circuit. Connect the two free end wires with the main lead wire running back to the point where the battery is to be fired. This point should be at least 100 yards to the rear and to the flank of the battery position.

NOTE: Muzzle covers are invariably kept on until the battery is ready to fire.

27. CAMOUFLAGING THE EMPLACEMENT AREA. - a. Camouflage is the concealment of all work done in such a manner as to give no indication of activity or change. The concealment of the emplacement must so conform to the surroundings as to preclude detection by aerial or ground observation or aerial photography. A Livens projector emplacement as viewed from the air is characteristic and unmistakable. Its identification is fatal to the surprise which otherwise makes it possibly the most efficient nonpersistent gas weapon. It is also necessary to avoid establishment of paths or leaving material exposed in such manner as to disclose the location of the batteries.

b. A special study of camouflage requirements must be included in preliminary reconnaissance. Natural camouflage is superior if it can be obtained. The concealment of emplacements and approaches must be completed before daylight.

28. FIRING THE BATTERY. - a. Although projector emplacements are often timed to be completed just prior to firing they may be left emplaced, when properly camouflaged, until the tactical situation or meteorological conditions are favorable. Emplacements consisting of numerous batteries may be fired simultaneously or in waves.

b. Connections between the lead wire and exploder are not made until the battery is to be fired. The exploder and circuit are both tested. All friendly personnel must be clear of the emplacement and field of fire before the exploder is connected. Safety pins are pulled and brought back to the firing point for recheck. The exploder is then connected to the lead wire and the battery fired by raising the rack bar to full length and depressing it quickly and positively to its lowest point.

29. MISFIRES. - Individual misfires are uncommon where individual charge cans give a positive test with a circuit detector. They may result from a wet or defective squib, wet powder, short-circuited squib,

or grounded circuit. Complete battery misfires cannot occur if the circuit is tested immediately before firing, unless every powder charge is defective.

30. SHORTS. - Shorts may be due to damp or defective powder or retardation of burning, or to improper or soft backing for the baseplate.

31. DUDS. - Duds result from the failure of the bursting mechanism to function and may be due to a defective burster tube or a wet or defective fuze.

32. PROCEDURE AFTER FIRING. - a. Check the Battery for Individual Misfires. Disconnect all wires before attempting to remove an unprojected shell. A shell should not be removed within 5 minutes after the battery has been fired. After waiting the required time insert the safety pin, remove the shell and propelling charge.

b. Reporting Shorts. The number of shorts and an estimate of the cause thereof should be reported to proper authority, together with the lot number of the propelling charges involved.

c. Disposal of Duds. Duds are extremely dangerous to handle, and a slight blow or attempted movement may cause them to explode. They must be destroyed in place in accordance with instructions contained in T.R. 1370A, paragraph 169.

d. Salvage. Projectors, baseplates, unprojected shell, misfires, propelling charges, and unused powder bags should be salvaged and the emplacement refilled. In peacetime all defective material should be segregated, labeled "defective", and held for investigation as to the cause of defects.

33. SAFETY PRECAUTIONS. - a. T.R. 140-5 prescribes general safety precautions in time of peace applicable to all weapons.

b. T.R. 415-35 prescribes additional safety precautions applicable to all weapons firing chemical ammunition. The more important of these are given in Chapter V, Section XII of this book.

c. The danger area for Livens projectors is prescribed in T.R. 140-5, paragraph 3 and in T.R. 415-35, paragraph 123 (i). With this exception there are no safety precautions applying exclusively to the Livens projector.

34. WIND AND SAFETY LIMITS. - a. Wind Limits. Within certain limits of wind direction, it is unsafe to fire Livens projectors and in others it is necessary to remove personnel from certain areas. There are also certain zones in front of Livens projector installations from which our own personnel are removed prior to the firing. Both the wind and safety limits, including map diagrams, are discussed in Book 4, Chapter II and in Reference Data.

35. DRILL WITH LIVENS PROJECTORS. - No drill is prescribed for Livens projectors. These operations involve much work and are usually carried out under cover of darkness.

CHAPTER V CHEMICAL MORTARS

(This chapter supersedes Chap. V, Book 3, Nov.-35)

SECTION		Paragraphs
I	History	1-3
II	The 4.2-inch Chemical Mortar MIAL, Complete with All Equipment	4-5
III	The Mortar MIAL	6-10
IV	Ammunition	11-15
V	Fire-Control Equipment	16-18
VI	Accessories and Spare Parts	19-21
VII	Transportation	22-27
VIII	Packing	28-32
IX	Summary of Weights	33
X	Care and Maintenance	34-36
XI	Operating Instructions	37-50
XII	Safety Precautions	51-52
XIII	Range Tables and Other Firing Data	53-54
XIV	The 4-inch Chemical Mortar MI	55-67

SECTION I

HISTORY

	Paragraph
Original Development	1
Use by the American Troops in the World War	2
Post-War Development	3

1. ORIGINAL DEVELOPMENT. - The 4-inch Stokes mortar was developed by the British to meet the demands of chemical warfare in a stabilized situation. Such a weapon had to meet the following requirements:

- a. High angle of fire - to meet the situation of firing from trenches against defiladed targets.
- b. Rapidity of fire - for effective use of nonpersistent agents.
- c. Mobility - to permit movement and emplacement by man power alone.
- d. Simplicity - both as to operation and repair, and to decrease the difficulties of manufacture.
- e. Cheapness - to permit the availability in large numbers.
- f. Sufficient shell capacity - for dispersing chemical agents in large quantities.

The 3-inch Stokes mortar (British) met these requirements except for shell capacity. Both 4 inch and 6-inch mortars were developed

to overcome this deficiency of the 3 inch mortar, but the 6-inch mortar did not meet the requirement of mobility and never advanced beyond the experimental stage.

2. USE BY THE AMERICAN TROOPS IN THE WORLD WAR. - The United States, upon entering the World War, had no chemical weapons. The 4-inch Stokes mortar best met the requirements and was adopted and used by the American forces throughout their participation in the war. During the latter part of the war a demand for smoke screens developed. The 4-inch Stokes mortar was deficient as a smoke weapon because of its short range and insufficient mobility. Being the best smoke weapon available however, it was used for this purpose even in mobile situations.

3. POST-WAR DEVELOPMENT. - a. The 4-inch Stokes mortar used by the U.S. Army, as now modified, is designated the 4-inch chemical mortar.

b. Since the war, development has been carried out with the object of overcoming the deficiencies of the 4-inch chemical mortar as a smoke weapon, while retaining its good features for the use of gas. The result of this development work is the 4.2-inch chemical mortar. This mortar has been adopted as to type and declared standard but is subject to further development.

SECTION II

THE 4.2-INCH CHEMICAL MORTAR MIAL COMPLETE, WITH ALL EQUIPMENT

	Paragraph
Characteristics	4
Equipment	5

4. CHARACTERISTICS. - The 4.2-inch chemical mortar is a rifled muzzle-loading weapon capable of firing at elevations between 800 and 1066 mils and traversing 100 mils to right or left of the center of traverse. The mortar fires a true-flight projectile and has a minimum range of 600 yards and a maximum range of 2400 yards. The projectile is equipped with a point detonating fuze which causes it to burst at or near the surface of the ground. With a well-trained mortar squad, the 4.2-inch chemical mortar may be fired at a sustained rate of fire of 5 rounds per minute and for short periods it may be fired at rates of 20 rounds per minute. The range is varied by changing the elevation or by varying the weight of powder in the propelling charge or by a combination of the two.

5. EQUIPMENT. - The following equipment is provided with the mortar in addition to chemical ammunition:

a. An accessories and spare parts set containing the necessary tools and materials for assembling, dismounting, emplacing, and cleaning the mortar, and such spare parts as can be installed by mortar squads in the field as replacements for parts worn out or damaged.

b. A hand-drawn mortar cart to transport the mortar, acces-

sories and spare parts.

- c. A hand-drawn ammunition cart to transport ten complete rounds.
- d. A special accessories set for the chemical mortar cart.
- e. A range indicator to furnish data for firing.
- f. A mil rule to aid in spotting bursts or impact of shell.
- g. Other fire control equipment consisting of range finder, compass, wind vane, protractor, and coordinate measure.

SECTION III

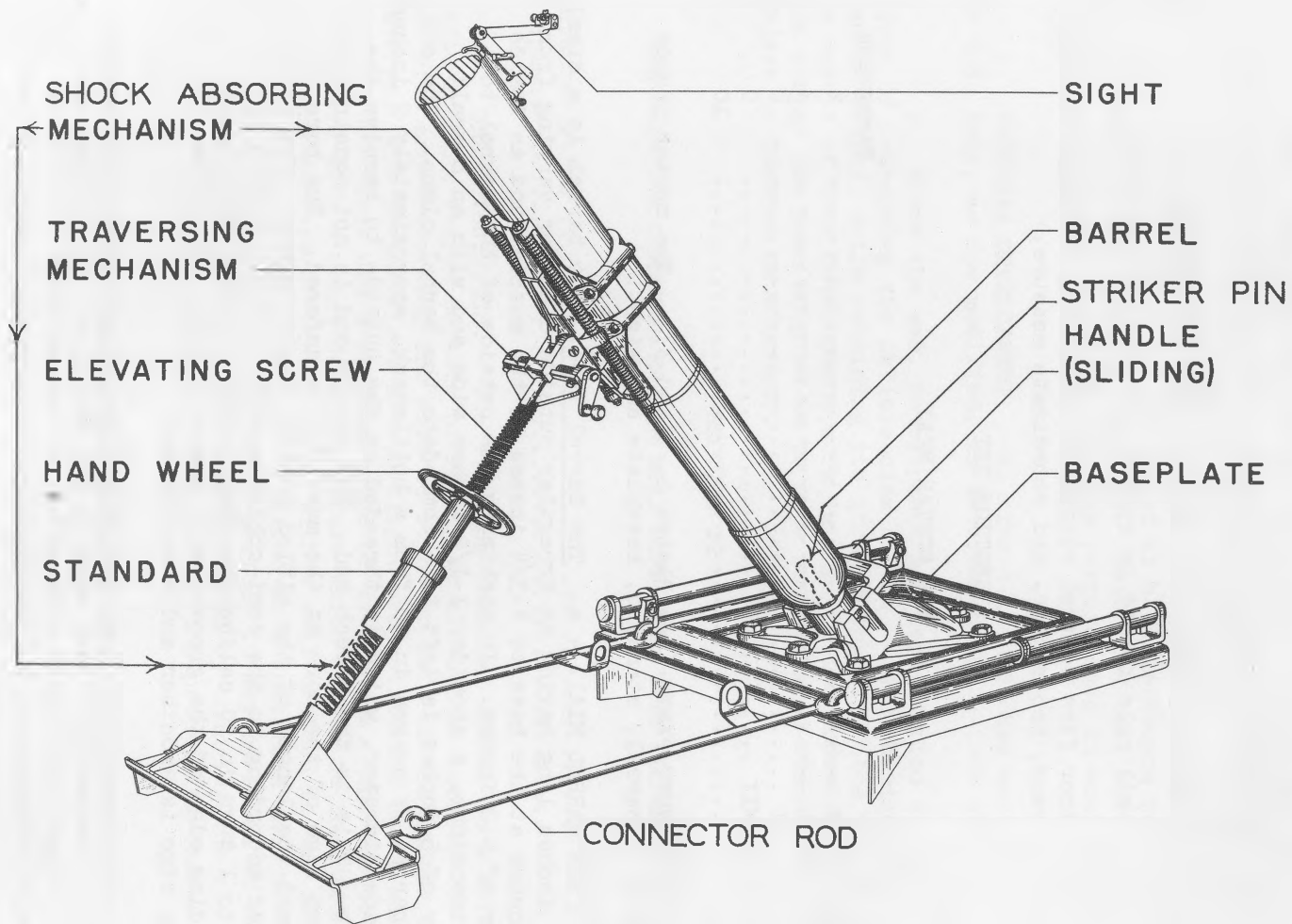
THE MORTAR MIAL

	Paragraph
Component Parts	6
The Barrel MIAL	7
The Standard MI	8
The Baseplate MII	9
The Sight MII	10

6. COMPONENT PARTS (See Plates 1, 2 and 3). - The mortar proper consists of a barrel, standard, baseplate and sight.

7. THE BARREL MIAL. - a. The Barrel Tube. The barrel is a steel tube 48 inches long having an irregular outside diameter varying from 5-1/8 inches at the base to 4-3/4 inches at the muzzle, and an inside diameter of 4.2 inches. In machining the outside of the barrel to these dimensions, a shoulder 1-1/2 inches wide and with an overall diameter of 5 inches is left to accommodate the barrel clamp. One end of the barrel is swaged in to form a bottleneck, approximately 2 inches in outside diameter, which is threaded on the outside to receive the base cap. This is the breech end. The muzzle end is not constricted. The sharp edge of the bore at the muzzle is chamfered. The bore is rifled and the length of the rifled portion is 42 inches. The barrel is rifled according to the semi-cubic parabola formula from 0 at the origin to 1 turn in 20 calibers at the muzzle, and has 24 grooves. The leading edge of the groove has a sharp cutting edge while the trailing edge is smoother and more sloping.

b. The Barrel Clamp and Shock-Absorbing Device. The barrel clamp is a sleeve-type clamp made in two sections. An annular channel is cut into the inside surface of the two sections to fit over the shoulder of the barrel thus preventing the sliding of the clamp along the barrel. The two sections of the clamp are held together by four bolts, two on each side of the barrel. Underneath the barrel, the lower section of the clamp extends in both directions a little more than 5 inches beyond the bolts. At the end of this extension the metal



THE 4.2-inch CHEMICAL MORTAR, MIA1

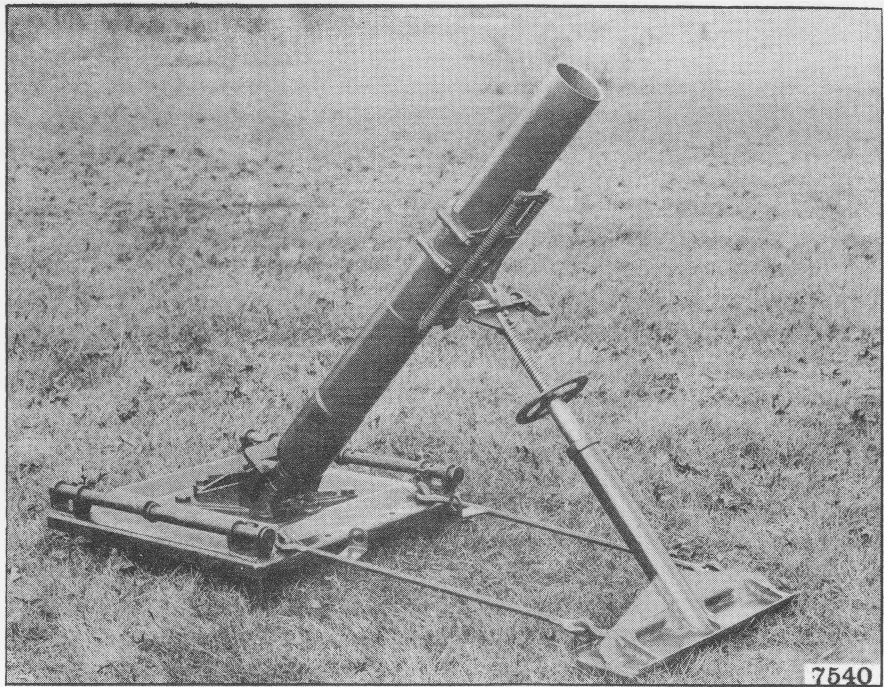
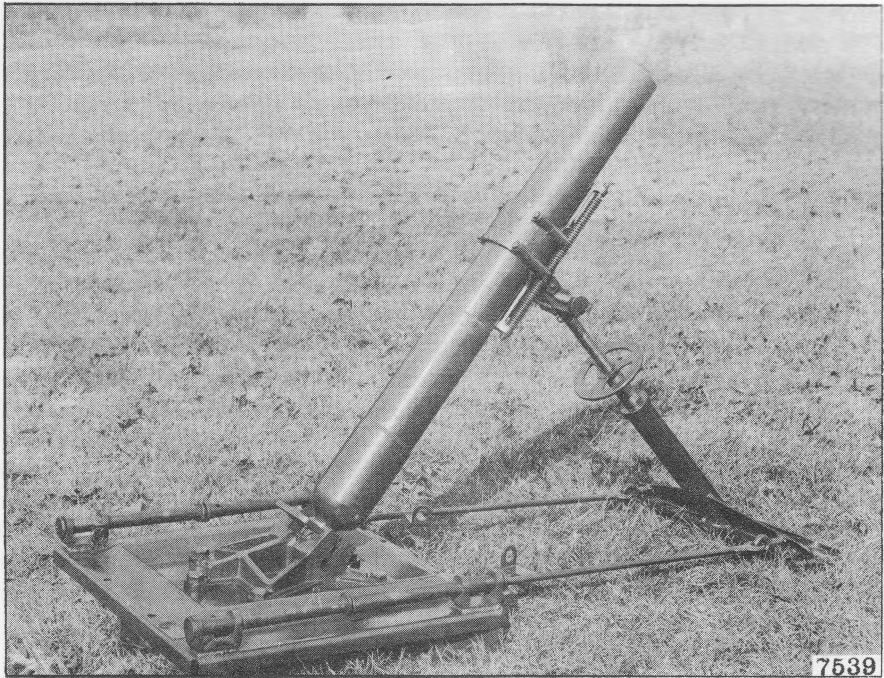
is thickened at the corners which are bent downward to form lugs or ears. In addition, the bottom of the lower section of the clamp has integral with it a slide with a groove in each side. A shoe, machined to fit the slide, is slipped on from the end. This shoe has two lugs or ears which project outward and upward, one from each side. Two springs are used on each side of the barrel clamp, a lug of the shoe separating each pair of springs. These springs when assembled to the barrel clamp have a rod running through each pair, and through holes drilled in the lugs on the shoe and in the lugs of the lower half of the barrel clamp. These rods are threaded at the ends and, after being assembled through the springs and the holes in the lugs of the clamp and shoe, are held in place by a castle nut and cotter pin on each threaded end. When the weapon is fired this assembly prevents the oscillatory shock of recoil from being transmitted to the standard with possible consequent bending or breaking of the elevating and traversing screws. The underside of the shoe has a lug projecting downward which is inserted between two upright lugs on the top of the traversing mechanism and fastened by the barrel pin. This barrel pin is a part of the standard and passes through holes drilled in all three lugs, the lug on the shoe being free to turn on the pin as an axis. This forms the connection between the barrel and the standard.

c. The Base Cap. The base cap is of cold-rolled steel and is cup-shaped. It is $3\text{-}1/2$ inches high and 3 inches in diameter. The wall of the base cap is threaded on the inside to fit over the threaded bottleneck of the barrel. At the bottom of the cap on the inside is a $3/4$ -inch hole threaded to receive the striker pin. The base cap has two pins each 1 inch in diameter and $1\text{-}7/8$ inches long which are screwed into two holes drilled radially 180 degrees apart in the outer walls at right angles to the center line of the base cap. The holes that receive these pins are 1 inch in depth and are just below the shoulder against which the end of the bottleneck of the barrel seats. When assembled in place, these pins fit into slots in the base-cap cup of the baseplate and prevent rotation of the barrel during firing.

d. The Striker Pin. The striker pin is of steel and is cylindrical in shape with a maximum diameter of $1\text{-}1/8$ inches and a length of $4\text{-}3/4$ inches. The upper end is beveled at an angle of 80 degrees, thus reducing the diameter of the flat top to $3/8$ of an inch. The lower end is reduced to $3/4$ of an inch and threaded to enable it to be screwed into the threaded hole in the bottom of the base cap. Beginning at a distance of $1\text{-}1/2$ inches from the shoulder at the bottom the pin is milled to form two parallel flats 1 inch in length on opposite sides to take a $15/16$ -inch end wrench.

e. The Base-Cap Washer. The base-cap washer is made of soft tempered copper which fits over the striker pin into the inside of the base cap so as to insure a gastight joint between the base cap and the barrel.

f. The Muzzle Cover. A leather muzzle cover is placed over the muzzle end of the barrel to protect the interior surface from mois-



THE 4.2-inch CHEMICAL MORTAR, MIA1

ture.

g. Assembling the Barrel. In assembling the barrel the striker pin is screwed into the base cap with a wrench; the base-cap washer is next inserted in place; the striker pin is inserted into the barrel through the bottleneck and the base cap is screwed home by a special wrench applied to the radial pins.

h. Weight. The total weight of the barrel complete is approximately 91 pounds.

8. THE STANDARD MI. - a. General. The standard is shaped like an inverted T. The cross of the T forms the base of the standard and rests upon the ground. The under surface of the cross is provided with two runners, one at each end which cut into the ground and tend to keep the standard in line with the baseplate as the force of recoil pushes them backward during the firing of the mortar. The support or stem of the T contains the standard spring and the elevating mechanism. The upper end of the elevating screw carries the traversing mechanism and the device for connecting the standard to the mortar barrel. The top of the support is closed by a retaining collar.

b. The Support Proper is a seamless steel tube 18-3/8 inches on its longest side, the bottom being cut at an angle of 45 degrees for welding to the center of the base. The outside diameter of the support is 2-1/2 inches and the thickness of the metal is 5/32 of an inch. The top of the support has an external thread extending downward for 3/4 of an inch. At a distance of 10-1/8 inches from the top are four 5/16-inch diameter holes, equally spaced around the circumference. These holes take 5/16-inch diameter pins which are driven into holes, correspondingly sized and placed, in the sleeve bearing for the elevating mechanism and welded in place which holds the sleeve bearing firmly fixed.

c. The Standard Spring is made from wire 7/32 of an inch in diameter and has 19-1/2 coils, wound left hand, with closed ends, the ends ground and annealed, heat treated after winding. The overall diameter is 2-1/8 inches and the uncompressed height is 12-3/8 inches. This spring absorbs the greater part of the whip of the barrel when shell are being fired, thus reducing to a minimum the effect of the recoil on the shell, elevating screw, and the setting of the mortar.

d. The Elevating Mechanism consists of the elevating screw which is attached to the elevating-screw sleeve, the lower thrust washer, the upper thrust washer and the elevating-screw wheel. Rotation of the sleeve by means of the elevating-screw wheel raises or lowers the elevating screw and consequently changes the elevation of the barrel when assembled. The thrust bearing makes the turning of the sleeve easy. The sleeve is prevented from moving along the elevating screw by the retaining collar above, and the thrust bearing below, the shoulder on the sleeve.

With this elevating screw, the mortar barrel can be elevated from 623 to 1256 mils. This is greater than the minimum and maximum elevation required in firing, which are 800 and 1066 mils respectively.

e. The Traversing Mechanism consists of the traversing slide, the traversing screw with the necessary bearings, the traversing nut and the traversing-screw handle, which is attached to one end of the traversing screw. This handle enables the traversing screw to be rotated, thus achieving lateral motion of the traversing nut with resulting lateral adjustment of the muzzle of the barrel. In addition, the projecting lugs of the traversing nut carry a barrel pin which when inserted through a corresponding hole in the barrel coupling connects the barrel to the standard.

The pitch of the threads of the traversing screw is such that when the mortar barrel has an elevation of 890 mils, one turn of the traversing screw handle will traverse the barrel 10 mils. The total traverse possible is 100 mils right and 100 mils left of the center.

f. Weight. The standard complete has a total weight of approximately 53 pounds.

9. THE BASEPLATE MII. - a. The Baseplate Proper. The baseplate is stamped from 1/4-inch chrom-nickel steel plate. During the forming operation the metal close to the edge of the plate is raised to form a ridge which extends all the way around the top surface of the baseplate. This ridge assists the baseplate to resist deformation. In addition, the edges of the plate are flanged downward and the ends of the flanges are welded together. This also gives additional strength. The baseplate is provided with retractable litter-type handles to facilitate handling and carrying. A cast-steel base-cap cup is bolted on to the rectangular surface inside the ridge. The bottom surface of the baseplate is provided with a Y-shaped spade, the stem of the Y facing to the rear. The spade is 5 inches deep.

b. The Base-Cap Cup. The base-cap cup consists of a rectangular block with three long and three short fingers with raised ribs to distribute the strain caused by the force of recoil. The block is cupped to receive the base cap and the necessary slots on the sides are provided to take the radial pins extending from the base cap. Additional slots on the sides at right angles to the base-cap pin slots and near the top of the latter are provided to take the U-shaped cup fork. This cup fork is attached to the base-cap cup by a short length of metal chain similar to sash chain. It is also provided with a flat spring on one tine of the fork. The spring bulges out slightly and has a hump on it near the end of the tine which fits under the shoulder of the base-cap pin slots and prevents the cup fork from jumping out of its own slots during the firing of the mortar. When the barrel and base cap are seated properly into the base-cap cup, the cup fork is inserted in place, which prevents the base cap and barrel from jumping out of the cup during firing. The center line of the cup is at an angle of 52 degrees with the surface of the baseplate proper. The di-

mensions of the cup and radial slots give a sufficiently loose fit with the base cap and radial pins to enable the barrel to be traversed, elevated, or depressed without binding.

c. The Baseplate Slings. Two slings are provided for each baseplate. They are made from heavyweight cotton webbing 2 inches wide and are olive drab in color. The maximum length is 76 inches and there is a slide and loop for adjusting the length similar to those found on the straps of the gas mask carrier. Each end of the sling has been doubled back on itself leaving an opening of 3-1/4 inches. The loops thus formed fit over the ends of the retractable handles of the baseplate. In using the slings one is connected to the front pair of handles of the baseplate and the other to the rear pair. Each of the two men carrying the baseplate passes the center of one sling around his shoulders and adjusts it to a comfortable position. The two slings thus transfer part of the baseplate load from the arms to the shoulders. The use of the slings is optional and depends upon various conditions, such as the tactical situation, the character of the terrain, and the distance which the baseplate must be carried.

d. Weight. The total weight of the baseplate complete is approximately 155 pounds.

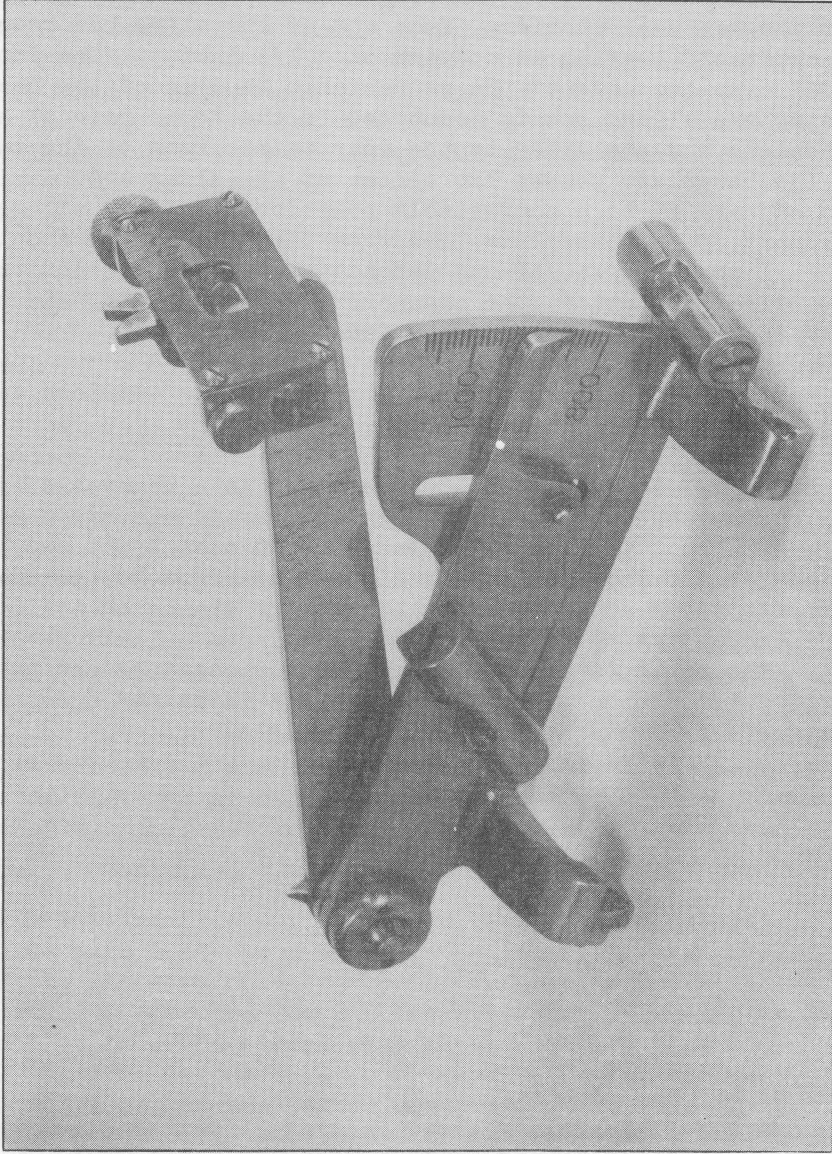
10. THE SIGHT MII (See Plate 3). - The sight is a removable type provided with both elevating and deflecting scales and elevation and cant-detecting bubbles. It permits traversing 150 mils right and 150 mils left of center and the elevation scale extends from 800 to 1070 mils. Both the elevating and traversing scales are graduated in 10 mil increments and the adjusting screws may be easily and quickly reached for operation. The sight is constructed of bronze castings and has a total weight of 1-1/2 pounds. When it is used it is placed upon the upper outside surface of the barrel near the muzzle.

