CHEMICAL WARFARE WEAPONS AND AMMUNITION

THE CHEMICAL WARFARE SCHOOL

Book III

DUPLICATING PLANT
THE CHEMICAL WARFARE SCHOOL
EDGEWOOD ARSENAL, MD
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CHAPTER I

CHEMICAL GRENADES

SECTION I

GENERAL

1. GENERAL. - A chemical grenade is a missile filled with gas or smoke producing material, dispersed by an ignition or exploding device, and thrown by hand or fired from a rifle.

Chemical grenades are intended primarily for use by Infantry to cause casualties, to screen movements or to blanket small targets, and to harass. They reach their greatest and most general utility in trench or stabilized warfare but find important though limited application in warfare of movement, in both offensive and defensive situations.

In peace time, tear gas and smoke grenades are very advantageously and effectively used in connection with unit training as a substitute for toxic gas or for the production of smoke screens, respectively. These weapons have further proved their effectiveness in quelling civil disorders.

Chemical grenades are manufactured by the Ordnance Department but are filled by the Chemical Warfare Service; they are then returned to the Ordnance Department by whom they are stored, distributed and issued.

2. CLASSIFICATION. - Chemical grenades are classified primarily as to method of projection, i.e., Hand Grenades and Rifle Grenades, and as to type of filling, i.e., whether gas or smoke. For purposes of instruction an additional classification is made

based upon construction, i.e., whether burning or exploding in operation.

3. BASIS OF IDENTIFICATION MARKINGS. - In common with all chemical munitions, chemical grenades are identified in the field by three distinct systems of markings stenciled or painted over the blue-grey waterproofing enamel of each grenade, as follows:

a. By symbol designation, in yellow or light green letters on upper half of body, denoting specific chemical agent, e.g., WP in yellow (White Phosphorus); CNS in light green (Chloracetophenone in solution).

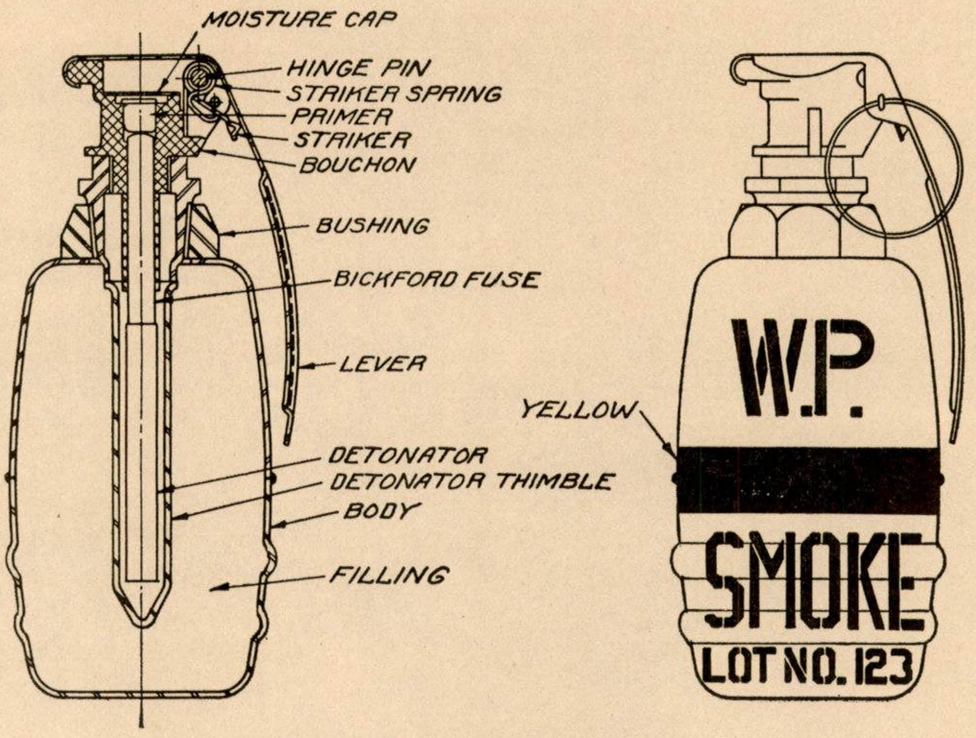
b. By colored band or bands around central portion, denoting type of agent and degree of persistence; yellow designating smoke; green designating gas. Non-persistent fillings are designated by one band; persistent substances, by two bands.

NOTE: A persistent agent is defined as a substance that will remain in the vicinity where released for at least 10 minutes, under average conditions.

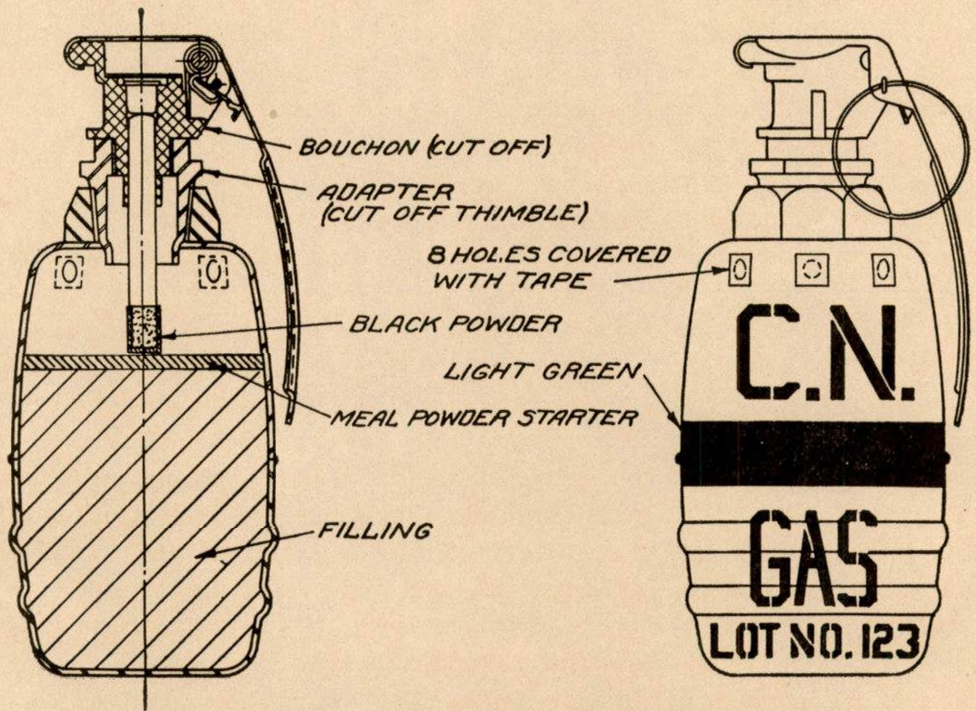
c. By the words Smoke or Gas stenciled in yellow or light green letters respectively, as the case may be, on the lower part of the grenade above the lot number.

SECTION II

CHEMICAL HAND GRENADES



GRENADE, HAND, SMOKE, (W.P.) MK II
(COMPLETELY ASSEMBLED)



GRENADE, HAND, LACHRYMATORY (C.N.) MK V
(COMPLETELY ASSEMBLED)

OCT. 1, 1929

PLATE I

4. GENERAL. - Chemical hand grenades are designed to be thrown by hand, and have a maximum range of 35 to 40 yards, depending on the individual. Their principal application is to clear shelters and dugouts, to screen or blanket, or to demoralize preparatory to attack or raid. They are of two distinct types, the exploding type and the burning type.

5. EXPLODING TYPE. - (See Plate I). This type consists of three parts: The body, the fuze, and the filling.

a. The Body is a barrel shaped container of thin drawn sheet steel, manufactured in two cup-shaped parts welded together. The outer surface is weather proofed by a coating of baked enamel. The Bushing is a flat steel nut welded to the body at its top to serve as a means of attachment for the thimble. The Thimble is a steel well tube closed at its lower end. It is screwed into the bushing and serves as a gas tight closure plug for the filling, and to prevent contact between the filling and the fuze. The inside of the detonator thimble is threaded to take the fuze.

b. The Fuze, Detonating, Hand Grenade, is attached to the grenade body by means of the threaded lower portion or stem. The Fuze Body is a casting of lead and antimony designed to take the firing mechanism and the detonator assembly. The Lever forms the cover for the fuze body, being attached to its protruding lip, extending over the firing mechanism and down over the shoulder of the grenade body. It is secured by an annealed steel Split Pin which passes through the wings of both the lever and the fuze body. The split pin forms the Safety Device. The lever prevents contact between the striker and primer. The Striker consists of a striker leaf and a striker point or firing pin and is attached by means of a hinge pin. A Striker Spring, of the "rat-trap" type, placed around the hinge pin, actuates the striker. The Detonator, Fuse and Primer are assembled in the recess of the fuze body as follows: The primer is pressed into its seat at the top of the recess and covered by a tin-foil disk to keep out moisture; the detonator and about half an inch of the fuse are inserted in a tin detonator cup, which is crimped to the fuse, with the tipped end of the fuse inserted immediately under the primer. The stem of the fuze body is crimped to the detonator cup. The fulminate primer is of the center-fire type. The fuse is a 5-second Bickford. The detonator is a No. 8 Commercial, and constitutes the entire bursting charge. A

piece of sheet steel fits over the threaded portion of the fuze body and forms the Fuze-Sealer or mud guard between the lever and the fuze body.

c. The Filling is a solid (or liquid) chemical agent.

d. Operation. When the safety pin has been pulled, the lever, held in place only by the grasp of the hand, acts as a detent to prevent the striker from moving. As the grenade leaves the hand, the striker is actuated by its spring, and, describing an arc, throws the lever clear of the grenade and explodes the primer. In turn, the primer ignites the five second fuse, the flash of which explodes the detonator. The resulting explosion ruptures the enclosing thimble and grenade body, and disperses the filling.

6. GRENADE, HAND, SMOKE, WP (WHITE PHOSPHORUS), MK. II. -

Description:

Type	5 sec. time fuse, exploding
Weight	15 oz.
Shape	Barrel, 3-3/8" x 2-1/8"
Body	Mk. II
Surface	Smooth, with two annular corrugations around lower body.
Color	Blue-grey
Safety Device	Safety-pin.
Igniter	Fuze, detonating, hand grenade, M-6, with a No. 8 commercial detonator.
Filling	White Phosphorus (solid) 10 oz.
Identification	Yellow letters "WP" " " "Smoke" One yellow band
Characteristics of Cloud	Pure white, dense, slightly acid, non-toxic smoke of great obscuring power; burst is accompanied by shower of burning particles rendered molten by heat produced, each burning particle contributing to cloud until expended.
Time of Burning	2 minutes
Diameter of Cloud	15 yards
Tactical Uses	To screen local movements; to blan-

	ket small targets; to inflict casualties; to set fire to readily inflammable objects. May be employed with gas, or to simulate gas.
Packing	Grenades and the fuzes, detonating, are packed separately. Grenades per box, 24; each grenade shipped with wooden closure plug. Fuzes, detonating, per box, 384.
Directions for Use	Assembly. (a) Remove wooden closure plug. (b) Screw the fuze tightly into grenade thimble, being careful not to jar or twist detonator. To fire. (a) Grasp the grenade, holding the lever firmly against the grenade body in the palm. (b) Withdraw safety-pin without releasing or altering grip. (c) Throw the greande with a full swing of the arm, or with a combination of shot-put and catcher's peg, to a safe distance, i.e., not less than 35 yards.
Precautions	WP Grenades must not be carried by the safety-pin rings. Handle with extreme care. The body must not be ruptured or allowed to rust as the filling spontaneously ignites on contact with air. The detonator is very sensitive to heat and shock. Store in a cool place. Improperly functioning or faulty grenades should be destroyed in accordance with Provisions of W.D. Cir. 13, 1923. See Change #6, O.F.S.B. No. 3, Sec. IV, Nov. 30, 1925, for disposition of Phosphorus Rifle and Hand Grenades. After being issued to a tactical unit these grenades must be expended within 12 months.

7. GRENADE, LACRIMATORY, HAND, CNS (CHLORACETOPHENONE IN SOLUTION), MK. II. -

Description:

Type	5-Second time fuse, exploding.
Weight	15 oz.
Shape	Barrel, 3-3/8" x 2-1/8".
Body	Mk. II.
Surface	Smooth, with two annular corrugations around lower body.
Color	Blue-grey.
Safety Device	Safety-pin.
Igniter	Fuze, detonating, hand grenade, M-6, with a No. 8 commercial detonator.
Filling	Chloracetophenone in solution of chloroform and chlorpicrin (liquid), 9 oz.
Identification	Green letters "CNS" " " "Gas" Two green bands.
Characteristics of Cloud	White spray resembling a fog, which settles to the ground in about 30 seconds where it continues vaporizing. The vapor is colorless and is carried by the wind. It is immediately irritating and incapacitating causing copious lacrimation. Nonlethal except in extreme concentrations.
Persistency	From 30 to 60 minutes, according to the temperature and terrain.
Diameter of Cloud	10 yards.
Tactical Uses	To clear shelters, dugouts, etc. To force masking. An incapacitating agent against unprotected personnel.
Packing	Grenades and the fuzes, detonating, are packed separately. Grenades per box, 24; each grenade shipped with wooden closure plug. Fuzes, detonating, per box, 384.
Directions for Use	Assembly. (a) Remove wooden closure plug. (b) Screw the fuze tightly into the grenade thimble, being careful not to jar or twist the detonator. To fire. (a) Grasp the grenade,

	holding the lever firmly against the grenade body in the palm. (b) Withdraw safety-pin without releasing or altering the grip. (c) Throw the grenade with a full swing of the arm, or with a combination of shot-put and catcher's peg, to a safe distance, i.e., not less than 35 yards.
Precautions	CNS grenades must not be carried by the safety rings. Handle with extreme care. The detonator is very sensitive to heat and shock. Store in a cool ventilated place.

8. GRENADE, HAND, SMOKE, FM (TITANIUM TETRACHLORIDE), MK. II. -

Description:

Type	5-second time fuse, exploding.
Weight	15 oz.
Shape	Barrel, 3-3/8" x 2-1/8".
Body	Mk. II.
Surface	Smooth, with two annular corrugations around lower body.
Color	Blue-grey.
Safety Device	Safety-pin.
Igniter	Fuze, detonating, hand grenade, M-6 with a No. 8 commercial detonator.
Filling	Titanium Tetrachloride (liquid), 9 oz.
Identification	Yellow letters "FM". " " "Smoke". One yellow band.
Characteristics of Cloud	Upon burst a dense white cloud of spray which hydrolyzes upon contact with the air, forming a white smoke which drifts with the wind. It is non-lethal but has a corrosive effect on metal.
Persistency	30 seconds.
Diameter of Cloud	15 yards.
Tactical Uses	May be used for screening. It is primarily used in training as a sub-

	stitute for the WP grenade, due to the higher cost, and greater danger in the handling, of the latter.
Packing	Grenades and the fuzes, detonating, are packed separately. Grenades per box, 24; each grenade shipped with wooden closure plug. Fuzes, detonating, per box, 384.
Directions for Use	Assemble. (a) Remove wooden closure plug. (b) Screw the fuze tightly into the grenade thimble, being careful not to jar or twist the detonator.
	To Fire. (a) Grasp the grenade holding the lever firmly against the grenade body in the palm. (b) Withdraw safety-pin without releasing or altering the grip. (c) Throw the grenade with a full swing of the arm, or with a combination of the shot-put and catcher's peg, to a safe distance, i.e., not less than 35 yards.
Precautions	FM is not particularly dangerous, except to the eyes, therefore gas masks should be worn when handling leaky grenades. The detonating fuze is very sensitive to both heat and shock, therefore care must be exercised in handling. Do not carry by the safety ring. Store in a cool ventilated place.

9. BURNING TYPE. - (See Plate I). This type consists of three parts; the body, the fuze, and the filling.

a. The Body is a barrel shaped container of thin drawn sheet steel, manufactured in two cup-shaped parts welded together. Eight small holes are punched around the upper body just under the shoulder for the emission of gases. These are covered with small squares of adhesive tape. The outer surface is weather-proofed by a coating of enamel. The Bushing is a flat steel nut welded to the body at its top to serve as a means of attachment for the thimble. The Thimble is a steel well tube cut off

and open at the lower end. It is screwed into the bushing. The thimble is threaded on the inside to take the fuze.

b. The Fuze, Igniting, Hand Grenade, is attached to the grenade body by means of the threaded lower portion or stem. The Fuze Body is a casting of lead and antimony. The Lever forms the cover for the fuze body, being attached to its protruding lip, extending over the firing mechanism and downward over the shoulder of the grenade body. It is secured by an annealed steel Split Pin, passing through the wings of both the lever and fuze body. This split pin forms the Safety Device. The lever prevents contact between the striker and the primer. The Striker consists of a striker leaf and a striker point or firing pin. It is attached by means of a Hinge Pin. A Striker Spring, of the "rat-trap" type, attached to the hinge pin, actuates the striker. The Primer and Fuse are assembled in the fuze body as follows: The primer is pressed in at the top of the recess and the fuse is inserted into the recess with the tipped end immediately below the primer. The lower end of the fuse is crimped into a small lead cup which contains about .15 grams of black powder.

c. The Filling is a solid (or solidified) chemical agent, occupying approximately three-quarters of the grenade. A layer of fast-burning mixture (meal powder) is spread on top of the agent as a starter.

d. Operation. When the safety-pin has been pulled, the lever, held in position by the grip, acts as a detent to prevent contact between the striker and primer. As the grenade leaves the hand, the striker, actuated by its spring, throws off the lever and strikes the primer. The primer ignites the fuse which, in 5 seconds time, ignites the black powder, which, in turn, flashes the starter mixture. The pressure resulting from combustion of the agent forces the adhesive tape from the emission holes, and the vaporized agent escapes.

The heat necessary to carry off the vapors is supplied by smokeless powder incorporated with the agent in cases where chemical reaction of the agent alone does not generate heat.

10. GRENADE, HAND, LACRIMATORY, CN (CHLORACETOPHENONE), MK. V. - (See Plate I). This is the only burning type of hand gren-

ade at present authorized. This grenade will become obsolete upon exhaustion of the present supply.

Description	
Type	5 sec. time fuse, burning.
Weight	12 oz.
Shape	Barrel, 3-3/8" x 2-1/8".
Body	Mark II.
Surface	Upper half, smooth; lower half, two annular corrugations 1/2" apart.
Color	Blue-grey.
Safety Device	Safety-pin.
Igniter	Fuze, igniting, hand grenade, M-7, with 0.15 grams black powder flash.
Starter Mixture	Layer of meal powder.
Filling	100 grams CN Mixture (Chloracetophenone, Smokeless Powder, and Magnesium Oxide).
Identification	Light green letters "CN". " " " "Gas". One light green band.
Characteristics of Cloud	Bluish-grey to colorless; immediately irritating and incapacitating, causing copious lacrimation; non-lethal (except in extreme concentrations); has but little obscuring power.
Time of Burning	2-1/2 minutes.
Diameter of Cloud	5 yards.
Tactical Uses	To clear dugouts or shelters; to force masking; to harass. May be employed with smoke. Primarily for use in civil disorders and for training.
Packing	Grenades shipped assembled. Grenades per box, 24.
Directions for Use	To Fire. (a) Grasp the grenade in the palm of the hand, holding lever firmly against grenade body. (b) Withdraw safety-pin, keeping a firm grip around grenade and lever. (c) Throw the grenade with a full swing of the arm, or with a combination of shot-put and catcher's peg.

Precautions	Grenades must not be carried by the safety-pin ring. Should a grenade be dropped after safety-pin has been pulled it may safely be recovered and thrown if quickly done. Improperly functioning or faulty grenades should be destroyed in accordance with provisions of W.D. Cir. 13, 1923. Store in a cool, ventilated place.

SECTION III

CHEMICAL RIFLE GRENADES

11. GENERAL. - a. The projection of chemical grenades 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 advantageous in trench warfare; but the chemical rifle grenade is particularly effective against targets that appear in the course of a rapid advance.

Chemical rifle grenades are mounted on a steel rod which is inserted into the muzzle of the rifle. They are fired by means of a special blank cartridge.

b. 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:

Elevation	Range (approx.)
15 degrees	185 yds.
25 "	235 yds.
45 "	265 yds.

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

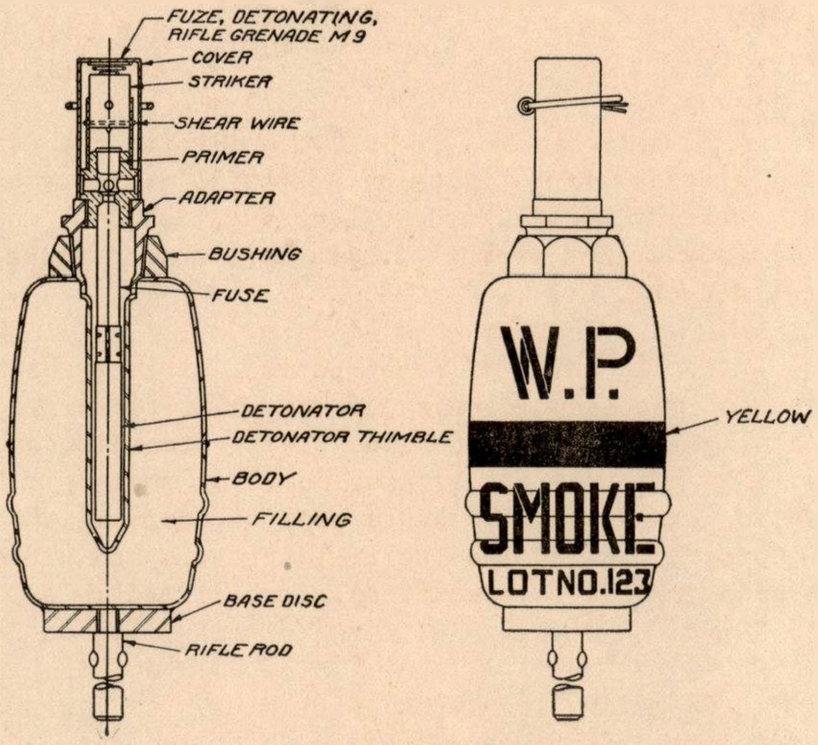
c. In point of construction, rifle grenades may be converted into hand grenades by the substitution of the hand grenade ignition device for the firing mechanism of the former. Thus rifle grenades may be considered of greater universal application. However, the employment of the standard rifle grenade (formerly called the "Combination Hand and Rifle Grenade") as a hand grenade is specifically prohibited by W.D. Cir. #35, 1923.

There are two types of chemical rifle grenades, the exploding type and the burning type.

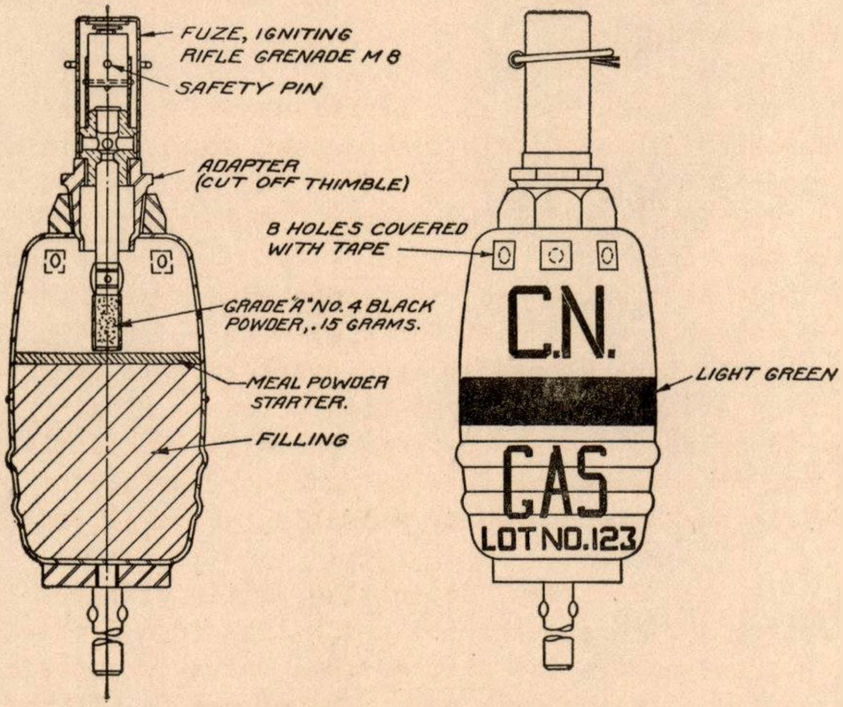
12. EXPLODING TYPE. - (See Plate II). This type consists of five parts: The body; the fuze; the filling; the rifle rod; and the cartridge.

a. The Body is a barrel-shaped container made in two cup-shaped parts of thin drawn sheet steel. It is similar to the exploding type hand grenade, with the addition of a small steel base disc soldered to the bottom. The Base Disc is drilled to take the rifle rod. The Bushing is a flat steel nut welded to the body at its top, and is tapped with a pipe thread to serve as a means of attachment for the thimble. The Thimble is a steel well tube closed at its lower end. It is screwed into the bushing and serves as a gas-tight closure plug for the filling and to prevent contact between the filling and the fuze. It is tapped to receive the fuze. The outer surface of the grenade body is weather-proofed by a coating of baked enamel.

b. The fuze, detonating, rifle grenade, consists of an adapter, a firing mechanism and a time fuse detonator assembly, all in one unit. The Adapter is a brass (or steel) device being threaded on the outside on its lower end to fit the grenade



GRENADE, RIFLE, SMOKE (W.P.) MK I
(COMPLETELY ASSEMBLED)



GRENADE, RIFLE, LACHRYMATORY (C.N.) MK II
(COMPLETELY ASSEMBLED)

thimble, and threaded on its upper end to receive the firing mechanism. It is drilled longitudinally, the lower end threaded on the inside to receive the time fuse detonator assembly. The Firing Mechanism consists of a brass inertia-pellet Striker in a brass chamber. The striker is normally held off the primer cap by means of a shear wire of copper. A brass cover fits snugly over the striker chamber to exclude dirt. Underneath this cover is a loose spring which automatically throws the cover off the mechanism when the safety pin is pulled. It is held in place by a split Safety-pin which passes thru the striker, striker chamber, and cover, and constitutes the Safety Device. The fuse-detonator assembly consists of an 8.3 second Bickford time fuse to which is crimped a #8 commercial detonator.

c. The Filling is a solid (or liquid) chemical agent.

d. The Rifle Rod is a copper plated steel rod 15" long. One end is threaded to screw into the base disc; the other end is champfered to facilitate insertion into the barrel.

e. The Cartridge is a .30 cal. special blank cartridge employed in the rifle as a 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 piece, the forward movement of the grenade and the inertia of the striker cause the retaining wire to be sheared and the striker to explode the primer. The flash from the primer ignites the fuse, which, after 8.3 seconds, flashes the detonator. This in turn ruptures both thimble and grenade body, and disperses the filling.