SECTION IV

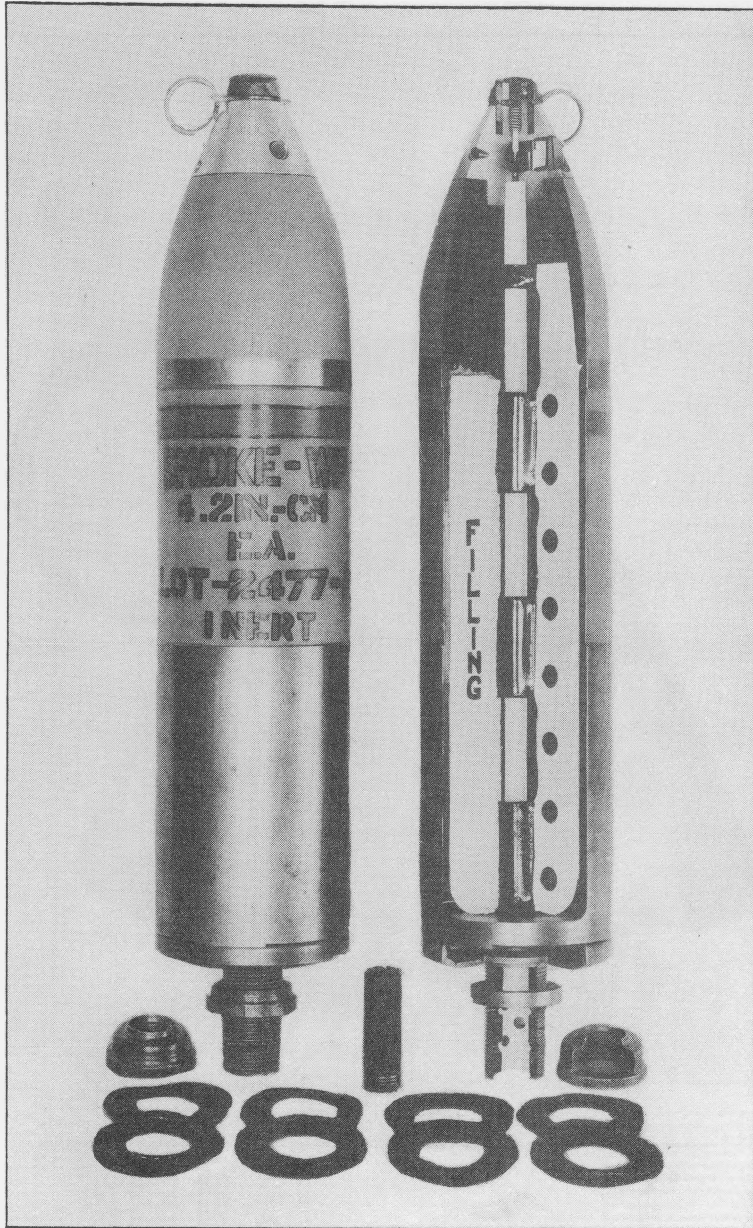
AMMUNITION

	Paragraph
The Complete Round	11
The Shell E38R2	12
The Fuze E15R8	13
The Propelling Charge MV	14
The Fillings	15

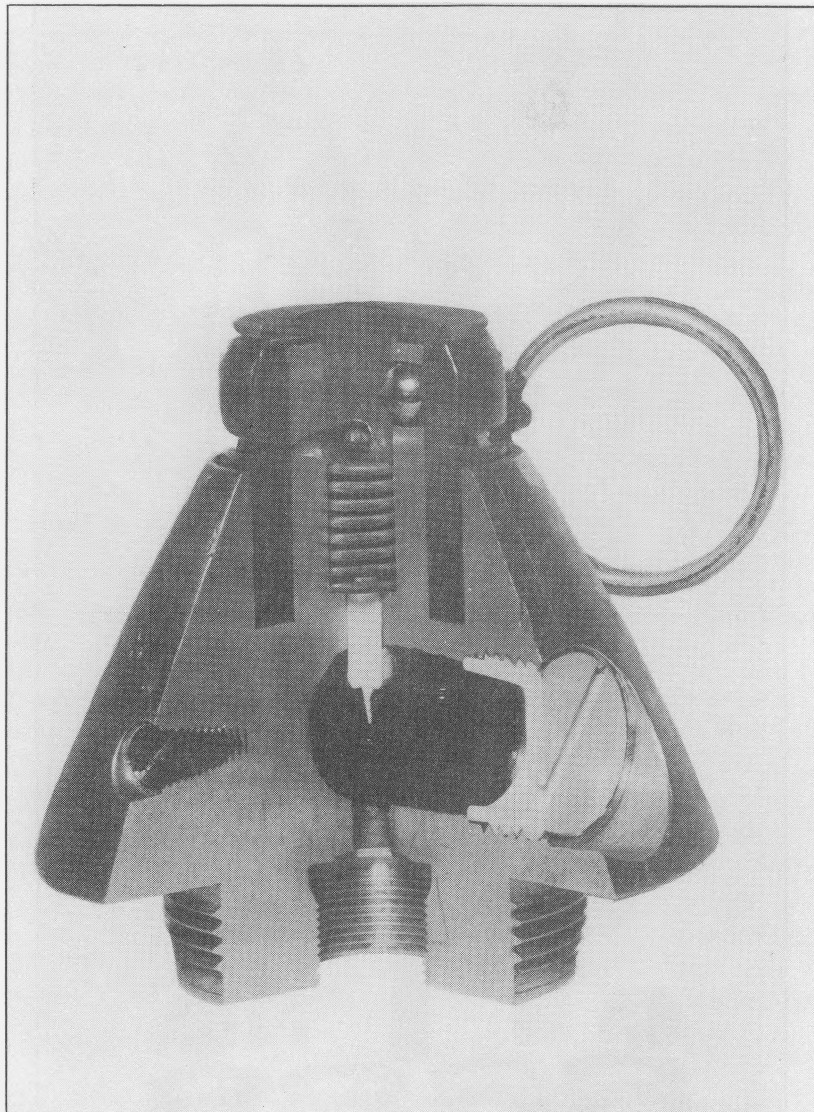
11. THE COMPLETE ROUND (See Plates 4 and 6). - The complete round consists of the shell E38R2, the fuze E15R8, the propelling charge MV, and the filling. When filled and completely assembled except for the propelling charge the complete round has a total weight varying from a maximum of 25-1/2 pounds to a minimum of 23 pounds according to the particular filling contained therein. Of this weight 18 pounds represents the weight of the metal components in all cases. The chemical efficiency therefore varies from 29.4 to 21.7%. The overall dimensions



SIGHT, MIL, 4.2-inch CHEMICAL MORTAR

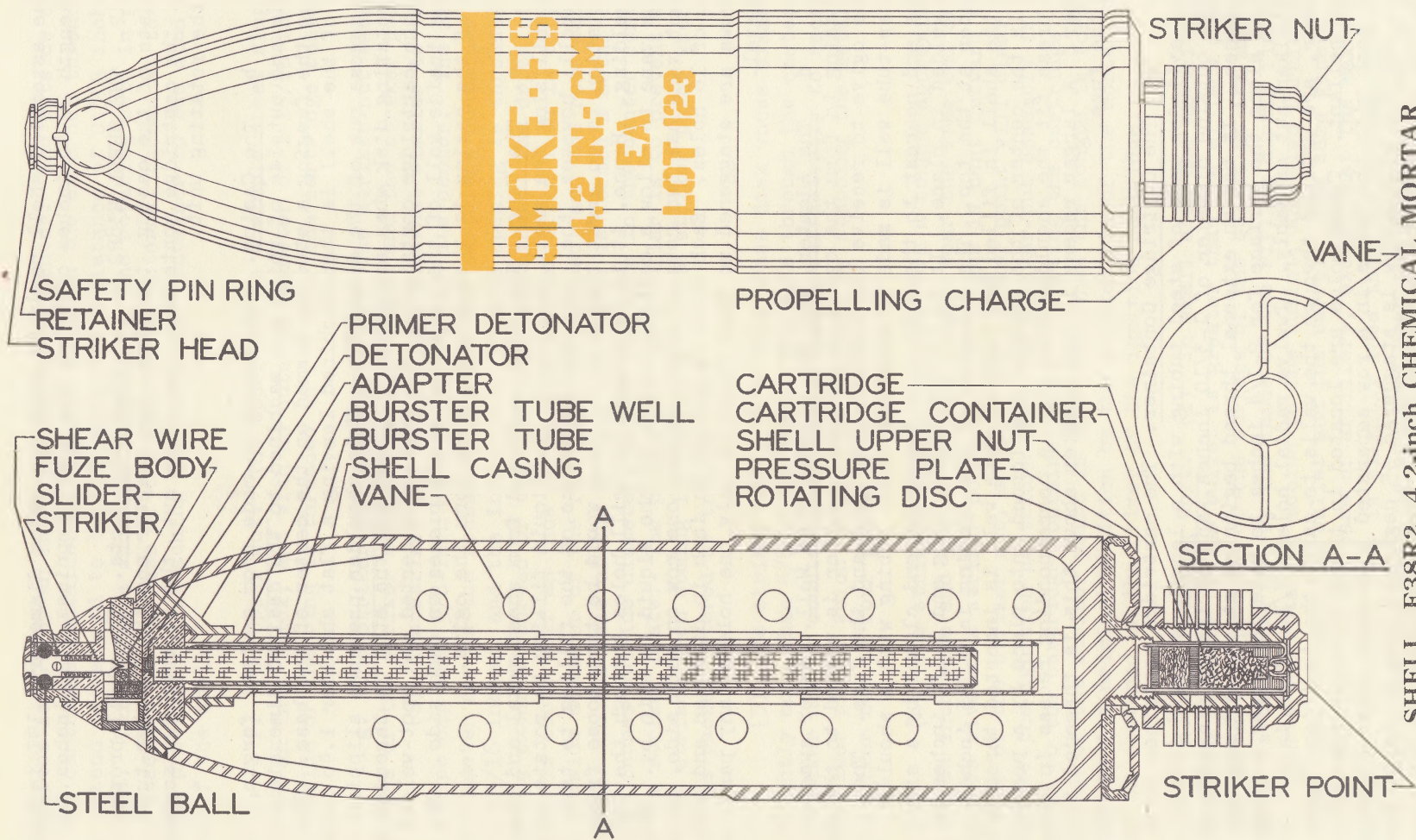


SHELL, E38R2, 4.2-inch CHEMICAL MORTAR



FUZE, E15R8, 4.2-inch CHEMICAL MORTAR

PLATE 5



SHELL, E38R2, 4.2-inch CHEMICAL MORTAR

of the assembled shell ready to fire are major diameter 4.191 inches and length 20.40 inches of which the fuze comprises 2.25 inches.

12. THE SHELL E38R2. - a. Component Parts. The shell proper consists of the casing, the vane, the adapter and the burster-tube well, the cartridge container, the upper nut, the striker-nut assembly, and the rotating unit.

b. The Casing. The casing is made from a steel forging, the inside and outside of which are machined to the desired dimensions. During the forging a stud is formed on the center of the base. The base of the shell is then machined leaving a flat shoulder 1.48 inches wide across one of the diameters. This shoulder prevents slipping of the rotating disk when assembled in place and the stud is threaded to take the cartridge container. The vane is inserted and spot-welded to the inside wall of the casing at eight places on each side. The nose of the casing is then swaged in to form the ogive.

c. The Vane. The vane is formed from sheet metal and aids in stabilizing the shell by forcing the liquid filling to rotate with the shell; however, the initial resistance of the filling to take up rotation is so great that a solid vane would be torn loose from its welding. Hence, it is necessary to drill holes through the body of the vane to allow a certain amount of the liquid to slip by. The present vane has two rows of eight holes, one row on each side, or a total of 16 holes. Each hole is $1/2$ of an inch in diameter and the two rows are staggered so that there is only one hole at any particular level.

d. The Adapter, and the Burster-Tube Well. After swaging the casing to form the ogive, a machined adapter is welded to the nose of the ogive to receive the burster-tube well and the fuze. The burster-tube well is made of seamless steel tubing with a shoulder at the end nearest to the fuze, and the other end closed by a steel plug welded in place. It is $13-7/8$ inches long and $1-1/8$ inches in diameter at the top. The diameter of the opening is 0.745 inches. When the shell is filled the burster-tube well is inserted through the hole in the center of the adapter and forced into place by a press; in this press fit the shoulder fits into a corresponding recess in the adapter. A larger recess in the adapter above this is threaded to take the fuze.

e. The Cartridge Container. The cartridge container is a hollow cylinder made of steel tubing with a length of $2-7/8$ inches, a maximum outside diameter of $1-3/10$ inches, and an inside diameter of 0.8 inches. It has an external thread beginning at one end and extending along the surface for $2-1/4$ inches to take the upper nut and the striker-nut assembly. Twelve radial holes, $7/32$ of an inch in diameter, are drilled through the walls to carry the ignition flash to the propellant. These holes are located in three circular rows of four holes each with the holes in a row separated from each other by 90 degrees, and the middle row is staggered 45 degrees. The distance from the bottom of the cartridge container to the center line of the lower row of holes is $5/8$ of an inch, while the distance between the rows

themselves is $\frac{3}{8}$ of an inch from center to center. The outside diameter of the cartridge container at the end to which the external thread does not extend is reduced to 1.215 inches for a distance of 0.365 inches from the end. This forms a shoulder which holds the rotating unit in place upon assembly to the base of the shell. An internal thread at the same end is provided for attaching the cartridge container to the stud on the base of the shell.

f. The Upper Nut. The upper nut is a simple steel ring $\frac{5}{16}$ of an inch thick, and with an outside diameter of $1\text{-}\frac{15}{16}$ inches. The inside of the ring is threaded to fit over the cartridge container.

g. The Striker-Nut Assembly. (1) The striker-nut assembly consists of the striker nut, the striker plate and the striker point.

(2) The striker nut has a shape somewhat similar to that of a pipe cap with $\frac{5}{8}$ -inch hole bored through its center. The maximum diameter across the recess into which the cartridge container fits is $1\text{-}\frac{15}{16}$ inches, and the inside wall of this opening is threaded to take the external thread of the cartridge container. The depth of the recess is about half an inch of which a quarter of an inch is threaded. The outside diameter of the rear part is reduced, and the rear edge is rounded. On the base of the striker-nut there is formed a metal collar $1\text{-}\frac{1}{16}$ inches outside diameter, around the hole in the center containing the striker plate. The purpose of this collar is to prevent any outside surface from coming in contact with the striker point when the shell is packed, stored or transported.

(3) The striker plate is a thin brass disk whose diameter is slightly more than $\frac{5}{8}$ of an inch. The hole through the center of the striker nut is counter-sunk on the inside sufficiently to receive the striker plate, which is held in position by stabbing the metal of the striker nut in four places.

(4) The striker plate is cut to form a tongue approximately $\frac{1}{4}$ of an inch wide and $\frac{5}{8}$ of an inch long. Near the free end of this tongue is riveted a striker point and the tongue is bent outward toward the base of the striker nut, so that the striker point will clear the primer of the ignition cartridge when the striker-nut assembly is assembled to the cartridge container after inserting the cartridge. The position of the striker point is such that when the tongue is forced inward to its original position by the striker pin of the mortar, the point is centered on the primer of the ignition cartridge.

h. The Rotating Unit. (1) In small arms and ammunition, the maximum diameter of the bullet is greater than the minimum diameter of the barrel. A portion of the surface of the bullet at its maximum diameter is therefore cut by the lands of the rifling during firing which imparts the rotating motion to the bullet, and also furnishes a gastight seal between the bullet and the barrel. The same general principle is followed in the case of artillery, except that the maximum diameter of the shell body is slightly less than the minimum diameter of the barrel and the shell is equipped near the base with one or more

copper driving bands whose diameter is greater than that of the shell body. The driving bands are cut by the lands forming a gastight seal, and impart rotation to the shell.

(2) The 4.2-inch chemical mortar operates on a different principle. It is a muzzle-loading weapon and yet the barrel is rifled and fires a true-flight shell. This is accomplished by means of the rotating unit of the shell. Before firing, the maximum diameter of the complete round is slightly less than the minimum diameter of the barrel and so it is possible to insert the complete round in the muzzle and let it slide down the barrel. When the propellant is discharged, however, the pressure of the gases causes an immediate expansion of the rotating unit to form the equivalent of a driving band.

(3) The rotating unit is assembled to the base of the shell and is held in place by the cartridge container. It consists of the rotating disk and the pressure plate.

(4) The rotating disk is made from a flat, circular plate of cartridge brass approximately $1/2$ of an inch thick. A hole 1.218 inches in diameter is drilled through the center. The surface of the plate which rests against the base of the shell is smoothed and the edge rounded. A slot $1-1/2$ inches wide and $1/16$ of an inch deep is cut all the way across this same surface and the center line of this slot coincides with a diameter of the plate. The opposite surface is recessed by machining until the thickness of the plate is reduced to $3/16$ of an inch except that a collar $1/8$ of an inch wide by $1/8$ of an inch high is left around the hole in the center. The side wall of the recess forms a flange around the circumference of the plate. This flange is $1/8$ of an inch thick and of the same height as the original thickness of the plate. The edge of the flange is smoothed and the inside corner of the edge is beveled. An annular groove is cut at an angle of 45° into the juncture of the flange and the bottom surface of the recess, leaving approximately $5/64$ of an inch of metal connecting the flange to the remainder of the finished disk.

(5) The pressure plate is made from a cold-rolled steel plate, $1/8$ of an inch thick. It is blanked out and formed into its final shape by a press. The center of the plate is then pierced leaving a circular opening of the same diameter as the corresponding hole in the rotating disk. The final shape as formed by the press is that of an annular flat-bottom trough which has been formed by raising the metal around the edge of the plate and around the hole. Both sides of the trough are very slightly sloping and the depth of the trough thus formed is only $9/64$ of an inch. The inner side is flattened out at the top forming a bearing surface, $1/8$ of an inch wide around the hole in the center, which is parallel to the bottom of the trough. The outer edge of the plate is then cut off square with the slope of the sides of the trough. In the forming operation the outer side of the trough is made slightly higher than the inner side so that when some metal is cut off in squaring the edge, the height of the outer side is reduced to that of the inner side. An annular groove is cut at the juncture of the bottom of the trough and the outer side, and a similar groove of smaller diameter at the juncture of the bottom of the trough and the

inner side. The remaining metal connecting the bottom of the trough to the sides is only 0.08 inches thick. A third annular groove of still smaller diameter of the same width and shape is cut on the opposite surface of the plate underneath the juncture of the inner side of the trough with the flat bearing surface around the hole. This leaves a narrow metal collar around the hole. The finished plate is cadmium-plated.

i. Assembling the Rotating Unit, Cartridge Container, Upper Nut and Striker-Nut Assembly to the Shell. The upper nut is first screwed on to about the middle of the cartridge container. The striker-nut assembly is next placed in its proper position, but it can be screwed on only a short distance until the end of the cartridge container rests against the shoulder formed by the reduced diameter of the rear end of the striker nut. In assembling the rotating unit to the shell, the hole of the rotating disk is placed over the stud and the slot fitted over the shoulder on the base of the shell. The end of the cartridge container with the shoulder is then passed through the hole of the pressure plate with the trough facing outward until the metal collar on the opposite surface bears against the cartridge-container shoulder. The same end of the cartridge container with the pressure plate thereon, is fitted over the stud on the base of the shell and screwed home with a bar wrench passed through two of the radial holes in the cartridge container. When thus properly and tightly assembled, the edge of the pressure plate is in contact with the bevel on the flange of the rotating disk, and the collar around the hole of the rotating disk is in contact with the flat bearing surface above the trough and around the hole of the pressure plate, thus leaving an air space between the remaining surfaces of the rotating disk and the pressure plate. The pressure of the shoulder of the cartridge container against the collar around the hole on the outer surface of the pressure plate maintains both components of the rotating unit in firm contact with one another as just described, and holds the complete assembly in place on the shell.

j. Functioning of the Rotating Unit. When the propelling charge functions, pressure is applied to the pressure plate by the gases formed, forcing the bottom of the trough into the airspace between the pressure plate and the rotating disk. As this occurs there is a tendency for the metal of the pressure plate to flatten, due to reduced thickness of the metal below the three grooves which act as toggle joints or hinges. This flattening effect increases the diameter of the pressure plate thus exerting pressure on the flange of the rotating disk. The reduced thickness of metal below the groove cut at the base of the flange on the rotating disk, also acts as a toggle joint or hinge allowing the flange to bend outward. As the hinge action of the flange progresses the edge of the pressure plate is forced into the groove of the rotating disk and the inner surface of the pressure plate finishes up against the inner surface of the rotating disk. The flange when thus forced outward conforms to the contour of the rifling thus becoming in effect a driving band which in following the rifling imparts rotation to the shell. The function of the grooves in the rotating disk and pressure plate is to insure that the toggle actions occur at the proper places in the surface of each component and to prevent uncontrolled buckling.

13. THE FUZE E15R8. - a. General Characteristics (See Plate 5). The fuze is a bore-safe impact fuze of the point detonating type which weighs about 1-1/2 pounds. The complete fuze consists not only of the aluminum fuze body, with its various components necessary for functioning but there is also screwed to the base of the fuze body a seamless steel tube 13-15/16 inches long, 9/16 of an inch of which extends into the fuze body. This tube contains the burster charge and fits inside the burster well of the shell body. The bursting charge is tetryl and weighs approximately 64 grams.

b. Safety Features. The fuze has four safety features:

(1) A safety pin which passes through the body of the fuze, the striker, and the retaining ring, securing the striker and retaining ring firmly against the body of the fuze, thus preventing their movement. This safety pin is pulled from the fuze just before firing.

(2) A copper-shear wire which passes through the fuze body and retaining ring, thus preventing any movement of the retaining ring even after the safety pin has been withdrawn, as long as the shear wire itself remains unbroken. There is an annular groove around the outer surface of the retaining ring into which the ends of the shear wire are bent. This prevents accidental damage to the shear wire from external sources and also enables the fuze to arm itself by cutting the shear wire inside the retaining ring only.

(3) The brass retaining ring which holds two steel balls in cylindrical holes 180° apart in the upper part of the fuze body and at right angles to its vertical axis. When the striker is depressed into the unarmed position two hemispherical recesses, 180° apart, in its stem are located opposite the two holes. The diameter of the holes is slightly larger than that of the balls, but the depth of the holes is less than the diameter of the balls. When the retaining ring is held in the unarmed position by the shear wire its inner surface closes the outer openings of the holes. The result of this is that approximately one-third of each ball fits into the corresponding hemispherical recess in the striker stem, while the other two-thirds remain in the cylindrical holes thus preventing the striker from moving up into the armed position. Immediately below the retaining ring is an empty well in the fuze body into which the retaining ring drops when the shear wire is cut.

(4) The slider which contains the primer detonator is a brass cylinder of two diameters, forming a shoulder at their junction, and into which has been cut the necessary holes to take the primer detonator, the striker point, and lockpin. A groove has also been cut for the guidepin. In the unarmed position the slider is so set that the primer detonator is out of line with the bursting charge and the striker. The point on the end of the striker stem fits into a hole in the slider thereby locking it in place as long as the retaining ring is held in place by the shear wire.

c. Assembling the Fuze to the Shell. There is a large stud on the base of the fuze body with a hole in the middle into which the

tube containing the bursting charge extends. This stud is threaded to fit into the recess in the adapter at the nose of the ogive of the shell. To assemble the fuze to the shell, it is only necessary to insert the tube containing the bursting charge into the burster-tube well until the threads of the fuze stud come in contact with those in the recess of the adapter and then screw the complete assembly home.

d. Functioning. (1) After the fuze is assembled to the shell it is necessary to remove the safety pin before the shell is inserted into the mortar barrel. When the propellant is ignited and the shell moves up the barrel the retaining ring, being a movable part, moves towards the rear and into the empty well immediately below it by its own inertia, cutting the shear wire which, up to this point, held the retaining ring in place. The inside surface of the retaining ring has been recessed at the top so that when the retaining ring drops into the well immediately below it the portion of the inside surface of the ring where the metal has been cut away, is opposite the holes in the fuze body containing the steel balls. The combination of centrifugal force and the pressure of the striker stem caused by the spring on the spherical surface of the steel balls forces them outward into the additional space provided by the cutaway surface of the retaining ring, thus releasing the striker stem. When the striker is thus released, the spring around its stem moves it up into the armed position with the head of the striker projecting 0.25 inches above the end of the fuze body.

(2) The striker is prevented from being forced entirely out of the fuze by a setscrew which passes through the upper part of the fuze body at the same level as the two steel balls and at 90° from each ball. A vertical slot is cut in the striker stem from the bottom of the striker head to the safety-pin hole. The point of the setscrew extends into this slot thus controlling the movement of the striker. The bottom of the safety-pin hole acts as a shoulder which engages the point of the setscrew and prevents further upward movement of the striker. A U-shaped slot is cut in the wall of the retaining ring at the point where the head of the setscrew projects out from the fuze body. This permits the retaining ring to fit around the head of the setscrew without interfering with the downward movement of the ring.

(3) When the striker is free to move the point is lifted out of the slider by the striker-stem spring, and the slider is then free to move. Centrifugal force caused by the rotating shell moves the slider outward until its shoulder meets another shoulder in the fuze body. On completion of this movement the slider is held fast in the armed position by a lockpin which also functions by centrifugal force and which prevents backward movement. The guidepin in the fuze body fits into a groove in the slider and prevents rotation of the slider until the lockpin functions thus assuring vertical alignment of the detonator when coming into the armed position. During the remainder of the flight of the shell the tension of the striker-stem spring holds the striker up in the armed position, and upon impact the spring is compressed and the point of the striker is driven into the detonator. The striker thereby sets off the primer detonator in the fuze body, which in turn detonates the tetryl in the bursting charge of the shell

and thus bursts the shell.

14. THE PROPELLING CHARGE MV. - a. The Ignition Cartridge. The ignition charge of the propellant consists of a commercial No. 12 gage blank shotgun shell loaded with 90 grains of special infallible powder.

b. The Propellant. The propellant proper is made up of thin perforated disks of nonhygroscopic powder. In the center of each disk is a hole which allows the disk to fit over and around the cartridge container. The disk powder is packed in bundles of individual disks placed together concentrically. A full bundle consists of 150 grains of powder and a half bundle of 75 grains. The full bundles are clipped together with two wire clips 180° apart; and the half bundles are put together with only one clip. A full charge consists of eight bundles of 150 grains each, making a total of 1200 grains. In addition, a half bundle (75 grains) is provided with each full charge. This half bundle is for use in filling in range gaps. The proper number of bundles depends upon the range desired, and is determined from the range tables. This type of propellant gives a muzzle velocity from about 200 to about 575 foot seconds with corresponding chamber pressure of about 1000 to 5500 pounds per square inch.

c. Assembling the Propelling Charge to the Shell. In assembling the propelling charge to the shell the ignition cartridge is inserted into the cartridge container after first removing the striker-nut assembly and then the proper number of bundles of powder to obtain the range desired is slipped over the cartridge container. The striker-nut assembly is then placed back upon the cartridge container and screwed home. The upper nut is then screwed down against the powder charge holding it firmly in place on the cartridge container between the upper nut and the striker-nut assembly.

15. THE FILLINGS. - Standard fillings now authorized are WP (White phosphorus), CG (Phosgene), HS (Mustard), and CNS (Chloracetophenone dissolved in equal parts of chloroform and chlorpicrin). Substitute fillings also authorized are FS (Sulphur trioxide in chlorosulphonic acid), FM (Titanium tetrachloride), and CNB (Chloracetophenone dissolved in benzene with carbon tetrachloride added). In filling the shell a variation from the prescribed total weight (not including the propelling charge) of plus or minus 0.25 pounds is allowed in all cases. The shell is filled through the hole in the adapter for the burster-tube well. Upon completion of the filling operation, the burster-tube well is inserted and pressed into its proper position. The press fit gives an efficient gastight joint.

SECTION V

FIRE-CONTROL EQUIPMENT

	Paragraph
The Range Indicator	16
The Mil Rule MI	17
Other Equipment	18

16. THE RANGE INDICATOR. - The range indicator consists of a laminated card made of material resembling celluloid. On both sides of this card are printed range tables and other firing data as given in Section XIII of this chapter. This item is still undergoing development.

17. THE MIL RULE MI. - a. Construction. The mil rule is made from a piece of wood about 6 inches long and 1 inch wide and $\frac{1}{8}$ of an inch thick, with one of the longer edges beveled. It thus resembles an ordinary desk ruler except for its shorter length. The beveled edge is graduated in five main divisions, each one an inch apart. The center main division is marked 0, the next two nearest to the center are marked 50, and the two outer ones are marked 100. Smaller graduation lines are also provided which subdivide each of the main divisions into five parts. These subdivisions are not numbered; thus the 0 mark represents the 0 line and the other four main marks represent 50 and 100 mils to the right and left respectively. Each of the smaller subdivisions represents 10 mils. Two holes are drilled through each flat side of the piece of wood near the ends, and a string with a finger loop in its center is attached to these holes, one end at one hole and the other at the other hole. The length of the string must be such that when the string is pulled taut by the finger loop, this loop will be 20 inches from the center of the rule.

b. Application. In using the mil rule the finger loop is grasped between the thumb and forefinger of either hand and is held against the face in front of either eye. The other eye is closed. The rule is then grasped with the other hand and held in front of the face with the string taut. By aligning the 0 mark on the target the angle in mils between it and the desired aiming point may be read directly.

18. OTHER EQUIPMENT. - Other instruments used with chemical mortars such as the protractor, compass, wind vane, anemometer, field glass, range finder, and sketching case are of standard design and used in common with other branches of the service.

SECTION VI ACCESSORIES AND SPARE PARTS

	Paragraph
General	19
The Accessories and Spare-Parts Set MIAL	20
The Mortar-Cart Accessories Set MI.	21

19. GENERAL. - Except in an emergency only the tools issued with the mortar will be used in making repairs and adjustments, and they must not be used for any other purpose. When not in use they should be stored in their proper place in the receptacle provided for them.

20. THE ACCESSORIES AND SPARE-PARTS SET MIAL. - a. Accessories. The following accessories are provided for the mortar:

- 6 - bags, sand burlap
- * 1 - can, oil, quart, oblong, 2-1/2 x 3-3/4 x 6-13/16 inches high, with screw cap, containing oil, lubricating, gun, medium grade.
- 1 - chest, packing
- 1 - cover, muzzle
- 1 - lanyard
- 1 - mattock, pick, handled.
- 1 - oil can, half-pint
- 1 - spade
- 3 - stakes, aiming
- 1 - gunner's tool roll consisting of:
 - 1 - pliers, 8 inch
 - 1 - screw driver, 4 inch blade
 - 1 - wrench, base cap
 - 1 - wrench, engineers', single-head 5/8-inch opening
 - 1 - wrench, engineers', single-head 15/16-inch opening
 - Spare parts (See b)
 - * 1/2 - pound waste
 - * 6 - cloth, emery, No. 00 sheets
- 1 - ammunition tool roll consisting of:
 - * 6 - cloth, emery, No. 00 sheets
 - 2 - files, flat, second-cut, 8-inch
 - 1 - hatchet, broad
 - 1 - wrench, fuze
 - * 1/2 - pound waste

b. Spare Parts. The following spare parts are provided for the mortar in the field and are carried in the gunner's tool roll:

- 1 - handle, traversing-screw
- 2 - bolts, slide, assembled with nuts and cotter pins
- 1 - pin, striker, 4.2-inch chemical mortar
- 2 - springs, front
- 2 - springs, rear

* Expendable.

c. Carrying the Accessories and Spare-Parts Set. The accessories and spare-parts set complete is carried on the mortar cart, except for the ammunition tool roll which is carried on the ammunition cart, and the packing chest which is ordinarily not carried beyond the point where the carts are loaded.

21. THE CHEMICAL MORTAR-CART ACCESSORIES SET MIAL. - The purpose of this set is to make necessary repairs and adjustments to the mortar carts and ammunition carts in the field and consists of:

- 1 - repair kit, tube, consisting of three items, namely: 1 tube rubber cement (1 oz. size),

- 1 rubber patch (27 in. sq. sheet)
- 1 roughener
- 1 - automotive adjustable wrench
- 1 - motorcycle tire hand pump
- 5 - valve cores (in box)
- 1 - tire iron (15" long)
- 1 - tool bag

The chemical mortar-cart accessories set is intended for use on both the mortar cart and the ammunition cart. It will be issued on the basis of one set per mortar squad and one per ammunition squad. In the mortar squad it will be carried in the tool box of the mortar cart and in the ammunition squad in the tool box of one of the ammunition carts.

SECTION VII

TRANSPORTATION

	Paragraph
General	22
The Chemical-Mortar Cart MIA1	23
The Chemical-Mortar Ammunition Cart MIA1	24
Interchangeability of the Mortar Cart and the Ammunition Cart	25
The Communications Cart	26
Transportation Over Long Distances	27

22. GENERAL. - The problem of transporting the 4.2-inch chemical mortar with its ammunition and accessories comprises first its transportation over long distances in rear areas, which is simple in solution, and its transportation in extreme forward areas, close behind, or in contact with the Infantry. The latter is a more difficult problem, requiring the use of specialized transportation in order that the necessary mobility of the mortar may be preserved. The type of transportation used in such cases varies in accordance with the tactical situation and the character of the terrain. For example, the company of chemical troops now situated in the Canal Zone uses a mule pack form of transportation, owing to the difficulty of using any kind of wheel transportation in the tropical jungles. This is a special situation, however, and at the present time applies to this one company only. Experimental mechanized mounts for the 4.2-inch chemical mortar have also been designed for possible use by cavalry or in connection with cavalry operations. This type of transportation solves jointly the local and long-distance problems. However, the types of transportation most widely used in the forward areas are the carts and equipment described in the succeeding paragraphs. These carts are standard equipment for all chemical troops at the present time except for the company in the Canal Zone.

23. THE CHEMICAL-MORTAR CART MIA1. - a. Characteristics. (See Plate 7). This hand-drawn mortar cart is provided to transport the mortar MIA1, complete, with accessories and spare parts, with the exception of the ammunition tool roll which is carried in the ammunition cart and the packing chest which is not carried at all. The complete cart consists of the chassis with built-in tool box and the mortar rack. The cart has a low center of gravity when loaded and is easily handled

by four men. Its total weight loaded complete is approximately 491 pounds. The weight empty is 165 pounds.

b. The Chassis. (1) The frame of the chassis is constructed of structural steel angle and is 25-3/8 inches wide and 36-1/8 inches long. The axle is welded to the under side of the frame on both side angles at a distance of 18-1/2 inches from the rear and carries motor-cycle wheels, the tires of which are approximately 27 inches outside diameter.

(2) Welded at the front end of the frame are U-shaped pieces to which is welded the pole brace. The pole and handle are attached to this brace. These three items are of steel tubing. The length of the pole is 39-1/4 inches plus 6-1/2 inches and the length of the pole handle is 39 inches. The pole braces project 1 inch beyond the tires and are at an angle so that in addition to strengthening the structure, they act as wheel guards and deflect any brush with which they may come in contact when in the field. They also serve as front handles in lifting the carts into and out of trucks. A tube 1-1/4 inches in diameter extends the entire width of the chassis frame under the rear angle and is welded thereto. Like the pole braces, it projects at each end to form guards for the wheels and also serves as rear handles when the carts are lifted into and out of trucks.

(3) In the center of the handle is a ring to which are attached by round-eye snaps two lead chains with handles.

(4) Each chassis is provided with two retaining chains. The ends of one chain are attached to the front corner of the chassis while the ends of the other are attached to the rear corner. At the center of the rear chain is permanently attached a screw coupling. This coupling, when hooked into the front chain and tightened puts sufficient tension on both chains to keep the load in place under all conditions. The length of the chains is sufficient to take care of both mortar and ammunition loads.

(5) The tool box is located between the pole brace and the front end of the chassis and contains the following items from the various accessories and spare parts:

The pick-mattock head, gunner's tool roll, the mortar-cart accessories set, half-pint oil can, and baseplate slings.

(6) The frame is equipped with the necessary supports, guides, pins, shoulders, locating plates, etc., to prevent movement of the various component parts and accessories of the mortar during transport when properly loaded in place.

c. The Mortar Rack. The mortar rack is 40-3/8 inches long, 10-1/8 inches wide and 9-1/8 inches high. The longitudinal members are constructed from structural steel angle, the cross members being channel shaped of steel plate and one piece of steel tubing. Above the cross members at each end is a steel strap which forms the barrel support to

receive the mortar barrel. At each side of the frame are rectangular guides to carry the aiming stakes. The rear cross member is provided with locking pins that enter drilled holes in the stakes, thus securely locking them in the mortar rack. The mortar rack is supported by four structural-steel angle posts; 1/2 inch diameter pins are welded to the bottom of these posts. These pins enter drilled holes in the baseplate locating the mortar rack and preventing any movement.

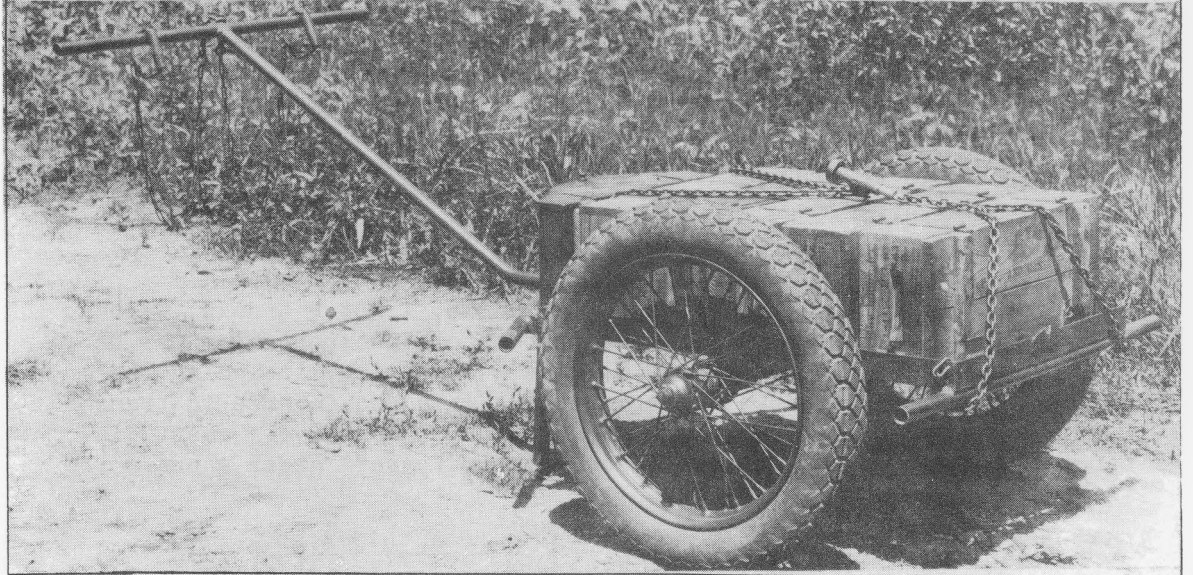
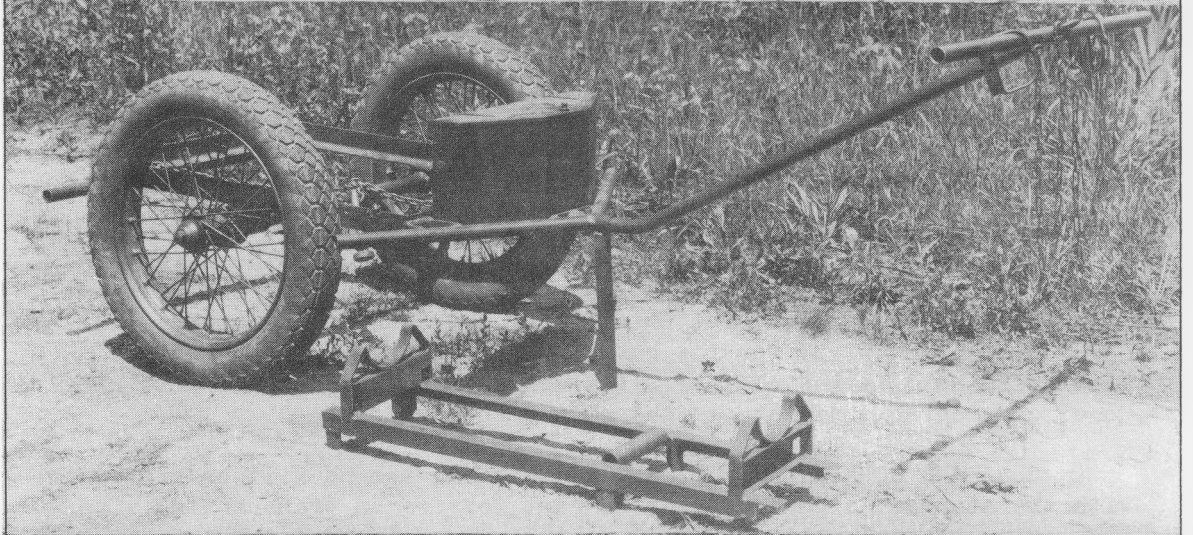
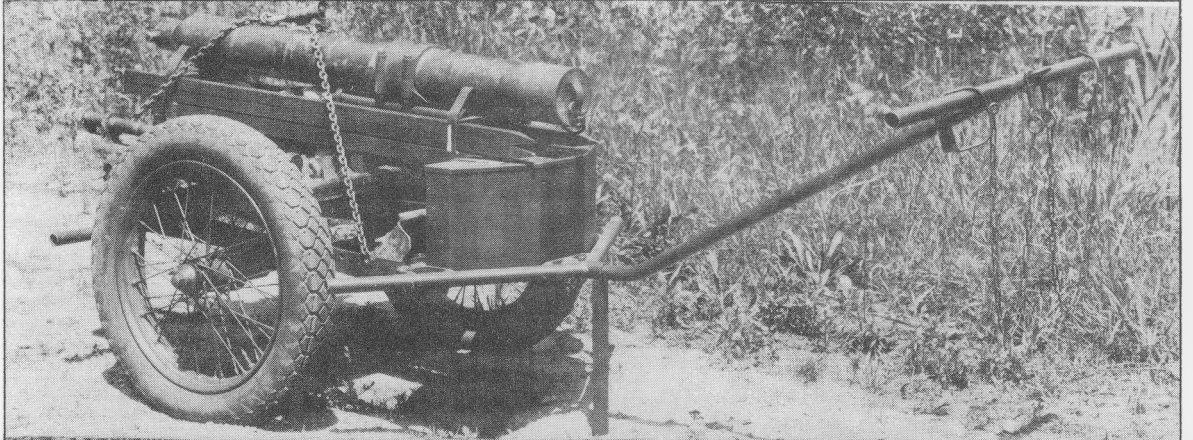
24. THE CHEMICAL-MORTAR AMMUNITION CART MIAL (See Plate 7). - The chemical-mortar ammunition cart is designed to carry five filled shell boxes (10 complete rounds), plus the ammunition-tool roll and the ammunition-cart accessories set, which are carried in the tool box. This cart is identical with the chemical-mortar cart MIAL except that the chassis has no spade and pick-mattock handle supports welded to the front angle and no standard shoulders and notched locating plate for the baseplate spade on the rear angle. The mortar rack is also omitted. The ammunition cart also has a low center of gravity when loaded and is easily handled by four men. Its total weight loaded complete is approximately 479 pounds. The weight empty is 149 pounds.

25. INTERCHANGEABILITY OF THE MORTAR CART AND THE AMMUNITION CART. - The mortar cart may be used as an ammunition cart by simply removing the mortar rack. The ammunition cart is so designed that in an emergency it can be used to carry the mortar load, except the spade and pick-mattock handle. The omission of the standard shoulders and notched locating plate for the baseplate spade does not prevent the load being held by the chains. If a mortar rack is available, it will be of considerable assistance and should be used.

26. THE COMMUNICATIONS CART. - Chemical troops will be provided with the standard signal corps reel cart for use in transporting wire and laying telephone lines. Reel Cart RL-35, now under development, is constructed of light materials and is equipped with motorcycle wheels. It is hand drawn and carries two reels, each containing a half-mile of W-110 Wire. Each platoon headquarters and company headquarters will be provided with one of these carts.

The other items of equipment provided chemical troops for fire control are small. They are normally carried by hand or on the person of members of the mortar or reconnaissance squad.

27. TRANSPORTATION OVER LONG DISTANCES. - Motor trucks, wagons, railways, airplanes, or other similar forms of transportation may be used to transport the mortar and all its accessories, including the carts, over long distances. The carts are intended for use in transporting the mortars and accessories only for comparatively short distances in the field, particularly in extreme forward areas where motor transportation cannot go.



TOP TO BOTTOM: MORTAR CART, LOADED;
MORTAR CART, EMPTY; AMMUNITION CART, LOADED

SECTION VIII

PACKING

	Paragraph
General	28
The Chemical-Mortar Packing Chest	29
The Chemical-Mortar Standard Box	30
The Shell Packing Box	31
The Propelling-Charge Container	32

28. GENERAL. - a. The following items are provided for packing the mortar, shell and accessories:

(1) Packing chest, chemical-mortar

(2) Standard box, chemical-mortar

(3) Packing box, shell

(a) Container, propelling-charge

b. The baseplate is not packed.

c. The mortar and ammunition carts are shipped in any satisfactory type of commercial packing crate or box. They may be stored either packed or unpacked.

29. THE CHEMICAL-MORTAR PACKING CHEST. - The packing chest is listed as an item in the accessories and spare parts set MIAL; but it is usually not taken into the field beyond the point where the mortar and ammunition is loaded on carts. It is used for packing the barrel, complete with base cap and striker pin, the sight, the baseplate slings, and the remaining items of the accessories and spare parts set. It is approximately 56 inches long x 15 inches wide x 12 inches high, and has a displacement of 5.9 cubic feet. The chest empty weighs 75 pounds and when loaded weighs 215 pounds.

30. THE CHEMICAL-MORTAR STANDARD BOX. - The standard box is approximately 40 inches long x 27 inches wide x 10 inches high, and has a displacement of 6 cubic feet. The box empty weighs 50 pounds and when loaded weighs 103 pounds. The only item packed in this box is the standard.

31. THE SHELL PACKING BOX. - Two complete rounds of the shell are packed in one box. The dimensions of this box are 25-1/8 inches x 10-1/8 inches x 5-11/16 inches. It weighs when empty 15 pounds. The cleats on the top and bottom of the box are staggered so that the boxes will nest. The height of the cleats is 9/16 of an inch, and since there are cleats on the top and bottom, the overall height of the box is 6-13/16 inches. The lid is fitted with two hinges and two hasps, each hasp with its individual latch.

32. THE PROPELLING-CHARGE CONTAINER. - The propelling charges are packed in a sealed fiber cylindrical container. Each container contains 16 full bundles of powder (two charges), 2 one-half bundles of powder, and 2 ignition cartridges. Every fifth container contains three ignition cartridges instead of two. These extra cartridges are for use, if necessary, in case of misfires. One of these containers is packed inside each shell packing box inasmuch as its contents forms part of the complete round.

SECTION IX

SUMMARY OF WEIGHTS

Table of Weights	Paragraph 33
------------------------	--------------

33. TABLE OF WEIGHTS. - For convenient reference the weight of the mortar and its component parts, the shell and its component parts, and the various additional equipment are listed in Table 1.

TABLE 1

Weights

<u>Item</u>	<u>Weight</u> lb.
Barrel	91
Standard	53
Baseplate	155
Shell, complete	23 to 25½
Fuze	1½
Sight	1½
Accessories and Spare Parts Set (less packing chest)	37
Mortar Cart	165
Ammunition Cart	149
Packing Chest	75
Standard Box	50
Packing Box, Shell	15

SECTION X

CARE AND MAINTENANCE

General	Paragraph 34
Inspection and Cleaning Before, During and After Firing ...	35
Painting	36

34. GENERAL. - a. In assembling and disassembling the mortar, no tools other than those issued in the accessories set, should be used except in an emergency.

b. The bore and springs of the barrel and all unpainted surfaces should be kept clean and free from rust. The bore must always

be kept lightly oiled with a light oil when not in actual use, and the muzzle covered with the muzzle cover. The use of the muzzle cover is especially important in rainy weather, as water, in addition to causing rust, may seriously affect the range of the mortar.

c. If the mortar is to remain unused for some time, all bright and unpainted parts, such as the bore, the shock-absorber slide, the striker pin, screws, threads, etc., after being first thoroughly cleaned, must be protected by a light coat of rust-preventive compound. The rust-preventive compound is removed by the use of burlap or waste. This removal is made easier by soaking the burlap or waste in gasoline.

d. The striker pin should be examined from time to time, and if found so worn, bent or defective as to cause misfires, it should be replaced, care being taken that the new striker pin is tightly screwed into the base cap.

e. Examine the springs for defects and tighten the nuts and screws occasionally.

f. To Remove Base Cap. Use the special wrench provided for this purpose, applying the wrench to the radial pins on the base cap. Light blows on the handle of the wrench may be necessary to loosen the threads.

g. To Replace the Base Cap. Use the same special wrench as used to remove the base cap. It is essential to obtain a tight fit between the base cap and barrel to avoid gas leaks; therefore, see that the base-cap copper washer is present and in position and screw the base cap home.

h. To Remove Striker Pin. Remove the base cap from the barrel. Hold the base cap fast by means of the base-cap wrench and apply the 15/16-inch engineers' wrench to the milled section of the striker pin.

i. To Replace the Striker Pin. Proceed in reverse order to that described in h. above, making sure that the base-cap washer does not catch under the shoulder of the striker pin. Put a drop of oil on the threads before screwing the striker pin firmly into the base cap.

j. There is no difficulty in dismantling parts of the remaining mechanism, and no special instructions should be necessary. Care must be taken in dismantling bolts, etc., not to batter the threads by driving them out with a hammer. A piece of hardwood or a copper drift should be interposed.

k. The sight should always be kept in its carrying case when not in use.

35. INSPECTION AND CLEANING BEFORE, DURING AND AFTER FIRING. -

a. Before Firing. (1) Swab the bore of the barrel as free from oil as possible, using the cleaning rod. Also remove any excess oil on

the outside of the barrel and the standard.

(2) See that the striker pin is firmly screwed home in the base cap and that the base cap is tightly screwed on to the barrel insuring a gastight fit.

(3) See that all nuts, bolts, and screws are in position and tight.

b. During Firing. The barrel should be swabbed out after every five rounds except in case of rapid fire when it will be swabbed out at the first opportunity.

c. After Firing. (1) Unscrew the base cap. Remove all residue. Clean and sponge out the barrel. Lightly oil the bore.

(2) Clean the striker pin and oil lightly. Then screw the striker pin tightly into the base cap.

(3) Clean and oil the base cap.

(4) Examine, clean and oil all working parts of the standard and barrel.

(5) Clean the baseplate.

(6) Tighten all nuts and screws.

36. PAINTING. - a. The entire mortar, with the exception of those parts listed in b., should be kept well painted as a protection against rust. The carts should also be kept well painted. Clean and wash the mortar and carts thoroughly to remove all dirt and grease and allow to dry before applying paint.

b. The following parts will not be painted:

(1) The bore and the shock-absorbing mechanism slide.

(2) The elevating and traversing screws and bearing surfaces of the standard.

SECTION XI

OPERATING INSTRUCTIONS

	Paragraph
Safety Precautions	37
Selection of Emplacement	38
Setting Out the Aiming Stakes	39
Preparation of Emplacement	40
Emplacing the Mortar	41
Laying the Mortar	42
Preparation of Ammunition	43
Firing the Mortar	44
Misfires	45
To Go Out of Action	46
To Load the Mortar Cart	47
To Unload the Mortar Cart	48
To Load the Ammunition Cart	49
To Unload the Ammunition Cart	50

37. SAFETY PRECAUTIONS. - For safe and proper operation of the mortar, the necessary safety precautions should be observed at all times. These are described in Section XII.

38. SELECTION OF EMPLACEMENT. - In addition to the limitations placed by the tactical situation, the location for emplacing the mortar should be selected with care. It should be as level and firm as practicable.

39. SETTING OUT THE AIMING STAKES. - There is no special technique applicable to the 4.2-inch chemical mortar insofar as setting out the aiming stakes is concerned. The general principles applicable to other accompanying weapons apply. Complete details are given in TR 415-35.

40. PREPARATION OF EMPLACEMENT. - If the ground is comparatively level and firm no excavation will be required. A space on the surface, approximately 30 inches wide and 80 inches long, with the long axis on line with the aiming stakes, should be cleared of all foreign matter. If the topsoil is loose or sandy, it should be removed in order to provide a firm emplacement for the baseplate. If the ground is very uneven, a space, as above, should be leveled off for the baseplate and the base of the standard.

41. EMLACING THE MORTAR. - Before emplacing the mortar it should be cleaned and checked in accordance with the provisions of paragraph 35. After the emplacement space is cleared, the baseplate should be set upon the ground and a center line, in line with base-cap cup, aligned with the aiming stakes, after which several men should stand upon the baseplate to make an impression of the Y-shaped spade on the ground. Then remove the baseplate about one pace to the rear of the emplacement space. Take the spade or shovel, and make a cut in the

ground along the outline of the Y-impression to a depth of about 5 inches. Each time the spade is inserted in the ground, force it from side to side to form a crevice about 1 inch wide along the entire outline of the Y-impression. Dig two narrow trenches several inches deep along the surface where the connector rods would otherwise rest when the standard and barrel are placed in position. When the baseplate digs itself into the ground the connector rods fit into these trenches thus preventing bending of the rods. Take the baseplate and insert the spade of the baseplate into the Y-shaped crevice. Then have several men stand on the baseplate and force it down until the under surface rests firmly on the ground.

Take the standard, and release the upper ends of the connector rods and hook them to the baseplate. Lower the base of the standard to the ground; take the barrel and assemble the base-cap end into the base-cap cup of the baseplate and lock it in place with the cup fork. Lower the barrel and raise the standard, connecting it to the barrel coupling. Align the barrel with the aiming stakes and then force the runners on the base of the standard into the ground.

Swab the barrel with the cleaning rod. Fill two sandbags with earth. Place the bags on the base of the standard. The mortar is then ready for final laying.

42. LAYING THE MORTAR. - After the barrel has been roughly aligned on the aiming stakes, or aiming point, take the sight, set it for the desired elevation, with the deflection indicator on the zero point, place it on the barrel, rotate it slowly around the barrel until the two cross bubbles indicate the level position. Elevate the mortar until the elevating bubble comes to the level position which indicates the desired elevation. Use the sight for the accurate alignment of the mortar with the aiming stakes. If the sight does not indicate alignment of the mortar with the aiming stakes, the error may be corrected by traversing the mortar, right or left, until the proper alignment is had. Care should be exercised at all times during the sighting operation to keep the cross level and elevation bubbles centered; otherwise, large errors in firing may occur.

If during action the mortar should shift from its original setting, it can be corrected only between rounds. The sight must not be on the mortar when it is in action.

43. PREPARATION OF AMMUNITION. - For purposes of safety, as well as economy of effort, the preparation of ammunition should be conducted under competent supervision in an orderly sequence of operations which should be strictly adhered to. Assuming that the shell boxes are loaded on the ammunition cart the proper sequence is as follows:

a. Remove shell packing boxes from cart as described in paragraph 50.

b. Open shell packing boxes. Take out shell and propelling-charge containers.

- c. Clean the shell by removing all dirt and rust-preventive compound from shell body, cartridge container surface, and flash-outlet holes. Remove rust or paint from the bourrelet and the full base diameter portion of the shell body by means of emery cloth.
- d. Examine fuze. See that safety pin is in place. See that the shear wire is in place and bent over into the groove at both ends.
- e. Examine bourrelet and the full base diameter portion of the shell body for burrs which might cause the shell to stick in the barrel. Burrs should be filed down.
- f. Open propelling-charge containers.
- g. Remove striker-nut assembly from cartridge container.
- h. Place the necessary number of bundles of powder on the cartridge container (see Table 2).
- i. Insert cartridge in cartridge container, taking care that the base flange of the cartridge is firmly seated against the bottom of the cartridge container.
- j. Replace the striker-nut assembly on the cartridge container and screw home.
- k. Screw the upper nut toward the powder charge until the bundles are held firmly in position between the upper nut and the striker-nut assembly.
- l. When necessary the split ends of the safety pin projecting beyond the fuze body may be straightened with a pair of pliers to permit easy and rapid removal.

44. FIRING THE MORTAR (See Plate 8). - The following is the proper sequence of operations which should be adhered to at all times:

- a. Be sure that the sight is removed from the barrel before firing.
- b. Immediately before firing and at no other time, remove safety pin from the fuze.
- c. To fire the mortar insert the assembled round, cartridge end down, into the muzzle up to the ogive. Then give the shell a quick push and immediately remove the hand from the muzzle.
- d. The mortar should be checked for elevation and alignment after the first round, as the initial round always tends to seat the baseplate into the ground thus causing a change from the original setting of the mortar.



4.2-inch CHEMICAL MORTAR SQUAD IN ACTION

PLATE 8

45. MISFIRES. - a. Definition. A misfire is the failure of the shell to leave the mortar after the complete round has been released into the barrel.

b. Causes. Misfires may be due to any of the following causes:

(1) Shell sticks in the barrel due to -

(a) Burrs, rust, dirt or paint on bourrelet and the full base diameter portion of the shell body.

(b) Dirty bore.

(2) Shell fails to impact upon the striker pin with sufficient force to discharge the ignition cartridge due to -

(a) Same as (1) (a).

(b) Same as (1) (b).

(c) Angle of elevation too small.

(3) Flat top of striker pin fails to force the striker point of the striker-nut assembly into the primer of the ignition cartridge due to -

(a) Debris, presumably from previous rounds, covering the top of the striker pin.

(b) Lack of centering of striker pin due to its being loose, bent, or otherwise defective.

(c) Lack of centering of cartridge container due to its being loose, bent or otherwise defective.

(d) Defective striker-nut assembly.

(e) Failure to screw striker-nut assembly home.

(4) Defective propelling charge due to -

(a) Defective primer or cartridge.

(b) Defective powder charge.

c. Action to be Taken. (1) In case of a misfire, all personnel remain at the sides or in rear of the mortar for at least one minute before taking any action. The cup fork of the base-cap cup is then removed, and the base cap is lifted out of the base-cap cup. The breech end of the barrel with the base cap is raised higher than the muzzle so that the misfired shell will slide out easily, but not too fast, into the hands of the man stationed alongside the muzzle to receive the shell.

The safety pin is immediately replaced in the fuze and the shell laid aside. The cause of the misfire is then determined. If possible the defect is corrected, the mortar reassembled, relaid, and rechecked, the safety pin again removed from the shell, and firing resumed. If the defect is in the mortar and cannot be corrected, then the mortar goes out of action and all ammunition including the misfired shell is returned to the ammunition dump. If, on the other hand, the defect is in the misfired shell, and cannot be corrected, the shell is replaced by another and firing resumed after reassembling, relaying, and rechecking the mortar. The defective shell is returned to the ammunition dump and is segregated from the good ammunition.

(2) If, for any reason, the shell should stick in the barrel on its way down, extreme care must be exercised in its removal. Any movement of the barrel may cause the shell to slide down the rest of the way and be discharged. In such a situation, efforts should be made to dislodge the shell by rocking or pounding the mortar without raising the breech end of the barrel and making sure that the barrel is not pointed toward any person or solid object. If all such efforts are without result, then it is necessary to proceed as in the case of an ordinary misfire, except that the breech end of the barrel should be raised as quickly as possible to a height greater than that of the muzzle, and the base cap and striker pin should be removed before making further attempts to remove the shell.

46. TO GO OUT OF ACTION. - The following operations are required:

- a. Remove sandbags.
- b. Dismount barrel from standard.
 - (1) Depress elevating screw to the minimum elevation.
 - (2) Withdraw coupling pin which connects standard to barrel.
 - (3) Lift out barrel from standard.
- c. Dismount barrel from base-cap cup.
 - (1) Remove U-shaped cup fork from its slots in the base-cap cup.
 - (2) Lift out barrel and base cap from base-cap cup.
- d. Disconnect connector rods from baseplate.
 - (1) Raise the standard in a rotary motion toward the baseplate until the eyelets of the connector rods are free.
 - (2) Remove eyelets of connector rods from the hooks on the baseplate.
- e. Secure connector rods to standard head.

(1) Bring the free ends of the connector rods together at the standard head.

(2) Secure the connector rods in the place provided at the head of the standard by replacing the coupling pin.

f. Raise baseplate from firing position.

(1) Grasp the baseplate utilizing the handles provided thereon. A small amount of earth may have to be removed to allow extension of the handles.

(2) Lift the baseplate from the firing position.

47. TO LOAD THE MORTAR CART. - The mortar load is placed on the cart in the following order:

a. The pick-mattock head, gunner's tool roll, mortar cart accessories set, one-half pint oil can, and baseplate slings, are put in the tool box.

b. The blade of the spade is placed in the spade support under the front frame angle on the left hand side of the cart, the handle extending to the rear and held in place by a reversible T-type retaining pin. The large end of the pick-mattock handle is inserted in the mattock support located under the front frame angle on the right hand side of the cart, and the hole drilled in the small end of the handle fits over a vertical pin at the right corner of the rear angle.

c. The standard is next laid on the frame, front side up with the base resting against the front angle with the baseplate ends of the connector rods between the standard shoulders on the rear frame angle, which prevents undue movement and assists in holding the standard in its proper place on the cart.

d. The baseplate is then loaded with the front of the plate facing the front of the cart and the three notches in the baseplate spade are fitted over the rear angle and the two side angles respectively. A notched-plate locator which extends above the rear angle is attached at its center, and the end of the baseplate spade passes through this notch. The insertion of the baseplate spade in this notch facilitates the mating of the forward notches of the spade with the side angles. It also prevents any lateral movement of the baseplate and in turn the baseplate prevents any movement of the spade, pick-mattock handle, and standard.

e. The mortar rack is now placed on the baseplate with the end containing the aiming-stake locking pins toward the rear, the four post pins of the rack entering the drilled holes in the baseplate. The aiming stakes, two on the right and one on the left hand side, are put through the rectangular guides on the sides of the mortar rack with

the points forward, and are retained in place by horizontal lock pins which enter the drilled hole in the stakes.

f. Six sandbags are folded and packed between the side angles of the mortar rack and in the rear of the baseplate cup. The mortar barrel, with the cleaning rod inside the barrel and the muzzle cover in position, is placed in the barrel support with the muzzle toward the front end of the cart and is moved forward until the shock-absorbing mechanism slide is against the front barrel support. The front end and rear retaining chains are now put over the mortar barrel and connected by the screw coupling. The coupling is now tightened until there is no more give to the chains, thus holding the entire load securely.