13. GRENADE, RIFLE, SMOKE, WP (WHITE PHOSPHORUS) MK. I. -

Description

Type	8.3 sec. time fuse, exploding.
Weight (ready to fire)	25.2 oz.
Shape	Barrel, 3-3/8" x 2-1/8"
Surface	Smooth, with two annular corrugations around lower body.
Color	Blue-grey.

Safety Device	Safety-pin.
Igniter	Fuze, detonating, rifle grenade, M-9, with No. 8 commercial detonator.
Filling	White Phosphorus (solid) 10 oz.
Identification	Yellow letters "WP". " " "Smoke". One yellow band.
Characteristics of Cloud	Pure white, dense, slightly acid, non-letnal smoke of great obscuring power; burst is accompanied by shower of burning particles, which continue to burn until expended.
Time of Burning	2 minutes.
Diameter of Cloud	15 yards.
Tactical Uses	To screen local movements; to blind small definite targets; to inflict casualties; to set fire to readily inflammable objects. May be used alone or with gas.
Packing	All components packed separately as follows: Grenades with wooden closure plugs, per box,24; firing mechanisms complete, 12 each per can, 20 cans per box; rods, per box, 120; cartridges, per package, 20.
Directions for Use	Assembly. (a) Remove wooden closure plug. (b) Screw rifle rod into base disc. (c) Screw firing mechanism tightly into grenade. Do not use force. Do not jar or twist detonator. To Load. Insert rifle rod in rifle barrel. Load rifle with special blank cartridge and lock the piece. To Fire. Assume a kneeling position on the right knee. Place the butt of the piece on the ground against and to the right of the right knee. Hold the rifle with the left hand above the lower band. Pull safety-pin and unlock the piece. Grip the small of the stock with the right hand, placing the forefinger on the

trigger. Hold the rifle at the desired angle and fire. (Piece may be fired with the thumb on trigger, with the knuckles turned well under, so that upon recoil neither the bolt nor the cocking piece will strike the hand.)

Precautions — Handle with extreme care. The body must not be punctured or allowed to rust, as the filling spontaneously ignites upon contact with air. The detonator is especially sensitive to heat and shock. Improperly functioning or faulty grenades should be destroyed in accordance with Provisions of W.D. Cir. 13, 1923. Store in a cool place. "Do not keep over 18 months".

Special Precautions — W.D. Cir. 40, 1925, requires the following safe-guards against premature explosions of WP Rifle Grenades in peace time. (a) Only one man, the firer, will be in the firing bay when the live grenade is actually fired. (b) He will be protected in the front and flanks by being in a traversed trench, or by a sandbag screen not less than 20 inches thick or by a board fence or panel with overhead cover, and with ports or slots through which the muzzle of the rifle can be projected. (c) Each grenadier when firing live grenades will wear a steel helmet. (d) At the time of firing, the firer's head will be lowered so that the helmet will be below the level of the muzzle of the rifle.

14. GRENADE, RIFLE, LACRIMATORY, CNS (CHLORACETOPHENONE IN SOLUTION), MK. II. -

Description

Type — 8.3 second time fuse, exploding.

Weight	24.2 oz.
Shape	Barrel, 3-3/8" x 2-1/8".
Surface	Smooth, with two annular corrugations around lower body.
Color	Blue-grey.
Safety Device	Safety-pin.
Igniter	Fuze, detonating, rifle grenade, M-9, with #8 commercial detonator.
Filling	Chloracetophenone in solution. 9 oz.
Identification	Green letters "CNS". " " "Gas". Two green bands.
Characteristics of Cloud	White spray resembling a fog, which settles to the ground in about 30 seconds and vaporizes. The vapor is colorless and is carried by the wind. It is immediately irritating and incapacitating, causing copious lacrimation. Non-lethal except in extreme concentrations.
Persistency	From 30 to 60 minutes, according to the temperature and terrain.
Diameter of Cloud	10 yards.
Tactical Uses	To force masking, neutralize or harass. To clear shelters. An incapacitating agent against unprotected personnel.
Packing	Grenades and the fuzes, detonating, are packed separately. Grenades, per box, 24, each being shipped with a wooden closure plug; fuzes, detonating, per box, 384.
Directions for Use	Same as for Grenade, Rifle, Smoke, WP (See Par. 13).
Precautions	CNS grenades must not be carried by the safety rings. Handle with extreme care. The detonator is very sensitive to heat and shock. Store in a cool ventilated place.

15. GRENADE, RIFLE, SMOKE, FM (TITANIUM TETRACHLORIDE), MK. I. -

Description

Type	8.3 second time fuse, exploding.
Weight	24.2 oz.
Shape	Barrel, 3-3/8" x 2-1/8".
Surface	Smooth, with two annular corrugations around lower body.
Color	Blue-grey.
Safety Device	Safety-pin.
Igniter	Fuze, detonating, rifle grenade, M-9, with a #8 commercial detonator.
Filling	Titanium Tetrachloride (liquid), 9 oz.
Identification	Yellow letters "FM". " " "Smoke". One yellow band.
Characteristics of Cloud	Upon burst a dense white cloud of spray which hydrolyzes upon contact with the air, forming a white smoke which drifts with the wind. It is non-lethal but has a corrosive effect on metal.
Persistency	30 seconds.
Diameter of Cloud	15 yards.
Tactical Uses	May be used for screening. It is primarily used in training as a substitute for the WP grenade, due to the higher cost, and greater danger in the handling of the latter.
Packing	Grenades and the fuzes, detonating, are packed separately. Grenades, per box 24, each being shipped with a wooden closure plug; fuzes, detonating, per box 384.
Directions for Use	Same as for the Grenade, Rifle, Smoke, WP (See Par. 13).
Precautions	FM is not particularly dangerous, except to the eyes, therefore gas masks should be worn when handling leaky grenades. The detonating fuze is very sensitive to heat and shock. Therefore, care must be exercised in handling. Do not carry by the safety ring. Store in a cool ventilated place.

16. BURNING TYPE. - (See Plate II). This type consists of five parts: The body; the fuze; the filling; the rifle rod; and the cartridge.

a. The Body is identical in design with the burning type of hand grenade, except that a small steel base disc is soldered to the bottom and drilled to take the rifle rod. It is a barrel shaped container of thin drawn sheet steel, made in two cup like halves and welded. A row of eight small holes are punched around the upper body just under the shoulder for the emission of the gases, and these holes are normally covered by small squares of adhesive tape. The outer surface of the grenade is weather proofed by a coating of baked enamel. The Bushing is a flat steel nut welded to the body at its top to serve as a means of attachment for the thimble. The Thimble is a steel tube which is screwed into the bushing as an adapter for the firing mechanism assembly. It is tapped to receive the firing mechanism assembly.

b. The Fuze, igniting, rifle grenade, consists of an adapter, a firing mechanism and a time fuse match-head assembly, in one unit. The Adapter is a brass (or steel) device threaded on the outside on its lower end to fit the grenade thimble, and on its upper end to receive the firing mechanism. It is drilled longitudinally, the lower end being threaded on the inside to receive the time-fuse match-head assembly. The Firing Mechanism consists of a brass inertia-pellet Striker in a brass chamber. The striker is normally held off the primer by means of a shear wire of copper. A brass cover fits snugly over the striker chamber to exclude dirt. It is held in place by a safety-pin which passes thru striker, striker chamber, and cover, and constitutes the safety device. The fuse match-head assembly includes a 5-second Bickford fuse which terminates in a cylindrical shaped lead tube containing 1.5 gm. of meal powder.

c. The Filling is a solid mixture of smokeless powder and chemical agent occupying approximately three-quarters of the grenade. A layer of fast burning mixture is spread on top of the agent as a starter.

d. The Rifle Rod is a copper plated steel rod 15" long. One end is threaded to screw into the base disc, the other end is champfered 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 piece, the forward movement of the grenade and inertia of the striker cause the retaining wire to be sheared and the striker to explode the primer. The flash from the primer ignites the fuse, which, after 5 seconds, flashes the match-head. This in turn, ignites the layer of starter mixture. The pressure resulting from combustion of the agent forces the adhesive tape from the emission holes. The heat necessary to carry off the vapors is supplied by smokeless powder incorporated with the agent, in cases where chemical reaction of the agent alone does not generate heat.

17. GRENADE, RIFLE, LACRIMATORY, CN (CHLORACETOPHENONE), MK. II. -

Description	
Type	5 sec. time fuse, burning.
Weight	19.65 oz.
Shape	Barrel, 3-3/8" x 2-1/8".
Surface	Upper half, smooth; 8-5/32" holes punched around grenade under shoulder, and covered with adhesive tape squares; lower half, two annular corrugations 1/2" apart.
Color	Blue-grey.
Safety Device	Safety-pin.
Igniter	Shear-wire inertia-pellet mechanism and time fuse match-head assembly
Filling	100 grams CN Mixture (Chloracetophenone, Smokeless Powder, Magnesium Oxide).
Identification	Light green letters "CN". " " " "Gas". One light green band.
Characteristics of Cloud	Bluish-grey to colorless; immediately irritating and incapacitating, causing copious lacrimation; non-lethal (except in extreme concentration); has but little obscuring power.

Time of Burning	3-1/2 - 5 minutes
Diameter of Cloud	Variable; depends upon speed of wind.
Tactical Uses	To force masking; to harass; may be employed with smoke.
Packing	Shipped assembled. Grenades per box, 24; rifle rods per box, 120; cartridges per package, 20.
Directions for Use	Assembly. (a) Screw rifle rod into base disc. (b) Insert rifle rod into rifle muzzle. (c) Load rifle with special blank cartridge, and lock the piece.
	To fire. Assume a kneeling position with right knee on the ground. Place butt of rifle on the ground to the rignt of and against the knee, left hand grasping the piece above the lower band. Withdraw safety-pin and remove cover. Unlock the piece and grip the small of the stock with the right hand with fore-finger on the trigger. Hold rifle at desired angle and fire. (Piece may be fired with the thumb on the trigger, with the knuckles turned well under so that upon recoil neither the bolt nor cocking piece will strike the hand).
Precautions	Handle with extreme care. The body must not be punctured or allowed to rust. Faulty grenades should be destroyed in accordance with W.D. Cir. #13, 1923. Store in a cool ventilated place.

CHAPTER II

CANDLES

SECTION I

GENERAL

1. DEVELOPMENT OF SMOKE CANDLES. - The development of candles for the production of warfare smokes and gases grew out of a demand for a small smoke producer which could be carried and employed by individual troops for screening purposes. Moreover, a munition was desired that would produce an extensive persistent cloud or fog on the ground, to meet objections raised against smoke produced by detonation - as from shell, a great portion of which was blown high into the air. The several smoke candles which made their appearance during the war have been superseded by more efficient munitions, including lacrimatory and irritant smoke candles as well.

2. TACTICAL USES. - From a tactical point of view candles for screening purposes are munitions of opportunity. Their successful use is dependent somewhat upon favorable wind, weather and terrain conditions. Moreover, smoke tends to draw enemy fire. However, candles are a very efficient weapon when properly employed, and afford advantages not possessed by other means. Candles are particularly valuable 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 divert by drawing fire on unimportant or remote objects. Emplacements of smoke candles, fired electrically may be employed to cover withdrawals. Irritant smokes have advantages pos-

sessed by clouds produced by cylinders. Smoke candles are effectively used in civil disturbances.

SECTION II

SMOKE CANDLES

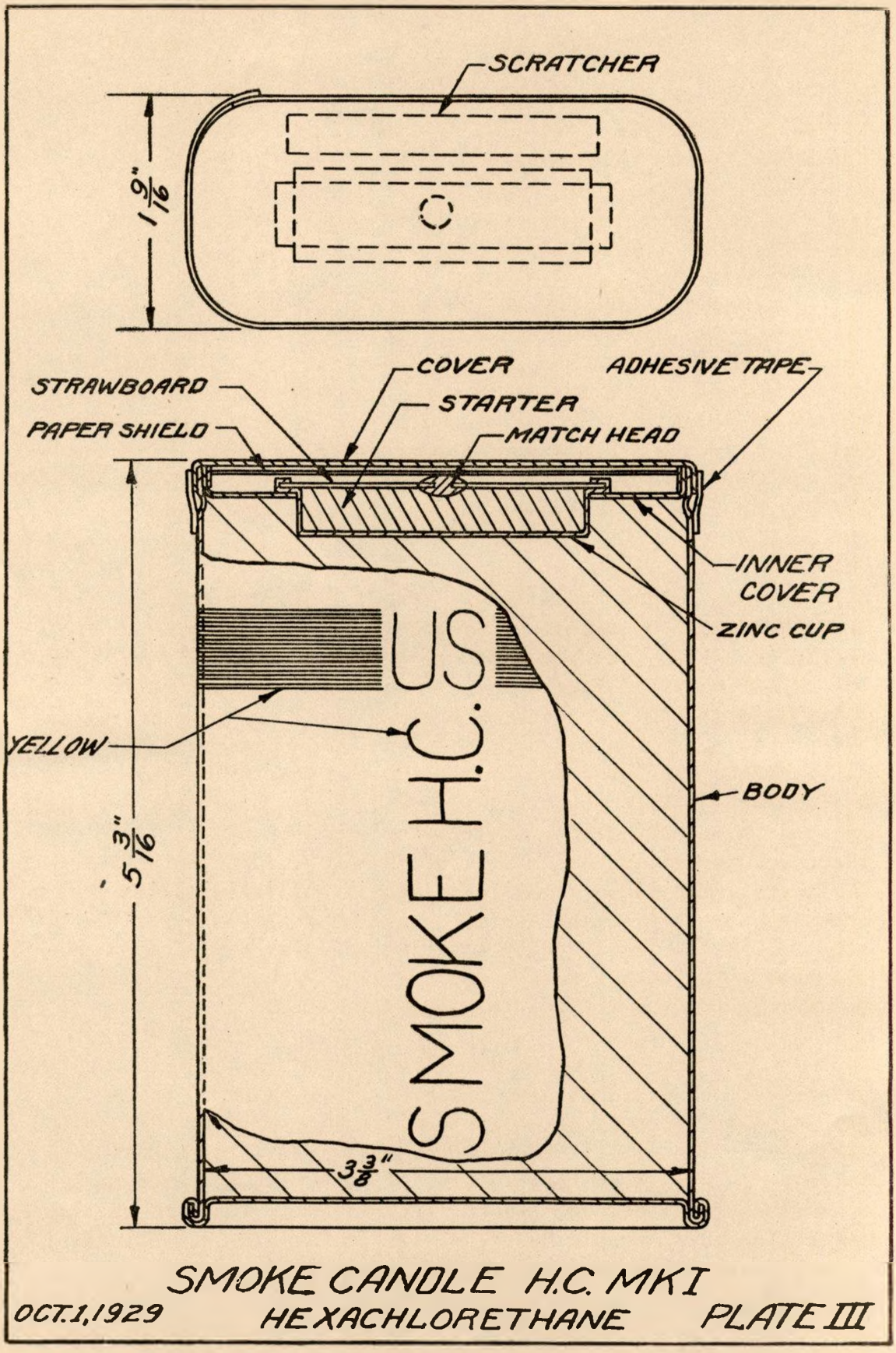
3. SMOKE CANDLES, SUBSTITUTE. - a. This candle, the first to make its appearance during the World War, is the original British S-type ground smoke candle. The present supply has been reconditioned for use; but the candle will become obsolete when the present supply is exhausted.

b. Description. The reconditioned candle consists of a metal cylinder 5-7/8" long and 3-3/8" in diameter. It contains a solid filling consisting essentially of potassium nitrate, sulphur, and hard pitch. The top of the can is sealed by a metal case cover with a 1 inch hole in the center through which the smoke escapes. A cardboard disc is cemented to the metal case cover. In the center of the disc is a match-head consisting of potassium chlorate, antimony trisulphide and dextrine. This match-head extends downward into the hole in the case cover as an ignition device for the filling. A phosphorus coated scratch-block is taped in place on the match-head disc. A metal cover snugly fits over the upper end of the candle, the joint being moisture-proofed by adhesive tape. The candle weighs 3 pounds. It is painted black.

c. Directions for Use. Remove adhesive tape from the cover of the candle, and remove cover. Place candle in a horizontal position on the ground with top downwind, remove the scratch-block, and draw it across the exposed match-head. The flash starts combustion of the filling, which burns from about 3 to 5 minutes.

d. Characteristics of Smoke. The candle produces a yellowish, non-lethal smoke of but moderate obscuring value. The smoke has an odor of burning pitch, and dissipates rather rapidly.

CHEMICAL WARFARE SCHOOL



SMOKE CANDLE H.C. MKI

OCT. 1, 1929 HEXACHLORETHANE PLATE III

e. Precautions. The match-head must be kept dry until ignited. Should the candle burst into flame at the orifice, the flame may be extinguished by striking the orifice quickly with any pliable object. Faulty or improperly functioning candles should be buried or thrown into water.

f. Uses. The reconditioned candle is intended only for experimental or training purposes.

4. SMOKE CANDLE, HC (HEXACHLORETHANE) MK. I. - (See Plate III). a. The HC Smoke Candle is the outgrowth of a line of experimentation which aimed at the improvement of the Berger Mixture employed by the French Army. This latter mixture was based on the chemical reaction between zinc and carbontetrachloride resulting in the formation of a zinc chloride smoke. The smoke was very satisfactory, but the mixture was not solid, was unstable, and otherwise objectionable. The HC candle met all objections.

b. Description. (See Plate III of Supplement). The HC Smoke Candle consists of a rectangular tin can, 1-1/2" x 3-5/16" x 5-1/4", with crimped joints and rounded corners. The can is entirely filled with a solid mixture weighing approximately 1.8 pounds. 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 match-head and serves as a cover for the starter mixture. A loose scratch-block is placed in the upper recess and is separated from the match-head 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 weather-proofed by a blue-grey coating of shell lacquer.

c. The Filling is a solidified mixture of three dry substances, hexachloretnane, powdered zinc, and zinc oxide. When kindled by the starter mixture these components react chemically with the evolution of considerable heat, to form zinc chloride. This, in turn, is forced by the heat into the air as a dense white smoke composed of very finely divided and highly refractive solid particles. The starter mixture is composed of potassium perchlorate, antimony and zinc.

d. Identification. The candle is marked by the letters "HC" in yellow, on both sides of the can, and one yellow band just below the cover.

e. Characteristics of Cloud. The HC Candle forms a dense, white, non-lethal smoke of great obscuring value. It burns at full volume from 2 to 3 minutes.

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

g. Packing. HC Candles are packed 25 to a box in a single layer, the box weighing about 60 lbs. with a displacement of .7 cu. ft.

h. Precautions. This candle is very stable as it contains no electrolytes to undergo dissociation and none of the components are liable to decompose on storage. Keep match-head dry until used. Bury faulty or improperly functioning candles or throw them into water.

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

5. DIRECTIONS FOR FIRING IN GROUPS ELECTRICALLY. - a. To fire the substitute smoke candle in groups by means of electrical squibs and exploder, proceed as follows: Locate line of emplacement and place candles along this line at such regular internals as will give a screen of the desired density. Remove adhesive tape and cover from the can. With a round, sharp, pointed stick of the approximate diameter of the squib, punch a hole in the cardboard disc. Remove cork from end of squib, and insert the open end into the hole, in such a manner that the flash from the squib when fired will ignite the starter mixture just below the match-head of the candle.

b. To fire the HC Smoke Candle electrically, after removing the cover withdraw the match-head and insert the open end of the squib into the match-head hole and tape securely in this

position. Squibs may be taped to the candle so that the flash will be communicated directly to the match-head instead of the starting mixture. With either of the preceding methods, best results are obtained by cutting off part of the squib paper at its open end, at a lengthwise angle of 30 degrees, thereby permitting the squib to be more securely taped in position.

c. In wiring connect the squib wires of not more than 20 candles in one electrical series, and connect the free ends of the first and last squibs to the terminals of the exploder (i.e., exploder, magneto, 30 cap. or exploder, electric, L.P.) using wire, firing, L.P., or its equivalent. Fire in the usual manner. For training purposes when exploders are not available, candle may be fired by connecting to an automobile battery.

d. 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 match-head to exclude moisture, but should not be forced into position as it might damage the squib or cut the wires. Do not connect up candles in multiple or parallel as the exploder will not function with certainty under such conditions. Under no circumstances use detonators or blasting caps in place of squibs.

NOTE: An electrical 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' or 6' wires; when ignited it produces a flash. An electrical detonator is a small copper tube containing an explosive charge of fulminate of mercury. It carries wires similar to those of a squib.

SECTION III

CANDLES, IRRITANT

6. CANDLE, SMOKE IRRITANT, DM (DIPHENYLAMINECHLORARSINE), MK. I. - (See Plate V). a. The irritant smoke candle is a com-

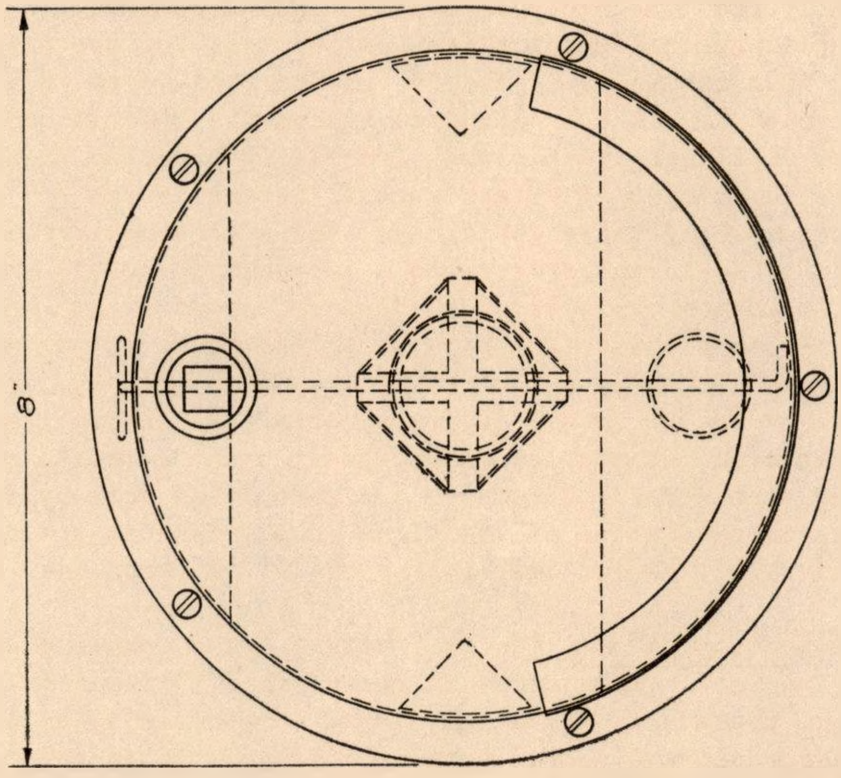
paratively recent development in cloud gas warfare. It differs fundamentally from the smoke candles already considered in that it is intended for harassing effect rather than for obscuring purposes. This candle, as a weapon, may be considered as a convenient substitute for the cylinder, within the limitations of its chemical filling. Vast clouds are easily produced which possess the advantages of extensiveness, pervasiveness and duration of action of cylinder gas clouds; but with a smaller expenditure of effort, and considerable increase in safety prior to firing, than the cylinder. 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 its use is dependent upon favorable wind and weather conditions. It shares a disadvantage with cylinders in that the concentration of the cloud is greatest at the point of emission, i.e., on our own lines where it is least desired.