48. TO UNLOAD THE MORTAR CART. - Proceed as outlined in the preceding paragraph, in reverse order.

49. TO LOAD THE AMMUNITION CART. - The chemical mortar ammunition cart is designed to carry the following items:

- a. 5 - shell boxes filled (10 complete rounds).
- b. 1 - ammunition tool roll (see Section VI, Accessories and Spare Parts). (Carried in the tool box).

The shell boxes are placed on their sides and crosswise on the frame of the cart. When placed properly in position, the ends of all the boxes rest against the side angles of the frame, and the sides of the front and rear boxes against the front and rear angles of the frame respectively. The front and rear retaining chains are put over the mortar barrel and connected by the screw coupling. The coupling is tightened until there is no more give to the chains, thus holding the entire load securely.

50. TO UNLOAD THE AMMUNITION CART. - To unload the ammunition cart, proceed as outlined in the preceding paragraph, in reverse order.

SECTION XII

SAFETY PRECAUTIONS

	Paragraph
General	51
Operating	52

51. GENERAL. - Training Regulations No. 140-5 prescribes general safety precautions for all weapons. Additional safety precautions when firing the 4.2-inch chemical mortar are prescribed in Training Regulations No. 415-35. The following extracts from these regulations are regarded as being especially important.

a. Responsibility. In all firing in time of peace, thorough precautions will be taken to preclude all possibility of accident. Safety in firing is the responsibility of the officer in immediate command of the unit or units firing, who may be assisted if necessary by

a range officer.

b. Firing Over the Heads of Personnel. In time of peace, firing of the 4.2-inch chemical mortar over the heads of personnel is prohibited.

c. Warning Signs and Guards. Before firing, signs will be placed at appropriate points to warn persons approaching the range. Guards, properly instructed as to their duties, will be posted so as to cover all approaches to the danger area. (The danger area shall be as prescribed in TR 140-5.)

d. Location of Observers. When chemical ammunition is fired, observers should be upwind of the line of fire.

e. Gas Masks. When chemical ammunition, other than smoke, is fired, all personnel will be provided with gas masks.

f. Use of the Lanyard. When white phosphorus or toxic chemical shell are fired, the lanyard will be used, and no persons except the man handling the lanyard shall be within 50 yards of the mortar.

g. Firing of White Phosphorus. White phosphorus shell should not be fired over ranges overgrown with brush or tall grass on account of the fire hazard. White phosphorus ammunition must be piled well away from personnel or shelter and in a space cleared of all combustible material.

h. Misfires. In case of misfire, the mortar will not be touched until at least one minute has elapsed. While the projectile is being removed, all persons should be at the sides of the mortar and no member of the mortar crew should be directly in front of or directly in rear of the mortar.

i. Duds. Signs, warning persons of the danger from duds, will be posted in the vicinity of the firing area at all times. Duds will be removed as prescribed in TR 1370-A.

52. OPERATING - For safe and proper operation of the mortar, the following precautions must be observed at all times.

a. Before firing make sure that all oil is removed from the bore of the mortar. If the bore is oily, smoke will be given off and the position disclosed.

b. See that the bourrelet and the full base diameter portion of the shell body are clean, otherwise the shell may stick in the barrel.

c. Be sure that the cartridge end of the shell is pointed downward when inserted in the mortar.

d. Do not fire a shell in which the striker or slider of the fuze is in the armed position, or when the shear wire has been cut or damaged.

e. Be sure to remove the hand quickly from the muzzle of the mortar after inserting the shell.

f. Do not try to force the shell down the barrel.

SECTION XIII

RANGE TABLES AND OTHER FIRING DATA

	Paragraph
General	53
Examples of the Use of Tables	54

53. GENERAL. - a. Range Table. The range table given in this chapter (see Table 2) is based primarily upon shell with the heaviest filling, but is sufficiently accurate for general purposes. For accurate range firing it will be necessary to furnish a special range table for each type of filling.

b. Drift and Wind Deviation (see Tables 3 to 7 inclusive). Deviation of the shell from the line of fire is caused by wind and drift. The amount and direction of deviation caused by the wind depends upon the direction of the wind and its velocity. Drift is due to rotation of the projectile and causes the shell to deviate to the right of the line of fire. Proper corrections must be applied to the sight settings to compensate for these factors.

54. EXAMPLES OF THE USE OF TABLES. -

Example No. 1: The magnetic azimuth of and the distance to a target have been determined from the map (method described in Sec. IV TR 415-35) to be magnetic azimuth 4020 mils and the range 1800 yards. What is the correction for drift?

Answer: From Table 3, it is found that the drift is $22\frac{1}{2}$ mils to the right at 1800 yards. Therefore $4020 - 23$ equals 3997 mils magnetic azimuth.

Example No. 2: The magnetic azimuth has been determined to be 15 mils and the range 2000 yards. What is the new magnetic azimuth for drift allowance?

Answer: Table 3 gives drift as 25 mils right. 15 mils - 25 equals -10 . 6400 mils - 10 equals 6390 mils magnetic azimuth.

Example No. 3: The magnetic azimuth has been found to be 3210 mils, the range 1875 yards. The velocity of the wind is 10 mph from 3 o'clock. What is the correction for drift and wind?

Answer: From Table 3, drift is 24 mils to the right equals

Left 24 mils. From Table 4, wind correction should be 13 mils to the right. Therefore 24 left - 13 mils right equals 11 mils left. 3210 - 11 equals 3199 mils magnetic azimuth.

Example No. 4: The range is 2000 yards and magnetic azimuth 2310. The wind is a head wind from 12 o'clock at 8 mph. What is the corrected range and correction for drift?

Answer: From Table 5, 2000 plus 65 equals 2065 yards. From Table 3, 2310 - 25 equals 2285 mils magnetic azimuth.

Example No. 5: The range is 1900 yards, magnetic azimuth 1300, wind 15 mph from 5 o'clock. What corrections?

Answer: From Table 7, range 1900 - 75 equals 1825 yards. From Table 3, magnetic azimuth 1300 - 23 equals 1277 mils for drift.

TABLE 2

RANGE TABLE - 4.2-INCH CHEMICAL MORTAR

<u>YARDS</u>	<u>2 Bundles</u>		
600	1066		
650 - - -	980	<u>2-1/2 Bundles</u>	
700	840	1050	
750	980	<u>3 Bundles</u>	
800 - - - - -	910	1070	
850	820	1000	
900		930	
950 - - - - -		870	
1000		800	<u>4 Bundles</u>
1050		1040	
1100 - - - - -		1000	
1150		950	
1200 - - - - -		910	
1250		850	<u>5 Bundles</u>
1300		800	1070
1350		1020	
1400 - - - - -		980	
1450		930	
1500		890	<u>6 Bundles</u>
1550		840	1050
1600		1010	
1650 - - - - -		980	
1700		930	<u>7 Bundles</u>
1750 - - - - -		890	1040
1800		840	1010
1850		800	980
1900		950	
1950 - - - - -		930	<u>8 Bundles</u>
2000		890	1070
2050 - - - - -		860	1040
2100		830	1000
2150		800	980
2200			940
2250 - - - - -			910
2300			870
2350 - - - - -			840
2400			800

TABLE 3

CORRECTIONS FOR DRIFT

<u>Range</u>	<u>Drift to Right</u>
Yd.	Mils
600 - - - - -	8
800	10
1200 - - - - -	15
1600	20
2000 - - - - -	25
2400	30

TABLE 4

CORRECTION FOR 3 O'CLOCK OR 9 O'CLOCK WINDS

(Flank Winds)

Deflection in Mils

Range	Velocity of Wind			
	5 mph	10 mph	15 mph	20 mph
600	0 Mils	5 Mils	5 Mils	13 Mils
800	0 "	5 "	10 "	15 "
1200	5 "	10 "	15 "	20 "
1600	5 "	10 "	20 "	25 "
2000	5 "	15 "	25 "	30 "
2400	10 "	20 "	30 "	40 "

For a wind from left give deflection left.
 For a wind from right give deflection right.
 Interpolate for midrange and winds.

TABLE 5

CORRECTIONS IN YARDS FOR 12 O'CLOCK OR
6 O'CLOCK WINDS

(Head or Tail Winds)

Range Yd.	Velocity of Wind			
	5 mph	10 mph	15 mph	20 mph
600	5 Yd.	10 Yd.	15 Yd.	35 Yd.
800	10 "	20 "	30 "	50 "
1200	20 "	40 "	60 "	80 "
1600	30 "	60 "	90 "	120 "
2000	40 "	80 "	120 "	160 "
2400	50 "	100 "	150 "	200 "

For tail wind (6 o'clock) subtract from the range.
For a head wind (12 o'clock) add to the range.
Interpolate for midranges and winds.

TABLE 6

CORRECTIONS FOR 10 TO 11 O'CLOCK WINDS OR 1 TO 2 O'CLOCK WINDS

Range Yd.	Velocity of Wind							
	5 mph		10 mph		15 mph		20 mph	
	Def. Mils	Rn. Yd.	Def. Mils	Rn. Yd.	Def. Mils	Rn. Yd.	Def. Mils	Rn. Yd.
600	0	+ 5	0	+ 5	0	+10	5	+15
800	0	+ 5	0	+10	5	+20	5	+30
1200	0	+15	5	+30	10	+40	10	+50
1600	5	+20	5	+40	10	+60	15	+80
2000	5	+25	10	+50	15	+80	15	+100
2400	5	+30	10	+60	15	+100	20	+130

For a wind from left give deflection left.

For a wind from right give deflection right.

Interpolate for midranges and winds.

TABLE 7

CORRECTIONS FOR 7 TO 8 O'CLOCK WINDS OR 4 TO 5 O'CLOCK WINDS

Range Yd.	Velocity of Wind							
	5 mph		10 mph		15 mph		20 mph	
	Def. Mils	Rn. Yd.	Def. Mils	Rn. Yd.	Def. Mils	Rn. Yd.	Def. Mils	Rn. Yd.
600	0	- 5	0	- 5	0	-10	5	-15
800	0	- 5	0	-10	5	-20	5	-30
1200	0	-15	5	-30	10	-40	10	-50
1600	5	-20	5	-40	10	-60	15	-80
2000	5	-25	10	-50	15	-80	15	-100
2400	5	-30	10	-60	15	-100	20	-130

For a wind from left give deflection left.

For a wind from right give deflection right.

Interpolate for midranges and winds.

SECTION XIV

THE 4-INCH CHEMICAL MORTAR MI

	Paragraph
Characteristics	55
Component Parts	56
The Barrel MI	57
The Bipod MI	58
The Baseplate MI	59
The Sight MII	60
Accessories and Spare Parts	61
The Complete Round	62
The Shell MI	63
The Fuze MXI	64
The Propelling Charge MIV	65
Weights	66
Range Table	67

55. CHARACTERISTICS. - The 4-inch chemical mortar is a modification of the old war-time 4-inch Stokes mortar, into which have been incorporated certain improvements which were originally designed for the 4.2-inch chemical mortar and which have been found equally adaptable to both mortars. It is a smooth bore muzzle loading weapon, designed for high angle fire and is capable of the same rate of fire as the 4.2-inch mortar. Its range, however, is considerably shorter than that of the 4.2-inch mortar, the maximum range being only 1075 yards and the minimum 200 yards. The operation and technique of the 4-inch chemical mortar are similar to that of the 4.2-inch chemical mortar except for the more limited range and greater inaccuracies of the former. It is expected that the 4-inch chemical mortar will become obsolete when the development of the 4.2-inch chemical mortar has been completed.

56. COMPONENT PARTS. - The 4-inch chemical mortar consists essentially of the barrel, bipod, baseplate and sight. Certain tools, spare parts and accessories, similar to those furnished with the 4.2-inch chemical mortar, are included with each mortar for use in the emplacing and servicing of the piece.

57. THE BARREL MI. - The barrel is the same as the barrel of the 4.2-inch chemical mortar with the following exceptions:

- a. The bore is not rifled.
- b. There is no shock-absorbing device.
- c. Instead of a single sleeve-type barrel clamp as in the 4.2-inch mortar, there are two such clamps joined together by a tierod through the lower halves of the clamps. These clamps are held 6.75 inches apart by a spacing tube through which the tierod passes. The lower half of the front clamp has a lug or ear projecting downward

through which is a horizontal hole threaded to receive the hollow traversing screw, which is the connecting link between the barrel and the bipod. The muzzle side of the rear clamp rests against a shoulder on the barrel thus preventing the barrel from being driven backward through the clamps by the force of recoil.

d. The base cap does not have radial pins for holding it in place in the baseplate cup.

58. THE BIPOD MI. - The bipod consists essentially of the following:

a. Legs. The legs consisting of two steel tubes fitted with feet and cross-stay lugs, are attached by means of male and female fork ends to the trunnion standard. They are held rigidly apart by the cross-stay which is hinged at its middle point, but which locks in position as the hinge passes dead center. The cross-stay end is tapped to take one end of the cross-stay tongue so that any wear which may occur in the cross-stay bolts can be taken up at this point.

b. Trunnion Standard. The trunnion standard forms the bipod head and also houses the elevating mechanism.

c. Elevating Mechanism. The trunnion standard is fitted with a bevel gear, threaded to receive the elevating screw, and a bevel pinion which turns on a stud. These gears are operated by an elevating gear handle. A clockwise movement of the handle elevates the screw. A bevel gear cover, fastened to the trunnion standard by three cap screws, protects the elevating mechanism. The upper end of the elevating screw is fitted with a yoke which holds the traversing mechanism.

d. Traversing Mechanism. Holes in each arm of the yoke form bearings in which the traversing-screw shaft revolves. The shaft supports and drives the hollow traversing screw by means of a dog clutch. The screw passes through and engages with threads in the lug of the barrel clamp. The screw is rotated by the traversing-screw shaft handle. The traversing-screw shaft, together with the clutch and traversing-screw handle, forms a bolt for locking the barrel and bipod together. This bolt is held in position by the traversing-screw shaft locking pin, which in turn is held in its socket by a spring. The traversing mechanism limits are 40 mils right and 40 mils left.

59. THE BASEPLATE MI. - The baseplate comprises a round steel plate 15 inches in diameter, with a raised cup in the center to receive the base cap, and a sub-base 17 inches wide, 36 inches long and 3 inches thick, made of oak strips bolted together. The steel plate is bolted to the sub-base, the whole forming a large surface for absorbing recoil. There are no slots in the base-cap cup, since the base cap does not have radial pins.

60. THE SIGHT MII. - This is the sight developed for use on the present 4.2-inch chemical mortar, but is equally suitable for use on the 4-inch chemical mortar and should be so used. Several other types of sights have been developed for use on both mortars, but they are all

obsolete or obsolescent.

61. ACCESSORIES AND SPARE PARTS. - The accessories and spare parts required for use with the 4-inch chemical mortar, are the same as those of the 4.2-inch chemical mortar with the exception that a different base-cap wrench must be provided due to lack of radial pins and a clinometer is provided for installing the baseplate. Two flat milled surfaces, 180 degrees apart, have been cut on the sides of the base cap of the 4-inch chemical mortar to receive a large engineers' wrench.

62. THE COMPLETE ROUND. - The complete round consists of the shell MI, the fuze MXI, the propelling charge MIV, and the various chemical fillings. The complete round assembled and ready to fire, but minus the propelling charge weighs approximately 25 pounds. Of this weight, from 6.8 to 9.5 pounds is the filling contained therein.

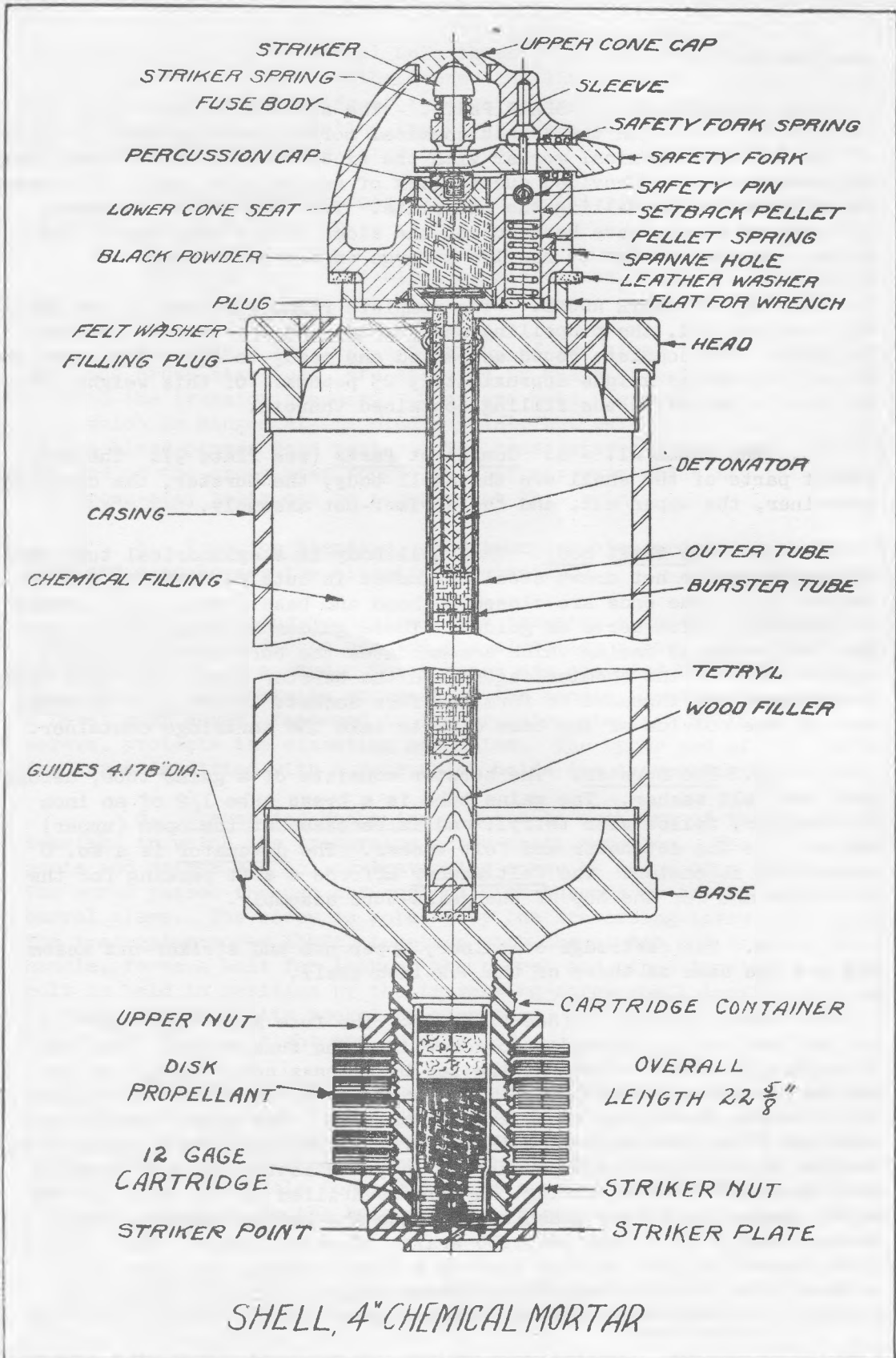
63. THE SHELL MI. - a. Component Parts (see Plate 9). The component parts of the shell are the shell body, the burster, the cartridge container, the upper nut, and the striker-nut assembly.

b. The Shell Body. The shell body is a cylindrical tube made of lap-welded or hot drawn steel, 4 inches in outside diameter and 15 inches long. The ends are closed by head and base disks, 4.178 inches in diameter, which serve as guides. These guides hold in place a central well-tube or casing which accommodates the burster and prevents contact between the chemical agent and the burster tube. The head disk is recessed and threaded to form the fuze socket. There is a threaded stud on the outside of the base disk to take the cartridge container.

c. The Burster. The burster consists of a gaine tube, detonator, and felt washer. The gaine tube is a brass tube 1/2 of an inch in diameter, filled with tetryl, and is recessed at the open (upper) end to take the detonator and felt washer. The detonator is a No. 8 commercial detonator. The felt washer affords a soft packing for the detonator and for the top of the gaine-tube assembly.

d. The cartridge container, upper nut and striker-nut assembly are the same as those of the 4.2-inch shell.

64. THE FUZE MXI. - (See Plate 9). The fuze MXI, "All-ways" is a hollow iron casting threaded to screw into the fuze socket. The body is centrally cored, closed at the top by a brass cone-cap and at the bottom by a brass screw plug. This cavity is divided into two chambers by a second screw plug above the bottom plug. The upper chamber carries the firing mechanism consisting of a floating-sleeve assembly which carries the striker and a percussion cap, the latter two are normally held apart by a spiral spring. A hole is drilled in the floor of the upper chamber to form a flash outlet into the bottom chamber. The bottom chamber is filled with 130 grains of black powder. The floor of this chamber is also drilled to form a flash outlet, the hole being covered by a disk of specially prepared muslin. A hollow brass rod termed the safety fork projects horizontally through the fuze and the



SHELL, 4" CHEMICAL MORTAR

sleeve of the firing mechanism. This fork is held against a coiled spring by means of a set-back pellet operating in a vertical chamber, and carrying a projection which penetrates the fork holding it in position. The pellet is held in position by a coiled spring, and in addition is normally pinned in this position by a safety pin which passes through the fuze body and pellet.

b. Operation. When the safety pin is withdrawn, the set-back pellet spring holds the pellet in position until its force is overcome by the set-back on the discharge of the mortar. On the discharge, the projecting pin of the pellet disengages the safety fork, and the spring of the safety fork forces the fork out of the fuze. However, the safety fork cannot arm the fuze until the shell has cleared the muzzle. When this takes place, the fuze is fully armed and the next shock will cause the firing pin to penetrate the percussion cap and thus actuate the fuze.

The set-back pellet and its spring are so designed (by specification) that the fuze is not armed unless the imparted shock is sufficient to throw the shell 100 yards when the mortar is fired at 45 degrees. This means that there is normally no danger of the explosion of a "short" which fails to carry less than 100 yards from the gun position.

The "all-ways" feature may be illustrated as follows: If the shell strikes on the base end, the inertia of the striker overcomes the resistance of the striker spring, drives downward through the sleeve and explodes the cap. Should the shell fall on its head, the inertia of the sleeve causes it to slide down on the striker, exploding the cap. If the shell strikes on its side or obliquely, the striker and sleeve are driven together as they attempt to ride the cam-like surfaces of the conical seats. As the 4-inch chemical mortar shell "tumbles" in flight it is necessary to employ a fuze which will function irrespective of the angle at which the shell strikes the ground.

The percussion cap, on discharge, flashes the black powder immediately below, which, in turn, is directed downward through the shellaced muslin disk to the detonator and bursting charge. The force of the resulting explosion is sufficient to open the shell and disperse the filling.

65. THE PROPELLING CHARGE MIV. - This propelling charge is the same as the propelling charge MV for the 4.2-inch chemical mortar, except each full bundle of disk powder contains 300 grains instead of 150 grains. A full charge consists of 4 bundles of 300 grains each, making a total of 1200 grains. A full charge is, therefore, the same for both mortars, except that it consists of 8 bundles of disks in the 4.2-inch chemical mortar, but only 4 bundles in the 4-inch mortar. No half bundles are provided for the 4-inch mortar.

66. WEIGHTS. - The weights of the important component parts of the 4-inch chemical mortar are as follows:

<u>Component</u>	<u>Weight</u>
Barrel	lb. 90
Baseplate	120
Bipod	32
Shell	25

67. RANGE TABLE. - To determine the amount of propellant to be used for the range desired, see Table 8.

TABLE 8

RANGE TABLE - 4-INCH CHEMICAL MORTAR

<u>YARDS</u>	<u>1 Bundle</u>			
200	1350	<u>2 Bundles</u>		
225 - -	1320 -	1400		
250	1280	1380	<u>3 Bundles</u>	
275 - -	1250 -	1360 -	1410	
300	1220	1340	1390	
325 - -	1190 -	1320 -	1370	<u>4 Bundles</u>
350	1160	1290	1350	1400
375 - -	1110 -	1270 -	1340 -	1390
400	1030	1250	1320	1380
425 - -	920 -	1230 -	1300 -	1360
450	810	1210	1280	1350
475		1190	1260	1330
500 - - - - -		1170 -	1250 -	1320
525		1140	1230	1300
550 - - - - -		1110 -	1210 -	1290
575		1080	1190	1280
600 - - - - -		1040 -	1180 -	1260
625		980	1160	1250
650		870	1140	1240
675			1120	1220
700 - - - - -			1100 -	1210
725			1070	1190
750 - - - - -			1040 -	1180
775			1000	1170
800 - - - - -			940 -	1150
825			880	1130
850			810	1110
875				1090
900 - - - - -				1070
925				1040
950 - - - - -				1010
975				960
1000 - - - - -				920
1025				880
1050 - - - - -				840
1075				800

CHAPTER VI

CHEMICAL MUNITIONS USED BY ARTILLERY

(This chapter supersedes Chap. VI, Bk. 3, Sept.-36)

SECTION		Paragraphs
I	- General	1-7
II	- Chemical Shell, General	8-14
III	- Standard Chemical Shell, Description	15-24
IV	- Chemical Shell, Firing	25-26

SECTION I

GENERAL

	Paragraph
Introduction	1
Characteristics of Artillery Weapons	2
The 75-mm. Field Gun	3
The 75-mm. Pack and Field Howitzers	4
The 105-mm. Howitzer M1	5
The 155-mm. Howitzer	6
The 155-mm. Gun	7

1. INTRODUCTION. - Chemical artillery shell were first introduced during the World War, tear-gas shell making their appearance as early as 1915. These were followed the next year by shell containing a variety of toxic agents, smoke shell, "sneeze-gas" shell, and shell containing numerous experimental mixtures including incendiaries. When mustard gas was introduced during the summer of 1917 its demonstrated efficiency as a casualty producer so far surpassed all other agents that it brought about a stabilization of chemical shell design, a reduction in the number of agents used, and an increase in the proportion of chemical shell used. About forty different substances (and mixtures) covering a wide range of potency and effect were employed. Germany adopted chemical agents for use in all caliber weapons above the 37-mm. gun. The requirements for gas and smoke shell had increased so greatly near the close of the War that production failed to meet these requirements.

2. CHARACTERISTICS OF ARTILLERY WEAPONS. - Chemical shell are fired from the same weapons used to fire high explosives and shrapnel and are supplied, handled, and fired in a similar manner. Only the general characteristics of artillery weapons will be considered in this chapter.

3. THE 75-mm. FIELD GUN. - a. General. There are at present four types of 75-mm. light field guns available for service - the M1897 M2, the M1897 (French), and M1917 (British), and the M1916 (American). The M1897 M2 combines the best characteristics of the M1897 (French) with the desirable characteristics of a high-speed carriage; wide and rapid traverse, variable muzzle velocities which permit of high-angle fire, and effective fire-control equipment for use in fire against

fast-moving targets. The M1897 (French) predominates in numbers. It is the weapon used by our Army during the World War. It will be continued in our service until it is gradually replaced by the standard type M1897 M2. All the various types make use of the same ammunition, and according to "Firing Tables for 75-mm. Gun, Model of 1897 (French)", 1934 edition, have an extreme range of 12,700 yards with H.E. shell Mk. IV and 8000 yards with H.E. shell Mk. I and shell Mk. II with gas and smoke fillings. Current development promises an extreme range of 13,500 yards. Rate of fire is 6 rounds per minute, for prolonged fire 3 rounds per minute.

b. Gun and Carriage M1897 M2. A light-rapid-firing field piece which employs three powder charges providing both flat trajectory and high-angle fire. By utilizing the tube and recoil mechanism of the M1897 (French) a split-trail carriage designed for towing at high speeds permits an 85° (1511 mils) traverse, with elevations from minus 10° (178 mils) to plus 45° (800 mils). This weapon is equipped with new oncarriage fire-control equipment, including panoramic sight and cross-leveling features as well as equipment for fire against fast-moving targets. Weight in firing position is 3450 pounds. This type will eventually replace types c, d, and e below as funds become available.

c. Gun and Carriage M1897 (French). A light rapid-firing flat-trajectory field piece. It is equipped with hydropneumatic recoil system, the effective operation of which permits of rapid return to firing position during firing without the necessity for relaying the piece for the next shot. The total traverse on the axle is 6° (105 mils). On level ground it can be elevated to 19° (325 mils) and depressed to minus 10° (178 mils). The piece is equipped with a simple optical sight. Weight in firing position 2650 pounds. Most of the guns of this type now in service have been modified for high-speed transport.

d. Gun and Carriage M1917 (British). This is an adaptation of the 3.3-inch (18-pounder) field gun with a tube designed to take 75-mm. shell. It is heavier and shorter than the French gun and has a hydrospring type of recoil but otherwise has about the same characteristics. It has a total traverse of 8° (150 mils) and an elevation on level ground of 16° (300 mils). The limited elevation of both this piece and the French gun without digging in the trail is, to a certain extent, a drawback to their most efficient use. All guns of this type now in service in the Regular Army and one-half of those in service in the National Guard have been modified for high-speed transport.

e. Gun and Carriage M1916 (American). This is somewhat similar to the French gun except that it has a hydrospring type of recoil with the recoil varying with the elevation to insure stability at low elevations and that it has a split-type trail. The maximum elevation is 53° (940 mils), and it has a total traverse of 45° (800 mils). Its weight in firing position is 3000 pounds.

4. THE 75-mm. PACK AND FIELD HOWITZERS. - Active pack-artillery units have recently been equipped with the 75-mm. pack howitzer M1.

This weapon is designed for breakdown into 6 loads for pack-animal transport. In order that mobility may be increased in those artillery units which organically furnish support to horse and mechanized cavalry, the 75-mm. field howitzer M3 has recently been standardized and is now being issued to all horse and mechanized-artillery units. These weapons employing the same tube and recoil mechanisms have wide traverse, furnish high-angle fire to a maximum range of approximately 9000 yards, and use either fixed or semifixed ammunition as desired. The rate of fire for each weapon is the same as that for the 75-mm. field gun. A military requirement for both gas and smoke shell for these weapons has been established, but the shell themselves have not yet been standardized.

5. THE 105-mm. HOWITZER M1. - Although the Field Artillery has a standard weapon in the 105-mm. howitzer M1, active development continues. The present standard weapon has approximately the same weight as the 75-mm. gun and has a traverse of 800 mils with an extreme range with H.E. shell of 11,960 yards. The rate of fire to be desired of a weapon of this caliber is 4 rounds per minute, with a prolonged rate of 2 rounds per minute. A military requirement for both gas and smoke shell for this weapon has been established, but the shell themselves have not yet been standardized.

6. THE 155-mm. HOWITZER. - This weapon, classed as medium artillery, is the French (Schneider) Howitzer, Model 1918. It is of modified box-trail type with a hydropneumatic recoil mechanism. It permits an axle traverse of 6° (105 mils) and an elevation of 42° (747 mils). The ammunition is separate loading and it fires a 95-pound projectile with a maximum range of 12,400 yards. Rate of fire for short bursts is 3 rounds per minute and for prolonged fire is 1 round per minute. It weighs 7,600 pounds in firing position. Smoke and gas shell are standard for this weapon. All howitzers of this type now in service in the Regular Army and one-half of those in service in the National Guard have been modified for high-speed transport.

7. THE 155-mm. GUN. - This weapon, classed as heavy artillery, is also of French design and is known as the 155-mm. G.P.F. (Grande Puissance Filloux), Model 1918. It is of the split-trail hydropneumatic type, having a traverse of 60° (1070 mils) and an elevation of 35° (610 mils). It fires a 95-pound projectile and has a range of 17,500 yards. Rate of fire for short bursts is 3 rounds per minute and for prolonged fire is 1 round per minute. It weighs 26,000 pounds. A modification of this gun is now in progress which is designed to increase the elevation to 65° (1160 mils) and to increase the range to 26,000 yards. The ammunition is separate loading. Gas shell are standard for this weapon, but smoke shell are not.

SECTION II

CHEMICAL SHELL

	Paragraph
Design	8
Differences between Chemical and H.E. Shell	9
Type of Fuze Used	10
Ballistic Characteristics	11
Efficiency	12
Methods of Filling	13
Supply	14

8. DESIGN. - In point of design chemical shell of the present standard type differ but slightly from H.E. shell; in fact the latter were converted into the former as a matter of expediency during the World War by providing a gastight adapter joint and by substituting an adequate booster. The term "booster" refers to a comparatively small amount of more sensitive explosive such as tetryl, for example, which is placed between the fuze and the main explosive charge in H.E. shell to insure detonation of the main charge. In the chemical shell, however, the booster is the only explosive present besides the fuze, and its function is to split open the shell. For this reason it is now called the burster in chemical shell while retaining its former name of booster in the H.E. shell. The shell which have been designed for and used exclusively with gas fillings include the Mk. II for the 75-mm. gun, Mk. II for the 155-mm. howitzer, and the Mk. VII for the 155-mm. gun.

9. DIFFERENCES BETWEEN CHEMICAL AND H.E. SHELL. - Chemical shell should differ from H.E. shell in one fundamental; complete fragmentation is highly desirable in latter and not in former. The efficiency of the H.E. shell is measured by the violence with which these jagged fragments accomplish their destructive mission. With chemical shell however fragmentation is incidental and the shell contains no more explosive than is necessary to split it open, crack the base, and adequately disseminate the contents. Too great an explosive effect may result in decomposition of the agent due to the heat and pressure generated by the bursting charge in the case of certain agents, or in too great a dispersion of the contents with resulting loss in concentration. However, unless a chemical shell is split open at least down to the rotating band a cup is formed which tends to carry the agent with it, either into the ground or away from the point of burst, on ricochet.

10. TYPE OF FUZE USED. - Chemical shell are usually equipped with "super-quick" (i.e., instantaneous) percussion fuzes of the long-nosed type. The purpose of fuzes of such a design is to secure a shell burst above the ground which minimizes cupping and consequent carrying of the agent into the ground. However at short ranges, where the angle of fall is too slight, the long-nosed fuzes are liable to bend or break off and thus fail to function. Under these circumstances, therefore, it is necessary to use ordinary short fuzes.

11. BALLISTIC CHARACTERISTICS. - The ballistic characteristics of

liquid-filled chemical shell vary considerably from solid-filled or H.E. shell. There are several reasons for this. In the first place a liquid-filled shell, unless it is standing on its base, has a center of gravity which does not coincide with the center axis of the shell body. This is due to the void which must be left in filling the shell which results in the liquid's collecting to one side of the center when the shell is laid on its side or at an angle, as when placed in the chamber of a gun. This uneven center of gravity, moreover, does not remain fixed but shifts during the flight of the shell. As long as the shell is accelerating the liquid filling tends to gather at the base of the shell. When deceleration commences, however, the liquid begins to run into the nose of the shell thus causing a considerable shift in the center of gravity.

An even more marked influence of the liquid filling, however, is due to the fact that the liquid does not take up rotation as quickly as the shell body itself when the shell is fired. This lagging behind of the liquid creates an internal braking effect which tends to slow down the rotation of the shell and may even cause tumbling occasionally at extreme ranges. Chemical shells are also usually somewhat lighter than H.E. shells.

All these effects caused by the liquid filling in a shell tend to produce a shorter range and a greater dispersion of these shells as compared with the corresponding solid-filled shell. Furthermore the external shape of the shell itself with its long-nosed fuze and special adapter causes an additional and similarly unfavorable effect upon the ballistic characteristics.

12. EFFICIENCY. - The chemical efficiency of chemical shells (i.e., the ratio of the weight of filling to the total weight of shell) varies approximately between 10% and 15%. The liquid-filled shell has a lower chemical efficiency than the solid-filled shell due to the void which must be left above the liquid to prevent rupture of the shell through hydrostatic pressure. Although the ideal chemical shell is the one with the greatest capacity a ballistic balance must be maintained between the mass of the agent and that of the shell in order to insure stability during flight. A new 75-mm. chemical shell is in process of development. This shell is to have a much greater chemical efficiency than any now used.

13. METHODS OF FILLING. - American chemical shells are filled to a constant volume or level, as specified for each agent, through the cavity for the burster casing. For gastightness reliance is placed upon the close metal contact between the tapered threads of the adapter and those of the shell body. The void allowed varies as the coefficient of expansion of the several fillings. Shells filled to constant volume will vary in weight - slightly for the same agent, considerably for different agents - and will therefore require corrections to be applied to firing data in order to minimize dispersion. Agents of low boiling points must be brought to very low temperature prior to filling. In the case of phosgene the temperature of the shell and agent

are reduced to about 10° Fahrenheit before filling.

14. SUPPLY. - The Chemical Warfare Service and Ordnance Department share responsibility for chemical shell. The Ordnance Department procures empty shell and loaded bursters. The Chemical Warfare Service procures the agent, then fills and closes the shell which are afterwards turned back to Ordnance for storage and issue.

SECTION III

STANDARD CHEMICAL SHELL, DESCRIPTION

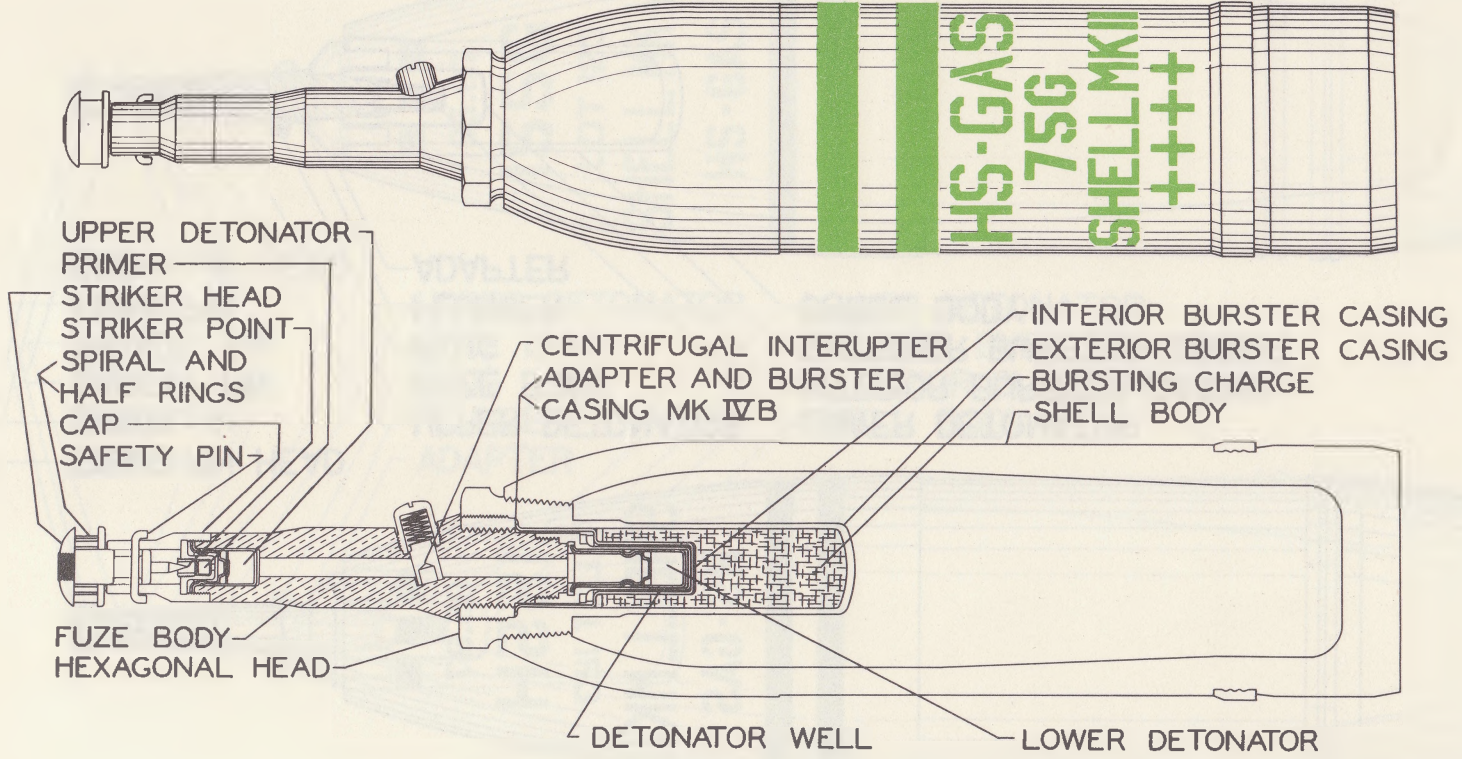
	Paragraph
The Complete Round	15
The Shell	16
The Adapter and Burster	17
The Fuze Mk. III	18
The Fuzes Mk. IV, Mk. V, and M35	19
The Fuze M46	20
The Cartridge Case and Propelling Charge	21
Weights of Shell	22
Identification Markings	23
Fillings	24

15. THE COMPLETE ROUND. - The complete round consists of the following components:

a. The shell, with adapter and burster, the filling, and the fuze.

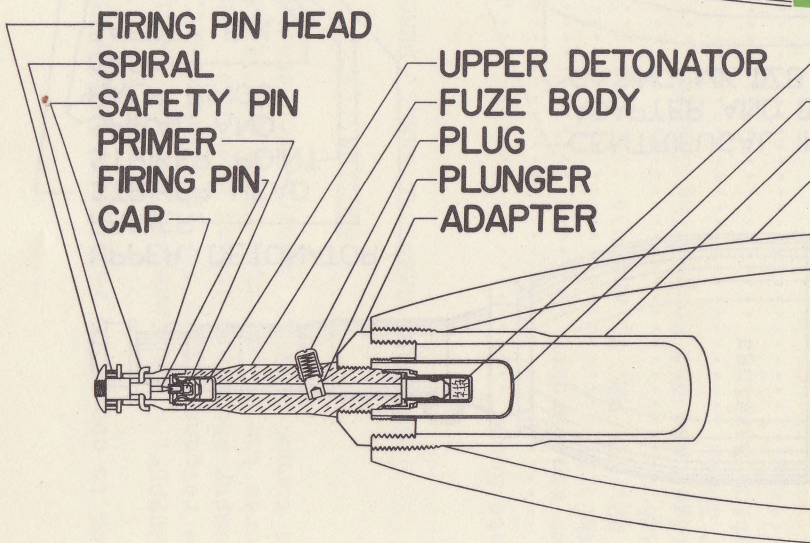
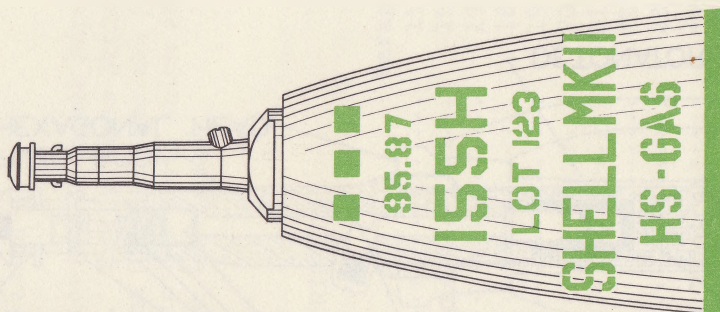
b. The cartridge case, with primer and propelling charge; or in the case of 155-mm. ammunition the propelling charge in silk bags, a separate primer, and no cartridge case.

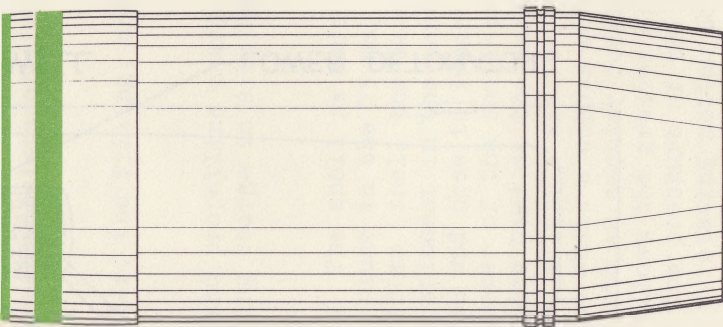
16. THE SHELL. - (See Plates 1, 2 and 3). The shell is made of common steel. It has an ogival head which is blunt in the 75-mm. shell and long in the 155-mm. In the case of the 155-mm. shell the base is boat-tailed (i.e., streamlined). The wall is thinnest in the central section but gradually thickens towards the base and nose to impart strength where most needed. The greatest diameter of the shell proper is at the bourrelet, the carefully machined guide band at the base of the ogive. Below the bourrelet the shell is of slightly smaller diameter and is rough-turned. Near the base of the shell a copper rotating band, beveled on its forward edge, is swaged into an annular recess. Upon firing the rotating band jams into and follows the grooves of the rifling. It serves as a gas-check to confine the pressure of the propelling charge behind the shell and to impart a rotating motion to the shell as it moves through the bore. The shell is thus stabilized in its flight (i.e., goes nose first). The 75-mm. gun shell and the 155-mm. howitzer shell each have one narrow rotating band. The 155-mm. gun shell has two bands because of the much higher pressures developed behind the shell. Otherwise the two 155-mm. shell are identical in construction.



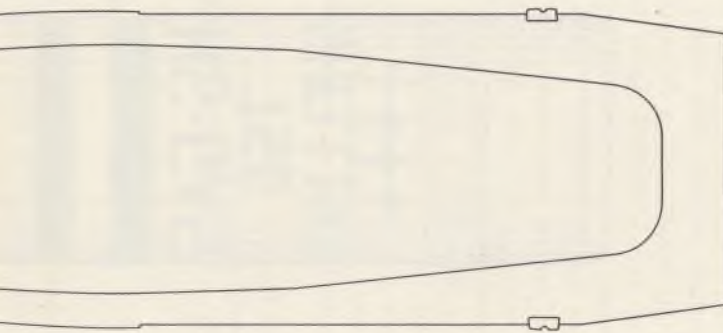
HS-GAS
 75G
 SHELL MKII
 ++++

CHEMICAL SHELL, 75-mm. GUN
 (MK I SHELL; MK II FUZE; MK IVB BURSTER)
 (TYPICAL MARKING FOR HS)





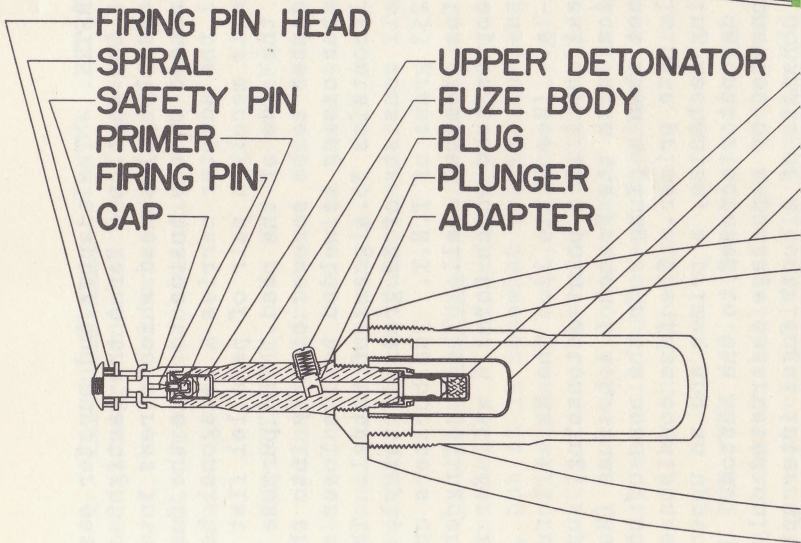
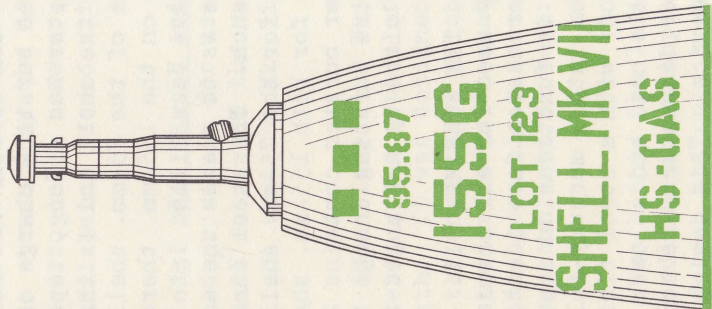
- LOWER DETONATOR
- INTERIOR BURSTER CASING
- EXTERIOR BURSTER CASING
- SHELL BODY

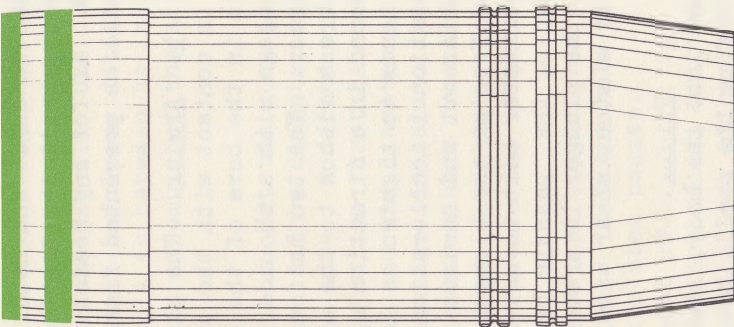


CHEMICAL SHELL FOR 155-mm. HOWITZER

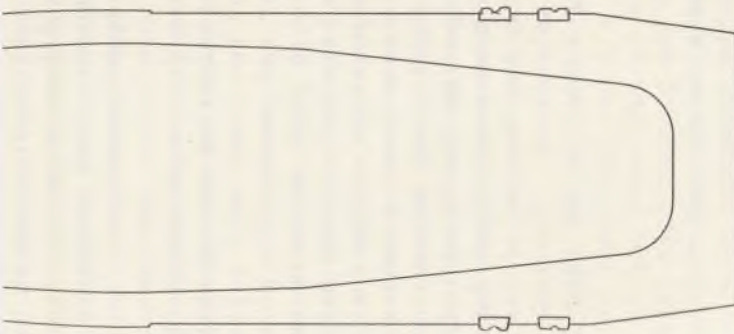
(MK II SHELL; MK III FUZE; MK VII B BURSTER)

PLATE 2





- ✓ LOWER DETONATOR
- ✓ INTERIOR BURSTER CASING
- ✓ EXTERIOR BURSTER CASING
- ✓ SHELL BODY



CHEMICAL SHELL, FOR 155-mm. GUN
(MK VIII SHELL; MK III FUZE; MK VII B BURSTER)

17. THE ADAPTER AND BURSTER. - The adapter and burster casing contains the bursting charge of the shell and forms the gastight closure. The adapter has a long, tapered (pipe) thread which screws into the nose of the shell and is threaded on the inside to take the fuze. In the case of the 75-mm. shell the adapter carries a hexagonal head, whereas on the 155-mm. there is merely a pair of parallel flat surfaces which have been milled into the side of the head. The purpose of both of these is to enable the adapter to be screwed tightly into the shell by a wrench. The steel burster casing is welded to its lower end. The burster for the 75-mm. shell contains 35.4 grams of tetryl. The inner burster for both 155-mm. shell consists of 29 grams of tetryl, while the outer burster contains 253 grams of T.N.T. The bursters constitute the entire bursting charge for chemical shell. The bursting charge is held in place by a flanged copper tube which forms a well for the fuze.

18. THE FUZE MK. III. - a. (See Plate 1). The Mk. III fuze formerly used for all chemical shell is a point-detonating, superquick, long, percussion fuze identical with the French I.A.L. fuze (Model 1916). It functions on impact when a plunger in the nose of the fuze is driven into a mercury-fulminate primer. The fuze consists of a brass body with a steel firing mechanism, a primer and an upper detonator in the head and a lower detonator screwed to the bottom. Upper and lower detonators are connected by a passage obstructed only by a safety device. This device consists of a centrifugal interrupter bolt, set in at an angle and held in place by a small spring, which blocks the passage until the "set-back" is over and the projectile is out of the gun. If for any reason the upper detonator fires prematurely the flash will be prevented from reaching the lower detonator.

b. Arming. The plunger or striker pin is prevented from coming in contact with the primer during transportation and while the shell is in the bore of the gun by means of two steel half collars which engage with a shoulder on the plunger and prevent its movement to the rear. The two half collars are held in place by being wrapped with a brass ribbon to the end of which is attached a third half collar. Being wound in a direction opposite to the rotation of the shell, the ribbon tends to tighten as long as there is rotational acceleration. When rotational acceleration ceases centrifugal force throws the third half collar out and unwinds the ribbon, releasing the inner half collars and freeing the plunger. At the same time centrifugal force causes the interrupter bolt to move outward against the tension of its spring, thus opening the passage between the two detonators. The fuze is then armed. The plunger is prevented from being forced to the rear during flight by a stout shear wire.

c. Firing. On impact the end of the plunger hits first and is driven into the body, shearing the shear wire and penetrating the primer before the shell itself has touched the ground.

d. Safety. The two half collars and brass ribbon are held in place by means of a gummed tape of oil cloth and a tinfoil cover.

e. Present Status. The Mk. III fuze has now been classified as limited standard and has been replaced as standard by the M46 fuze. Very few of the latter have been manufactured to date, however, and at the present time most chemical shells are still being issued with the Mk. III fuze.

19. THE FUZES MK. IV, MK. V, and M35. - a. The Mk. IV and Mk. V fuzes are ordinary short-nosed fuzes designed primarily for use with H.E. shells. They are used with chemical shells only when the range is so short and consequent angle of fall so slight that the Mk. III fuze would probably fail to function.

b. The M35 fuze is a newer fuze. (See Plate 4). This fuze resembles the Mk. III fuze in appearance, design, and method of functioning, but it is somewhat shorter in length. It was designed with the idea of retaining most, if not all, of the advantages of the long-nosed Mk. III fuze, but made sufficiently shorter so as to enable it to be used at ranges considerably shorter than possible with a Mk. III fuze. Only a small number of M35 fuzes were manufactured before it was replaced by the M46 fuze.

20. THE FUZE M46. (See Plate 4). a. The M46 is the latest type fuze for chemical shells. It has been standardized and will probably eventually replace the Mk. III and the M35 fuzes, but only a small number have been manufactured to date. This fuze is about the same size and length as the M35 fuze which means that it is more adaptable and better suited to firing at short range than the Mk. III fuze. It also has a similar system of upper primer-detonator and lower detonator with a passageway and centrifugal interrupter bolt in between as in the Mk. III and M35 fuzes. The construction and assembly of the striker pin, however, are entirely different.

b. The fuze body tapers near the end, but the nose is blunt. A circular recess about 1/2 an inch deep and with a diameter sufficient to receive the striker head is cut into the nose. A second circular recess is cut into the center of the bottom of the first recess. This second recess is only about 1/32 inch deep, and the diameter is sufficient to receive the striker support. A passage similar to that between the two detonators but of smaller diameter leads from the center of the bottom of the second recess to the upper detonator. The diameter of this passage is just sufficient to receive the striker stem.

c. The striker support is a cylindrical cup of thin copper about 3/8 inch high and 1/4 inch in diameter. It has a hole in the center of the base through which the striker stem passes.

d. The striker head is nearly 1/4 inch thick, but the lower half has been cut down to form a shoulder and a base which has the same diameter as the striker support. In assembling the striker to the fuze the striker support is inverted and its rim fitted into the second recess with the base projecting upward. The striker point is then inserted into the hole in the base of the striker support and pushed down

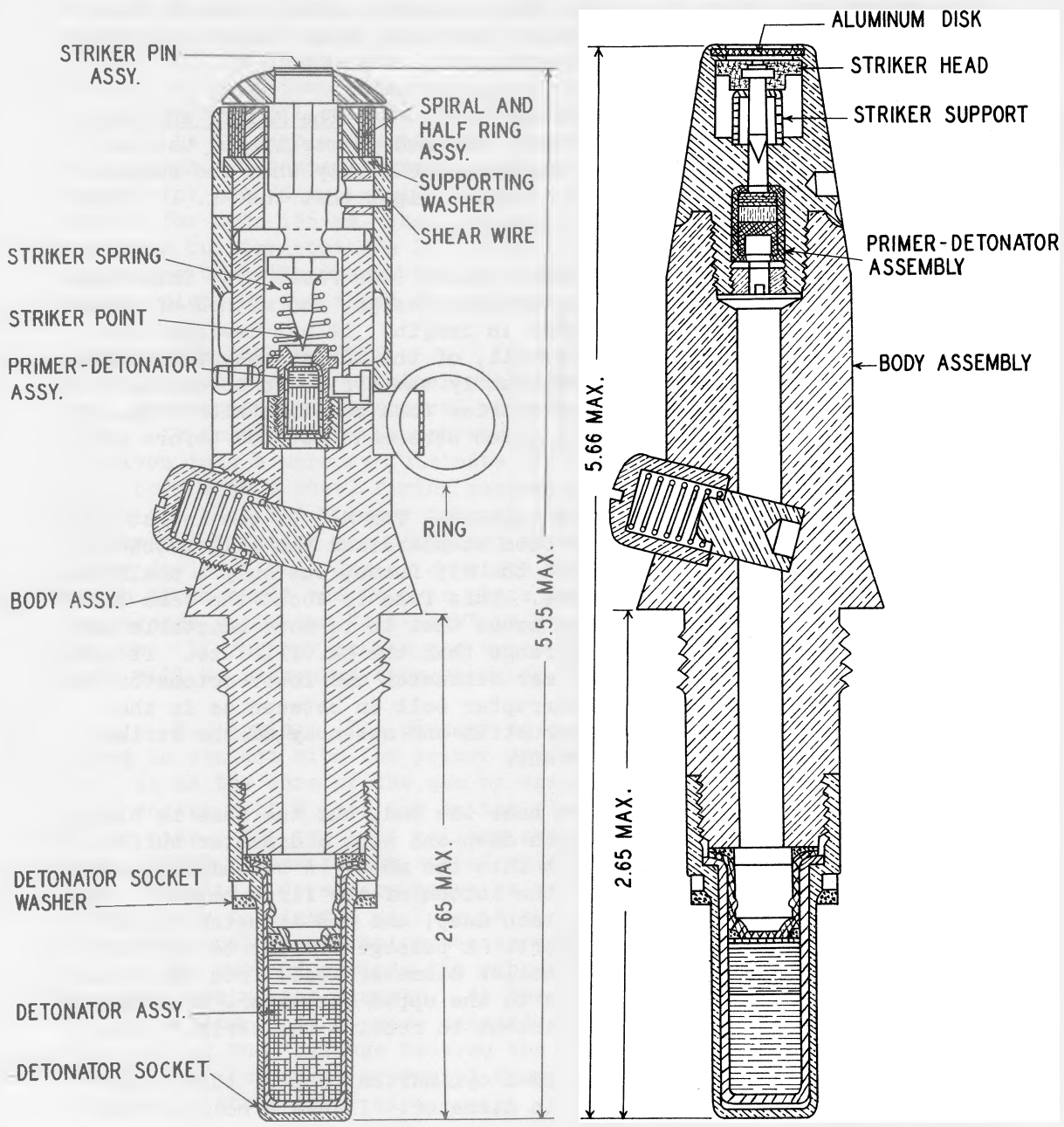


PLATE 4

until the point enters the passage leading to the upper detonator and until the base of the striker head rests against the striker support. When thus assembled the top of the striker head is slightly below the rim of the larger recess. It is held in place by a circular disk of aluminum which is crimped into the rim immediately above the striker head.

e. When the fuze in the fired shell strikes the ground nose first, the force of impact against the aluminum disk and striker head collapses the walls of the striker support and drives the striker point into the upper detonator. If the impact is against rock or very hard ground the side wall of the larger recess also collapses, thus allowing the striker point to be driven into the upper detonator. The strength of the striker support is such that the fuze will function in a fired shell on water or very soft ground, and yet it is possible to assemble the fuze to a loaded 155-mm. shell and drop it nose first on concrete from a height of thirty inches without causing functioning of the fuze. No safety pin is therefore considered necessary, and none is provided.

21. THE CARTRIDGE CASE AND PROPELLING CHARGE. - a. The cartridge case of the 75-mm. shell is a brass casing containing the propelling charge of nitrocellulose powder. The charge is ignited by a primer in the end of the case.

b. In the case of the 155-mm. howitzer and gun shell the ignition and propelling charges are contained in combustible silk bags and placed in the breech, the primer being inserted in the breech mechanism. These charges are made up of several parts to permit varying the muzzle velocity. This is to allow the use of the smallest charge giving the desired range and the maximum angle of fall. This facilitates reaching behind slopes or other features of the terrain.