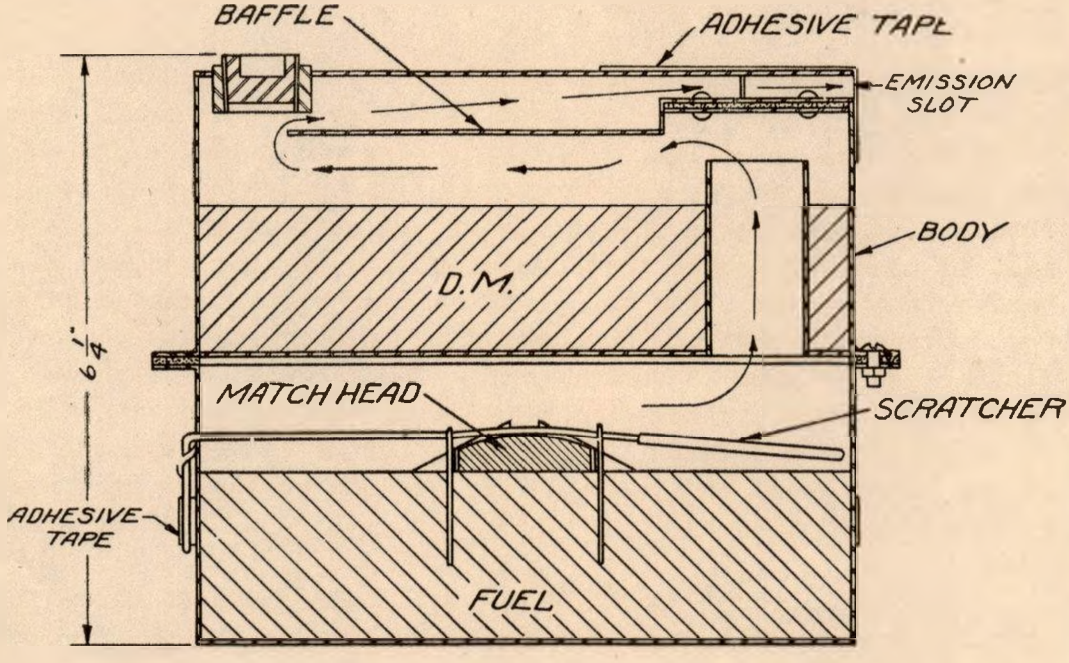
b. Description. The DM Irritant Smoke Candle consists of two cylindrical compartments of sheet steel 7" diameter by 2-7/8" high, placed one above the other, and bolted together (with asbestos packing) on an external flange. It is painted olive-grey.

The lower compartment contains a 3-1/4 pound cake of smokeless powder which is used as fuel to supply heat. Mounted on the cake is an ignition device consisting of a match-head and phosphorus-coated wire scratcher. The match-head 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 top of the anchor posts serve as guides for the scratcher wire. The coated portion of the wire normally lies to one side of the match-head. The uncoated portion extends outward thru a hole in the side of the compartment where it terminates in a loop. The loop is flattened against the side of the compartment and is held in place and protected by a wide adhesive tape covering.

A flue 1" in diameter and 2" 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





TOXIC SMOKE CANDLE (D.M.) 9LB. MK I
DIPHENYLAMINECHLORARSINE

OCT. 1, 1929

PLATE V

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 under normal conditions. It is therefore necessary to cause the agent to vaporize at a temperature lower than its normal boiling point. This is accomplished by passing the hot gases from the burning smokeless powder thru the flue into the upper compartment and across the surface of the DM as it is being heated. The solid DM is thus converted directly into a vapor and is carried above the baffle, and through the slot into the air where the vapor quickly condenses to form very minute solid particles, thus forming 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 firing mechanism. 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 outward quickly until it stops. A hissing sound indicates ignition has taken place. In case of failure on first trial, push wire back to 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 canary yellow cloud with a "smoky" odor, having considerable obscuring power, and having an immediate irritating action on unprotected personnel. The physiological effects are manifested in sneezing and coughing followed by vomiting and physical and mental depression. Altho rapidly incapacitating, the effects of DM are not fatal except under most extreme conditions. DM smoke has considerable corrosive action on metals, rusting iron and steel and tarnishing bronze and brass.

The candle burns for 2 minutes.

DM Smoke is a particulate cloud having a decided ability to penetrate a gas mask lacking adequate filters.

f. Packing. DM Toxic Smoke Candles are packed 12 to a box in double row, the box weighing 165 pounds, and having 5.8 cu. ft. displacement.

g. Precautions. Do not attempt to ignite candle or to enter cloud witnout adequate protection. Do not remove tape covering the starter wire, or straighten or pull the wire loop, until ready to use. When firing, gas exit must be pointed downwind, the operator being upwind. Faulty or improperly functioning candles should be buried at least 4 feet in the ground or 15 feet under water.

Under normal conditions DM Smoke Candles may be stored indefinitely without deterioration.

h. Tactical Uses. For harassing effect primarily, but having a screening effect also, DM is used to penetrate masks 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 formation of large irritating smoke clouds.

i. Identification. The DM Candle is marked in green with letters "DM", with one band, and with word "Gas".

SECTION IV

LACRIMATORY CANDLES

7. CANDLES, LACRIMATORY, CN (CHLORACETOPHENONE) MK. I. - a. Description. (See Plate IV). This candle is a tear producing munition. It consists of a cylindrical container of tin 4 inches in diameter and 2-3/4" high. A disc of tin plate is crimped in place about 1/8" below the upper edge of the container forming a depressed case cover. A 7/8" hole is punched in the center as an outlet for the gases, and a 1/4" hole to one side for the match-head. A small scratch-block is taped in

place opposite the match-head. The candle is provided with a removable cover sealed with adhesive tape. The candle weighs 1.3 pounds and is painted blue-grey.

b. The Filling is a solidified mixture of chloracetophenone, smokeless powder and magnesium oxide, weighing 12 oz. 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 nitro-cellulose and acetone.

c. Identification. This candle is identified by means of the letters "CN" and "Lac.", and a 1/2" band around the circumference of the candle, all in green.

d. Directions for Use. Remove sealing tape and cover. Remove scratch-block. Place candle on the ground and draw the coated side of the scratch-block across the match-head. Lacrimator is given off in three seconds.

The CN Candle may be fired in groups, electrically, as described under Smoke Candles, Substitute. In this case the electrical squib is taped to the candle in such a manner that the open end lies against the match-head.

Should the candle burst into flame at the mouth upon ignition, extinguish the flame by striking the mouth lightly and quickly with any light pliable object.

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 immediately lacrimatory effect on unprotected personnel. It is incapacitating, but is non-toxic except in extreme concentrations. The condensed 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 cu. ft.

g. Precautions. The match-head 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 under 2-1/2 feet of ground, or in 10 feet of water.

h. Tactical Uses. The CN Candle is an harassing agent. It is used to advantage against mobs; and is a very effective irritant as a substitute for lethal gases and irritant smokes in connection with chemical warfare training.

SECTION V

UNIVERSAL CANDLES

8. GENERAL. - a. Universal candles are designed for use either as a grenade or as a candle. When thrown by hand the maximum range is 35 yards. Their principal application is to clear shelters, to screen, or to demoralize. Other than for screening, their principal use will likely be in connection with civil disturbances. They are suitable for operating from fast moving vehicles such as armored cars or tanks. When so used they may be either thrown by hand or fired by means of improvised dropping tubes.

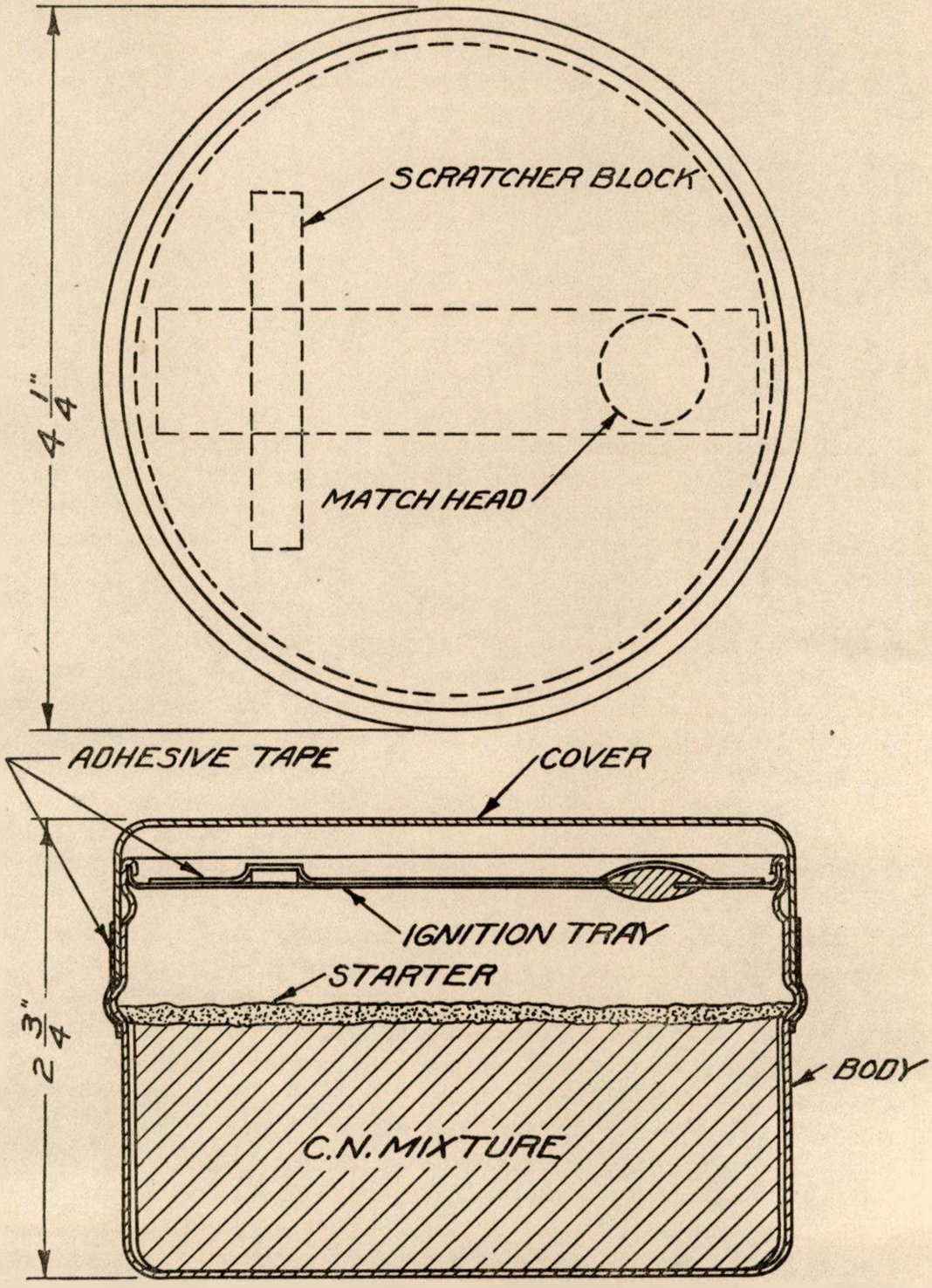
b. Identification Markings. - Universal candles in common with all chemical munitions are identified in the field by three distinct systems of markings stenciled or painted over the blue-grey water-proofing enamel of each candle, as follows:

(1) By symbol designation, in yellow or light green letters on upper half of body, denoting specific chemical agents, e.g., CN in light green (chloracetophenone); HC (hexachloroethane) in yellow.

(2) By a colored band around central portion, denoting type of agent, e.g., green designating gas; yellow designating smoke.

(3) By the words gas or smoke stenciled in light green or yellow letters respectively, on the lower part of the candle above the lot number.

CHEMICAL WARFARE SCHOOL



CANDLE, LACHRYMATORY (C.N.) MK I
(CHLORACETOPHENONE)

OCT. 1, 1929

PLATE IV

c. Universal candles, less the fuzes, igniting, are manufactured, stored and issued by the Chemical Warfare Service. Fuzes are manufactured by the Ordnance Department. Candles are packed with fuzes assembled thereto, 25 in a box.

9. CANDLE, LACRIMATORY, CN, FAST M-I. - a. Description. - This candle is a tear producing munition. It 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 tin discs 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 in which is inserted and soldered an adapter. This is externally threaded to take the ingiting fuze. The container wall has three rows of 6 small holes, while the top has 6 small holes, all of which are 5/32 inch diameter and covered by squares of adhesive tape 1/4" x 1/4".

(2) The fuze, igniting, 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. The striker is sharply indented to form a firing pin. 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 thru which a split-pin of annealed steel passes, securing it to the body. This pin forms the safety device for the firing mechanism. The fuse assembly consists of a primer of fulminate of mercury and a 2 second delay powder train in a lightly sealed lead container projecting downward from the fuze body.

(3) The filling consists of about 290 grams of chemical agent containing - chloracetophenone 28.0% (about 4 ounces), smokeless powder 69.4% and magnesium oxide 2.6%. A layer of fast burning mixture is spread on top of the agent as a starter. This consists of about 5 grams of mixture containing Army Black Powder, Grade A No. 7, 60% Binder solution of celluloid and acetone 40%.

(4) The total weight of the candle, lacrimatory, CN, fast M-I. filled is 16 ounces.

b. Operation. - (1) Throwing by hand: When the safety pin has been pulled, the lever held in the palm of the hand, acts as a detent to prevent contact between the striker and the primer. As the candle leaves the hand, the striker actuated by its spring throws the lever clear and strikes the primer. The primer flashes the fuse which in 2 seconds time ignites the starting mixture. The pressure resulting from the combustion of the agent forces the adhesive tape from the emission holes, permitting the vaporized agent to escape. The heat necessary to carry off the vapors is supplied by smokeless powder incorporated with the agent in cases where the chemical reaction of the agent alone does not generate sufficient heat.

(2) To ignite as a candle: Place candle on ground, hold 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 b. (1) above.

(3) Dispersion of agent: The vaporized agent is initially emitted within 3 seconds following release of the lever. An even evolution of the vapor continues for a period of 15 to 40 seconds thereafter.

CHAPTER III

CHEMICAL CYLINDERS

SECTION I

GENERAL

1. DEFINITION. - The chemical cylinder is the name given generally to various tanks for the handling and transportation of liquefied gas; but as here used it applies specifically to a portable container used as a weapon 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 significant means employed during the World War for the projection of warfare gases. 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, searching depressions, dugouts and shelters, and often penetrating enemy territory to considerable depth.

For nearly a year after its inception in April 1915, cloud gas was the most formidable form of chemical attack, but it gradually became less effective as the efficiency of respirators increased, and as collective experience and vigilance nullified the element of surprise.

The first cylinders used were approximately 3'9" long and weighed about 180 pounds when filled. Groups of four were installed in pits dug under front line parapets, in the firing step, or bottom of the trench, along an extended front. All four cylinders were connected by a rubber hose 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 cloud being liberated 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, and in addition to this was the labor of installation. Until fired, these installations were a source of danger to troops through accidental discharge by enemy shell fire.

Altho relegated to a position of minor importance during the last few years of the war, cylinders were effectively employed by the British in the latter part of 1918. In these instances the disadvantages indicated above were overcome 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 active warfare gases 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 search out and penetrate inferior, weakened, 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 CYLINDER. - a. Cylinders are used with non-persistent 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). It is evident that

cylinders reach their greatest utility in stabilized warfare, or in the initial phases of attack. Open warfare and rapid movement will undoubtedly limit the use of cylinders, but the possibility of this method of attack cannot be disregarded.

b. Flat or gently sloping terrain is best suited to cloud gas attack. Gullies and intersecting valleys act as flues and may give a direction to the travel of a cloud divergent from that of the prevailing wind. Clumps of trees or woods tend to break up a cloud, to cause it to rise or be deflected; but woods tend to increase the persistency of clouds by retarding travel. A low velocity wind (i.e., 3 or 4 miles per hour) will blow a cloud of high concentration intact up a gentle slope.

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

Altho a weapon of opportunity, the potentiality of cloud gas warfare is still sufficiently great to warrant consideration. Cylinders will therefore continue to be an important chemical weapon.

SECTION II

THE PORTABLE CHEMICAL CYLINDER

6. DESCRIPTION. - a. (See Plate VI). The Cylinder, Chemical Portable, M-I, Type 1, consists of four parts as follows -

the cylinder
the Y-valve and eduction tube
the carrier
the nozzle

b. The Cylinder is a thin drawn steel tank 8" in di-

ameter and 18" long. The top is spun over, and is drilled to receive a circular collar with a hexagonal top. This collar is pressed into place and welded to the outside of the cylinder; and it is tapped to receive the Y-valve and eduction tube. The bottom of the present cylinder is constructed by pressing a flanged bottom into the end of the cylinder and closing the coincidental edges by a gas tight weld. The cylinder normally stands on end.

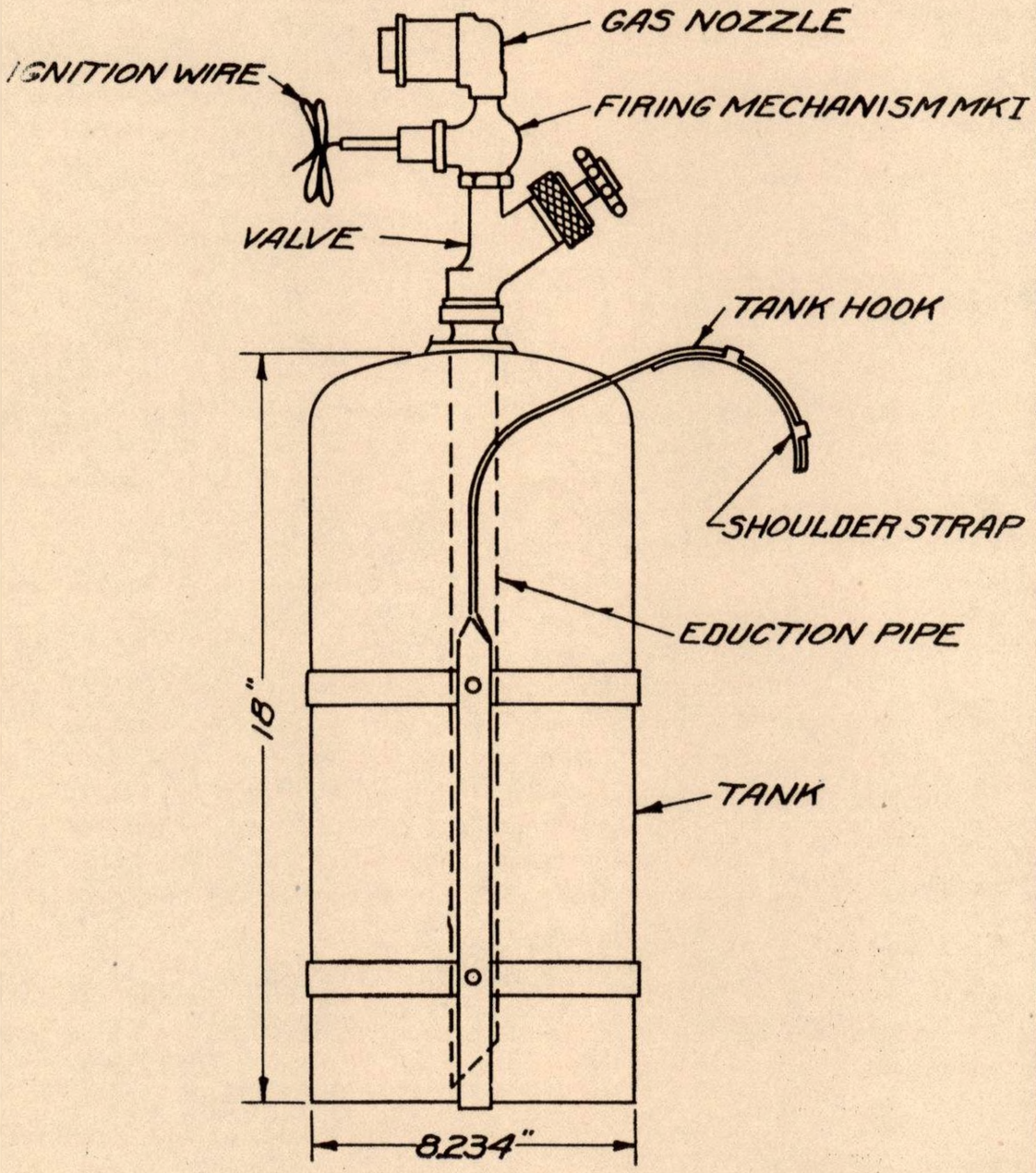
c. The discharge of the cylinder is accomplished by means of a Y-valve and eduction tube. The former is a brass valve with a monel metal stem, set at an angle of 50 degrees to the axis of the eduction tube and outlet pipe. The outlet pipe is a part of the Y-valve, and is normally closed by a screw cap. The lower end of the valve carries a pipe-thread by which it is attached to the collar of the cylinder, and is tapped to receive the eduction tube. The eduction tube is a small iron pipe which is screwed into the valve and terminates close to the bottom of the cylinder. The end is cut off at 45 degrees to insure positive discharge. This tube permits the discharge of the cylinder when in upright position.

d. The Carrier is provided to increase the portability of the cylinder. It consists of two band iron hooks formed to fit a man's shoulders, attached to the cylinder by two bands. 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 when on the shoulders, and which slide back out of the way when the hooks are forced into the ground.

The cylinder is painted blue-grey. Loaded it weighs 48 pounds, when filled with 30 pounds of chemical agent. The efficiency of the cylinder averages about 60 percent, as the weight of the agents vary from about 25 pounds to 30 pounds.

e. The Nozzle. (1) The portable chemical cylinder is fitted with a special nozzle which attaches to the threaded end of the outlet tube of the Y-valve by means of a reducing fitting. The nozzle is designed to minimize the loud hissing noise which is characteristic of escaping gas under pressure, and which is fatal to the necessary surprise in attack. Incidentally, the nozzle permits the rapid release of gas with less liability toward freezing, (i.e., constriction of the nozzle by ice formation, due to the cooling effect of vaporization) than would

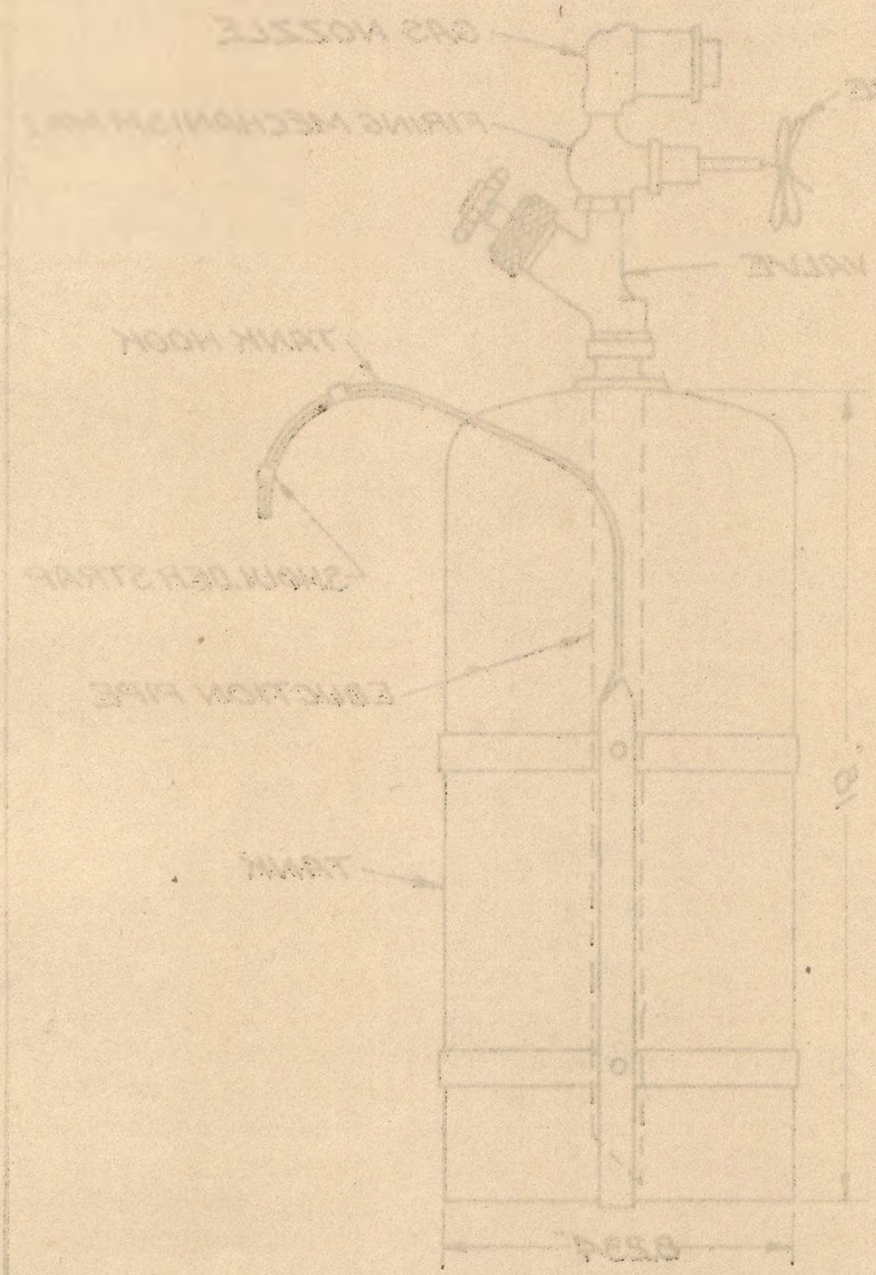
CHEMICAL WARFARE SCHOOL



CYLINDER, CHEMICAL PORTABLE MARK I

OCT. 1, 1929

PLATE VI



CYLINDER, CHEMICAL PORTABLE
MARK I

otherwise be possible. A more uniform concentration of gas is obtained throughout the cloud due to the fan-shaped spray.

(2) The nozzle is of brass. 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 a sheath of several layers of fine mesh steel gauze held in place by a circular retainer. The inlet is opposite the slot grid. A cap-cover carries a projection which extends nearly to the bottom of the chamber, this projection 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 which it carries, registers with the slot grid, being held in place by a spring catch.