22. WEIGHTS OF SHELL. - a. The weights of individual shell vary appreciably within minimum and maximum allowable limits. This weight range is subdivided for purposes of accuracy of fire into five weight groups and each shell is marked according to its weight as shown in the tables below.

WEIGHT MARKINGS FOR ARTILLERY CHEMICAL SHELL

b. For the 75-mm. shell the weights are designed by pluses (+) stenciled just above the rotating band, as follows:

<u>From</u>	<u>To</u>	<u>Weight Mark</u>
10 lb. 11 oz.	11 lb. 0 oz.	L
11 lb. 0 oz.	11 lb. 5 oz.	+
11 lb. 5 oz.	11 lb. 11 oz.	+ +
11 lb. 11 oz.	12 lb. 0 oz.	+ + +
12 lb. 0 oz.	12 lb. 5 oz.	+ + + +

c. For the 155-mm. howitzer and gun shell weights are des-

ignated by squares around the nose of the shell, as follows:

<u>From</u>	<u>To</u>	<u>Weight Mark</u>
91 lb. 3 oz.	92 lb. 5 oz.	<input type="checkbox"/> <input type="checkbox"/>
92 lb. 5 oz.	93 lb. 6 oz.	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
93 lb. 6 oz.	94 lb. 8 oz.	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
94 lb. 8 oz.	95 lb. 10 oz.	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
95 lb. 10 oz.	96 lb. 12 oz.	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>

23. IDENTIFICATION MARKINGS. - a. In common with all chemical munitions, chemical shell are divided into five classifications based upon tactical employment, namely, gas nonpersistent, gas persistent, gas irritant, smoke and incendiary.

b. Nonpersistent gases are indicated by one green band around the shell; persistent gases by two green bands; irritant gases by one red band, regardless of persistency; screening smokes by one yellow band; incendiary by one purple band.

c. The word "GAS" or "SMOKE" is stenciled on the body of the shell preceded by the C.W.S. symbol designation of the specific agent contained, all in the same color as the designating band.

24. FILLINGS. - The following comprises those agents now standard for the different calibers.

- a. 75-mm. Field Gun and Howitzer:
 Gas Shell - Mustard Gas (HS)
 Smoke Shell - White Phosphorus (WP)*
- b. 105-mm. Field Howitzer:
 Gas Shell - Mustard Gas (HS)
 Smoke Shell - White Phosphorus (WP)*
- c. 155-mm. Field Howitzer:
 Gas Shell - Mustard Gas (HS)
 Smoke Shell - White Phosphorus (WP)*
- d. 155-mm. Field Gun:
 Gas Shell - Mustard Gas (HS)

*Titanium tetrachloride (FM) and sulphur trioxide-chlorosulphonic acid smoke mixture (FS) are furnished for peacetime training.

e. Pertinent data on chemical agents and certain weapons employed by Artillery are given in the table on page 11.

PERTINENT DATA ON CHEMICAL AGENTS AND WEAPONS USED BY ARTILLERY

WEAPONS	RATES OF FIRE		TYPE AND APPROXIMATE WEIGHT				RANGE (d)		
	Rounds per Min.		IN POUNDS OF CHEMICAL AGENTS				Extreme	Maximum Effective	
	Short Bursts	Pro-longed	USED IN EACH WEAPON					Accu-rate Fire	Area Fire
			HS Mustard Gas (a)	CG* Phos-gene	WP Smoke (b)	FS & FM Smoke (c)			
75-mm. Gun	6	3	1.3		1.8	1.8	8,000	7,000	8,000
155-mm. How	3	1	11.2	11.3	15.5	16.25	12,400	10,000	11,200
155-mm. Gun	3	1	11.2				17,500	14,400	16,200

NOTES:

Identification Marks -

- (a) "HS Gas", and two bands, all in green
- (b) "WP Smoke", and one band, all in yellow
- (c) "FS Smoke" or "FM Smoke", and one band, all in yellow (substitute and limited standard)
- (d) Ranges given are approximate only. Important factors are accuracy of corrections applied, previous adjustment, nature of target, and facilities for observation.

*Suitable as a filling but not standard.

SECTION IV

CHEMICAL SHELL, FIRING

	Paragraph
General Considerations	25
Calibers best Suited to Various Types of Agents	26

25. GENERAL CONSIDERATIONS. - a. Although the general principles which govern the firing of chemical and H.E. shell are identical, special technique based upon the properties of the specific agents and a knowledge of the behavior of agents upon release are essential to make the most effective use of chemical ammunition. For example liquid-filled chemical shell have a shorter range and a greater dispersion than H.E. shell. Such factors must be considered in firing a nonpersistent lethal agent such as phosgene, for too great a dispersion tends to nullify the effect at the target and must be compensated for by increasing the concentration of fire. Dispersion, however, is not an important factor in the use of lacrimators because of the great power of these agents even in low concentration. On the other hand, where mustard gas is used to deny areas dispersion accomplishes a desirable distribution over the target.

b. When an H.E. shell bursts on the ground the effect is principally lateral and reaches targets only within the radius of burst and is entirely spent within a few seconds thereafter. When a chemical shell bursts the agent is thrown in all directions by the force of the explosion, partly in liquid and partly in vapor form, and some liquid enters the ground. In the case of nonpersistent agents the liquid spattered on the ground is rapidly converted into a vapor

which under the influence of the wind immediately moves away from the point of burst. The concentration of the cloud is greatest at the point of burst; as the cloud travels, influenced by the speed and direction of the wind, it spreads and heightens resulting in a progressive but gradual dilution to a point of harmlessness. Numerous shell burst in close proximity form clouds as above, which merge into a single extensive cloud of high initial concentration. Succession of fire has the effect of maintaining a continuity in the generation and concentration of the cloud. In the case of persistent agents a large portion of the agent splatters on the ground. That portion in the air acts the same as a nonpersistent gas; but the evaporation of the agent on the ground will continue to put into the air a dilute cloud so long as there is any liquid remaining. This evaporation is hastened by heat, such as warming by the sun, and is retarded by cold. It is thus seen that chemical shell produce a continuity of action in point of time and extensiveness, not only on the immediate target but over downwind areas, and that the effect may continue for hours, days, or even weeks, depending upon the agent used and the meteorological conditions.

c. (1) In considering the relative casualty-producing value of chemical and H.E. shell it may be said that either will make a casualty of anyone in the immediate vicinity of its burst. However if 100 H.E. shell would be approximately 100 times as effective as 1 H.E. shell, 100 chemical shell would be much more than 100 times as effective as 1 chemical shell. This is due to the cumulative effect of chemical shell in building up a lethal cloud which drifts downwind - a property not possessed by H.E. shell.

(2) Personnel in deep trenches and dugouts are reasonably protected from H.E. shell fire. If the target is not accurately located and fire accurately adjusted no amount of shelling with H.E. shell will have the desired effect. If, on the other hand, chemical shell are used the cloud will roll into trenches and dugouts. Gas has no trajectory as have shell fragments. It is heavier than air and seeks the lowest point. All that is necessary is that the chemical shell burst fairly close upwind from the target. Accuracy is not so necessary. The gas itself will seek out its target. The fragments of H.E. shell are effective for perhaps one second. The vapor from a chemical shell may be effective for a short time to several days, depending upon conditions.

d. Precision Firing. From the above it is evident that direct hits on a target are not absolutely essential in firing chemical shell inasmuch as upwind bursts of shell aimed at the target will produce a cloud which will drift over the target with but little dilution. However the greatest effectiveness is possible only under conditions of precision firing, with chemical agents as well as H.E. or shrapnel.

e. Future Possibilities. Experimentation since the World War indicates that the tactical use of HS in artillery shell may be considerably broadened by equipping the shell with a time fuze adapted to burst the shell above ground. With an adequate burster HS would thus be showered as a fine mist. Under these circumstances the HS would be only moderately persistent and, in fact, it would approach the status

of a highly volatile vesicant. A very accurate and reliable time fuze would be required and no fuze for this purpose has yet been developed.

26. CALIBERS BEST SUITED TO THE VARIOUS TYPES OF AGENTS. - a. In general small caliber shell are best suited for persistent agents and large shell for nonpersistent agents.

b. In firing mustard gas, for example, a given weight of agent is most effectively used over a given area when evenly distributed in a large number of small spots. The low capacity of the 75-mm. shell (1.3 lb. of HS per round), the high rate of fire, and normal dispersion make that caliber most suitable for persistent agents. The 75-mm. gun will give over eight times as many contaminated spots as the 155-mm. howitzer or gun firing the same quantity of agent inasmuch as it takes about eight rounds of 75-mm. shell to fire as much HS as one round of 155-mm. shell. Of course the 155-mm. howitzer or gun must be used to put mustard gas on targets beyond the range of the 75-mm. gun.

c. The opposite is true for nonpersistent agents. As in the case of phosgene the maximum effect is secured only when the total required amount is delivered on the target in a two-minute burst. The large capacity of the 155-mm. shell (11.1 lb. per round) makes this munition suitable for phosgene, although this filling is not standard at present.

d. Smoke is used in the 75-mm. shell and in the 155-mm. howitzer. Although the necessarily large bursting charge breaks up the white phosphorus into small particles and thereby reduces the time of burning, these weapons must be used on smoke targets which are inaccessible to other more efficient smoke weapons.

CHAPTER VII
CHEMICAL WEAPONS USED BY THE AIR CORPS

(This chapter supersedes Chap. VII, Book 3, Jan.-37)

	Paragraphs
SECTION I - General	1-4
II - Spraying and Sprinkling Apparatus	5-9
III - Standard and Special Type Bombs	10-12

SECTION I

GENERAL

	Paragraph
Introduction	1
World War Development	2
Post-War Development	3
Present Status	4

1. INTRODUCTION. - Both Chemical Warfare and Aviation, as they are applied today, are of recent origin. Though chemical attack dates back as far as the Siege of Troy, and the use of balloons has been known for generations, each remained in comparative obscurity until the World War.

2. WORLD WAR DEVELOPMENT. - Chemical agents were not disseminated by airplane during the World War, and what little development work was done was confined largely to bombs containing incendiary substances. A smoke bomb was developed by the French, but it was used for bombing training only to mark the registration of hits. White phosphorus was used as an incendiary but not as a smoke substance. Thermit was also used as an incendiary filling for airplane bombs.

3. POST-WAR DEVELOPMENT. - a. The effectiveness of the airplane as a means of projecting chemical agents has been demonstrated. The following agents are suitable for such projection: HS, CNS, FS, FM and WP.

b. The wide radius of action and potency of the chemical effects now possible with aircraft, make installations and movements in rear areas much more vulnerable and important as military objectives.

4. PRESENT STATUS. - a. The methods now being considered as feasible for dispersing chemical agents and smoke by aircraft, are as follows:

- Sprinkling apparatus - pressure type. (Used by the Navy only.)
- Spraying apparatus - nonpressure type.
- Bombs.

b. Although the development of apparatus and of aviation

chemical tactics is still in an experimental stage, the work has been carried sufficiently far to demonstrate its physical, chemical and military feasibility.

c. All chemical apparatus is designed to be attached in such a manner that it may be dropped by the pilot in an emergency.

SECTION II

SPRAYING AND SPRINKLING APPARATUS

	Paragraph
General	5
Sprinkling Apparatus - (Pressure)	6
Spraying Apparatus - (Nonpressure)	7
Value of Spraying and Sprinkling	8
Tactical Uses	9

5. GENERAL. - a. Liquid chemical agents may be projected directly into the air from airplanes in two general ways: first, as drops whose size approximate the size of rain drops; second, as a fine spray or mist. Two general types of apparatus have been developed, one to give each of the above-named results. The sprinkling type apparatus produces large drops; the spray produces a fine spray or mist.

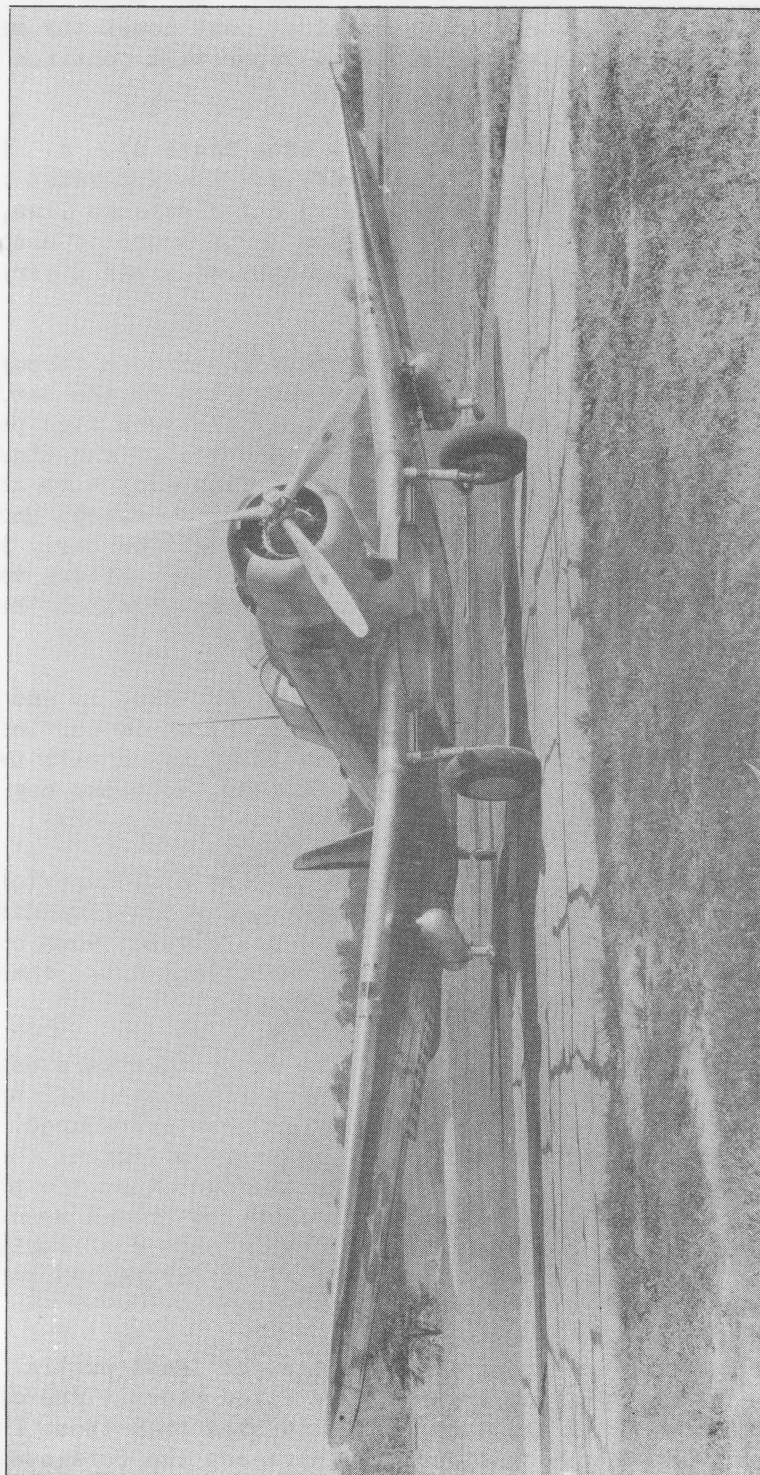
b. The area covered, and the drift of these particles or drops, depend upon their size, the altitude at which the liquid is released and the direction and velocity of the wind.

6. SPRINKLING APPARATUS (PRESSURE). - a. The sprinkling type was the first experimental apparatus developed for chemical dispersion. It consists essentially of a tank containing the agent, plus carbon-dioxide gas to furnish the pressure, a discharge line and the necessary valves. This apparatus is suspended from the bomb racks by shackles and the agent is discharged underneath the plane. In operating this type of apparatus, the carbon dioxide gives sufficient pressure to expel the agent backwards at approximately the airspeed of the plane. This results in large drops which readily fall to the ground.

b. Since a high pressure is required for this apparatus, it is necessary that the tanks be of rugged construction. This reduced its chemical efficiency. The sprinkling apparatus was, therefore, never standardized in the Army and its further development was dropped in favor of the spraying apparatus. The Navy, on the other hand, has continued to use this apparatus.

c. The chemical agents which may be used are HS, CNS, CNB, FS, and FM. This apparatus is usually operated at comparatively high altitudes. Liquid smokes when used in this apparatus for screening purposes produce the smoke curtain.

d. When drops of liquid are released in the air, they drift with the wind. The width of the contaminated strip of ground varies directly with the wind velocity and with the altitude at which the



ATTACK AIRPLANE (Northrop A-17)

Two non-pressure tanks are used to disperse chemical agents by this type of airplane.

PLATE 1

chemical agent is released. The larger the drops, the less they are effected by these factors. In the pattern formed, the largest and heaviest drops will be found on the upwind side; next comes the medium and then the small drops, while some mist and vapor will continue to drift with the wind.

7. SPRAYING APPARATUS (NONPRESSURE). - (See Plate 2). a. This type of apparatus uses only the force of gravity. The apparatus consists of a streamlined tank, a discharge valve and discharge line, an air vent and the necessary connections. Since no pressure is used, the tanks may be made of very light material; the apparatus has a very high chemical efficiency.

b. When the valve is opened, the agent flows down through the discharge line and into the air. Here it is subjected to the natural shearing effect of the airblast and is broken up into very fine particles which drift with the wind. Due to the tendency of the minute droplets to remain in the air and to travel as a fine mist with the wind, the spray must be operated at very low altitudes, except under the special conditions such as sometimes exist at night or early in the morning. As with the sprinkling type, the width of the pattern varies directly with the wind velocity and with the altitude at which the chemical agent is released.

c. The agents suitable for use are HS, CNS, CNB, FS and FM. Due to the altitude limitations, this type of apparatus is particularly suited to fast, low-flying planes. Each plane is equipped with two spray tanks, one being carried on each wing. These two tanks may be fired either simultaneously or separately.

8. VALUE OF SPRAYING AND SPRINKLING. - a. The efficiency of dispersing chemical agents from planes by spraying apparatus lies mainly in the effective concentrations that can be accurately put down on personnel under conditions approaching complete surprise and the inadequacy of any practical protection against such an attack.

b. The principal disadvantage of the spraying apparatus lies in the fact that the atomization increases the surface area of the liquid to such an extent that the persistency is greatly reduced. Chemical agents released by this method are not very efficient for contamination purposes. Another disadvantage is the fact that the plane carrying the spraying apparatus must fly close to the ground when releasing the agent in order to provide a reasonable chance of striking the target and that the spray will not be too widely dispersed before reaching the ground.

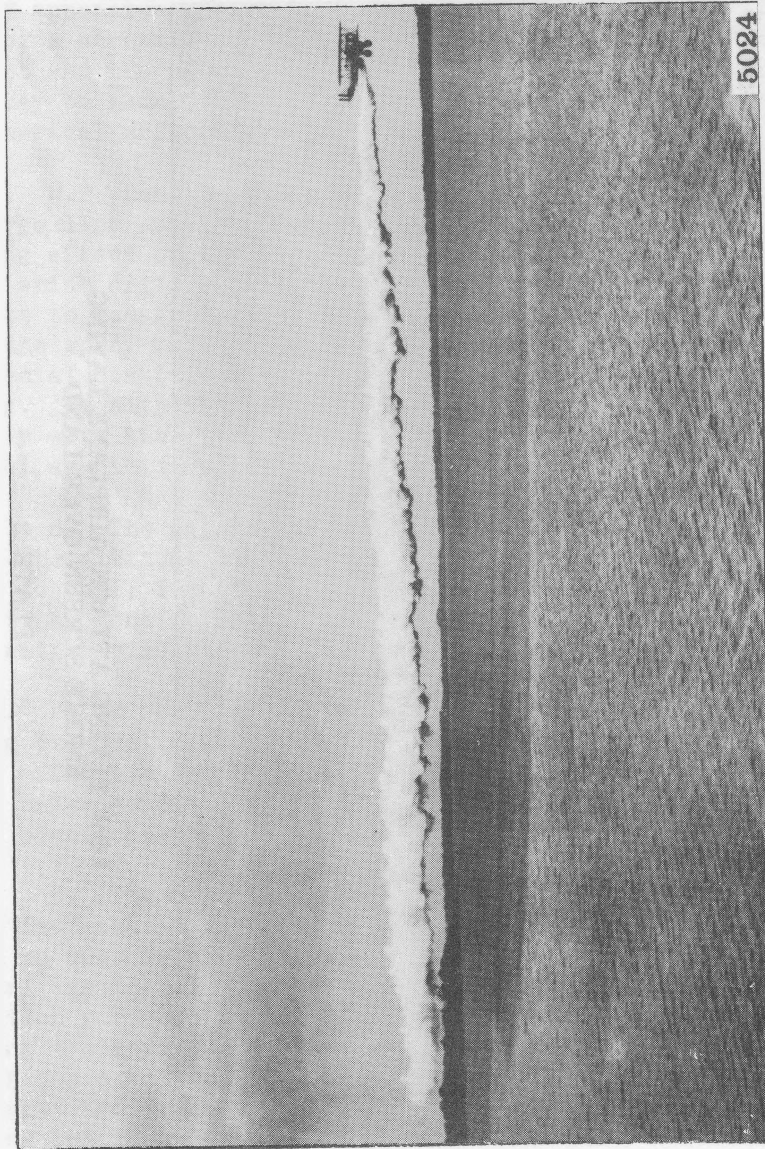
c. The sprinkling apparatus overcomes, at least partially, the disadvantage of the spraying apparatus as cited above. The drops produced from this apparatus are much larger in size than those from the spraying apparatus, which considerably increases the persistency as well as the permissible height at which the plane can fly above the ground.

9. TACTICAL USES. - a. Smoke screens and blankets are laid by



**LOW FLYING ATTACK AIRPLANE LAYING
SMOKE SCREEN OVER LAND**

PLATE 2



LOW FLYING ATTACK AIRPLANE LAYING SMOKE SCREEN OVER WATER

PLATE 3

low-flying attack planes (see Plates 2 and 3). Smoke may be used very effectively in this manner to screen bombing planes or other attack planes from ground observation. Smoke clouds laid by airplanes may also be used occasionally to conceal the movements of fast moving ground forces.

b. Lacrimators are used for harassing or delaying the enemy.

c. Vesicants, when dispersed by spraying, may be employed directly against personnel for casualty effect and for general harassing purposes. For neutralization purposes, the airplane spray is not very effective due to decreased persistency.

SECTION III

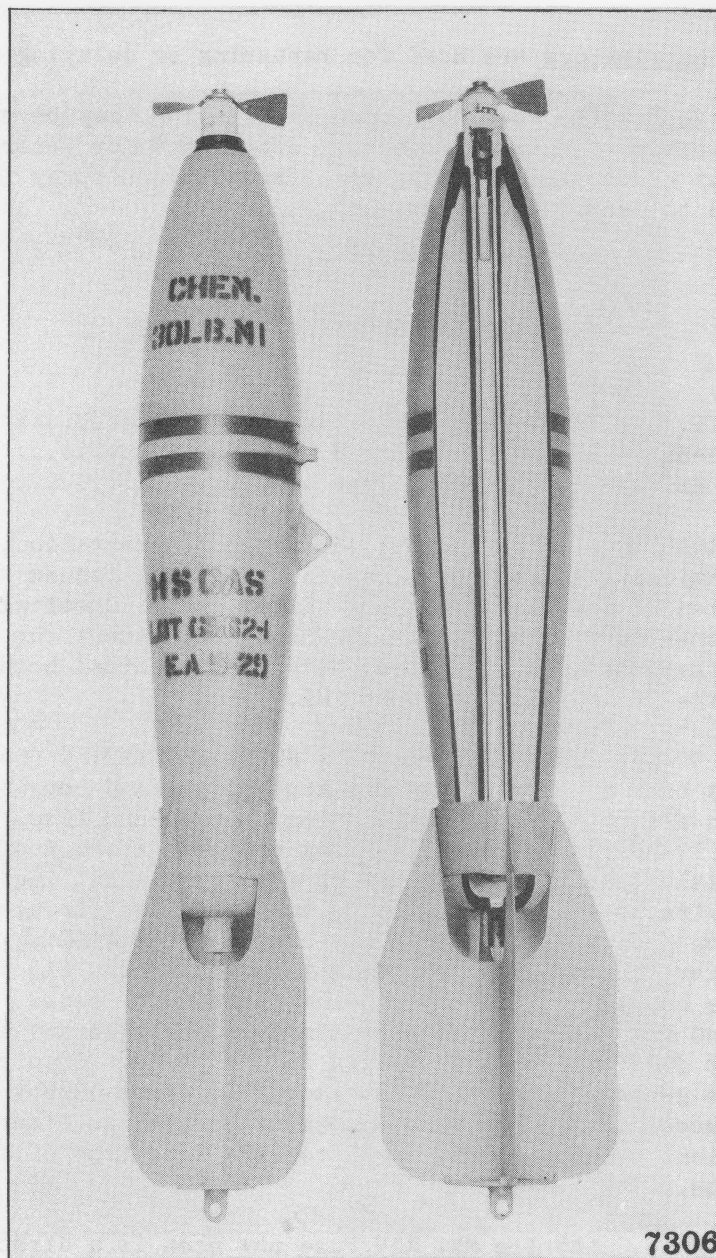
STANDARD AND SPECIAL TYPE BOMBS

	Paragraph
General	10
The 30-lb. Chemical Bomb, MI - Standard Type	11
The Floating Smoke Bomb - Special Type	12

10. GENERAL. - All army bombs, including fragmentation, demolition, and chemical are developed, manufactured, and issued by the Ordnance Department. Chemical bombs are filled by The Chemical Warfare Service and then turned back to the Ordnance Department for storage and issue. There is only one approved type of chemical bomb. This is known as the 30-lb. Chemical Bomb, MI.

11. THE 30-LB. CHEMICAL BOMB, MI - STANDARD TYPE. - (See Plate 4). a. This bomb is streamlined for true flight and consists of a body with fin assembly, filling, bursting charge, and fuze. The body weighs about 19 pounds and is drawn from seamless steel tubing. It carries a little less than 10 pounds of mustard gas filling. The bomb does not require special filling holes but is filled through the fuze opening at the nose of the bomb and is closed after filling by screwing in an outer burster casing or well tube which runs the entire length of the bomb. A pipe-thread joint insures the seal. The bursting charge and fuze are shipped separate from the bomb and are assembled to it just before being loaded on the plane. Chemical bombs have the same general appearance as demolition bombs except that they are painted according to the same system of marking as other chemical filled munitions. They are released from the same type of bomb racks as other bombs.

b. Fuze. (1) The Mk. XIV Fuze now used is a direct impact fuze consisting of a striker pin, sleeve, arming vane and cup, eight steel balls, shear wire, and safety pin. The striker pin is suspended in the sleeve by the shear wire and a circle of eight steel balls placed between the flange of the striker pin and the sleeve prevents any upward motion of the pin before the fuze is armed. The balls are held in position by a cup fastened to arming vanes, which screw onto



CHEMICAL BOMB - 30 LB. - MI

PLATE 4

the extremity of the striker pin. When the fuze bomb is in the bomb rack, a safety pin which is attached to the rack by means of a wire, passes through an eye on the side of the fuze body and through a small hole in one of the vanes to prevent rotation. Additional safety is secured by another safety pin which passes through the fuze body and striker pin where it remains until just before the bomb is released during flight.

(2) Operation. When the additional safety pin is pulled and the bomb is released, the falling bomb pulls away from the safety pin attached to the rack, thereby permitting the arming vanes to rotate as a result of the air pressure against the vanes caused by the downward flight of the bomb. After 13 turns the arming vanes and cup drop off, releasing the steel balls and thus arming the fuze. On impact the shear wire is cut and the striker pin penetrates the primer.

12. THE FLOATING SMOKE BOMB - SPECIAL TYPE. - a. This bomb is designed for naval use. It has an aluminum head and a wooden rear body and is equipped with four steel stabilizers. It carries a water-impact percussion fuze in the nose and a check valve in the tail. The filling is HC (hexachlorethane) smoke mixture. The filled bomb weighs 50 pounds.

b. Upon striking the water the fuze ignites a starter mixture which kindles the HC smoke mixture. The bomb is designed to return to the surface of the water after the initial plunge, where it floats tail up. A pure white, dense, nonirritant smoke of great obscuring power is released through the check valve. The bomb continues to burn for five minutes.

CHAPTER VIII

THE TECHNIQUE OF FIRING CHEMICAL AGENTS

	Paragraphs
SECTION I - General Considerations	1-8
II - Use of Screening Smoke	9-13
III - Use of Gas	14-17

SECTION I

GENERAL CONSIDERATIONS

	Paragraph
Introduction	1
Dilution of Chemical Clouds	2
Reinforcement of Chemical Clouds	3
Probability of Hitting a Target with a Chemical Cloud	4
Probability of Hitting a Target with Projectiles	5
Probability of Hitting a Target with Air Bombs	6
Probability of Hitting a Target with Liquid Spray	7
General	8

1. INTRODUCTION. - The tactical commander selects the target, the agent, the time for firing the agent, and states the object to be accomplished. The methods by which chemical agents are fired by artillery, chemical troop and aviation commanders depend upon the characteristics of the gun or munition used and the application of the laws of chemical cloud travel to the problem at hand so as to accomplish the mission with the minimum quantity of munitions. Each situation is a problem in itself, but certain general rules can be stated which give a great deal of assistance in the solution of such problems. It is the purpose of this chapter to present such rules with pertinent illustrations.

2. DILUTION OF CHEMICAL CLOUDS. - When a chemical cloud (gas or smoke) is generated at a point the cloud rises, spreads out laterally, and becomes longer, thus becoming progressively less dense as it moves downwind. However, if a large number of small clouds are generated on a line, each merges with and reinforces the other laterally so that the range of the cloud (i.e., the distance downwind to which an effective concentration is carried) becomes greater as the length of firing front increases and as the amount of agent released per foot of front is increased. The following table gives some idea of the way in which the concentration drops off, the amount of agent released per foot front remaining constant.

DILUTION TABLES

Initial Concentration	<u>Distance Downwind from Source</u>						
	<u>100 yards</u>	<u>200 yards</u>	<u>300 yards</u>	<u>400 yards</u>	<u>500 yards</u>	<u>600 yards</u>	<u>700 yards</u>
	<u>Small Shoots 100 - 400 yards front</u>						
100%	75%	56%	42%	31%	23%	17%	13%
	<u>Medium Shoots 400 - 800 yards front</u>						
100%	85%	72%	61%	52%	44%	38%	32%
	<u>Large Shoots 800 - 3000 yards front</u>						
100%	90%	81%	73%	66%	60%	54%	48%
	<u>Very Large Shoots - Over 3000 yards front</u>						
100%	95%	90%	85%	82%	78%	74%	70%

3. REINFORCEMENT OF CHEMICAL CLOUDS. - When a smoke or gas cloud has moved downwind to the point where the cloud is no longer effective it can be reinforced by the addition of enough agent to bring the concentration up to an effective value. In general it is more economical to fire chemical agents in this way than to fire enough at one point to produce an effective concentration on the whole front. (See Plate 1).

4. PROBABILITY OF HITTING A TARGET WITH A CHEMICAL CLOUD. -
 a. If the chemical agent is released on a line from cylinders or DM candles, the line of release should be at approximate right angles to the wind direction and should be directly upwind from the target to be covered. When chemical agents are fired in this way, it is essential that the cloud be generated on a sufficiently wide front to cover the target under field conditions, as it is difficult to predetermine the most suitable firing position due to variations in wind direction.

b. A chemical cloud should be generated on a front as wide as the target to be covered plus 0.2 of the distance to the target; but must be at least one-half as wide as the distance from the firing line to the target. It is necessary to use these precautions in order to be reasonably certain of striking all parts of the targets with the cloud. However, this general rule may be modified where the wind is extremely steady, where the target is very large, or where there are terrain features such as valleys or buildings along the side of streets which will insure the cloud passing directly from the origin to the target without appreciable loss due to the spread, or where the point of release is very close to the target, such as sometimes occurred in the front line trenches during the World War. (See Plate 2).

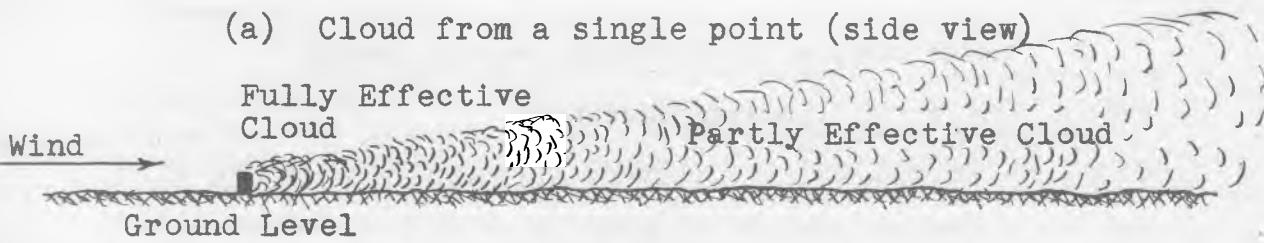
Example 1: A target 800 yards across is 2000 yards away. How wide a firing front will be necessary?

Solution: $0.2 \times 2000 = 400$ yards plus 800 yards width of target is 1200 yards, width of firing line.

Plate 1

REINFORCEMENT OF CHEMICAL CLOUDS

(a) Cloud from a single point (side view)



(b) Reinforced cloud (side view)

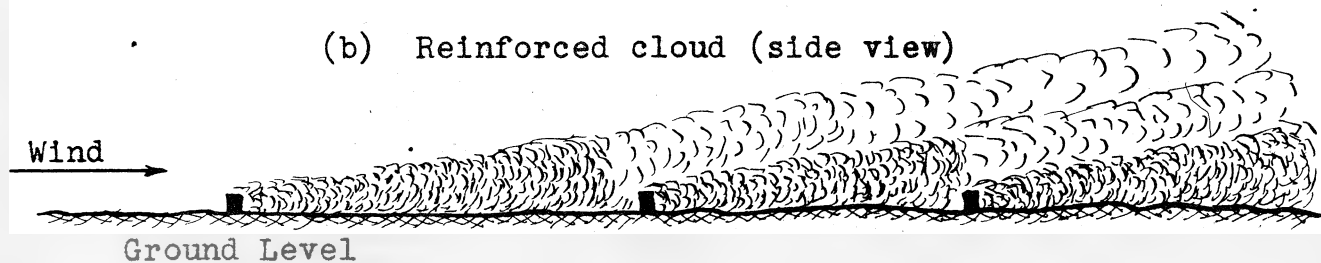
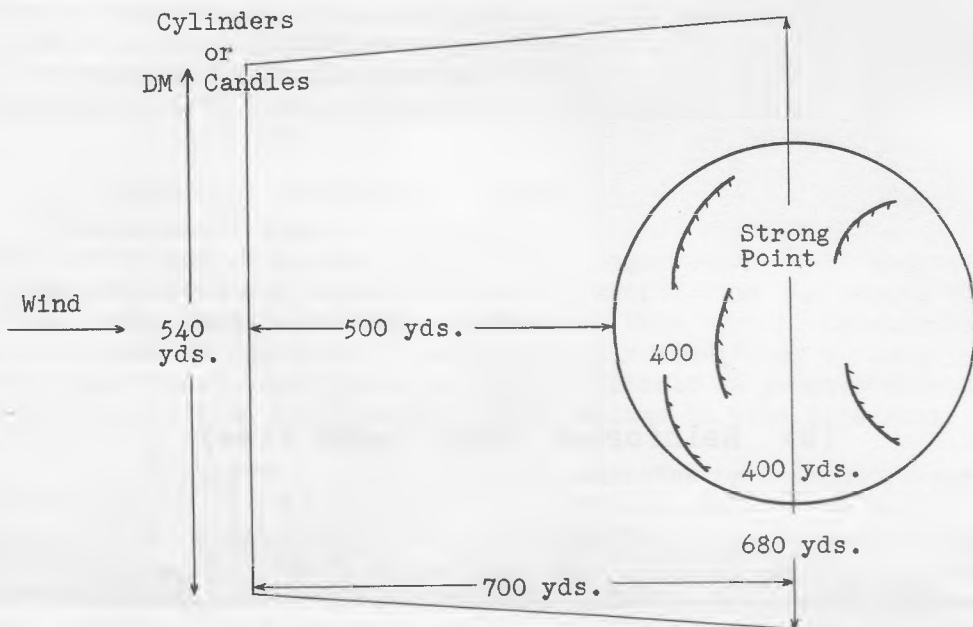


PLATE 2

USE OF CHEMICAL CLOUDS AGAINST DEFINITE TARGETS
(Average Conditions)



Example 2: A point target is 200 yards away. How wide a firing line should be used to hit this target?

Solution: One-half of the range requires a front 100 yards wide in this case.

5. PROBABILITY OF HITTING A TARGET WITH PROJECTILES. - a. When chemical agents are fired by means of any type of cannon fixed in position, the projectiles strike the ground at different points in range as well as in deflection. The area covered by shell when fired from a single gun in fixed position is called the "rectangle of dispersion", and the phenomenon of scattering both in range and direction is called "dispersion".

b. The outstanding fact noticed when fire is conducted from a single gun set in direction and elevation is that the shell do not strike the same point, but cover a considerable area. If a line is drawn through the rectangle of dispersion so that one-half of the impacts fall beyond the line and one-half fall short of the line, that line is called the "center of impact for range"; similarly, if a line is drawn so that one-half of the shots fall to the right and one-half to the left, that line is called the "center of impact for direction". The intersection of these two lines is the center of impact. If the whole rectangle of dispersion in the direction of fire is divided into eight equal zones, it is found that in the long run one of these zones over and one short from the center of impact each contains 25% of the total number of rounds fired, whereas the next zones, both over and short, each contains 16% of the shots fired. The successive zones contain 7% and about 2%. A few shell may stray out of the rectangle of dispersion. Each of these zones is one range probable error wide. The deflection probable error is obtained in the same way as the range probable error. (See Plate 3). The probable error varies with the type of cannon used, the range, the reliability of the ammunition, the fuze used, and the type of filling.

c. The following table shows the average probable errors for several important weapons:

TABLE II

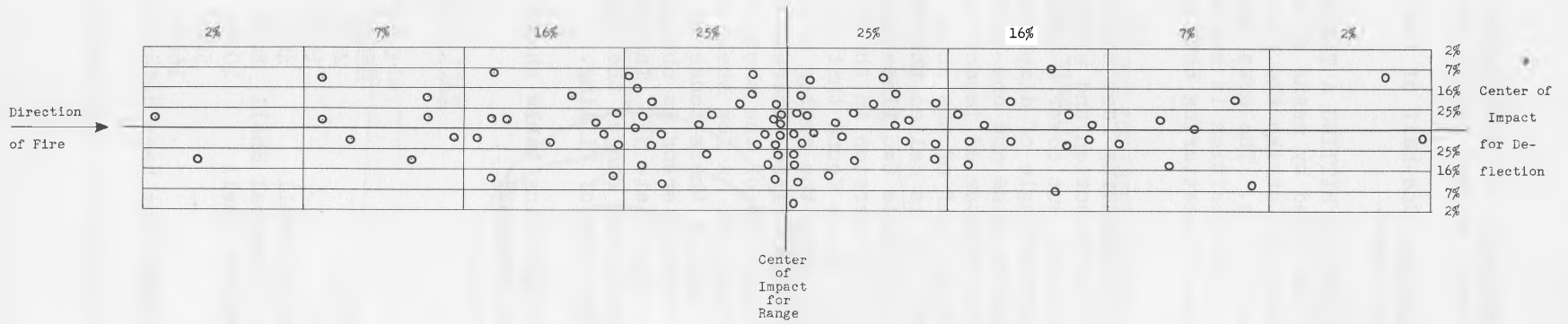
<u>Weapon</u>	<u>Range</u>	<u>Range</u>		<u>Deflection</u>	
		<u>P.E.</u>	<u>Yds.</u>	<u>P.E.</u>	<u>Yds.</u>
4.2" Chemical Mortar	2000	20		10	
Livens Projector	1000	40		30	
75-mm Gun - Chemical Shell	4000	25*		5*	
155-mm Howitzer - Chemical Shell	8000	50*		6*	
155-mm Gun - Chemical Shell	10000	60*		8*	
Airplane Bomb	5000 ft. alt.	49		49	
Airplane Bomb	16000 ft. alt.	147		147	

*These data have not been determined for chemical shell.

d. Fire should be conducted by direct observation of the

PLATE 3

RECTANGLE OF DISPERSION FOR MORTAR AND ARTILLERY SHELL
(Fall of 100 rounds)



fall of the shots on the target wherever possible, as best results are obtained under such conditions.

e. Under some conditions it is impossible to get direct observation on the target, but some auxiliary target may be seen on which fire can be adjusted. Using a proper factor of correction, fire may be shifted from the auxiliary target to the real target with a high degree of accuracy. Such a general method of fire control is called "transfer of fire" and is applicable for artillery. In observed fire an area 200 x 200 yards is a suitable target for chemical agents. In transfer of fire an area 300 yards deep and 250 yards wide must be covered in order to certainly include a target 200 x 200 yards. After transfer of fire is thus made, the area to be covered should be walked through by successive change in range of two probable errors until the entire area has been covered. In this way one is reasonably certain to include the area desired within the beaten zone.

f. In some cases it is necessary to fire with several batteries on one target by computing the necessary firing data from the best available maps. When airplane surveillance is available so that the artillery commander is given the sense of fire (that is; over or short, right or left) map data corrected by airplane surveillance can be used upon the same size area as that covered by transfer of fire. Since a larger area is covered in a transfer of fire than in observed fire, a suitable increase of ammunition must be allowed.

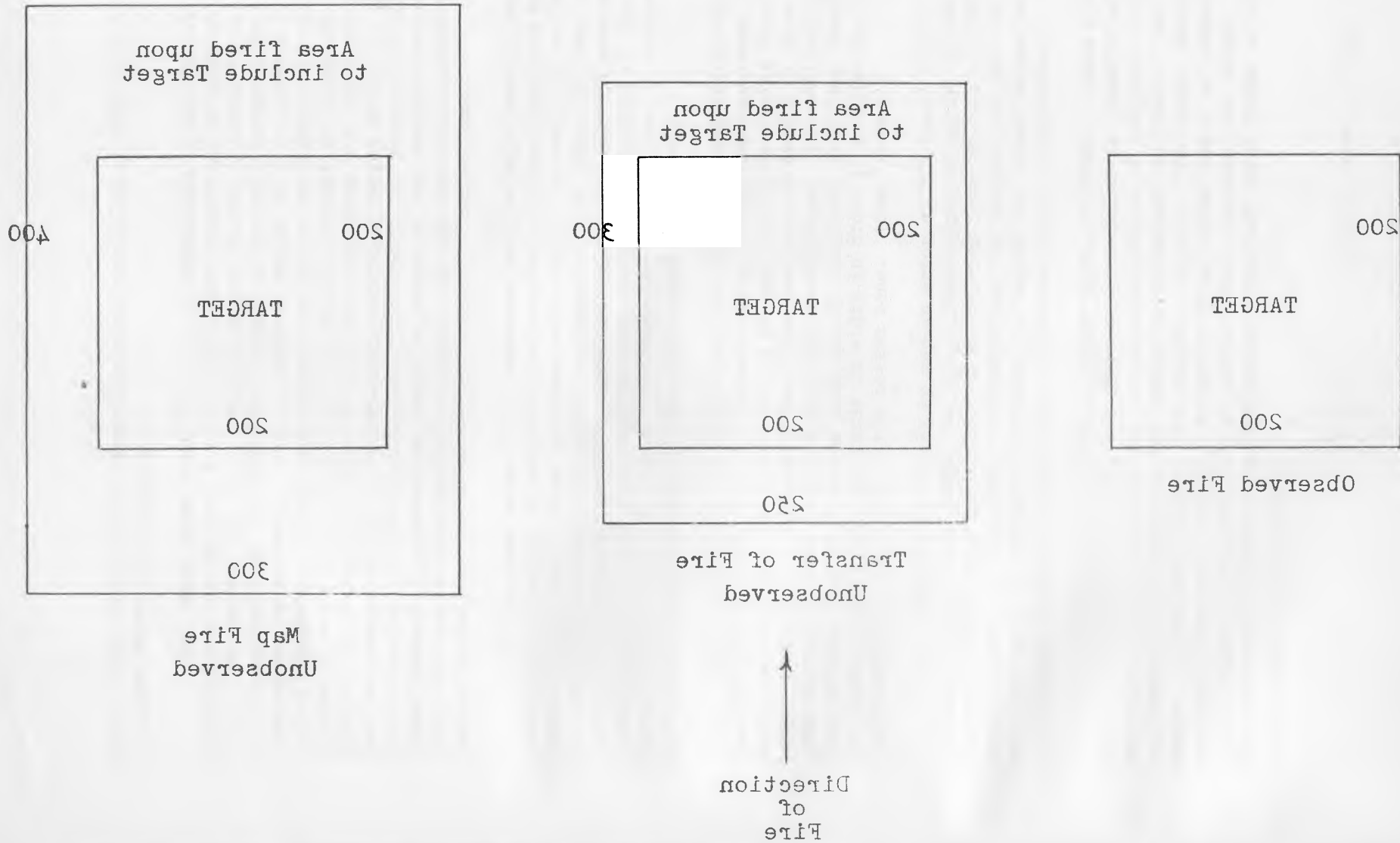
g. Even where the target and gun positions are accurately located on a reliable map and meteorological conditions are known so that a correction for the moment can be applied to the firing data, a larger area must be covered by map fire than by a transfer of fire in order to include the target within the beaten zone. The smallest unit area of this type of fire has been set by the Field Artillery Board at 400 yards in depth and 300 yards in width in order to include the 200 x 200 yard unit area within the beaten zone. (See Plate 4).

h. Suppose in firing by map an error of 100 yards exists in the map, giving a map range 100 yards greater than actually existed. Suppose further that the deflection calculated from the map is fifty yards in error to the left. By scattering the projectiles over an area 300 yards in width by 400 yards in depth, the actual target would be included in spite of the error in the map data. (See Plate 5).

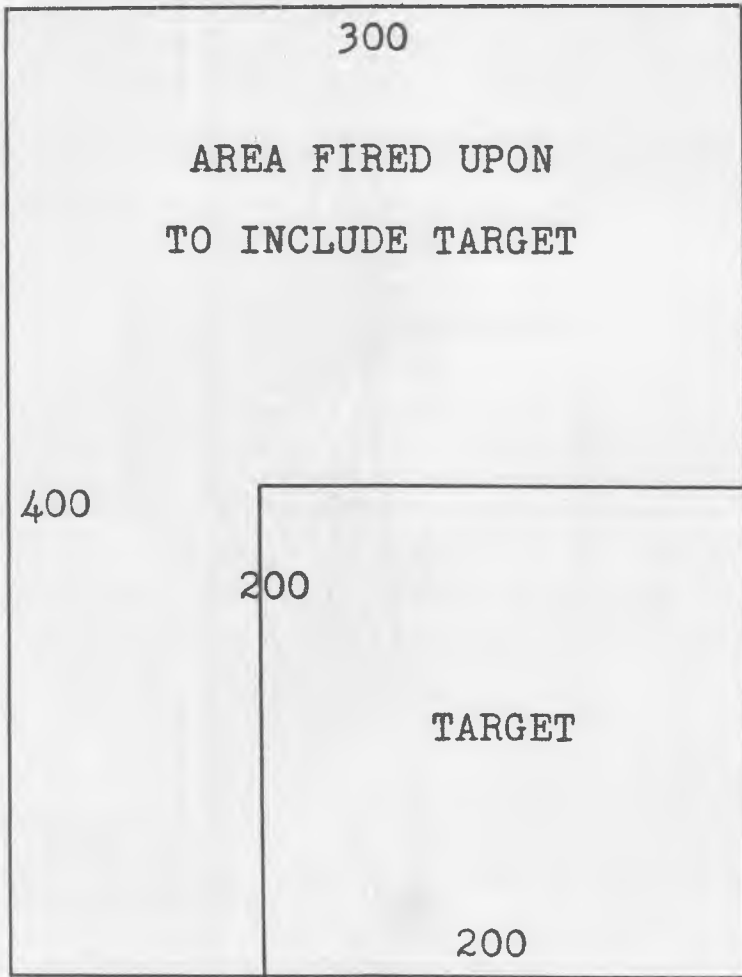
6. PROBABILITY OF HITTING A TARGET WITH AIR BOMBS. - When a target is bombed from the air, ballistic errors similar to those in artillery fire exist. In addition, the personal errors of the pilot in flying the correct course and the bomber in releasing his bomb at the proper instant are added to the ballistic errors. The chance that any particular bomb will strike a target is thus rather small as compared to the chance of an artillery or mortar shell striking its target. The area covered by bombs must therefore be about three times as large as the target to be covered.

VARIOUS METHODS OF CONDUCTING ARTILLERY FIRE

8



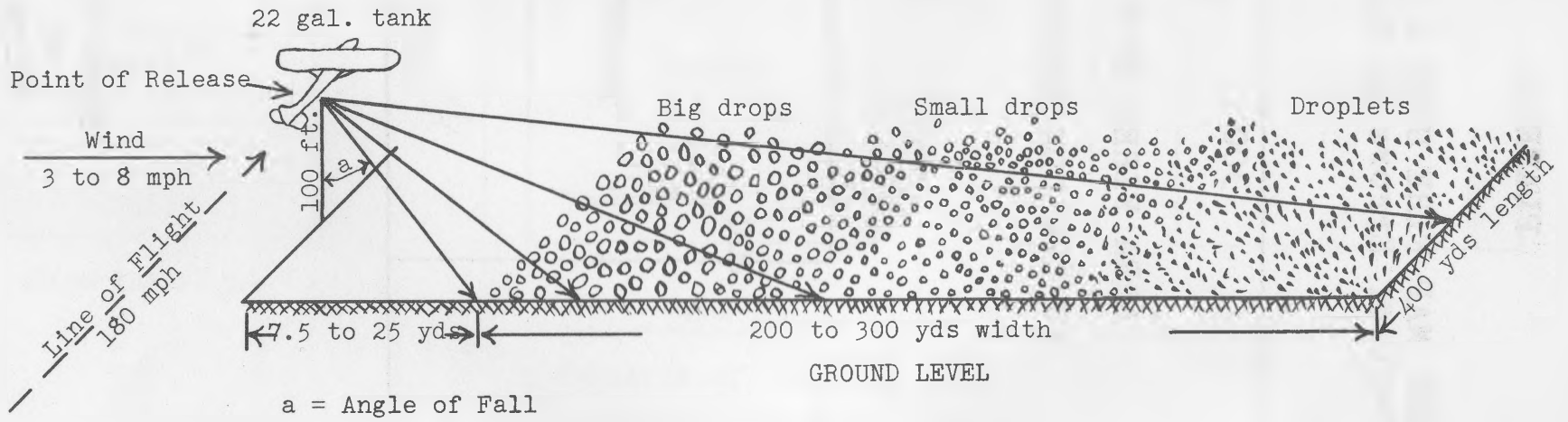
ARTILLERY MAP FIRE UPON A SMALL TARGET
(Showing effect of Errors in Location of Target)



↑
Direction
of
Fire

PLATE 6

FALL OF LIQUID DROPS



7. PROBABILITY OF HITTING A TARGET WITH LIQUID SPRAY. - When a liquid spray is released by an air burst projectile or by an airplane at some distance above the ground it is found in practice that the liquid is broken up into drops of various size. Large drops fall faster and drift downwind less than small drops, while very small drops (called droplets) drift very great distances downwind. The surface tension of the liquid and the explosive charge, or the nozzle used, are the controlling influences in the size of drops. Height of release and wind velocity are controlling factors in the spread of drops on the ground. (See Plate 6). There are so many factors in this case that individual skill in estimating the various elements involved can be obtained only by actual practice.

8. GENERAL. - Rules for the use of smoke and gas are given in Sections II and III. The quantity of munitions required for various types of operations is given in Chapter III.

SECTION II

THE USE OF SCREENING SMOKE

	Paragraph
Use of Smoke by Chemical Mortars and Artillery	9
Use of Smoke Pots	10
Airplane Smoke Screens	11
Airplane Smoke Bombs, 30 Pound	12
Smoke Generators	13

9. USE OF SMOKE BY CHEMICAL MORTARS AND ARTILLERY. - a. The direction of the wind with respect to the front to be screened is the controlling factor in determining the technique of firing smoke shell by artillery weapons. Four wind directions will be considered, (a) Following or six o'clock, (b) Quartering, (c) Flank and (d) Head or twelve o'clock. The designation of wind direction is made with respect to the front to be covered. In every case twice as many rounds should be fired during the first minute as are estimated to maintain the screen each minute thereafter. In flank winds twice as many rounds should be fired on the upwind point of impact as upon the points fired upon to reinforce the screen.

(1) Six o'clock winds.

(a) For maximum smoke effect the center of impact for range should be placed six probable errors in front of the line to be screened and the fire evenly distributed on this front by observation. (See Plate 7). When firing to cover an infantry advance lift the center of impact to the enemy line during the last four minutes of fire. Increase the rate of fire during this last phase to about twice the normal rate. This last phase of fire is effective in keeping down enemy fire. It permits our troops to advance as close as possible to the enemy under cover of the smoke screen.

PLATE 7

SCREENING WITH A FOLLOWING WIND

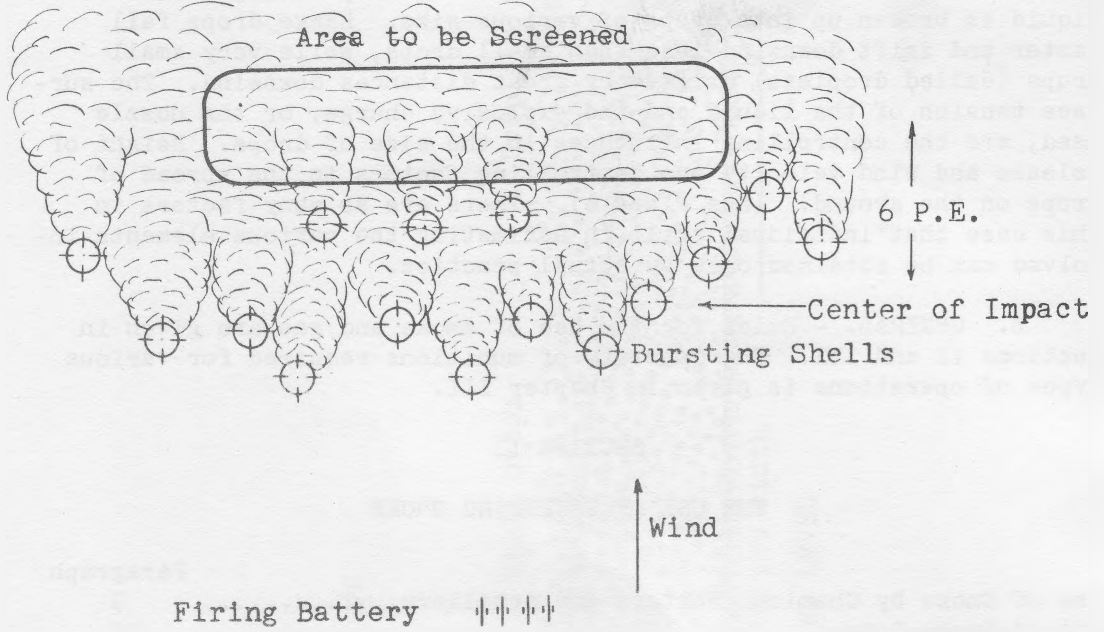
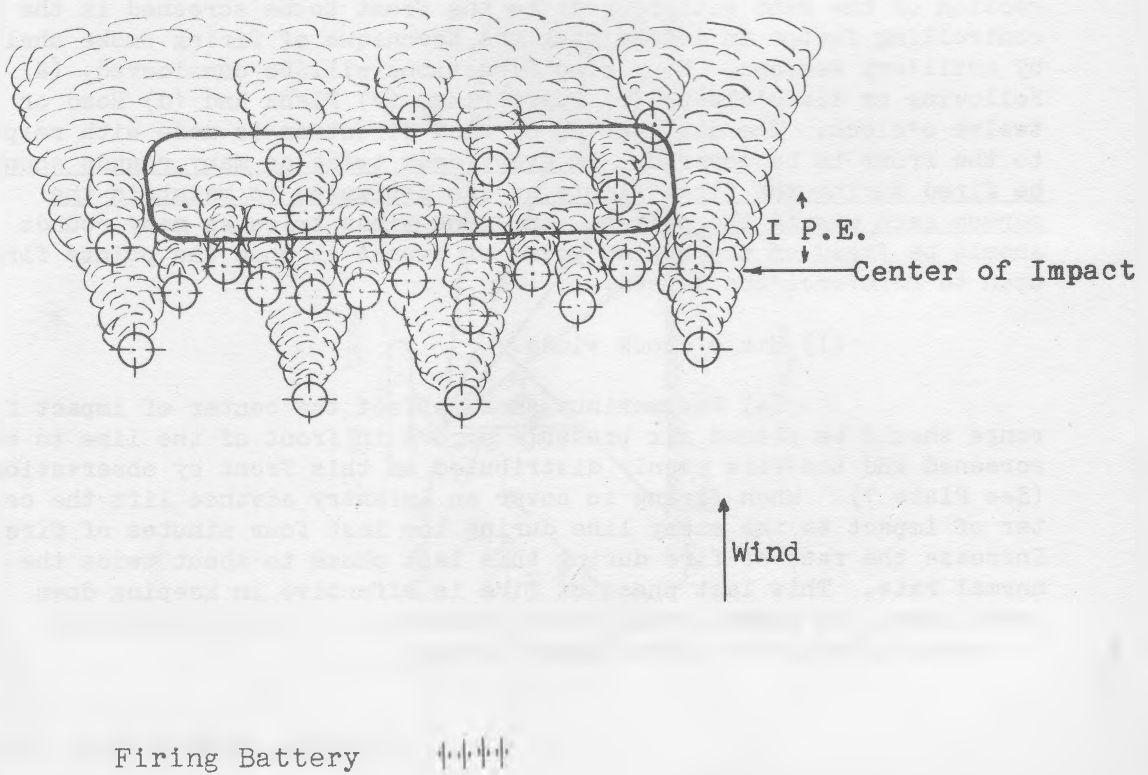


PLATE 8

SCREENING WITH A FOLLOWING WIND



(b) For a combination of casualty effect and screening action place the center of impact one probable error in front of the line to be screened. The shell should be evenly distributed along the line and should cover more front than the line to be screened. (See Plate 8).

(2) Quartering Winds.

(a) Under these conditions smoke should be fired the same as for six o'clock or twelve o'clock winds. Not quite so much ammunition is required as for six o'clock winds.

(3) Flank Winds. In flank winds the center of impact should be placed two probable errors in front of the line to be screened. The screen should be started upwind from the line and the points of impact should be placed at suitable intervals which depend upon the smoke producing capacity of the shell. (See Plate 9). Fire twice as many shell on the upwind point as upon points downwind.

(4) Head Winds. In head winds the center of impact should be well in rear of the enemy's front line, usually from 200 to 500 yards, upon the support positions or line of supporting strongpoints. Casualty effect is thus obtained on the supporting strongpoints and the whole area placed in smoke which hinders the enemy and reduces his fire power. Downwind from the enemy lines the smoke will be thinned out to a mist and thus interfere very little with our own troops. (See Plate 10).

10. USE OF SMOKE POTS. - Smoke pots may be used as dictated by the circumstances. They should be fired on a time schedule by men posted in position for that purpose. Best results will be obtained when each man is instructed to keep three pots burning in his vicinity, firing a pot every time one burns out. Pots should be placed so that the clouds merge before reaching the line to be screened. Holes in the cloud are thus prevented. Pots may be wired in batteries and fired electrically. When smoke is desired from a single point for more than the burning time of one pot, and men are not available, two or more pots can be placed on their sides in a shallow trench half the depth of a pot diameter, and the top of one pot placed against the bottom of the one ahead. In this way the burning pot sets off the succeeding pot in time to cause continuous smoke generation from that point. Where there is danger from fire from burning pots, place them in a trench one foot wide and six inches deep. In any case the officer in charge must be certain by observation that a continuous smoke blanket is placed on the line to be screened. (See Plate 11).

11. AIRPLANE SMOKE SCREENS. - a. The entire cloud laid by an airplane begins moving as soon as laid. Due to terrain and variations and in wind velocities at different altitudes, the leading edge moves more rapidly than the trailing edge of the cloud. The cloud therefore becomes wider and less dense as it travels with the wind.