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

7. OPERATION. - a. The cylinder operates on a principle similar to that of the siphon, or seltzer bottle. At the time of filling, liquefied gas is drawn from bulk containers and run into the cylinders, and adequate "void" or empty space being left above the liquid. The Y-valve, with outlet tube, is screwed into place and closed.

b. The high vapor pressure of the liquefied gas within the cylinder(i.e., the inherent tendency of the liquid to convert itself into a gas) results in the building up of considerable pressure in the void above the liquid. The amount of pressure at any moment depends upon the particular gas or gases enclosed, the volume of the void and the temperature and pressure of the outside atmosphere. The accumulated pressure is exerted against the surface of the liquid as well as against the cylinder walls. The source of this pressure is readily understood when it is noted that one pound of liquid chlorine at atmospheric pressure and 68 degrees Fahrenheit, when converted into a gas at the same pressure and temperature, occupies 5.33 cubic feet of space - 470 times the original liquid volume.

c. When the cap is removed from the Y-valve outlet and the valve is opened, the pressure above the liquid forces the liquid downward; and it seeks outlet thru the eduction tube and valve outlet. Upon being projected into the atmosphere, where

the pressure is greatly diminished as compared with that within the cylinder, the agent can no longer maintain its liquid state and immediately gassifies. The tremendous expansion 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, unless provided for, may result in constriction and stoppage of the flow.

d. From the foregoing considerations, it will be evident that, from the view-point of operation, cylinders function best on warm days, or when artifically warmed; and conversely, function poorly or may fail to function, in excessive cold.

8. FIRING CYLINDERS BY ELECTRICAL MEANS. - Several devices for firing cylinders by electrical means have been developed. One type employs an electrical detonator which is intended, upon explosion, to blow off the face of a specially designed composition valve, thereby permitting the unobstructed release of the agent. The other, a more recent development, is an electrically controlled brass check valve interposed between cylinder and nozzle. In this device, the check valve is normally held against its seat, (and against the pressure of the cylinder), by means of a fusible plug placed behind the end of the valve-stem. The valve-stem guide is surrounded by a compartment containing a fuel-mixture of powder and an electrical squib. When fired by an exploder, the squib ignites the powder mixture, which fuses the plug when sufficient heat has been developed. The gas pressure within the cylinder then forces the check from its seat, thereby permitting escape of the agent.

Neither of the devices above described have been carried beyond a preliminary stage of development and have not as yet received official approval.

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

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

It has the highest efficiency of any gas weapon at present authorized (i.e., ratio of the weight of gas contained,

to weight of filled containers).

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

It avoids much of the noise and work of installation that, with the older cylinders, gave warning of an attack.

It avoids the danger to our own troops of loaded cylinders remaining some time in the front line, subject to accidental discharge by enemy gun 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

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

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

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

It must have a high vapor pressure or low boiling point and be readily convertible into a true gas at ordinary temperatures. An agent deficient only in this respect may be mixed with CO_2 or other gas of high vapor pressure to supply the deficiency; but such expellants dilute toxic concentrations to the extent used.

It must be obtainable in large quantity under war conditions.

11. AGENTS USED IN CYLINDERS. - Non-persistent agents only are used in cylinders. Altho 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 necessary to expel the mixture. With 8% by weight of CO_2, this phosgene mixture produces a positive uniform discharge over a wide range of temperatures, in a minimum of time.

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 liquefied CO_2 as an expellant, and the use of a special nozzle. These adaptions are not officially authorized and are employed only for experimental or instructional purposes.

a. The CN lacrimatory filling is an example. In this case 2-1/4 lbs. of solid CN are dissolved in 10 lbs. of benzene and 10 lbs. of carbon tetrachloride as solvents. About 1-1/2 lbs. of liquid CO_2 is added, which gives a pressure of about 150 pounds per square inch. Great care must be exercised not to exceed this pressure on account of the danger of bursting the cylinder.

b. The CN nozzle used with this mixture consists essentially of an outer shell into which is screwed a spiral core. In passing thru this nozzle, the stream of liquid is broken up into a fine spray and is forced vertically into the air as a very finely divided mist. On evaporation of the solvents the CN is left in the air in suspension, but it gradually settles to the ground.

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 to the direction and velocity of the wind. Wind limits, including map diagrams, are discussed in Book IV, Chapter II.

SECTION IV

BULK CONTAINERS

14. GENERAL. - Military necessity, economy and safety require the storage, or shipment to distant points, of chemical agents in bulk, to be transferred into smaller containers or munitions for use in the field. As an example, most of the mustard gas manufactured in the U.S.A. during the World War was shipped to France in ton containers, reloaded into French shell, and issued to the French and American Armies. A knowledge of the construction and operation of these containers, and of the principles and practice of transferring bulk agents are essential to all who may be called upon to do such work.

Such containers are of various sizes, shapes and composition. Those designed for the shipment of chemical agents must conform to the regulations laid down by the Interstate Commerce Commission. Two of these containers - the 150 pound cylinder (which is designed for shipment of certain war gases), and the one (1) ton container (used for storage of certain war gases) are described below.

15. THE 150 POUND CYLINDER. - The 150 pound cylinder consists of the following parts:

the cylinder
service valve
transit and discharge caps
transit cover.

a. Description. (1) The cylinder is a drawn steel tube 11-1/8" in diameter by 52-1/2" long, having a slightly concave base and a spun shoulder and neck. It weighs 185 pounds empty, holds 150 pounds of agent, and has a displacement of 3.8 cubic feet. The neck is tapped to receive a service valve,and threaded externally to receive the transit or discharge caps. There is

no eduction or siphon tube.

(2) The service valve is a specially designed bronze valve with a monel metal stem seating against bronze. It is packed with asbestos and graphite. A set screw thru the packing nut permits the locking of the stem while in transit.

(3) The transit cap is a pressed bronze cup which screws against a lead gasket over the service valve. It protects the valve and precludes the escape of gas while in transit.

(4) The discharge cap is a cast bronze cover which screws into the place of the transit cover when the latter has been removed. It is furnished with a bronze stem or spindle which passes thru a packing gland in the top of the cap. This carries a socket which engages the stem of the service valve, and is the means by which the latter is opened. The agent escapes thru a port in the side wall of the cap. The port carries an external thread.

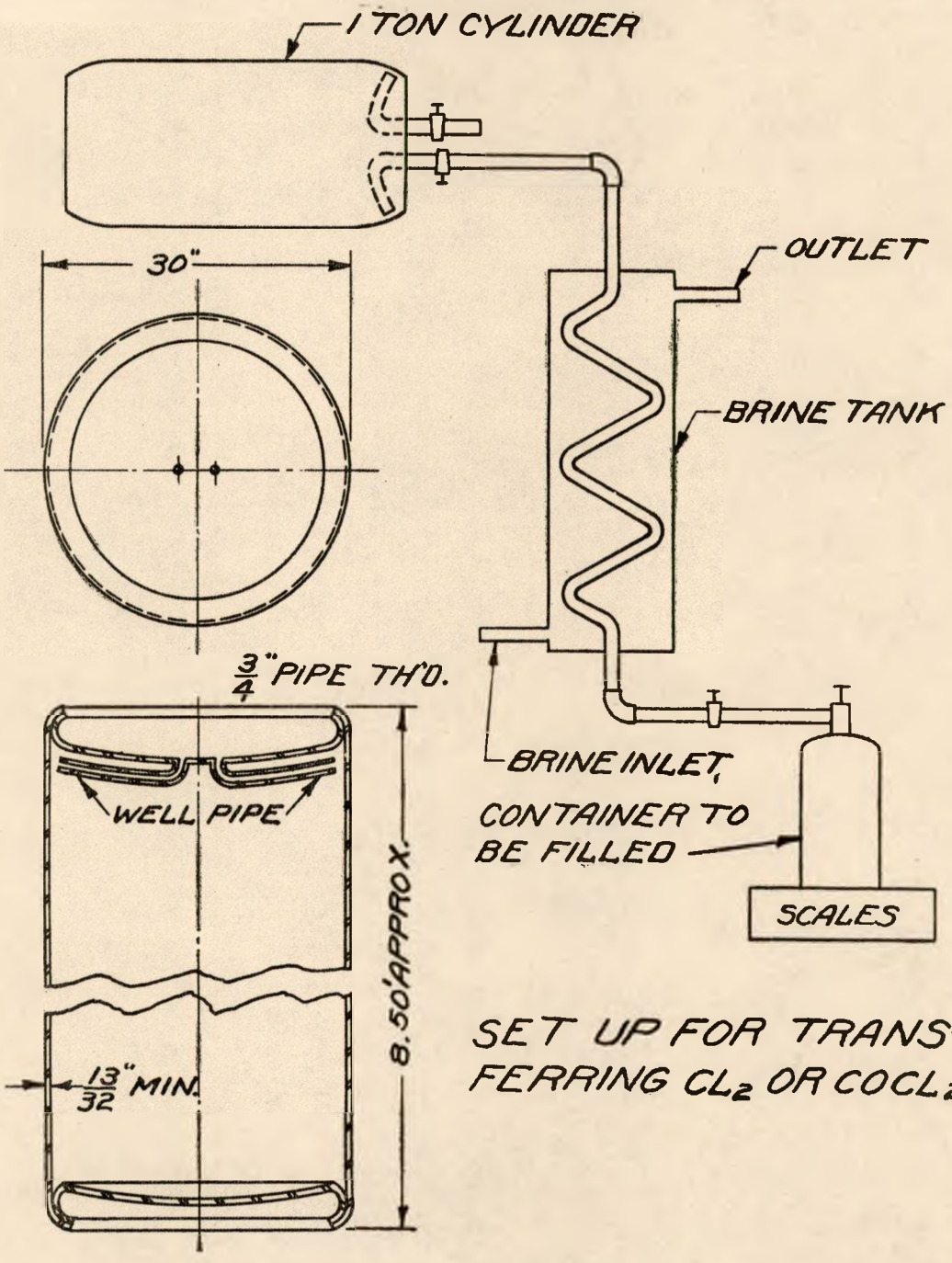
(5) The transit cover is a steel sleeve which fits snugly over the end of the cylinder to protect the valve and transit cap in shipment.

b. Removal of Agent from Cylinder. When the cylinder is filled, a "void" or empty space is always left above the liquid to provide against rupture by the expansion of the liquid content when the cylinder becomes heated. The vaporization of the liquefied gas within the cylinder builds up a gas-pressure in this void, which is later utilized to expel the liquid.

If it is desired to remove the agent in liquid form, the cylinder and contents should first be cooled by refrigeration or improvised means in order to reduce the internal pressure and to bring about conditions more favorable to the maintenance of gas in the liquid form. The cylinder is then placed on its side and the valve is cautiously opened. The liquid may then be conducted away to other containers thru any hose or piping not affected chemically by the agent.

In the case of true gases which have been liquefied, the agent may only be conducted away thru artificially cooled pipes if it is desired to maintain the liquid state.

CHEMICAL WARFARE SCHOOL



SET UP FOR TRANSFERRING CL_2 OR $COCL_2$

CYLINDER 1 TON

OCT. 1, 1929

PLATE VII

To release the agent as a gas it is only necessary to stand the cylinder up on its base, and open the valve.

It should be remembered that the rapid release of liquefied gases into the atmosphere is accompanied by a considerable cooling effect; and that clogging of the valve may result from the frost and ice formed thereon.

c. The 150 pound cylinder is authorized to be used for the shipment of the following toxics: Chlorpicrin, Mustard Gas, Chlorpicrin - Stannic Chloride Mixture, Phosgene, Phosgene - Chlorpicrin Mixtures.

NOTE: Chlorine, Bromine compounds, NO_2 and Ammonia, should not be used in these cylinders because of the excessive corrosion of the valves due to their presence.

16. THE ONE TON CONTAINERS. - (See Plate VII). The one ton containers consist of the following parts: the cylinder, two well pipes, and two valves.

a. Description. (1) The ton container is an all-welded steel cylinder 30" in diameter and 80" long. It is made of 3/8" plate, with 3/4" ends. The ends are flanged and set in; the coincidental edges of flanges and cylinder being welded and spun-in to form a round shoulder. The valve head is concave, and carries two valves 4" apart, in the center. The opposite head is convex.

(2) The well pipes are two pipes within the cylinder which originate at the valve orifices and extend in diametrically opposite directions to within a short distance of the cylinder walls. They lie in the same plane, and follow the contour of the valve head. These well pipes serve either as vent, or eduction tubes.

(3) The valves are of brass with monel metal stems and brass seats. They have a side outlet with an external thread, which is normally closed by a brass cap. The valve is provided with a hand wheel to facilitate opening.

b. The container has a capacity of 26.67 cubic feet, a displacement of 44.44 cubic feet, and when empty weighs 1350 pounds. It is tested to 500 pounds pressure per square inch.

c. Although initially designed for the shipment of chlorine and phosgene, it does not meet the requirements of Interstate Commerce Regulations and is now used for storage of the following gases in quantities as shown:

Chlorpicrin,	not	to	exceed	2000	pounds
Mustard gas	"	"	"	1800	"
Chlorine	"	"	"	1800	"
Phosgene	"	"	"	1650	"

17. CHANGING VALVES ON TON CONTAINERS. - a. Valves on ton containers occasionally become leaky or otherwise defective through electrolytic corrosion and it becomes necessary to change them. To change valves with safety and with a minimum loss of agent requires a certain understanding of the physical properties of liquefied gases and of a procedure based on experience.

b. If the air temperature is high, the pressure within a closed container of liquid chlorine, for example, will be considerable. At 90 degrees Fahrenheit it amounts to about 153 pounds per square inch; at 50 degrees F., 72 pounds per square inch, and at 32 degrees F., 50 pounds per square inch. Containers of true gases should therefore be cooled as far as practicable before attempting to change a valve, in order to reduce the pressure to a reasonable point. This may be done by packing in ice and salt; or by wrapping in burlap or blankets (for a number of hours), which have been kept moist. When cooled, proceed as follows:

(1) Place the container in such a position that the valve to be changed is vertically above the other valve. In this position the well pipe of the valve to be changed will project above the liquid level in the tank into the void.

(2) Have a new valve ready at hand and partly opened, in order to reduce the pressure when it is screwed into place.

(3) "Break" the joint of the old valve sufficiently with a wrench so that it can be unscrewed by hand.

(4) Open ("crack") the valve to be changed to vent the pressure. Quickly unscrew it, insert the new valve into its

seat, and quickly screw it into place; then close the new valve and screw it down with a wrench.

c. If it is impossible materially to reduce the pressure, the valve may be changed by using sufficient force to hold it into the opening until it can be screwed into place, as follows:

(1) All preparations having been made, the valve to be changed is loosened until it can be unscrewed by hand. Three men protected with gloves and gas masks line up, one directly behind the other. The man nearest the container holds the partly opened new valve in one hand, and completes the unscrewing of the old valve. With the hand wheel of the new valve held in the palm of his hand against his leg, just above the knee, he, with the assistance of the men behind, forces the valve into its seat, and screws it tightly into place.

d. Precautions. (1) Never attempt to change valves until everything is in complete readiness. Gas masks must be worn. Gloves must also be worn, particularly in the case of chlorine, to prevent freezing the hands. A cylinder of ammonia gas to neutralize the chlorine in case of accidental discharge, is advisable. Always stand to the windward, and in case of accident move to the windward.

(2) Phosgene valves may be changed with little or no trouble at ordinary or low temperatures. It is not necessary to first cool the containers, but this may be done to advantage, if convenient.

(3) Valves may be changed on containers of mustard gas and chlorpicrin without trouble, since their vapor pressure is very low and little internal pressure is generated. However, protective gloves and clothing as well as the mask must be worn when working with mustard gas.

18. TRANSFERRING BULK CHEMICAL AGENTS. - (See Plate VII). a. If a large number of portable cylinders or other munitions are to be filled from ton containers, a refrigeration plant should be devised, to reduce the pressure to safe workable limits.

b. The filling chapel has been devised for this pur-

pose. It consists of a heavy frame structure 12 or 14 feet high, with a cradle for the ton containers on a platform six feet above the ground. An 8" I-beam with a carrier and chain hand-hoist is used to place the containers in the cradle. Below the container is a small single coil refrigeration tank, with cracked ice and salt packed around the coil. A vent pipe is connected with the vent valve of the container and run down to a master shell (i.e., a measuring container) which is placed at an elevation that will permit the cylinder to be filled immediately below a three-way control valve, permit the emptying of the same, and the filling of the cylinder. The gas line is connected to the lower valve of the ton container. The vent valve must be vertically above the outlet or lower valve. If a gas similar to mustard or chlorpicrin is being handled, it is not necessary to run it thru the refrigeration coil but thru the by-pass direct to the master shell.

A light frame housing is built over the entire frame, and an exhaust fan with about 50 feet of 14" galvanized sheet iron pipe is employed to draw escaping gas away from the men engaged in operating the plant.

c. If only a small number of cylinders are to be filled, it may be done in the cool part of the day or night, by running the liquefied gas directly into the cylinders which have previously been placed upon a scale to measure the filling content. In the case of the more volatile gases, every reasonable precaution should be taken to cool the gas, and to protect those at work. The operation should be done at a sufficient distance from any habitation to insure safety to the unprotected.

d. Ammonia gas should be kept at hand for reasons above stated. If breathed in small quantities ammonia will give relief from effects caused by breathing chlorine or phosgene.

e. The Army gas mask does <u>not</u> afford protection against <u>ammonia gas.</u>

SECTION V

FLAME THROWERS

19. 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 successful, but they disappeared as soon as their limitations were learned.

Several types were recognized, i.e., portable and large. Both consisted essentially of two tanks, one containing nitrogen under great pressure, the other filled with a rapidly burning 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 thru the nozzle, being ignited as it was projected into the air. The portable flame thrower had a range of 14 to 17 meters but 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 arising 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. Altho some casualties were caused among green or isolated troops, the chief effect was demoralization.

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.

CHAPTER IV

LIVENS PROJECTORS

SECTION I

GENERAL

1. INTRODUCTION. - a. The Livens projector is a crude form of mortar designed to throw large quantities of chemical agents to produce high concentrations on distant targets. It was designed by Captain Livens of the British Salvage Service, who sought a means to utilize large numbers of gas-filled cylinders which were on hand. Captain Livens' original idea was to equip the cylinder with a bursting device, and to project it from a steel tube by means of a powder charge. After several unsuccessful attempts the use of cylinders was abandoned, and a steel drum or shell was substituted. With further improvements in the barrel and charge box, the projector, as it came to be called, evolved into a very efficient weapon. It was continuously and successfully employed by all belligerents during the last year of the World War. The present weapon is essentially similar in design and construction to the war projector.

b. Projectors are installed in the ground and fired electrically in batteries of 25, any number of batteries being fired together. 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 by the amount 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, as on reverse slopes, or in ravines or depressions.

c. Efficiency. A battery of projectors fires but one shell per projector per installation, but after firing the projectors may be reinstalled and fired. The filled shell weighs approximately 63 lbs., when filled with 30 lbs. of agent - an efficiency of 47%. This factor permits the more rapid delivery of agent on a target in higher concentration and with greater surprise than is obtainable by any other weapon, providing secrecy of installation is obtained.

d. Mobility. The projector is a weapon of limited mobility. It requires the transportation of about 225 lbs. of material for each individual projector installed; but the component parts are capable of being carried considerable distances by hand. As projector attacks are always in the nature of special operations, the material is transported by truck as far forward as the tactical situation or cover permits; beyond this point it must be carried by hand.

e. Dispersion. For ranges between 1000 and 1450 yards approximately 96% of all shots fired will fall within an area 225 yards front and 150 yards in depth (approximately 3-1/2 squares); while 67% will fall within an area 150 yards front by 100 yards depth (approximately 1-1/2 squares) - when the entire battery is sighted on a single aiming point. The weapon is not designed for great accuracy nor is that essential.

3. VALUE AS A WEAPON. - a. By means of Livens projectors, chemical agents may be delivered in great quantity 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 even an extensive target, in concentrations so great as to search out the slightest defects in the condition or adjustment of protective apparatus. After producing these initial results, the cloud is carried bodily by the wind as a pervading blanket, seeking every depression and penetrating territory to consider-

able depth until diluted below effective concentration. In this respect the projector is the most efficient chemical weapon known for non-persistent agents.

b. The highest state of protective training and discipline is necessary to successfully meet a projector attack. The concentrations easily reached are such as to require instantaneous and perfect adjustment of the gas mask before a single breath is taken.

c. As compared with the cylinder, the projector is less dependent upon favorable wind, weather or terrain conditions. It produces a cloud of greater concentration and with greater surprise on the target; and is not nearly 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 releases, always on condition that information of the installation does not reach the enemy.

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

SECTION II

DESCRIPTION

5. THE COMPONENT PARTS. - (See Plate XI). The component parts of the Livens projector include:

the projector
the shell
the propelling charge
firing accessories

6. THE PROJECTORS. - a. The projector complete consists of the barrel, muzzle cover and the base plate. A support for the barrel is used with the semi-surface emplacement.

b. The Barrel (M-I) is a smooth bore tube, approximately 8" inside diameter, made of 3/8" steel, open at one end, rounded and spun over at the other. It is 2'9" long and weighs 105 pounds.

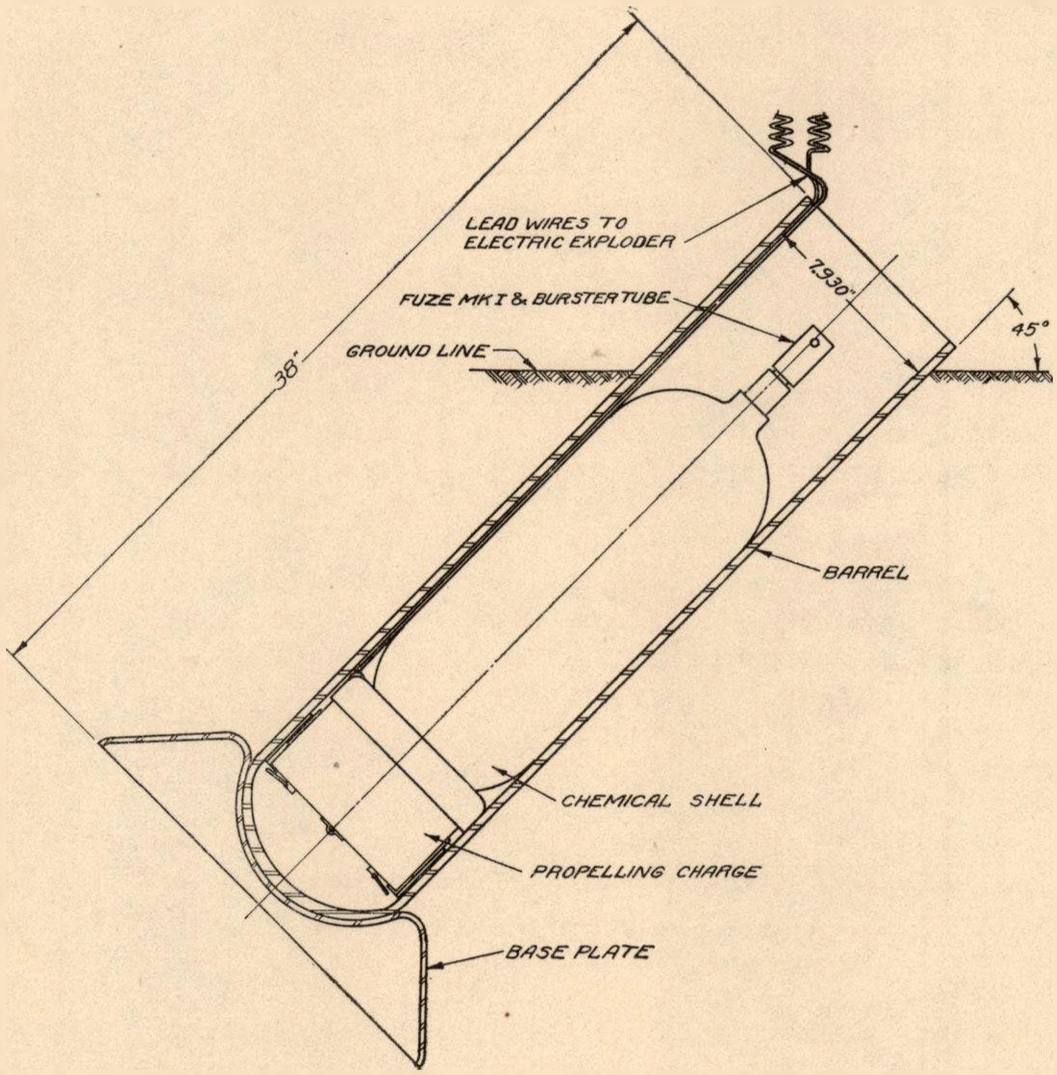
c. The Muzzle Cover is a cap of olive drab canvas, provided with a draw cord, by which it may be tied on the open end of the projector. Its purpose is to exclude rain and dirt.

d. The Base Plate (M-I) is made of 1/4" steel. It has a rounded depression in the center to receive the butt end of the projector. The crimped edges, which have been flattened to permit the closer installation of projectors in the battery emplacement, form a flange to prevent the burying of the barrel on recoil. The base plate has a rope handle, and weighs 30 pounds. It is 19" long and 12" wide.

e. The Support is a bent iron stand 22" long and 10" wide, made of 3/8" round stock. It consists of two parellel uprights which carry a yoke between them to support the barrel. The two uprights have spiked feet and are made rigid by a horizontal bar of 1/4" stock which is welded to them 6" from the lower ends. The support weighs approximately 3 pounds. This support is the most satisfactory of the types yet developed, but has not as yet been approved for manufacture.

f. Packing. (1) Projectors are packed, with muzzle covers, one to a box. The packed box weighs 140 pounds and displaces 3 cu. ft.

(2) The base plates are packed 5 to a box weighing 185 pounds and displacing 5 cu. ft.