PLATE 9

SCREENING WITH A FLANK WIND

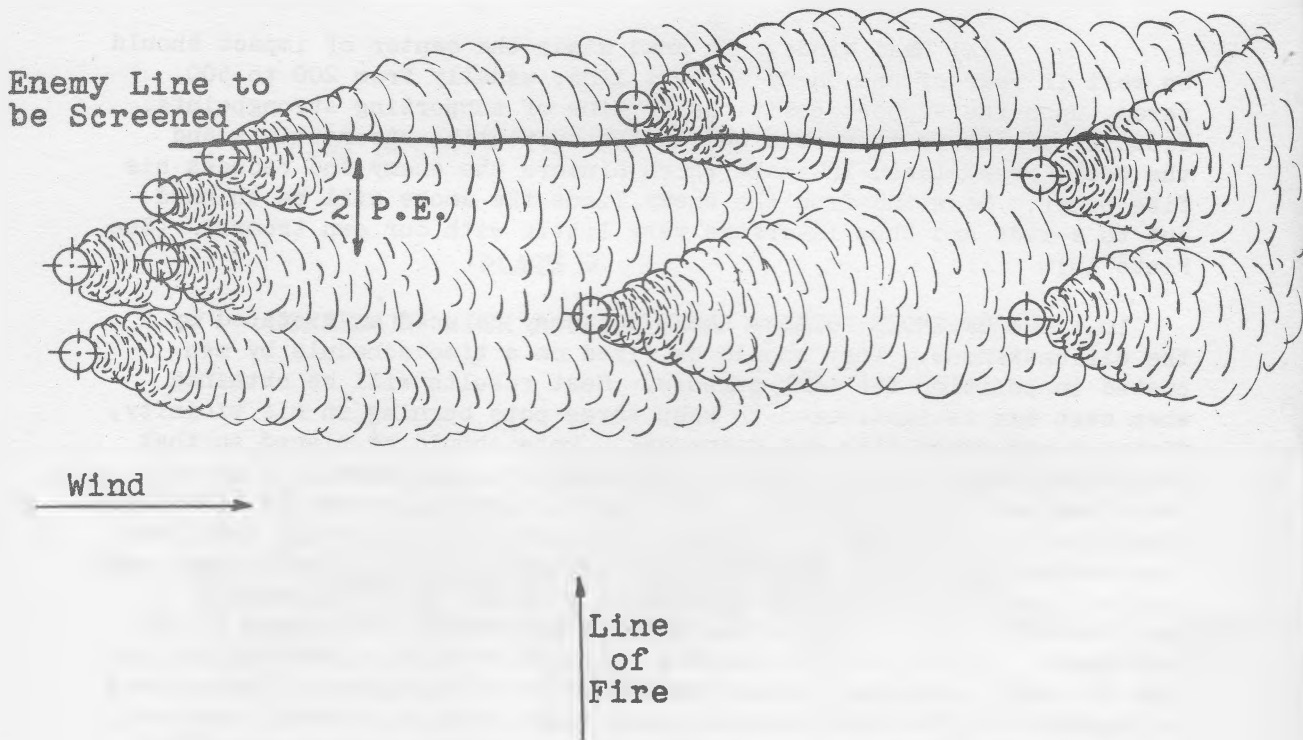


PLATE 10

SCREENING WITH A HEAD WIND

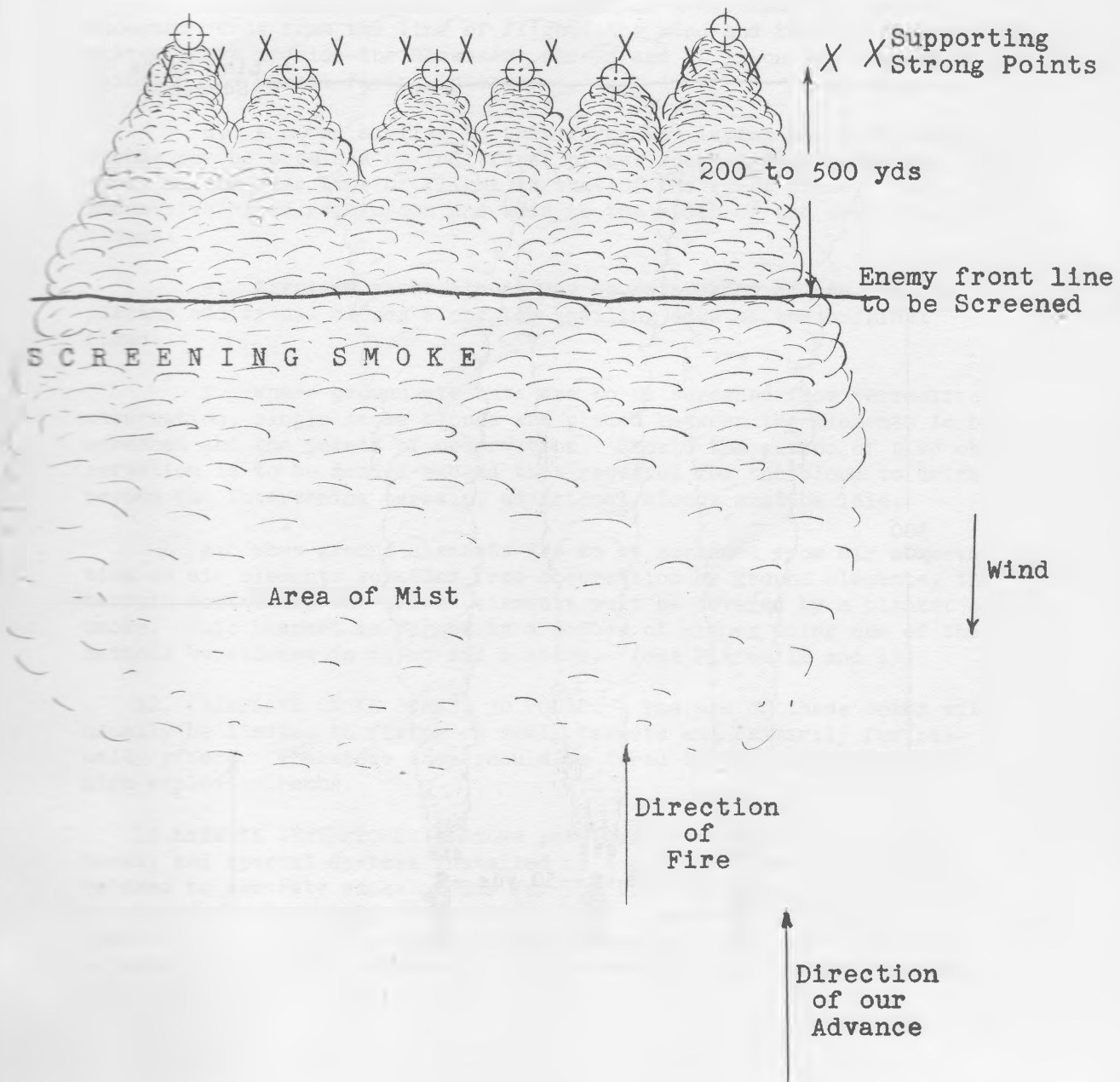
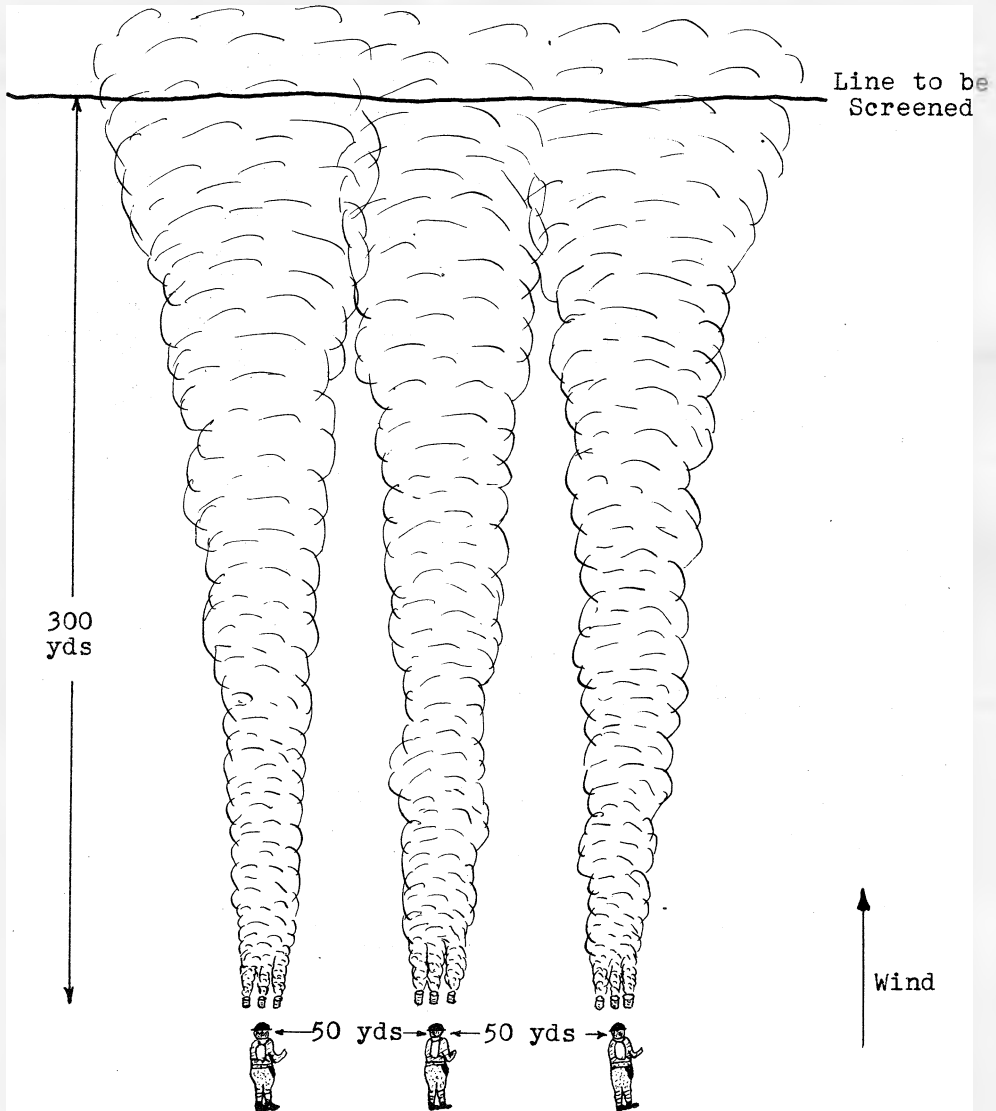


PLATE 11

THE USE OF SMOKE POTS IN 6 O'CLOCK WINDS



b. When several clouds are laid simultaneously by planes flying in line the individual clouds act as above described and because of their spread will eventually merge into one large cloud. The time required for merging is governed by the interval between planes. For clouds that are to merge in 800 to 1000 yards travel, the average interval is 400 yards.

c. Where the area to be covered is a distance of several thousand yards from the line of flight, the wind and terrain factors stated above provide the necessary spread and it is only necessary to maintain the normal flying interval.

d. A cloud similar to that formed by laying parallel smoke clouds may be obtained by individual planes successively releasing the smoke on the same line of flight as that of the first plane. Each successive cloud reinforces and adds to the width of the preceding clouds.

e. Airplane smoke clouds may be reinforced at any time by placing additional clouds along the trailing edge of the original cloud.

f. Where ground elements are to be screened from terrestrial observation, single smoke clouds are placed between the elements to be screened and the points of observation. Should the period of time observation is to be denied exceed that required for the cloud to drift beyond the intervening terrain, additional clouds must be laid.

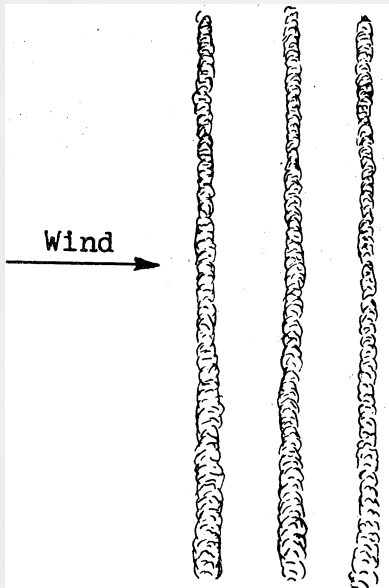
g. When ground elements are to be screened from air observation or air elements screened from observation by ground elements, the terrain containing the ground elements must be covered by a blanket of smoke. This blanket is formed by a number of planes using one of the methods considered in b, c, and d above. (See Plates 12 and 13).

12. AIRPLANE SMOKE BOMBS, 30 POUND. - The use of these bombs will usually be limited to firing on small targets and primarily for casualty effect. Therefore they should be fired in the same manner as high explosive bombs.

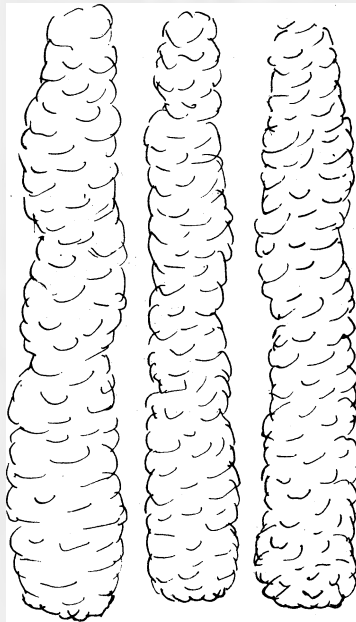
13. SMOKE GENERATORS. - Smoke pots, smoke cylinders on trucks or tanks, and special devices installed as a part of fixed defenses may be used to generate smoke clouds for specific purposes. The direction of wind with respect to installations to be covered, the quantity of smoke needed, and the purpose of such clouds will all have to be considered and a specific technique worked out for each special purpose. (See Plate 14).

PLATE 12

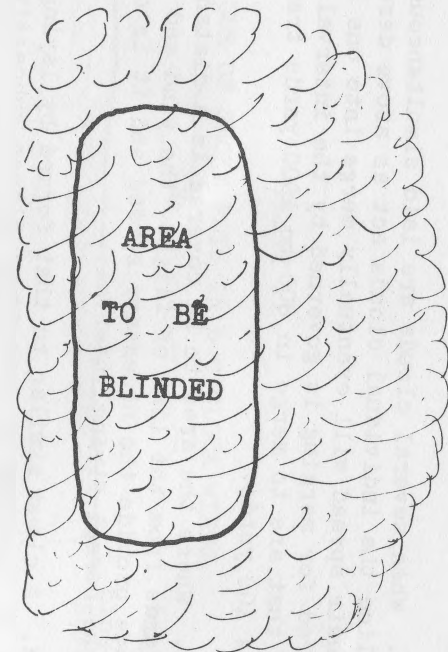
AIRPLANE SMOKE CLOUDS



Initial Clouds



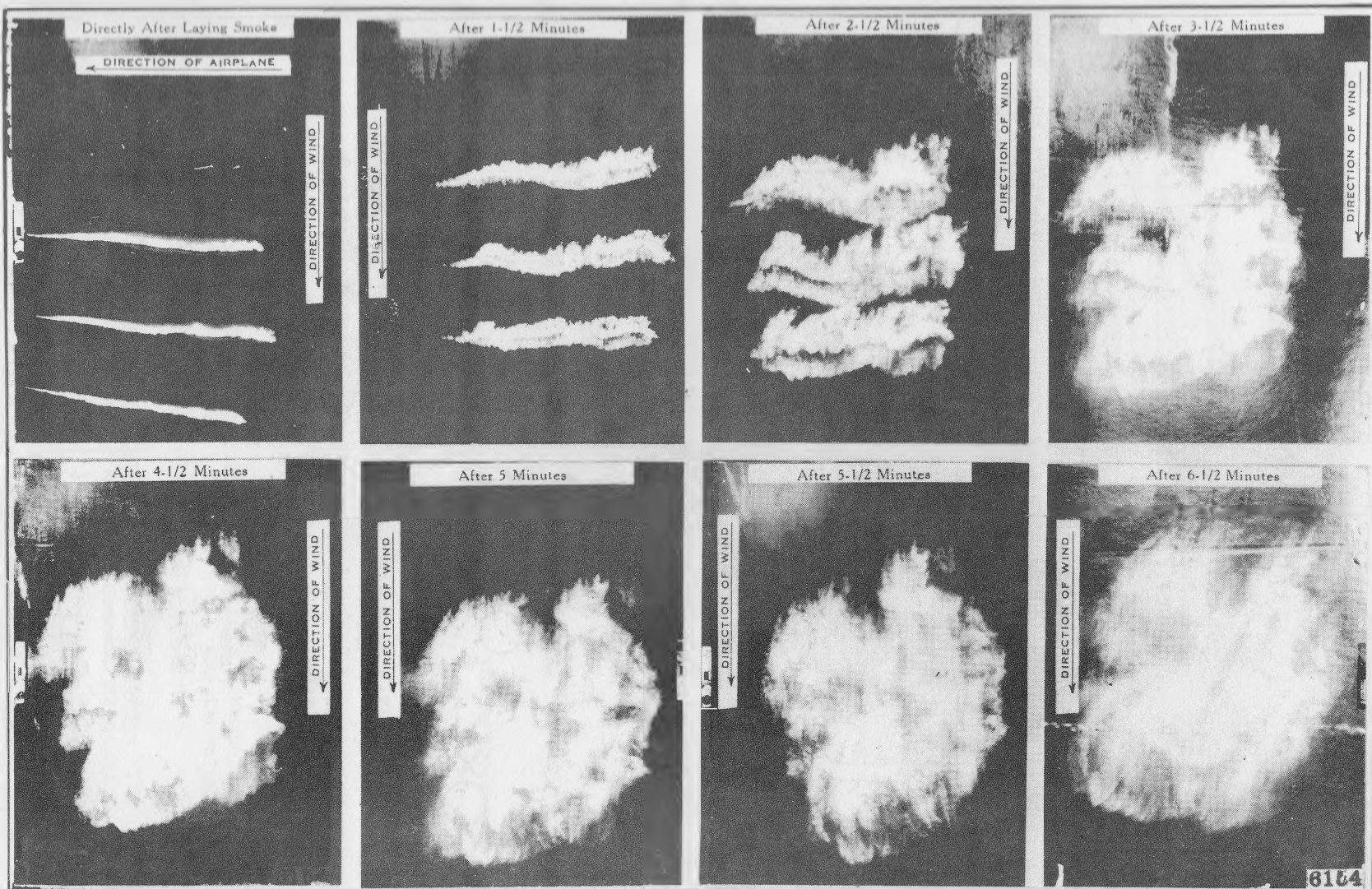
2d Phase



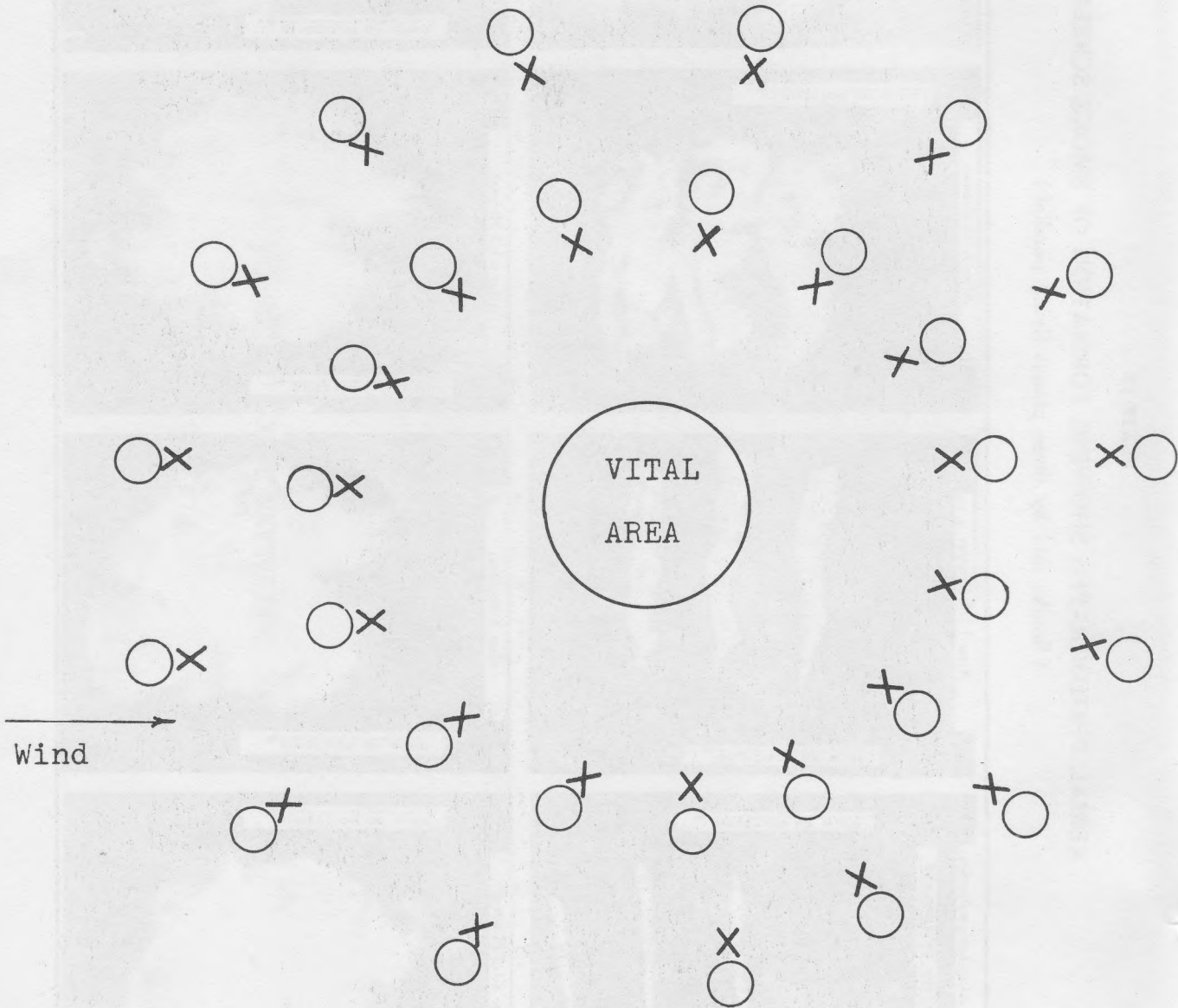
Single Cloud

AERIAL PHOTOGRAPHS SHOWING FORMATION OF SMOKE SCREEN

(Smoke laid by three planes flying parallel)



AREA SMOKE SCREEN GENERATORS



Fire all generators to set up the cloud initially, then cut out the generators on the downwind side after the smoke blanket is established.

SECTION III

THE USE OF GAS

	Paragraph
Comparison Between Technique of Firing Gas with that for Smoke and High Explosive	14
Mustard Gas Type Agents	15
Phosgene Type Agents	16
Use of Harassing Agents in Artillery Shell	17

14. COMPARISON BETWEEN TECHNIQUE OF FIRING GAS WITH THAT FOR SMOKE AND HIGH EXPLOSIVE. - a. In general, the technique of firing nonpersistent agents is similar to that for smoke for combined casualty and screening effect, with the important exception that the firing must be completed within a period of two minutes or less. If this is not done, the desired concentration of gas on the target will not be attained.

b. The technique of firing persistent agents is very similar to that of high explosive.

15. MUSTARD GAS TYPE AGENTS. - a. Mustard gas is a type persistent vesicant agent. Lewisite, ethyldichlorarsine, and several other agents all belong to this same class. The technique of firing this class of agents is the same as for mustard gas.

b. Mustard gas can be used as follows:

- (1) In artillery and chemical mortar shell.
- (2) Airplane spray.
- (3) Airplane bombs.
- (4) Static firing.

c. The following principles give some idea of the methods of disseminating mustard gas.

(1) The Use of Mustard Type Agents Against Area Targets. When firing on a large area occupied by troops, use zone fire, repeating until the required amount of ammunition has been fired. Roads, battery positions, command posts, and other important features known to exist within the target area should be covered with additional accurate fire from favorably located batteries.

(2) The Use of Mustard Gas on Point Targets. When firing mustard gas on point targets, roads, flanks, etc., the technique is the same as for high explosive or similar targets.

(3) Use of Airplane Spray Against Troops on Roads. The three-plane formation can be used during daylight hours. At night a target should be covered by three planes in succession. The technique of the operation of the plane and the release of the spray is the same

as when a smoke cloud is similarly released.

Discussion: The chief difficulty of striking any small target with airplane spray is the difficulty of estimating changing wind direction and velocity on the ground and near the ground. It is thus rather difficult for a single airplane, with certainty, to strike any small narrow target, such as a column of troops marching on a road. However, if three planes fire upon the target it is reasonably certain that one of the three planes will strike it.

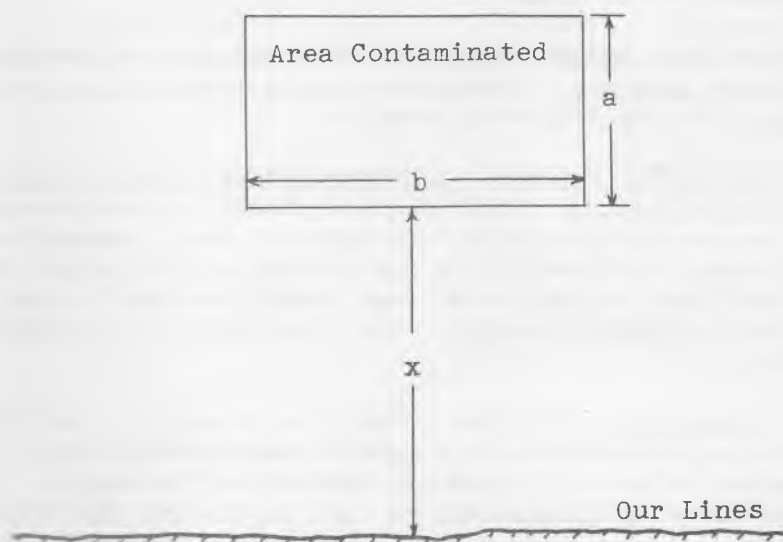
(4) Use of Airplane Bombs, 30 Pound, Chemical Type. Normal attack aviation formations and bombing methods may be used. If a target is an area, the bomb should be placed thereon as nearly as possible in the same manner as in the case of artillery fire. Mustard gas bombs may be used against troops on the march. In this case it is necessary to cover a fairly large area with the bombs in order to be reasonably certain to include the desired target within the beaten zone. The airplane should therefore follow the same procedure as when spraying mustard gas, namely in a three-plane formation. The center plane should attempt to strike the target, while both the flank planes release their bombs at the same time, thus covering three times the necessary area which should include the desired target.

(5) Static Explosion of Mustard Gas Type Agents. Place the munitions in a staggered line so as to make it difficult for a person to cross the area without coming in contact with the agent. In woods hang the containers in bushes and trees so as to get air burst effects. In the defense of a beach against a hostile landing party, bury the munitions under the sand so as to prevent the casual observer from locating the firing lines. Machine guns and artillery should be so located as to force an advancing enemy to take cover and crawl through the contaminated area.

(6) Minimum Distances from Friendly Troops at Which Mustard Type Agents may be Used. See Plate 15.

PLATE 15

GENERAL GUIDE FOR THE USE OF MUSTARD GAS AND OTHER HIGHLY PERSISTENT VESICANTS



Let: x = Safe distance from our lines to near edge of contaminated area
 a = Depth of area in direction of fire
 b = width of area

Then $x = a + \frac{1}{2}b$

This equation does not apply in the case of barriers less than 500 yards in depth; however, such barriers ordinarily will not be placed closer than 1000 yards to friendly troops.

DISCUSSION:

The time of day, direction and velocity of wind, topography, temperature of air and ground, size of area, amount of agent fired, and length of time consumed in firing all determine the vapor concentration set up on the downwind edge of a mustard gas target and the concentration that will exist at various distances downwind. The foregoing guide is given for average conditions. If the prevailing wind is blowing from 6 o'clock, the safe distance may be reduced.

If there is a sharp valley from the target to our lines, the safe distance must be increased when the prevailing wind blows toward our lines.

16. PHOSGENE TYPE AGENTS. - a. Phosgene is used for purposes of illustration as a type nonpersistent casualty agent of the lung irritant class. Any agent of this type should be used in the same manner as phosgene. Agents of this type can be used in the following manner:

- (1) Cloud attack from cylinders.
- (2) Livens projectors.
- (3) Medium artillery and chemical mortars.
- (4) Static explosion.

b. In any case, sudden high concentrations must be generated to catch the enemy unmasked. Hence surprise is essential in the use of this agent. See the following examples.

(1) The Use of Phosgene in Chemical Mortar and Artillery Shell against Definite Targets. Observed fire should be used wherever possible to lay phosgene on this type of target. A heavy concentration of phosgene should be fired on the upwind edge of the target, and one-half the amount fired on the upwind edge should be added to the cloud each 100 yards distance downwind. The fire should be concluded within two minutes.

Discussion: This method of fire allows for the building up of a lethal concentration on the upwind edge of the cloud, keeping it up to a lethal value as it travels downwind on the target. The highest practicable rate of fire should be used in placing this type of fire. The fire should be conducted by every weapon available in order that the fire may be concluded within two minutes, otherwise personnel in the area will be masked, and no great effect is to be expected from further continuation of fire.

(2) Phosgene against Definite Targets by Livens Projectors. When firing Livens projectors on small definite targets, all batteries should be laid by map data or direct laying upon the center of the target.

Discussion: The Livens projector has a range probable error of about 40 yards and a deflection probable error of about 30 yards, varying, however, with the character of the ground from which the projector is fired and the care used in the installation of the battery. Its maximum effective range is about 1450 yards. The smallest target which can be covered is thus about 320 yards in depth and 240 yards in width. A target 200 x 200 yards at the center of the beaten zone would contain about 80% of the shell fired. Under average conditions, the cloud generated by Livens projectors fired on a target of this size will completely cover the target itself within thirty seconds.

(3) The Use of Phosgene in Cylinders. The technique of firing cylinders is the same as that for firing smoke candles, due consideration being given, of course, to the proper ammunition requirements as laid down in the following chapter.

17. USE OF HARASSING AGENTS IN SHELL. - When an area is to be

harassed by lacrimators or other agents of this type the whole area should be walked through each hour at range intervals of 100 yards, so as to place a scattering of shell over the entire target. An additional quantity of agent should be fired on the upwind edge of the target so as to set up effective concentrations.

Discussion: Firing every hour keeps the concentration built up to an effective value and causes additional harassing due to the fall of shell. When phosgene is used for harassing purposes the shoot must be repeated every thirty minutes. HE mixed with phosgene or phosphorus is also an effective harassing combination.