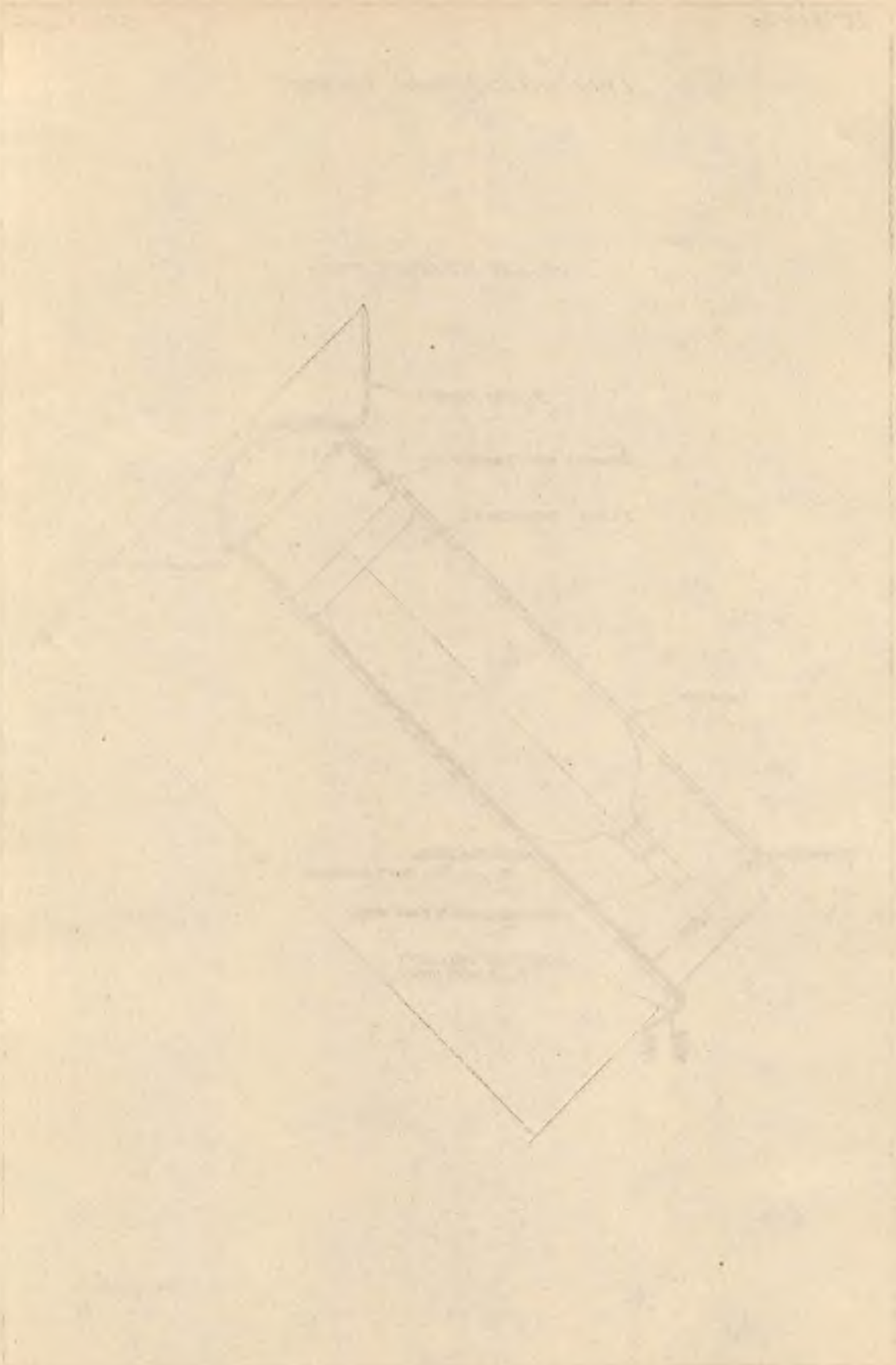


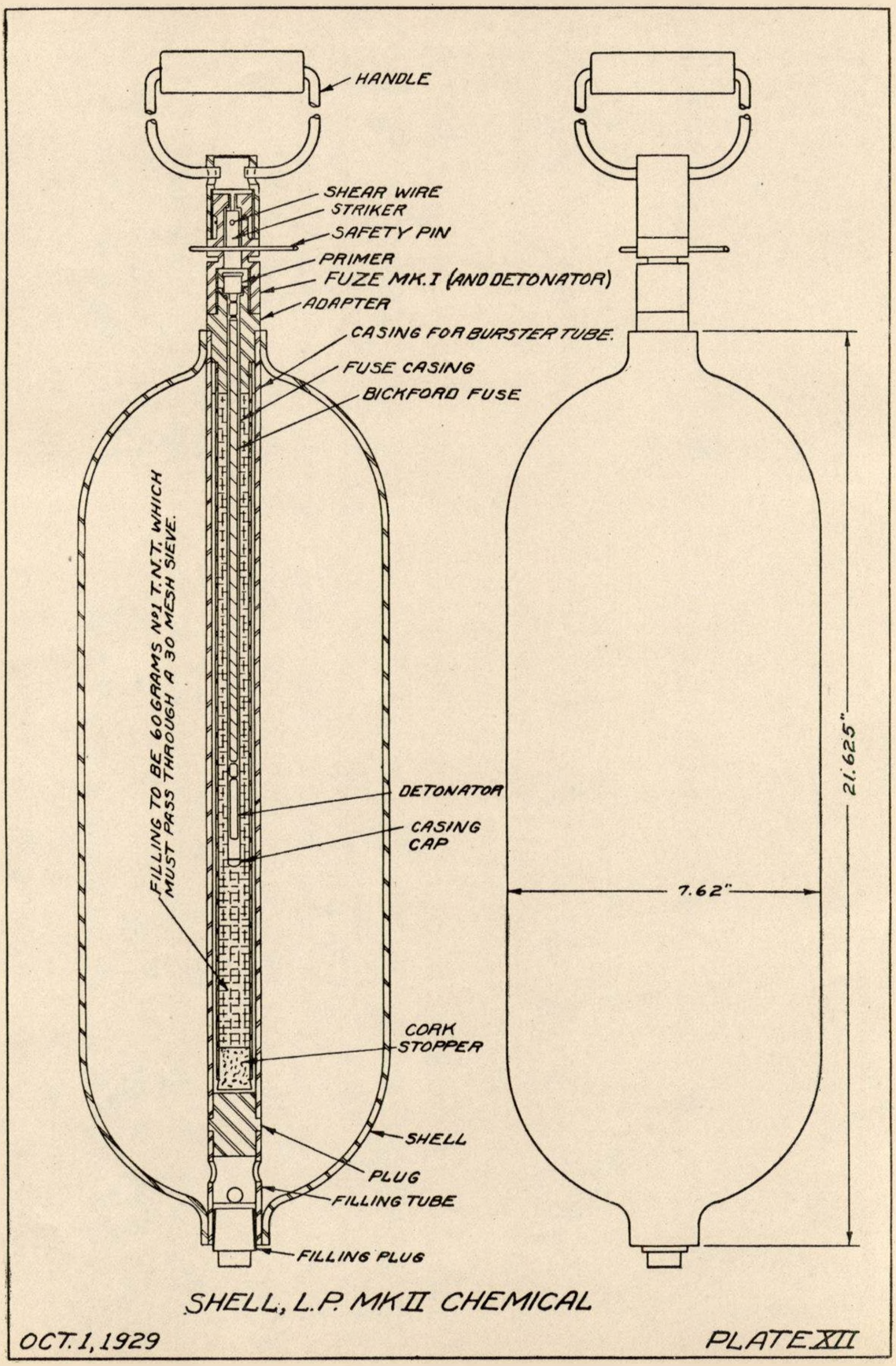
FULL SURFACE SET UP

LIVENS PROJECTOR MK I

OCT. 1, 1929

PLATE XI





SHELL, L.P. MK II CHEMICAL

OCT. 1, 1929

PLATE XII

7. THE SHELL. - (See Plate XII). a. General. All Livens projector shell are essentially similar in general construction and functioning. They differ only in points of construction by which they are adapted to the different types of agents with which they are filled. All use the same type of bursting mechanism.

b. Classification of Livens Projector Shell. There are two types of shell, namely, M-I and M-II; and these are identical except in the material from which the shell body is made. The M-I shell is made of lap welded steel pipe and is used only with fillings not liable to exert high pressures in storage, e.g., F.M. (Titanium Tetrachloride). The M-I shell is made of seamless drawn steel pipe and is used for ture gases.

c. The Complete Shell consists of the following:

Shell body
Bursting mechanism
Filling

d. The Shell Body is 22" long and 7-5/8" outside diameter, and made either of lap welded or seamless drawn steel pipe (as indicated in paragraph b above). A central tube is run thru the shell, welded in at both ends, and threaded. A steel plug is welded into the tube about 2" from one end. Several half inch holes are bored thru the tube in this 2" space, thru which liquid fillings enter the shell. After filling, a steel plug is screwed into the end by machine, resulting in a joint that is gas proof and so tight that it is impossible to remove the plug with field tools and methods. The other end of the central tube forms a well or casing for the bursting mechanism,and prevents contact between the filling and bursting mechanism. A closure plug is loosely screwed into the booster well to exclude dirt and moisture, and to prevent damage to the threads.

e. Capacity, Weight, Efficiency. Livens projector shell have a total capacity of 725 cu. in., 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 pounds, and holds on an average of 30 pounds of gas per shell. The shell weighs about 63 pounds filled. The efficiency of the snell is therefore approximately 47%.

f. Identification Markings. All Livens projector shell are painted slate gray and are marked with reference to the filling to conform to the system of identification markings common to all chemical munitions. (NOTE: All shell on hand will retain old markings until repainting becomes necessary).

8. THE BURSTING MECHANISM. - a. The Bursting Mechanism of the Livens projector shell consists of the following component parts:

the adapter and burster casing (M-I), with
the shear-wire pistol head (with handle), and
the 22-sec. Bickford fuse assembly (M-I).

b. (1) The Adapter and Burster Casing consists of an open end steel tube 7/8" in diameter and 17" long which is sweated on to the lower shoulder of the adapter. One end of the adapter screws into the threaded opening of the shell, the other, a projecting threaded nipple, takes the firing head. The adapter is recessed and drilled, and fitted into it is a closed tube of brass or copper 5/16" in diameter by 13-1/2" long, which serves as a well to prevent contact between explosive and fuze assembly.

(2) The bursting charge. consisting of 60 grams (2 oz.) of granular Tetryl, is loaded into the lower end of the burster casing and is stoppered by means of a long cork moisture-proofed with shellac. When screwed into place in the shell, the projecting end of the cork seats against the steel plug of the central tube.

The explosive charge is no larger than is necessary to split open the shell and positively discharge the contents. Excessive bursting or fragmenting action is not desired.

c. The Shear-Wire Pistol Head, and Handle. The pistol head consists of a steel turning, 1-1/4" in diameter and 3-3/4" long, which screws on the upper part of the adapter. It is chambered to receive a brass inertia pellet with a small steel striker pin or nipple, and is normally suspended in place by a copper shear-wire. A double-pronged safety pin passes thru the head immediately under the inertia pellet and precludes any downward movement. A sleeve with two holes to receive a detach-

able handle is screwed to the pistol head, and acts as a protection for the shear-wire.

d. 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.

e. Packing. Each adapter and burster casing is packed with a shear-wire pistol head screwed to it. These combinations 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 33 pounds and displaces 1 cu. ft.

f. The Fuse Assembly, M-I (Time). A 22-second time fuse is used for all shell. It consists of a 10" length (22-second) of Bickford (black powder) fuze, with an igniter head consisting of a .410 pistol (fulminate) cap on one end, and a No. 8 commercial copper detonator loaded with fulminate of mercury at the other. When in place in the burster-casing well, the igniter head projects slightly above the adapter.

g. Packing. Livens projector fuse assemblies are packed 10 to a tin box, 10 tin boxes to a chest. Each individual container has a piece of felt in both top and bottom as protection against shock. Each fuse is suspended in a paper tube. After the lid is put on, the joint is wrapped with friction tape and shellaced. The chest weighs 35 pounds and displaces 1 cu. ft.

9. OPERATION OF THE BURSTING MECHANISM. - When the safety pin has been pulled and the projector is fired, the set-back cuts the shear-wire and the striker pin penetrates the pistol cap. The Bickford fuse is thus ignited, and in 22-seconds flashes the detonator, which in turn explodes the Tetryl bursting charge. The safety pin is never withdrawn until just prior to the time the projector is to be fired.

10. PREPARATION OF AMMUNITION. - a. The components of the complete round are transported to the emplacement area in separate boxes. They are there opened and assembled under competent supervision.

For purposes of safety as well as economy of ef-

fort, the following sequence of operations should be adhered to:

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

(2) Remove closure plug from shell.

(3) Insert burster casing and screw it tightly to shell with wrench.

(4) Unscrew firing head.

(5) Insert 22-second Bickford fuse, being careful not to twist, jar, hammer or otherwise force a fuse that cannot be entered easily by hand. See that the cap is seated well in the adapter.

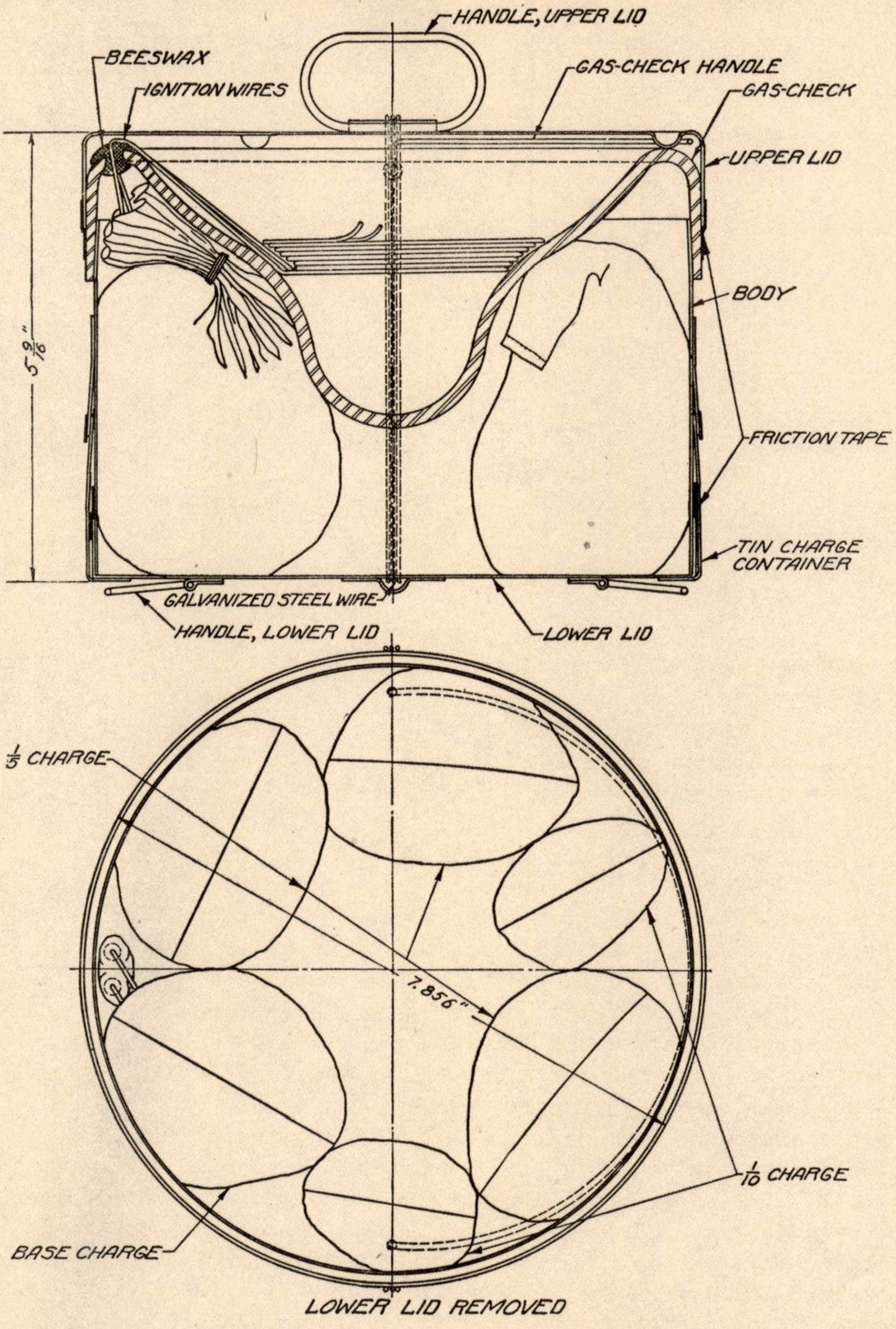
(6) Replace firing-head being careful not to strike the fulminate cap in so doing. Screw down tightly and carefully by hand - do not use wrench.

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

11. THE PROPELLING CHARGE. - (See Plate XIII). 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 box 7-3/4" in diameter and 7-1/2" high. The bottom cover which holds the powder charge in place has embossed upon it the word "Charge". This cover has two metal straps that hook thru two eyes soldered to the can body, and has two one-finger loop handles. On the top of the can is a steel stamping which is soldered to the upper rim of the can. 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 thru 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 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 a copper wire; and the cover joints are moisture-proofed by adhesive tape.

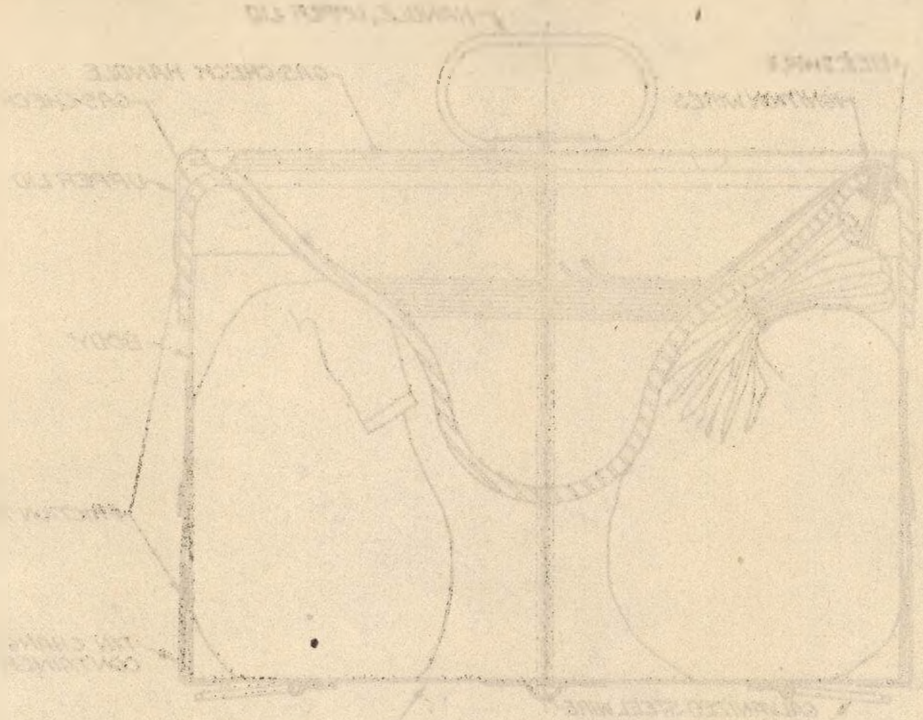
CHEMICAL WARFARE SCHOOL

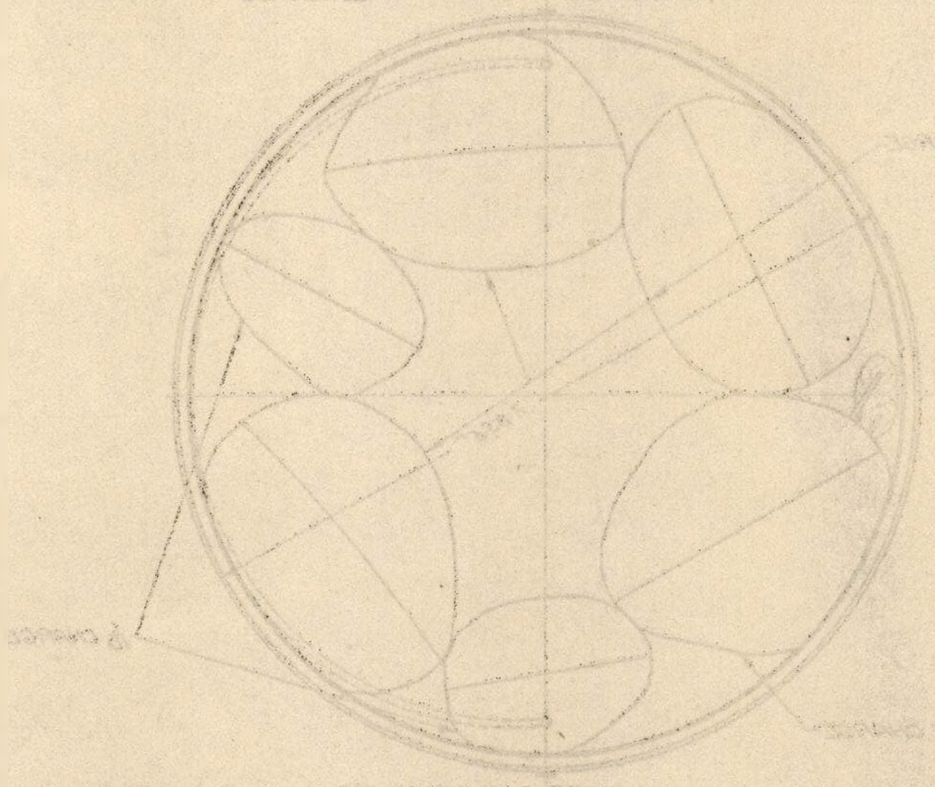


LIVENS PROJECTOR CHARGE PROPELLANT

OCT. 1, 1929

PLATE XIII





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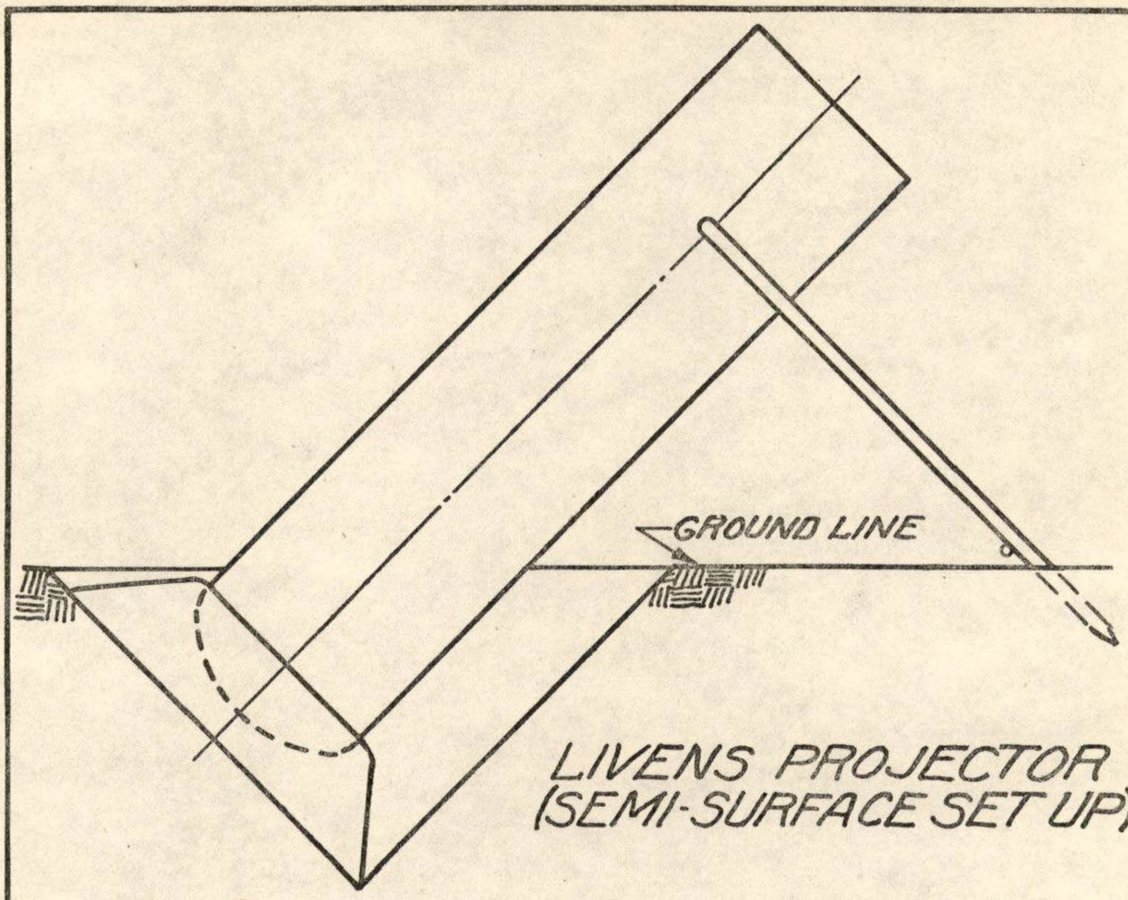
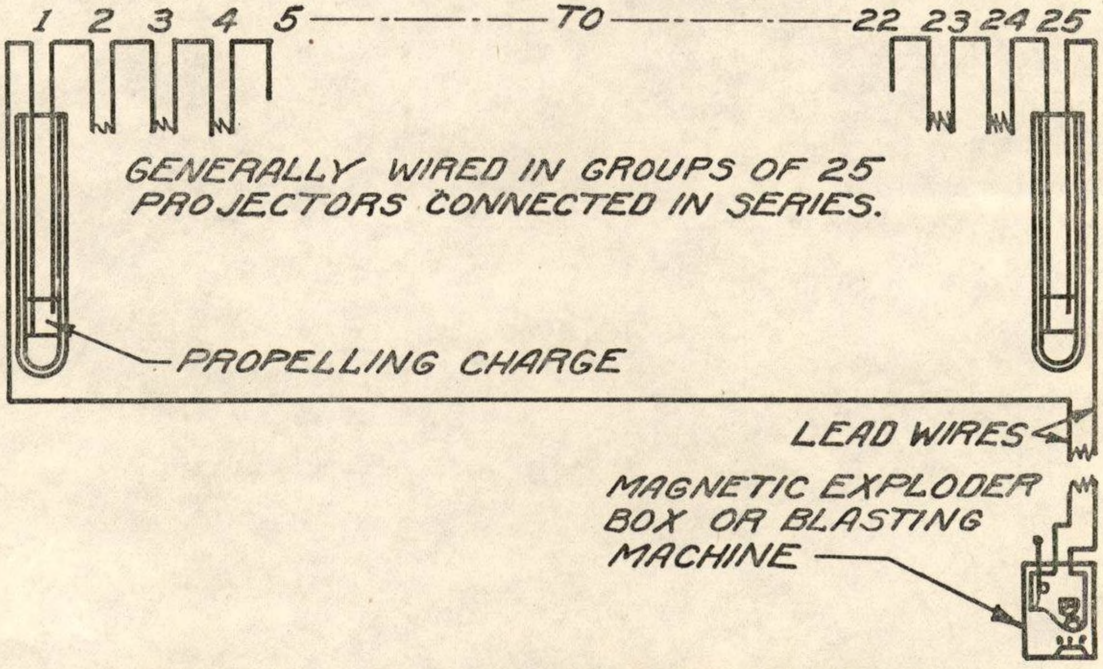


LIVENS PROJECTOR
(SEMI-SURFACE SET UP)



METHOD OF WIRING PROJECTORS

OCT. 1, 1929

PLATE XIV

c. The charge at present used consists of a priming charge - 8 oz. of black powder in a red bag; three 8 oz. bags and three 4 oz. bags of smokeless powder. The priming charge bag encloses an electrical squib to which the lead wires of the charge can are attached.

d. Packing. Charge cans are packed complete four to a box, weighing 55 pounds and displacing 2 cu. ft.

12. PREPARATION OF THE PROPELLING CHARGE. - a. The bottom cover of the charge can (i.e., the cover marked "Charge") is removed. The amount of charge corresponding to the range desired, and exclusive of the priming charge, is left in, and the cover replaced. Insert the tin straps into the metal eyes of the can, bend them upward, and flatten them against the sides of the can. Care should be taken not to injure the squib or scrape the insulation of the lead wires. Excess powder should be destroyed.

b. The cover is then removed from the gas-check, the lead wires carefully uncoiled, and their ends scraped bright from the insulation for about 3".

13. FIRING ACCESSORIES. - The firing 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 6' sections of 1/2" pipe spiked at one end and painted red and white in alternate bands 6" wide, with luminous paint.

(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" wide. It comes in 100' rolls and is used for marking off projector emplacements.

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

(2) Clinometer.

c. For Wiring the Emplacement. (1) Friction Tape is

used to wrap splices or joints in the lead wire and connections between the charges in a projector battery. This prevents short circuiting and corrosion of the joints, which would result in an increase of resistance and possible mal-functioning.

(2) Wire, Firing. This is flexible twisted pair lead wire, each wire consisting of 7 strands of copper wire, rubber insulated, braided with cotton, and weather-proofed. This wire is furnished in 1000' coils weighing 38 pounds.

(3) Firing 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' of lead wire. Weight filled, 50 pounds; displacement 1.5 cu. ft.

(4) Pliers. These are 8" box-joint cutting pliers.

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

(2) Circuit Detector (Commercial).

e. For Firing the Battery. (1) Exploder, Magneto, 30 Cap Engineer.

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 inequality of fuzes.

NOTE: A successful dynamo exploder (C.W.S. Model, M-II) with a capacity of 550 caps has been developed at Edgewood Arsenal. It has not as yet been officially approved.

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

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

14. FILLINGS FOR LIVENS PROJECTOR SHELL. - a. During the World War, four distinct types of agents were developed and used in projector shell, namely, gas, smoke, incendiary and high explosive. Chlorine, phosgene, and chlorpicrin were used singly

and in combination, and even mustard gas was attempted; but the principal survivors were the chlorine-phosgene combination, the chlorpicrin-stannic chloride mixture, and phosgene alone. The tendency of development was directed toward the production of lethal (i.e., lung irritant) cloud gas. The chief incendiary filling was thermite (a mixture of iron ioxide and aluminum which, when ignited, generated molten iron with a temperature approximating 3000 degrees C.). Solidified oils were used to a small extent. Their purpose was to set fire to construction, and for the destruction of material and stores. High explosive was used against temporary field works, particularly against wire entanglement, and with gas for terrorizing effect. Smoke, as such, was little used.

b. Gas Fillings for Projectors are at present limited to non-persistent agents.

15. FILLINGS FOR LIVENS PROJECTOR SHELL, M-I. - This shell is adapted only for the use of solid fillings or liquids of low vapor pressure.

Smoke Filled Shell. (1) Shell, Livens projector Smoke, M-I, FM.

Description	As above.
Filling	Titanium Tetrachloride, 30 pounds.
Identification	Letters "Smoke-FM" in yellow on body. One yellow band around body.
Character of Burst	Dull explosion.
Characteristics of Cloud	White, dense, slightly acid, non-toxic smoke of great obscuring power. Obscuring effect increases with humidity in atmosphere.
Tactical Uses	None. This filling is used for training only.

16. FILLINGS FOR LIVENS PROJECTOR SHELL, M-II. - Gas Filled Shell. Shell, Livens Projector Chemical, M-II, CG.

Description	As above.
Filling	Phosgene, a liquefied gas; 24.5 pounds.
Identification	Letters "Gas-CG" on body in green. One green band around body.
Character of Purst	Muffled explosion. Non-fragmenting.
Characteristics of Cloud	Colorless, highly toxic, non-persistent 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. Contaminates exposed food and corrodes metals.
Tactical Uses	For casualty effect.

17. PRACTICE SHELL. - Livens projector shell, rendered inert and filled to weight with sand, are used in training.

SECTION III

TECHNIQUE

18. 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 strong point, an area of dugouts, or other object offering concentrations of personnel. If the target is large the individual batteries or groups may be assigned to cover definite portions of it, each group having a definite impact point, in order to secure the best dissemination of the agent. These considerations, together with the necessity of separating the various batteries of the emplacement, in order to minimize accidental damage from direct shell fire, require that each battery be individually aligned to register on the target.

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

a. Line Targets. Targets offering a front of 225 yards or less are small targets and require a single aiming point. For greater frontages allow one aiming point for every 200 yards of target. This will give the maximum uniform distribution of agent. To increase the concentration on a part, or all, of the target, assign additional batteries to the same aiming point or points. Aiming points are located on the up-wind edge of the target in such a manner as to insure maximum coverage. Determine range as follows: Draw a line thru the center of each target area parallel to the wind direction. The range to be used is the distance from the emplacement to the point where this crosses the up-wind of the target.

b. Area Targets. The normal dispersion of the battery permits a desirable distribution of agent on a target for area fire. Targets larger than 225 yards front and 150 yards depth (i.e., approximately 3-1/2 squares, 100 yds. by 100 yds. each) must be divided into sections for aiming purposes to insure maximum uniform coverage, allowing a single aiming point for each equivalent area. Draw lines beginning at, and parallel to, the target front 125 yards apart. Establish aiming points on these lines at 200-yard intervals, aligning rearward points on those of the first line, beginning at the up-wind edge. As in the case of line targets, coverage is determined by the location of aiming points; concentration by the number of batteries assigned to any single aiming point.

20. 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" chemical mortar.

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

22. RANGE TABLE. - The following range table for Livens projectors is for use with the propellant now being used (reconditioned propellant in bags).

Projector - 2'9"
Powder - Smokeless
Projectile - Shell, weight 63 pounds (approx.)

TENTATIVE RANGE TABLE

LIVENS PROJECTOR

Charge (oz)	Range (yds)
8	520
12	640
16	740
20	840
24	960
28	1070
32	1180
36	1260
40	1400
44	1450

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

24. EFFECT OF WINDS. - Because of the high trajectory, long time of flight, tumbling, and bulk 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 aimed on the target area and by laying the battery more into the wind.

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

(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 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:

(a) Minimize the number of troops to be withdrawn from the danger zones between emplacement and target.

(b) Minimize danger to adjacent commands, of fire aimed at the destruction of the emplacement, or retaliation after the operation.

b. Distribution of Batteries in the Emplacement Area.

(1) Projectors are generally dug in 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) Influence of Terrain. The nature of the terrain may determine and fix the exact location of a battery as to allow little or no latitude in the choice of a position. Ease of camouflage should be considered.

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

(5) Protection from Shell-Fire. The various batteries of an emplacement should be so separated as to afford maximum protection from shell fire. This is important, especially for large shoots which must be prepared considerably in advance of the time of the operation.

26. METHODS OF INSTALLING A BATTERY OF PROJECTORS. - There are two methods of installing a battery of projectors, as follows:

a. Full Surface Set-Up. (See Plate XI).

(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 base plate. This method is invariably 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 aiming 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 fire to mark the intersection of the emplacement line.

(3) (a) Aligning the Trench. An emplacement line is then marked off at right angles to the line of fire, running thru the stake. This is done either with a large 45 degree triangle (constructed of wood), or by a geometrical method such as the following:

(b) Place two small stakes on the line of aim, one on either side to the emplacement-line stake and exactly equidistant therefrom, i.e., each on the line of aim, and four feet from the stake. Using one of the small stakes as a center, with a piece of cord at least six feet long, describe an arc wide enough to cut the approximate emplacement line. With the same cord and radius, describe an arc using the second small stake as a center. Mark the intersection of the two arcs with a third small stake. Now repeat the process on the other side of

the line of aim, and establish a fourth stake. A line joining the third and fourth stakes is perpendicular to the line of aim, at the emplacement line stake.

(c) The emplacement line thus determined, it is marked with white (or luminous) tape. A trench 4'0" wide is then marked out using the same tape, allowing 14" in length for each projector.

NOTE: It is essential to accurate firing that the emplacement line be absolutely perpendicular to the line of aim and on a horizontal plane; and that all construction be referred to this line. A hillside emplacement must be level and must not follow the slope.

(4) Digging the Trench. (a) A V-shaped trench is then dug whose front and rear walls are inclined at an angle of 45 degrees from the horizontal. The base plate is backed against the rear wall; the barrel rests almost its entire length against the forward slope.

(b) Experience has demonstrated the following method to be the most economical of time and effort in making the excavation: With a long spade, dig a trench the length of the emplacement midway between the front and rear marking tapes. This trench should be the width of the spade and 22" deep. The bottom should be horizontal and cleared of dirt, which is heaped immediately to the rear of the emplacement. Beginning just inside the marking tape and continuing the slope to the near corner of the bottom of the small trench, the front and rear walls are carefully beveled off, care being taken to maintain the 45 degree slope. Do not take off to the finish line but allow leeway for "shaving". Frequently test the slope with the clinometer. When all the excavated earth has been cleared out and heaped to the rear, notch out or under-cut the front wall by sinking the spade vertically downward where the front wall meets the level bottom; but continue the back wall at its 45 degree slope. The resulting recess accommodates the base plate flange and permits maximum support for the barrel.

(c) Care should be taken that the front slope is smooth, and is free from waves or buckles; and that the axis of the barrel is normal to the plane of the base plate when in the firing position.

(5) Alignment of the Projectors. (a) The center or "sighting" projector and its base plate 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 sighting projector, and carefully made parallel to it. The flat sides of the base plates are placed together to economize trench space. The individual projectors ordinarily are not sighted; but the end projectors are frequently "toed-in" 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 base plates and between the barrels, taking care not to change the line of sight. The completed emplacement is slightly higher than the initial surface, and the muzzles project slightly above the surface to exclude water. Muzzle covers are put on.

c. Semi Surface Set-Up. (See Plate XIV). (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 base plates. The emplacement line having been laid out, a trench 2' wide is marked out, allowing 14" in length for each projector.

(3) Digging the Trench. Proceed to dig a small trench down the length of the emplacement as above described, but only 8" deep. When this has been done, level the front and rear walls and undercut the front wall to accommodate the base plate, as previously described.

(4) Aligning the Projectors. The center projector is the sighting projector. As the barrels are put into place, iron supports are used to hold up the muzzle end. The support should hold the barrel about 8" 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.

SECTION IV

OPERATION

27. ASSEMBLY OF THE BATTERY. - a. The shell and propellant charges are prepared at or near the battery position as the projectors are being dug in. Method and orderly procedure are essential during the assembly and wiring of the battery to economize on time and effort, especially in night operations.

b. Charge cans are placed in a row immediately in front of the muzzles. The shell, firing-heads outward, are placed in a row in front of the cans, allowing a narrow aisle between rows. After carefully uncoiling, straightening, and separating the lead wires, (the ends having been scraped of insulation) each individual charge box is tested with the circuit detector. If the circuit is intact, the can is lowered into the muzzle by means of the wire bail, gas check uppermost. The lead wires should follow along the upper wall; and they are then made parallel, but separated (i.e., not twisted or crossed) and are bent over the rim of the muzzle to hold them taut. Shell, in sequence, are then lowered into the barrels, firing-heads upper-

most, care being taken not to disturb the insulation of the lead wires. Wires that are crossed, or from which the insulation has been scraped, are likely to result in a short circuit when current is applied, and a failure of that projector to fire will result. The various operations in the assembly of the battery should proceed in sequence beginning at one end of the battery and working thru to the other.

28. WIRING THE BATTERY. - (See Plate XIV). a. The individual projectors of a battery are connected together in one electrical series. This is done by splicing one lead from a projector to one lead from the adjacent projector, and continuing thus thruout the battery, in such a way that the current flows from the end projector to the next, from that to the next, etc., to the other end of the battery. This leaves only two free (unspliced) wires, one on each end projector.

b. In order to prevent short circuiting by splices coming in contact with metal or moisture, 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. Testing the Circuit. When the wiring has been completed the circuit of the battery as a whole is tested by connecting the free end wires 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, and then 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: 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 thru corrosion, as well as to afford better insulation. Muzzle covers are invariably kept on until the battery is ready to fire.

d. Connecting the Batteries of Large Emplacements. The methods used to interconnect the various batteries of large emplacements depend upon the voltage and amperage of the supplying source. In the case of the C.W.S. Dynamo Exploder, 550-cap capacity (experimental), batteries, consisting of varying numbers of projectors, are interconnected in multiple and in several circuits by means of a special multiple-series harness. Circuits of large emplacements are tested in a manner similar to that of the single battery.

29. 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 direct observation, or aerial photography. The Livens projector set-up as viewed from the air is characteristic and unmistakeable, as there is nothing else quite similar to it in appearance. Its identification is fatal to the surprise which otherwise makes it possibly the most efficient non-persistent gas weapon. Due to the ease with which terrain becomes marked when working parties are emplacing this heavy material, and also to the give-away arrangement of batteries sighted on definite targets, it is necessary to consider and provide against new tracks, regularity of lines, production of shadows, or leaving any work uncovered.

b. Preliminary reconnaissance must include a special study of camouflage requirements. Natural camouflage is superior if it can be obtained without itself or its loss being noticed. The concealment of emplacements and approaches must be completed before broad (i.e., photographic) daylight.

30. FIRING THE BATTERY. - a. Altho emplacements are often timed to be completed just prior to firing, they may be left when properly concealed 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 main lead wires and exploder or other source of current 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 by the one designated to fire the battery, who brings them back

to the firing point for recheck. The exploder is then connected and the battery fired by raising the rack bar to full length, and depressing it quickly and positively to its lowest point.

31. MISFIRES. - 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.

32. SHORTS. - Shorts may be due to damp or defective powder, or retardation of burning (as in the case of powder charges consisting of segregated components), or to improper or soft backing for the base plate.

33. DUDS. - Duds result from the failure of the bursting mechanism to function, and may be due to a defective firing-head or a wet or defective 22-second Bickford fuse assembly. 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 W.D. Circular 13, 1923.

34. PROCEDURE AFTER FIRING. - After firing a battery, disconnect all wires before attempting to remove an unfired shell. Insert safety pin, remove shell and charge can, and destroy powder. Unfired shell should not be removed within 5 minutes after battery has been fired. All material should be salvaged and the emplacement refilled.

35. SAFETY PRECAUTIONS. - a. War Department Circular No. 40, 21 September, 1925, prescribes the following safety precautions for Livens projector in firing in peace time:

(1) No chemical ammunition will be fired over troops. Support fire may be executed when the guns are located sufficiently to the flank of the troops to afford adequate protection.

(2) When firing Livens projectors with gas shell, personnel should be placed 200 yards to the flank from the line of fire or from point of burst for protection from shell fragments, and should be up-wind for protection from gas.

b. Personnel should be at least 100 yards from, and

not directly to the rear of the emplacement at moment of firing.

36. WIND AND SAFETY LIMITS. - a. 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 to the direction and velocity of the wind.

b. Safety Limits. Since the Livens projector is a very crude form of artillery, its fire is accompanied by a large dispersion of shots both in range and deflection. Again, due to defective propellants and other causes, shorts quite frequently occur. As these shorts may fall from one or two hundred yards in front of the emplacement, and if the fuze is armed, they explode and become a source of danger to our own troops. Therefore certain safety zones are prescribed, from which our own personnel are removed prior to the firing of Livens projectors.

c. Both the wind and safety limits, including map diagrams are discussed in Book IV, Chapter II.

37. 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. The emplacements are usually laid out and marked by an advance reconnaissance party. Projectors are later installed and loaded, and circuits are wired and tested by specially qualified men. After the emplacement is camouflaged, the details are moved away and a guard and firing detail is left until the time of firing.

CHAPTER V

CHEMICAL MORTARS

SECTION I

GENERAL

1. GENERAL. - a. The 4" mortar was developed by the British to meet the demands of gas warfare in a stabilized situation. Such a weapon had to meet the following requirements:

(1) High angle of fire - to meet the situation of firing from trenches against defiladed targets.

(2) Rapidity of fire - to permit the firing of non-persistent agents.

(3) Mobility - to permit movement and emplacement by man power alone.

(4) Simplicity - both as to operation and repair, and to decrease the difficulties of manufacture.

(5) Cheapness - to permit the availability in large numbers.

(6) Sufficient shell capacity - for dispersing chemical agents in large quantities.

The 3" Stokes mortar (British) met these requirements except for shell capacity. Both 4" and 6" mortars were developed to overcome the deficiency of the 3" mortar, but the 6" mortar did not meet the requirement of mobility and was not employed for other than experimental purposes.

b. The United States, upon entering the World War, had no such chemical weapon. The 4" Stokes mortar best met the requirements and was adopted and used by us throughout our participation in the war. During the latter part of the war a demand for smoke grew up. The 4" Stokes mortar was deficient as a smoke weapon because of its short range, inaccuracy of fire and insufficient mobility. Being the best smoke gun available it was used for this purpose even in mobile situations.

c. Since the war development has been carried out along the lines of overcoming the deficiencies of the Stokes 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" chemical mortar. This mortar has been adopted as to type but is subject to further development regarding means of transporting and mounting.

SECTION II

DESCRIPTION OF THE 4.2" CHEMICAL MORTAR

2. CHARACTERISTICS. - The 4.2" chemical mortar is a rifled muzzle loading weapon designed for high-angle fire, capable of a

maximum range of 2400 yards and a minimum range of 600 yards. It may be fired at a sustained rate of fire of five rounds per minute, and if emplaced in hard ground may be fired for a rapid burst of 20 rounds per minute. The range is varied by changing the elevation, by varying the propellant charge, or by a combination of the two.

3. COMPONENT PARTS. - The mortar consists essentially of a barrel, bipod and baseplate. A sight is furnished for laying elevation and direction. Certain tools, spare parts, and accessories are included with the equipment for each mortar squad for the purpose of the emplacement, care and maintenance of the piece.

4. THE BARREL. - The barrel is a steel tube finished to careful inside dimensions and closed in at one end called the breech or base end. It is fitted near the muzzle with barrel clamps. The clamps are so designed that the barrel is free to rotate but cannot move longitudinally with reference to the clamp. On the underside of the front clamp is a threaded lug through which the traversing screw travels. The breech is closed and fitted with a base cap which carries a striker pin protruding into the barrel. The base cap is screwed over the breech or base end of the barrel. The base cap washer is placed in the base cap to insure a gas-tight joint between the base cap and barrel. The base cap has two pins projecting radially which fit in slots in the baseplate cup and prevent rotation of the barrel. The barrel is rifled with 24 grooves and lands. The depth of the groove is 0.03 inch, the width of land is 0.0625 inch. The pitch is zero to one turn in 20 calibers. The recoil of the mortar is transmitted to the ground through the baseplate, against which the base cap rests. The barrel is supported near the muzzle by a bipod fitted with elevating and traversing screws. A muzzle cover of canvas or leather is placed over the muzzle end of the barrel to protect the interior surface from moisture.

5. THE BIPOD. - 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 the 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 tne 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 tne 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.

6. THE BASEPLATE. - The baseplate is made of alloy steel in the form of a truncated pyramid 25 inches square at the base. A cast-steel cup is bolted to the baseplate. The cup is slotted to receive the pins on the base cap and steel latches are closed over the pins to keep the barrel from rebounding from the baseplate when the mortar is in action.

7. THE MI SIGHT. - The MI sight consists essentially of three parts, viz., body, traversing head and sighting tube. It serves the purpose of determining the elevation of the barrel, aiming the mortar on initial set up, and correcting the mortar position between rounds during action. The body is so designed that it is readily attached to a bracket carried on the front barrel clamp. On the body is mounted the traversing head with sighting tube. The traversing head is designed so that it can

be rotated both horizontally and vertically. The degree of movement is indicated by scales graduated to mils. Two level bubbles indicate the position of the barrel with reference to the horizontal or ground line. The sighting tube, mounted on the traversing head, carries the open sights and also the vertical cross wire and slit. The sighting tube is held by two fulcrum screws which allow the sighting tube to swing in a vertical plane without disturbing the traversing head setting. This sight does not correct for "cant" or "drift".

8. THE GONIOMETER SIGHT. - The goniometer sight has been issued in the past to certain organizations and is now obsolescent. This sight is a compact right angle telescope containing cross lines and a mil scale. It is mounted on a base which fits the upper edge of the muzzle of the mortar when in the firing position. A cross bubble is provided to set the sight in the vertical plane of the axis of the bore. In operation, the sight is placed on the upper edge of the muzzle, the bubble centered, and the desired deflection laid off by traversing the mortar. This operation places the sight off center, and it is necessary to again center the bubble and traverse the mortar. This sight corrects for "cant" but not for "drift".

9. THE WEIGHTS. - The weights of the component parts are as follows:

Barrel	95 lbs.
Baseplate	100 "
Bipod	35 "
Total	230 "

Tools and spare parts	25 lbs.
Pick, shovel and aiming stakes	12 "
Aggregate	267 "

10. THE MORTAR PACKING BOX. - The mortar packing box is a strongly braced wooden box fitted with a hinged lid secured with metal hasps and a padlock. The inside of the box is provided with partitions and cross members for holding the various mortar components, accessories, and spare parts. The packing box has four rope handles to facilitate handling. It is approximately 55 inches long by 18 inches wide by 13-1/2 inches high, has a displacement of 7.7 cubic feet and a combined box and packing weight of 263 pounds.

SECTION III

DESCRIPTION AND FUNCTIONING OF SHELL AND FUZE

11. THE SHELL. - (See Plate X). a. The shell, 4.2" chemical mortar Mk. I, filled and completely assembled ready to fire weighs 25 lb. 8 oz. Of this weight about 8 lbs. is the filling, 1 lb. 8 oz. is the assembled fuze, burster tube, and bursting charge. The standard fillings now authorized are: (WP) white phosphorus, (CG) phosgene and (CNS) chloracetophenone in solution.

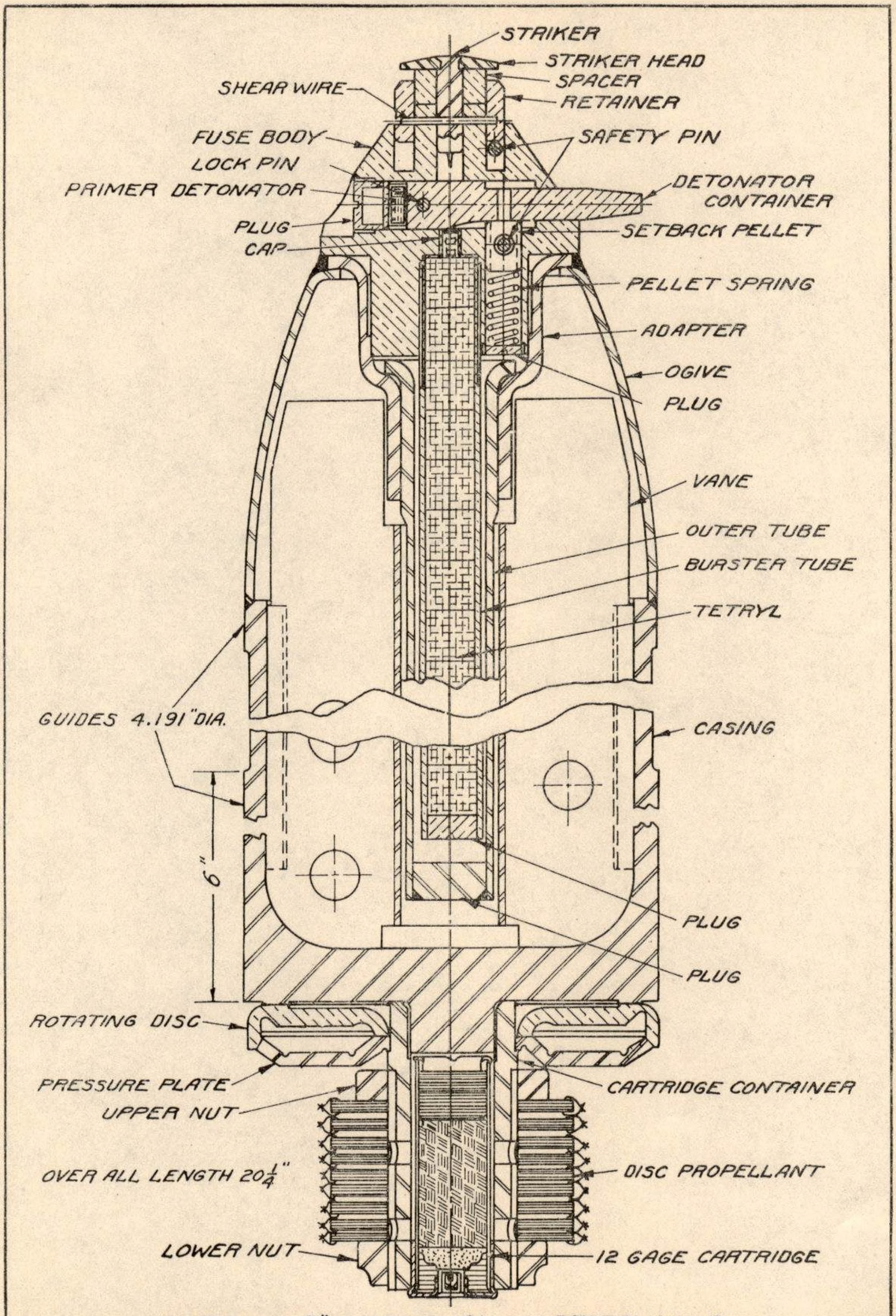
b. The overall dimensions of the assembled shell ready to fire are: major diameter 4.191 in., length 20.40 in., of which the fuze comprises 2.00 in.

c. Two complete rounds of shell are packed into a box which weighs 10 lb. and whose approximate dimensions are 26 in. x 10 in. x 6 in. The total weight of the box containing two complete rounds is 61 lb. approximately.

12. THE SHELL BODY. - a. The shell body is made from a steel forging, machined inside and out. A sheet-steel vane is welded inside the body to aid in stabilizing the shell by forcing the liquid fillings to rotate with the shell. On the base of the shell, integral with the forging, is a threaded stud to which the cartridge container is secured. The cartridge container is made of steel tubing. It has an external thread and two nuts for holding the propellant in the proper location. Radial holes are drilled through the walls to carry the ignition flash to the propellant. An internal thread is provided for attaching the cartridge container to the shell.

b. The nose of the shell is made from drawn steel and welded to the body of the shell. The nose has an adapter which is threaded to take the fuze and a finished cylindrical projection into which the central outside burster tube is pressed, after the shell is filled, thus forming a gas-tight seal. The ro-

CHEMICAL WARFARE SCHOOL



SHELL, 4.2" CHEMICAL MORTAR MKI

OCT. 1, 1929

PLATE X

tation unit consists of two discs, one of brass called the rotating disc, and one of steel called the pressure plate. The brass member is held to the base of the shell and is approximately equal to the diameter of the shell. The pressure plate is smaller in diameter and fits into the brass disc. The pressure of the propellant gases expands the brass disc forcing it into the rifling grooves.

13. THE FUZE. - a. The fuze is a bore-safe point-detonating fuze which weighs 1 lb. 8 oz; of this weight 57 grams comprises the tetryl burster charge. The fuze has three safety features:

(1) The setback pellet.

(2) The detonator container which cannot arm until the fuze is fired from the mortar.

(3) The two brass spacers held under the head of the firing pin which prevents the firing pin from being forced down until the spacers are removed by centrifugal force after the fuze is fired from the mortar. To prepare the fuze for firing, it is only necessary to remove the safety pin by pulling same from the fuze just before the shell is dropped down the mortar barrel.

b. The fuze is assembled to the shell and, after removing the safety pin, the shell is ready to fire. When the propellant is ignited, the pressure of the gases creates a setback force which causes the setback pellet to move down against the setback spring, thus releasing the combination detonator carrier and safety fork. At the same time the setback force acts on the retaining ring causing it to cut the shear wire releasing the two brass spacers supporting the firing pin head and firing pin. Although the two brass spacers are released, they remain in position until setback ceases, after which centrifugal force causes them to fly free of the fuze. Centrifugal force also causes the detonator carrier to move in the direction of its projection from the fuze body. The detonator carrier, however, cannot move over into armed position until the shell is clear of the gun, because the free end of the carrier is held back by the inner surface of the barrel. Once the fuze is clear of the muzzle centrifugal force carries the detonator carrier out to the full armed position where the detonator is in line

with the firing pin and explosive train. In this position, centrifugal force also actuates the lock pin causing it to move partly out of the detonator carrier into a hole provided in the body, thus locking the carrier in the armed position. After the spacers leave the fuze, the firing pin is supported by the shear wire which prevents air pressure forcing the firing pin against the detonator while the shell is in flight. On impact with the ground or other obstacle, the firing pin is driven down, shearing the wire and setting off the detonator, which detonates the tetryl and so bursts the shell.

14. THE PROPELLANT. - One unit of the propellant consists of a standard No. 12-gage shotgun cartridge loaded with five grains of black powder and 150 grains of ballistite. The black powder is placed next to the primer and acts as an aid in igniting the ballistite. The second unit is made up of thin perforated discs of non-hydroscopic powder. In the center of each disc is a hole which allows the disc to slip over the cartridge container. To assemble the propellant, the disc powder, which is packed in bundles of 150 grains each, is slipped over the cartridge container and the compression nuts adjusted to hold the discs in proper location with reference to the radial holes in the cartridge container. The 12-gage cartridge is then inserted in the cartridge container and pushed forward until the flange of the cartridge is seated against the container. A full charge consists of eight bundles of discs of 150 grains each, making a total of 1200 grains. The charge may be increased or diminished by adding or removing the number of bundles of powder discs. This type of propellant gives a muzzle velocity from 200 to 575 foot seconds, with corresponding chamber pressures of 1000 to 5500 pounds per square inch.

SECTION IV

OPERATING INSTRUCTIONS

15. EMPLACING MORTAR. - An excavation should be made and the baseplate fitted so that it faces normal to the line of fire and is bisected by it. The baseplate should make an angle with the horizontal equal to the complement of the angle of elevation. In order to add stability in soft ground, four sand bags filled and flattened to three (3) inches thickness should be placed under baseplate. When ground is very wet or soft three (3) 2-inch boards should be placed under sand bags. These boards are carried on ammunition carts. The excavation should be deep enough so that when barrel and bipod are in firing position, the bipod feet will be firmly on the ground with the following precautions observed:

a. Barrel normal to baseplate.

b. Plane of bipod normal to barrel.

c. Not more than six (6) inches of elevating screw visible above the bevel gear.

The lower end of the barrel is placed in the depression of the baseplate cup and the steel latches clamped over the radial pins of the base cap. With the barrel held in a position approximating the desired setting of the mortar, the bipod is placed in position and locked to the barrel. The feet of the bipod should be planted firmly in the ground, with the legs as nearly as possible at right angles to the barrel. A line from the center of the baseplate in the direction of fire should pass midway between the feet of the bipod. Sand bags are placed upon each foot of the bipod to overcome any tendency of the mortar to lift up the feet of the bipod during action. Sand bags are also

placed on the baseplate around the base of the barrel to aid in stabilizing the mortar, one bag wedged between barrel and ground.

16. LAYING THE MORTAR. - After the mortar is emplaced, minor adjustments for lateral direction are secured by means of the traversing screw. The barrel is then given the elevation corresponding to the desired range by operating the elevating screw. The sight, being set for the desired range indicates when the barrel has the proper elevation. On the initial setting of the mortar, the sight is set for the desired elevation. The mortar is then adjusted until both bubbles are centered. The mortar is now ready for laying on the target. When lining the sight on the target or aiming stake, the traversing head should read zero. This will simplify subsequent adjustments as all readings will be direct from the scale. If during action the mortar shifts from its original setting, it can be restored by recentering both bubbles and relining sight on target or aiming stake. This must be done between rounds, as sight cannot be safely operated during action.

17. RANGE, DRIFT AND WIND TABLES AND EXAMPLES. - Deviation of the shell from the line of fire is caused by wind and drift. These factors must be corrected by proper changes in the deflection applied to the sight. Drift is due to rotation of the projectile and causes the shell to deviate to the right of the line of fire. Corrections for wind and drift are shown in the following tables.

TABLE I

RANGE TABLE - 4.2" CHEMICAL MORTAR

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

TABLE II

CORRECTIONS FOR DRIFT

Range Yds.	Drift to Right Mils
600	8
800	10
1200	15
1600	20
2000	25
2400	30

TABLE III

CORRECTION FOR 3:00 O'CLOCK OR 9:00 O'CLOCK WINDS

(Flank Winds)

Deflection in Mils

Range Yds.	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 "
16	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 IV

CORRECTIONS IN YARDS FOR 12:00 O'CLOCK OR 6:00 O'CLOCK WINDS.

(Head or Tail Winds)

Range Yds.	Velocity of Wind 5 MPH	10 MPH	15 MPH	20 MPH
600	5 yds.	10 Yds.	15 Yds.	35 Yds.
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 (6:00 o'clock) substract from the Range.

For a head wind (12:00 o'clock) add to the Range.

Interpolate for midranges and winds.

TABLE V

CORRECTIONS FOR 10:00 TO 11:00 O'CLOCK WINDS OR 1:00 TO 2:00 O'CLOCK WINDS

Range	Velocity of Wind							
	5 MPH		10 MPH		15 MPH		20 MPH	
Yds.	Def.	Rn.	Def.	Rn.	Def.	Rn.	Def.	Rn.
	Mils	Yds.	Mils	Yds.	Mils.	Yds.	Mils	Yds.
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 VI

CORRECTIONS FOR 7:00 O'CLOCK TO 8:00 O'CLOCK WINDS OR 4:00 TO 5:00 O'CLOCK WINDS.

Range Yds.	Velocity of Wind							
	5 MPH		10 MPH		15 MPH		20 MPH	
	Def. Mils	Rn. Yds.	Def. Mils	Rn. Yds.	Def. Mils	Rn. Yds.	Def. Mils	Rn. Yds.
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.

EXAMPLES SHOWING USE OF WIND AND DRIFT TABLES

Example No. 1. The magnetic azimuth and range to a target has been determined from the map (method described in Par. 7d TR 415-35) to be magnetic azimuth 4020 mils and the range 1800 yds. What is the correction for drift?

Answer. From Table I, it is found that the drift is 22-1/2 mils to the right at 1800 yds. Therefore 4020-23 = 3997 mils magnetic azimuth.

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

Answer. Table I gives drift as 25 mils right. 15 mils - 25 = 10, 6400 mils - 10 = 6390 mils magnetic azimuth.

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

Answer. From Table I, drift is 24 mils to the right = Left 24 mils.
From Table II, wind correction should be 13 mils to the right.
Therefore 24 left - 13 mils right = 11 mils left.
3210 - 11 = 3199 mils magnetic azimuth.

Example No. 4. The range is 2000 yards and magnetic azimuth 2310. The wind is a head wind from 12:00 o'clock at 8 M.P.H. What is the corrected range and correction for drift?

Answer: From Table III, 2000 + 65 = 2065 yds.
From Table I, 2310 - 25 = 2285 mils magnetic azimuth.

Example No. 5. The range is 1900 yds., magnetic azimuth 1300, wind 15 M.P.H. from 5 o'clock. What corrections?

Answer. From Table V. Range 1900 - 75 = 1825 yds. Range.
From Table I. Magnetic Azimuth 1300 - 23 = 1277 mils for drift.

From Table V. 1277 + 15 = 1292 mils magnetic azimuth.

18. PREPARATION OF AMMUNITION. - a. The shell are packed in boxes containing two complete rounds including fuze and bursting charge. In each box there is a sealed container in which are packed two complete propellant charges consisting of two No. 12 gage cartridges and 16 bundles of disc powder. This allows one cartridge and 8 bundles of powder for each shell. Thus packed, the boxes are delivered to the mortar ammunition dump.

b. For purpose 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, as follows:-

(1) Open boxes and propellant containers.

(2) Remove outside nut from cartridge container. Clean the shell by removing all rust prevention compound and dirt from guides, body, cartridge container and flash outlet holes. Remove any rust or paint from guides by means of emery cloth.

(3) Examine guides for burrs which would cause the shell to stick in the barrel. Burrs should be filed or hammered down.

(4) Place the necessary number of bundles of disc powder on the cartridge container and replace the outside nut so as to secure the powder in a firm compact bundle. Unused powder discs will be salvaged for future use.

(5) Insert cartridge in cartridge container taking care that base flange of cartridge is firmly seated against the cartridge container.

(6) When necessary the split pin of the safety pin may be straightened with a pair of pliers, to facilitate rapid removal by the gun squad.

(7) The shells are now ready for delivery to the firing point.

c. (1) Immediately before firing and at no other time,

remove safety pin from fuze. The shell is now ready for firing.

(2) To fire the shell, drop the assembled round into the muzzle of the mortar.

(3) Remove hand quickly from muzzle of the mortar after dropping the shell.

d. As the round nears the bottom of the barrel, the primer of the cartridge strikes the striker pin and fires the cartridge. The flames from the explosion of the cartridge pass through the holes in the cartridge container and ignite the disc powder. The shell, carrying the cartridge case with it, is projected from the barrel and the mortar is ready for another shell.

19. MISFIRES. - a. Misfires may be due to any of the following causes:

(1) Defective cartridge.

(2) Loose, worn or bent striker pin.

(3) Dirty shell guides.

(4) Dirty bore.

(5) Burst cartridge container from previous rounds.

(6) Bent or crooked cartridge container.

(7) Primer from propellant cartridge of previous round stuck to the striker pin.

b. (1) In case of a misfire all personnel should remain at a safe distance for one minute. The base of the mortar is raised and tilted so that the misfired shell will slide out easily into the hands of a member of the gun crew. Immediately, on receiving the shell, the safety pin should be replaced in the fuze and the shell carefully examined for defects. If shell and cartridge are found correct, an inspection must be made of the inside of the barrel to determine the cause of misfire. In removing the shell, no member of the gun crew should be directly in front or directly in rear of the mortar.

(2) As the fuze is not armed until the shell leaves the muzzle after positive discharge, a misfire normally presents no hazard to the safety of the gun crew, unless a heated barrel or sparks should ignite the disc powder during unloading.

20. SAFETY PRECAUTIONS. - For safe and proper operation of the mortar, the following precautions should be observed at all times:

a. Be sure to remove the hand quickly from the muzzle of the mortar after dropping the shell.

b. Always see that the upper and lower guides (head and base) of the shell are clean.

c. Be sure that the cartridge end of the shell is pointed downward wnen firing and that the shell is dropped into the mortar cartridge end first.

d. See that the cartridge fits closely in cartridge container.

e. 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.

f. The position of the mortar should be checked after the first round as the initial charge always tends to seat the baseplate in the ground, thus causing a change in the setting of the mortar.

21. TO ASSEMBLE AND DISASSEMBLE THE MORTAR. - In assembling and disassembling the mortar no other tools than those issued with the outfit should be used.

a. To dismount barrel from bipod. (1) Lift out the traversing screw shaft locking pin.

(2) Withdraw the traversing screw shaft assembly, which locks the barrel and bipod together.

(3) Lift out the barrel.

(4) Replace tne bolt and traversing screw shaft

locking pin.

b. To replace the barrel on bipod. Lift out the traversing screw shaft locking pin, withdraw the traversing screw shaft assembly,and proceed in the reverse order to that outlined in "a" above.

c. To remove base cap. Use special wrench provided for this purpose applying the wrench to the radial pins on base cap. Light blows on the handle of the wrench may be necessary to start the threads.

d. To replace base cap. Use special wrench for replacing base cap. Care should be taken to insure a tight fit between the base cap and the barrel, to avoid gas leaks.

e. To remove striker pin. Remove base cap from barrel and apply combination wrench to flat milled section of the striker pin. The base cap may be held against rotation, during the operation, by means of the base cap wrench.

f. To replace the striker pin. Proceed in reverse order to that described above. Put a drop of oil on the threads before screwing the striker pin firmly into the base cap.

g. The personnel will have no difficulty in dismounting parts of the remaining mechanism. Care should be taken in dismounting bolts, etc., not to batter them by driving them out with a hammer. A piece of hardwood or a copper drift should be interposed.

SECTION V

CARE AND MAINTENANCE

22. CARE OF THE MORTAR. - a. The bore of the barrel and all unpainted surfaces should be kept clean and free from rust.

The bore should always be kept slightly 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, seriously affects the range of the mortar. The muzzle cover should be held in place by means of its cord.

b. If the mortar is to remain unused for some time, all bright and unpainted parts, such as the bore, striker pin, screws, gears, threads, etc., after being first thoroughly cleaned should be protected by a light coat of rust-preventing compound as issued. The rust preventing compound is easily removed by the use of burlap or waste dipped in gasoline.

c. 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.

d. Examine and tighten the nuts and screws occasionally.

23. CLEANING OF THE MORTAR, BEFORE, DURING AND AFTER FIRING. - It is important that proper attention be given to the cleaning and inspection of the mortar before, during and after firing.

a. Before firing. (1) Remove all oil from the bore. Also remove any excess oil on the outside of the barrel and the bipod.

(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 gas-tight fit. Use the base-cap wrench for tightening the base cap.

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

b. During firing. (1) The barrel should be swabbed out after every five rounds, except when firing rapid bursts.

(2) The base cap and firing pin should be examined at every opportunity and cleaned and tightened.

c. After firing. (1) Unscrew the base cap and clean and sponge out the barrel, removing all residue. Lightly oil the bore.

(2) Clean the striker pin and then oil lightly.

(3) Clean the base cap and oil.

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

(5) Clean the baseplate.

(6) Tighten all nuts and screws.

24. PAINTING OF THE MORTAR. - a. All parts of the materiel, with the exception of the bore and bearing surfaces, should be kept well painted as a protection against rust. Clean and wash the materiel thoroughly to remove all dirt and grease and allow to dry before applying the paint. If the weather is cold, warm the materiel before applying the paint.

b. The following parts will be painted in accordance with instructions on drawings and specifications:

(1) The barrel, complete, with sleeve and clamps, except traversing screw and bore.

(2) The bipod, except the gear teeth, elevating screw, and bearing surfaces.

(3) The baseplate.

SECTION VI

TOOLS, ACCESSORIES AND SPARE PARTS

25. TOOLS, ACCESSORIES AND SPARE PARTS. - 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. The tools, accessories and spare parts include the following:

12 bags, sand, O.D. duck
1 brush, striping, 1/8"
1 chest, packing
*6 cloth, emery, No. 00, sheets
1 cover, muzzle
1 lanyard, complete
*1 oil, engine, No. 1, qt. can
1 pick-mattock
1 sight, chemical mortar, complete
1 roll, tool, gunners
Consisting of:
1 handle, traversing screw, complete w/locking pin
1 oiler, 1/2 pt.
1 pin, striker
1 screw, traversing
*1 washer, copper, 2" dia. 1-3/16" hole
*1/2# waste
1 pliers, combination, 8"
1 wrench, base cap
2 wrenches, combination
1 roll, tool, ammunition
Consisting of:
*6 cloth, emery, No. 00, sheets
2 files, flat, mill, 8"
1 hatchet
*1/2# waste
1 wrench, fuze
1 spade
3 stakes, aiming, 1-1/4 x 1-1/4 x 3'
1 swab
2 washers, copper, 2" dia. 1-3/16" hole
*1 waste, bag, 1#

Spare parts:

*1 nut, 3/8", U.S. standard hexagonal for cross-stay center bolt.
*1 nut, 1/2", U.S. standard, hexagonal for bevel pinion stud.

*Expendable

Spare parts (cont'd):

*1 nut, 1/2", U.S. standard, hexagonal for cross-stay bolt.
*1 nut, 3/4", U.S. standard, hexagonal for tie rod.
*1 nut, 0.825" pitch dia., U.S. standard hexagonal for elevating screw.
*1 nut, 3/8", U.S. standard, hexagonal for clamping bolt.
*2 pins, cotter, 1/8" x 1".
*2 pins, cotter, 3/16" x 1-1/8".
1 pin, striker, 3.718, short, w/nipple.
*2 pins, cotter, 3/16" x 2".
*1 pin, taper, #1, 1-1/2" long.
*1 pin, taper, #2, 1" long.
*1 pin, yoke.
*1 screw, cap, 5/16" for bevel gear cover.

*Expendable.

SECTION VII

THE HAND CART

26. GENERAL DESCRIPTION. - a. The 4.2" chemical mortar and its accessories and ammunition is transported by means of two wheeled man drawn carts. The carts are constructed of steel and fitted with wire wheels and pneumatic tires, 27 inches in diameter. A detachable draw bar is provided for pulling the carts and handles are attached to the frame for use in lifting the carts onto motor trucks, transport wagons or other vehicles. The overall length of the cart including the draw bar is 6 feet 9-1/2 inches. The tread of the cart is 31-1/4 inches; the inside width of frame is 25-1/4 inches; the inside length of frame is 32-1/4 inches. The cart complete weighs 167 pounds.

b. The carts are so designed that they may be used interchangeably for carrying either the mortar and accessories

or the ammunition. The dimensions of the inside of the frame are such that five shell boxes may be carried thus allowing ten rounds of ammunition for each cart. The shell boxes are carried with sides resting on the frame and are held in place by means of straps running diagonally across the cart.

27. LOADING THE MORTAR AND ACCESSORIES. - a. In transporting the mortar and accessories, two metal frames are used. These frames fit inside the cart frame proper and are known as the barrel frame and baseplate frame. To pack the mortar on the cart, the barrel frame is placed in position on the cart frame proper. The mortar barrel, bipod, pick and spade are then placed on the barrel frame and fitted into the indentations or projections provided in the frame for carrying each item. The baseplate frame is then placed on the cart and held in place by means of lugs which register with slots in the barrel frame. The baseplate is then fitted into its frame and the whole load is made secure by means of straps passing diagonally across the cart.

b. The new cleaning rod is carried in the bore of the mortar. The old cleaning rod may be carried with the aiming stakes, or may be shortened by cutting off and rethreading pipe shaft in which case, it can be carried in the mortar.

SECTION VIII

DRILL, THE MORTAR SQUAD

28. THE MORTAR SQUAD. - The mortar squad consists of one

corporal and eight privates. No. 2 is the gunner and in the absence of the corporal commands the squad. Two hand drawn carts are furnished each squad, one for the transportation of the mortar with accessories and spare parts and one for the transportation of ammunition.

a. The normal depth of one cart including lead ropes, is 12 feet.

b. The normal distance between carts in column is 2 paces.

c. The normal interval between carts in line is 6 paces.

29. TO FORM THE SQUAD. - a. Formation. The chemical squad is formed in double rank as follows: Numbers 2, 4, 6 and 8 in front rank, in order from right to left; numbers 1, 3, 5 and 7 in the rear rank, in order from right to left. No. 1 covering No. 2. The squad forms with forty (40) inches between ranks.

b. To Form. The corporal places himself three (3) paces in front of and facing the point he desires the center of the squad to rest when formed and commands: "FALL IN".

At this command the men assemble at attention, the corporal then commands: "CALL OFF". Commencing at the right the men call off alternately rear and front rank 1,2,3,4,5,6,7,8. The command CALL OFF, may be given at any time during the drill. At this command, the members of the squad call off their numbers to indicate the positions they held at the time the command is given.

c. Pistols, if carried, are then inspected at the command of the corporal, as prescribed in TR 50-55.

30. TO PROCURE CARTS. - The squad being formed as described in Par. 29 above, the corporal directs the squad (or designates certain men of the squad) to procure the two carts and gives instructions for placing them.

NOTE: Carts are usually placed as described in Par. 28b, with the mortar cart in front. After the carts have been properly placed, the corporal reforms the squad three paces in rear of and facing the carts.

31. TO TAKE POSTS. - The squad being formed and the carts placed as described in Par. 30; the corporal places himself one pace in front of and facing the carts and commands "POSTS". At that command, the squad executes "RIGHT BY TWOS", at double time, halting without command when they have reached their respective positions, which are as follows:

Nos. 2 and 4 lead ropes of mortar cart, No. 2 on the right.
" 1 and 3 handles " " " , " 1 on the right.
" 6 and 8 lead ropes of ammunition cart, No. 6 on the right.
" 5 and 7 handles " " " , " 5 on the right.

The corporal then takes post to the right of and on line with No. 2, facing to the front.

32. TO PROCURE EQUIPMENT. - The mortar squad being formed at the command "(1) SECURE (2) EQUIPMENT", the men fall out and secure the following:

Corporal - Compass and dispatch case, containing mil rule, note-book, range table, flashlight and protractor.

No. 1 - Aiming stakes, sight and clinometers
No. 2 - Tool roll, gunners
No 3 and 4 - Baseplate
No. 5 and 6 - Barrel
No. 7 - Bipod
No. 8 - Pick-mattock, spade and sand bags.

No. 1 passes to right of cart and grounds aiming stakes and bag containing sight and clinometer on line with right wheel, points even with end of cart handle, and takes post by center of stakes facing to rear.

No. 2 passes to right of cart, grounds tool roll on line with rear of cart and one pace to the right thereof and then removes baseplate rack and grounds same one pace from right wheel, and takes post facing cart.

Nos. 3 and 4 pass to left of cart and ground baseplate one pace to left of cart, then face toward cart.

Nos. 5 and 6 pass to left of cart and ground barrel be-

tween baseplate and cart muzzle to the front. They then face the barrel.

No. 7 halts one pace in rear of cart and grounds bipod on line with right wheel. Then faces the front.

No. 8 halts one pace in rear of cart and grounds pick-mattock, spade and sand bags, in line with right wheel. Then faces front. The corporal halts three (3) paces in rear center of cart.

33. TO LOAD MORTAR CARTS. - The command is "(1) BY DETAIL (2) LOAD (3) BARREL (4) BIPOD (5) BASEPLATE RACK (6) PICK AND SPADE (7) BASEPLATE (8) TOOL ROLL (9) AIMING STAKES (Note: If lanyard is carried, it is loaded by No. 1 at this point.) (10) SAND BAGS (11) SECURE LOAD". At the commands from (3) to (11) inclusive, the carts are loaded as follows:

BARREL. At this command Nos. 5 and 6 place barrel on cart in grooves provided for holding barrel, muzzle to the front. They then proceed to the ammunition dump of the mortar squad if ammunition has been removed from cart. If no ammunition is to be handled, No. 5 takes post at right handle of ammunition cart, No. 6 at right lead rope of ammunition cart.

BIPOD. At this command, No. 7 places bipod on cart, in grooves provided for same, yoke forward. He then assists in loading ammunition, if required, otherwise, he takes post at left handle of ammunition cart.

BASEPLATE RACK. At this command No. 2 places rack on cart, and after baseplate is in place, places tool roll in hollow of baseplate. He then stands fast to assist Nos. 1 and 3 to strap load to cart, after which he takes post at right lead rope of mortar cart.

PICK-MATTOCK AND SPADE. At this command, No. 8 places pick-mattock and spade in groves provided for same on rack, handles to the front and folds the sand bags in half. He remains at the cart until he later places the sand bags in position.

BASEPLATE. At this command, Nos. 3 and 4 place baseplate on rack; then No. 3 stands fast to assist Nos. 1 and 2 to secure load. No. 4 takes post at left lead rope.

TOOL ROLL. At this command, No. 2 places tool roll on top of baseplate and stands fast to assist Nos. 1 and 3 in securing load.

AIMING STAKES. At this command, No. 1 places aiming stakes points to the front on tool roll and sight case and, after No. 8 loads sand bags, assists Nos. 2 and 3 to secure load.

SAND BAGS. At this command, No. 8 having folded sand bags in half places them firmly over center of load. He then assists in loading ammunition, if required, otherwise he takes post at left lead rope of ammunition cart.

SECURE LOAD. At this command, No. 2 goes to rear of cart and passes rear straps to Nos. 3 and 1 who connect same with forward straps, pulling load tight and fastening buckles. They then take posts as described above.

34. TO LOAD AMMUNITION CARTS. - Carts are habitually loaded from the right by Nos. 5,6,7 and 8. At the command "LOAD AMMUNITION", No. 5 places one box of ammunition on front of cart. He then takes post on left of cart and holds boxes in place until the remaining 4 boxes are loaded by Nos. 6,7 and 8. When all boxes are in place, Nos. 5 and 6 place baseplate boards on top of boxes, after which the whole load is secured by cart straps, Nos. 5 and 6 handling front straps and Nos. 7 and 8 handling rear straps.

35. COMMANDS. - The commands for and execution of movement and change of direction, mounting mortar, and inspection are similar to those prescribed in TR 415-20, Drill, The Chemical Squad, Platoon and Company.

36. DUTIES. - The duties in the service of the mortar in firing are as prescribed in TR 415-20 and 415-35, Technique of Chemical Weapons.

37. LOADING AND UNLOADING OF CARTS FROM MOTOR TRUCKS. - In loading hand carts on motor trucks, the loading is done by squads, which approach the truck from the rear and are halted. The squads being halted as stated, the corporal commands: "(1) LOAD (2) CARTS". At the command "LOAD", Nos. 2 and 4 climb into rear of truck and grasp handle of cart which is handed up to them by Nos. 1 and 3. Nos. 5,6,7 and 8 ground handle and lead

ropes of ammunition cart and take a position behind mortar cart. At the command "CARTS", Nos. 1 and 3 grasp forward grips and Nos. 6 and 8 rear grips of cart, Nos 5 and 7 grasp back of cart. All then lift cart to level of truck floor, when it is pulled in truck by Nos. 2 and 4. Ammunition cart is then loaded in like manner. The reverse method is used in unloading.

NOTE: Care should be taken that spokes of wheels are not used in lifting carts.

SECTION IX

DRILL, THE MORTAR PLATOON

38. FORMATIONS, GENERAL. - a. The platoon is formed in line or column.

b. The normal distance between sections in column is 5 paces.

c. Commands for execution of movement and change of direction are similar to those prescribed in TR 415-20.

39. TO FORM LINE TO FLANK. - The platoon being in column of carts. The command: "(1) CARTS RIGHT (Left) (2) MARCH". At the command "MARCH", the men on cart handles pivot cart on inside wheel and take up the half step until men on lead ropes have made the turn, which they do at double time. All then take up the quick time.

40. TO DEPLOY THE PLATOON. - The platoon is habitually deployed in section column, the section extending in depth only. The movement requires two separate commands, unless the platoon is already in line of sections.

For the first movement, the command is "(1) LINE OF SECTIONS (2) RIGHT (Left) (3) MARCH (4) PLATOON (5) HALT". At the

command "MARCH", the leading section continues to march to the front, the second section obliques until it has gained an interval of 25 paces, then marches to the front.

For the second movement, the command is "(1) EXTEND ON REAR CART (2) MARCH". At the command "MARCH", corporals place themselves 5 paces in front of their leading carts and carts follow at 5 paces; and platoon sergeant follows in the rear interval between sections.

SECTION X

SAFETY PRECAUTIONS IN TIME OF PEACE

41. 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.

42. FIRING OVER THE HEADS OF PERSONNEL. - In time of peace firing with this weapon over the heads of any personnel is prohibited.

43. 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.

44. DANGER AREA. - The danger area shall be as prescribed in TR 141-1.

45. LOCATION OF OBSERVERS. - Observers should be to windward of the line of fire. No person will be allowed to stand directly in rear of the mortar.

46. GAS MASKS. - When chemical ammunition,other than smoke, is fired, all personnel will be provided with gas masks.

47. FIRING OF WHITE PHOSPHORUS AND TOXIC AGENTS. - When white phosphorus or toxic chemical shell are fired, the lanyard will be used, and no person except the man handling the lanyard shall be within 50 yards of the mortar.

48. MISFIRES. - In case of misfire, the mortar will not be touched until at least one minute has elapsed. When the projectile is removed, all persons should be at the sides of the mortar.

49. DUDS. - Signs, warning persons of the danger from duds, will be posted in the vicinity of the firing area at all times. For the removal of duds see TR 1370-A.

SECTION XI

DESCRIPTION OF THE 4" STOKES MORTAR

50. CHARACTERISTICS. - (See Plate VIII). The 4" Stokes mortar is a smooth bore muzzle loading high angle of fire weapon, capable of firing 15 - 20 rounds per minute for short bursts under favorable conditions, or a sustained rate of 3 to 5 rounds per minute can be maintained. The maximum range is 1075 yards and the minimum 200 yards. The range is varied by changing the elevation, by varying the propellant charge, or by a combination of the two.

51. COMPONENT PARTS. - The mortar consists essentially of a barrel, bipod, baseplate. Certain tools, spare parts and accessories, similar to those furnished with the 4.2" chemical mor-

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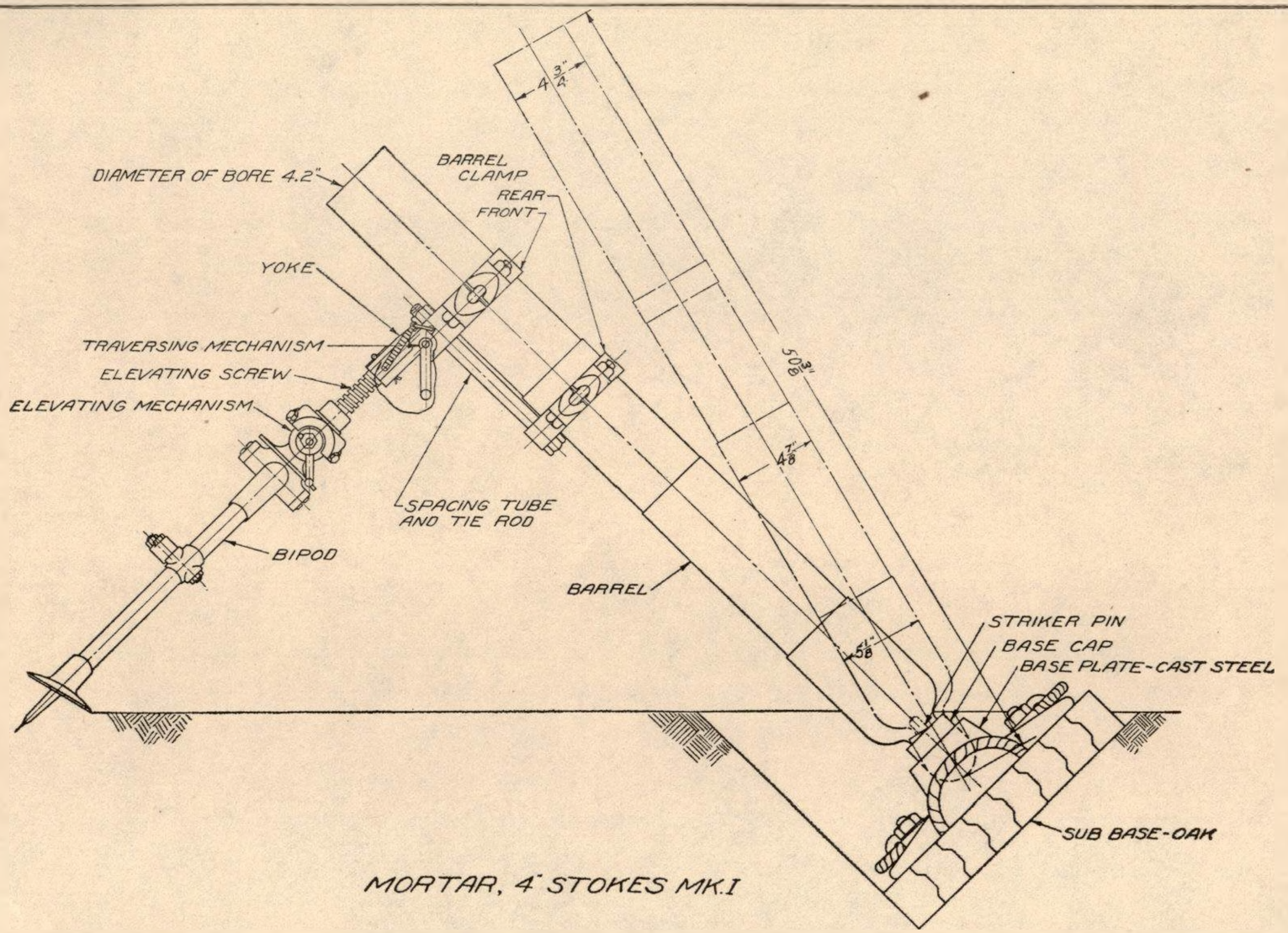
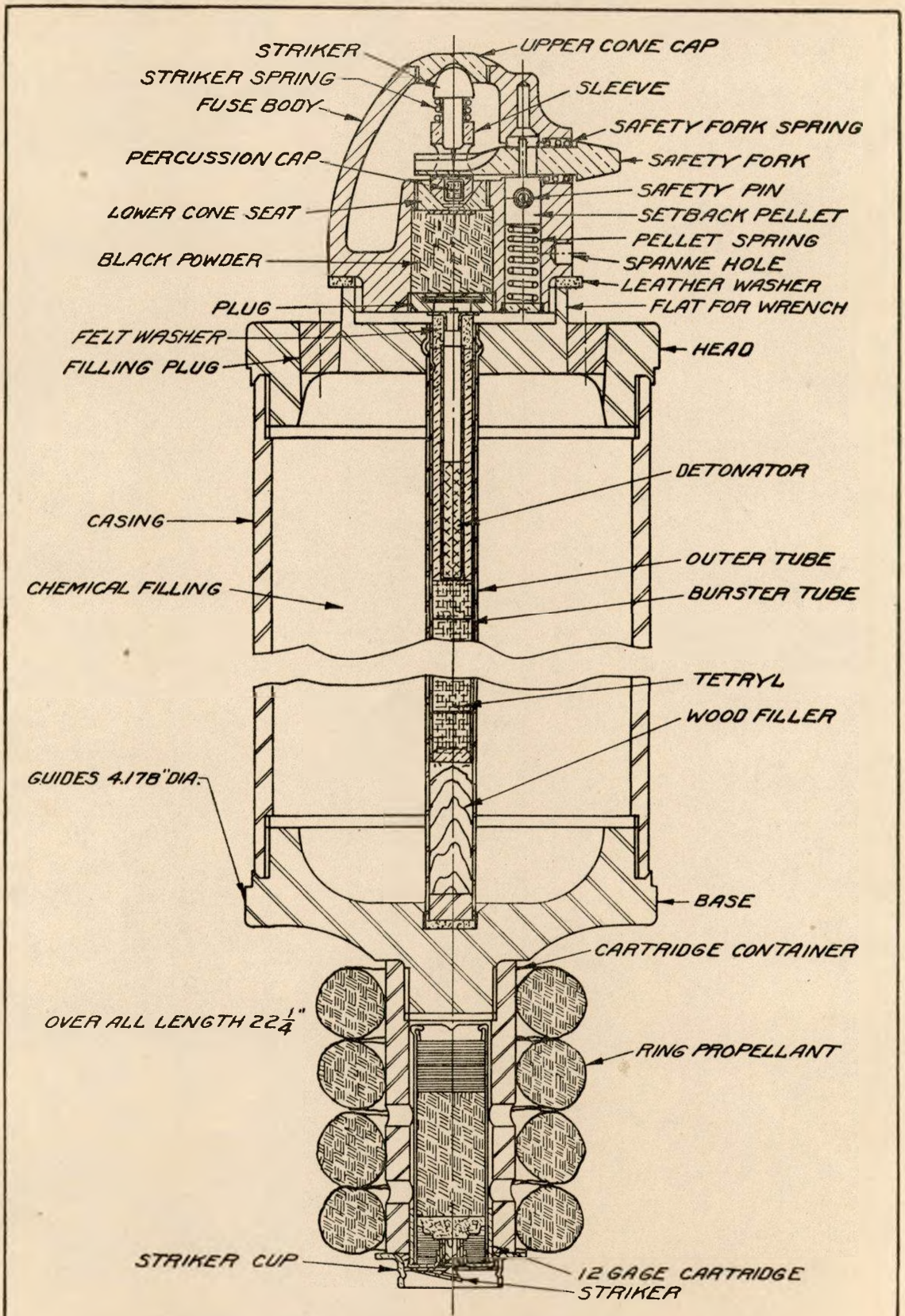


MORTAR, 4" STOKES MK.I

PLATE VIII

CHEMICAL WARFARE SCHOOL

CHEMICAL WARFARE SCHOOL



SHELL, 4" S.M. CHEMICAL MK I

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PLATE IX

tar, are included with each mortar for use in the emplacing and servicing of the piece.

a. The Barrel complete consists of the barrel, base cap, firing pin, two clamps, tie rod, and traversing screw. The Barrel is a seamless drawn steel tube with a smooth bore of 4.2" in diameter. The base cap does not carry projection for securing it to the baseplate as does the 4.2" chemical mortar. Otherwise the barrel is similar in design to that of the 4.2" chemical mortar.

b. The Bipod includes a two-legged trunnion standard with elevating and traversing mechanisms. It is similar in design to that of the 4.2" chemical mortar.

c. The Baseplate includes a round steel plate 15" in diameter, and a sub-base 17" wide, 36" long and 3" 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.

d. The Tools, accessories and spare parts comprise those provided for use with the 4.2" chemical mortar (See Par. 25, Chapter V).

e. The Weights of the component parts are as follows:

Barrel	90	pounds
Baseplate	120	"
Bipod	32	"
Total	242	pounds
Tools and spare parts	25	pounds
Pick, shovel and aiming stake	12	"
Aggregate	279	pounds

52. THE SHELL. - (See Plate IX). a. The shell, 4" Stokes mortar, chemical, Mk. I, filled and completely assembled ready to fire weighs approximately 25 pounds. Of this weight from 6.8 to 9.5 pounds is the filling, depending upon the chemical agent with which the shell is filled. The standard fillings now authorized are - (WP) White Phosphorus, (CG) Phosgene, and (CNS) Chloracetophenone in solution.

b. The complete round consists of the shell body, burster, fuze, and propellant.

(1) The Shell Body is a cylindrical tube, made of lap welded or hot drawn steel, 4" in outside diameter and 15" long. The ends are closed by head and base discs 4.178" 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 agent and the burster tube. The head disc is recessed and threaded to form the fuze socket. The base disc is threaded externally to take the cartridge container. The cartridge container is a steel cylinder 2-7/8" long with sixteen 3/16" holes drilled into it to provide flash outlets. It holds snugly a 12 gauge shot gun shell.

(2) The Burster consists of a gaine-tube detonator and felt washer. The gaine-tube is a brass tube 1/2" in diameter, filled with tetryl (trinitrophenylmephylnitroamine), and is recessed at the open (upper) end to take the detonator and felt washer. The detonator is a #8 commercial detonator containing fulminate of mercury. The felt washer affords a soft packing for the detonator and for the top of the gaine-tube assembly.

(3) (a) The Fuze (See Plate IX of Supplement) Mk. XI, "Always" 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 specially prepared muslin. A hollow brass rod termed the safety fork projects horizontally thru the fuze and the 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 thru 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 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 "always" 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 thru 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" S.M. 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 below, which, in turn, is directed downward thru the shellaced muslin disc to the detonator and bursting charge. The force of the resulting explosion is sufficient to open the shell and disperse the filling.

(4) The Propellant or propelling charge for the 4" S.M. shell consists of a cartridge and powder rings. The Cartridge is a 12 gauge shot gun cartridge filled with 5 grains of black powder and 150 grains of ballistite. The Powder rings consist of 375 grains of Hivel #2 or Dupont M.R. No. 31 smokeless powder, enclosed in an annular silk bag, and designed to fit tightly over the cartridge container. The capacity of the container is four rings. This type of propellant gives a muzzle

velocity of about 400 foot seconds, and a pressure from 3500 to 4000 pounds per square inch.

53. MISCELLANEOUS. - a. The 4" Stokes mortar will become obsolete when the development of the 4.2" chemical mortar reaches the stage of warranting quantity production.

b. The operation and technique of the 4" Stokes mortar are similar to that of the 4.2" chemical mortar with the exceptions of the more limited range and greater inaccuracies of the former.

c. Range Table for the 4" Stokes Mortar:

4" STOKES MORTAR

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

CHAPTER VI

CHEMICAL WARFARE WEAPONS USED BY ARTILLERY

SECTION I

GENERAL

1. INTRODUCTION. - Chemical artillery shell were introduced during the World War. Tear gas shell made their appearance as early as 1915. These were followed the next year by lethal shell containing a variety of agents, by smoke, and "sneeze gas" shell, and by numerous experimental mixtures including incendiaries. When mustard gas was introduced, in 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 to all others used. About forty different substances (and mixtures) covering a wide range of potency and effect were employed; and Germany had adapted chemical agents for use in all caliber weapons above the 37 mm gun. The requirements for gas and smoke shell had increased so greatly at the close of the War that their use was limited only by production.

2. CHARACTERISTICS OF ARTILLERY WEAPONS. - Chemical shell are fired from the same guns used to fire high explosive and shrapnel, and are supplied, handled and fired in similar manner. Only the general characteristics of the artillery will here be

considered as this matter is covered in detail in other texts.

3. THE 75 MM GUN. - There are at present three types of 75 mm light field pieces available for service - the French, Model 1897; the British, Model 1917; and the American, Model 1916. The last two mentioned are held in reserve. The French model, which predominates and was used exclusively in France, will be used in service until an improved type is developed and issued. All types use the same fixed ammunition. The extreme range with the H.E. Mk IV shell is 12,500 yards, while with the H.E., Mk I shell and the Mk II shell used for gas and smoke fillings, the extreme range is 8,800 yards. Rate of fire for short bursts is 6 rounds per minute,and for prolonged fire is 3 rounds per minute.

a. The French (1897) Gun is a light, rapid firing, flat trajectory field piece. It is equipped with a hydro-pneumatic recoil system. The recoil is checked by a hydraulic oil brake; the counter recoil is accomplished by means of compressed air. The rapid return to the firing position, after firing, without causing sufficient movement of the carriage to necessitate relaying the piece for the next shot, makes it the most effective gun of its kind. The permissible elevation of the gun (on level ground) is 19 degrees; depression 10 degrees. The traverse amounts to 3 degrees on either side of center. The piece is equipped with a simple optical sight. When in firing position, the piece weighs 2650 pounds.

b. The British (1917) Gun is an adaption of the 3.3" (18 pounder) field gun, with a tube designed to take 75 mm shell. It is heavier, shorter and more rugged than the French gun, but has about the same characteristics. It has a total traverse of 8 degrees, and an elevation of 16 degrees. It weighs 2800 lbs.

The limited elevation obtained on both the French and British material is to a certain extent a drawback to their most efficient use.

c. The American (1916) Gun is somewhat similar to the French gun, except that it has a hydro-spring type of recoil (the recoil varying with the elevation, to insure carriage stability at low angles), and has a split trail type of carriage. The maximum elevation is 53 degrees; total traverse 45 degrees. Its weight in firing position is 3000 lbs.

4. THE 105 MM HOWITZER M1. - Now in process of development, this materiel may be added prior to any future operations. This piece has approximately the same weight as the 75 mm Gun. The extreme range with semi-fixed H.E. shell is 11,960 yards. Rate of fire for short bursts is 4 rounds per minute, and for prolonged fire is 2 rounds per minute. At present, no chemical shell has been provided for this piece; however, certain chemical fillings are considered suitable and will doubtless be employed if the gun is adopted.

5. THE 155 MM HOWITZER. - This materiel, classed as medium artillery, is the French (Schneider) Howitzer, Model 1918. It is of box trail type with a hydro-pneumatic recoil mechanism. It permits an axle traverse of 6 degrees and an elevation of 42 degrees. It fires a 95 pound projectile to a 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. The ammunition is separate loading. Smoke and gas filled shell are standard for this weapon.

6. THE 155 MM GUN. - This materiel, 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 hydro-pneumatic type, having a traverse of 60 degrees and elevation of 35 degrees. It fires a 95 pound projectile to a range of 18,000 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 degrees, and to increase the range to 25,000 yards. The ammunition is separate loading. Smoke and gas filled shell are standard for this weapon.

SECTION II

CHEMICAL SHELL

7. DESIGN. - In point of design, chemical shell differ but slightly from high explosive shell - in fact the latter were converted into the former as a matter of expediency during the World War, by providing a gas-tight adapter joint and by substituting an adequate booster. The Mark II shell has since been designed and is now exclusively used for gas fillings.

8. DIFFERENCES BETWEEN CHEMICAL AND H.E. SHELL. - Chemical shell differ from high explosive in one fundamental, in that, in the case of the latter, complete fragmentation is highly desirable. The efficiency of the 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 explosive effect may result in decomposition of the agent due to the heat and pressure generated at the point of burst, in the case of certain agents, or in too great a dispersion of the contents with a resulting loss in concentration. 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. It is possible that the cupping effect is due to the rush of liquid to the nose of the shell on impact, creating a void in the base which cushions the detonating impulse.

9. TYPE OF FUZE USED. - All chemical shell at present are equipped with "super-quick" (i.e., instantaneous) percussion fuzes of a long-nose type. This is necessary in order to secure a burst above the ground, to minimize cupping and the carrying

of the agent into the ground.

10. BALLISTIC CHARACTERISTICS. - The ballistic characteristics of liquid filled chemical shell vary somewhat from solid filled or high explosive shell. This is due partly to the "braking" effect, exerted against the inside surface of the rotating shell by the more slowly rotating and inert liquid. This latter effect, of course, varies with the physical properties of the various agents. These effects are chiefly manifested in a decrease in range as compared with solid filled shell, and in greater dispersion. Chemical shell are usually somewhat lighter.

11. EFFICIENCY. - The efficiency of chemical shell (i.e., the ratio of the weight of filling to the total weight of shell) varies approximately between 10% and 15%. This is a little lower than corresponding solid filled shell, due to the "void" which must be left above the liquid, to prevent rupture thru hydrostatic pressure. Altho 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 efficiency than any now used.

12. METHODS OF FILLING. - Chemical shell are filled to a constant volume thru the cavity for the booster casing. For gas-tightness, reliance is placed upon the close metal contact of the tapered threads of the adapter. The void allowed varies as the coefficient of expansion of the several fillings. Shell filled to constant volume will vary in weight, 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 zero Fahrenheit, before filling.

13. SUPPLY. - The Chemical Warfare Service and Ordnance Department share responsibility for chemical shell. The Ordnance Department procures the shell. The Chemical Warfare Service procures the agent and fills the shell, after which they are turned back to Ordnance for storage, supply and issue.

SECTION III

CHEMICAL SHELL, DESCRIPTION

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

the shell, with adapter and booster, and filling,
the fuze,
the cartridge case, with primer and propellant (or charge in the case of 155 mm ammunition).

15. THE SHELL. - (See Plates XV and XVI). 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; and in the case of the 155 mm shell, a boat-tailed (i.e., stream-lined) base. The wall is thinnest in the central section but gradually tapers toward the base to impart strength where most needed, and thickens toward the nose to give strength about the closure joint. The greatest diameter of the shell 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, tapered 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 thru the bore. The shell is thus stabilized in its flight (i.e., goes nose first). The 155 mm Howitzer shell has one narrow rotating band. The 155 mm gun shell has two bands because of the much higher pressures developed in the breach; otherwise these two types are identical.

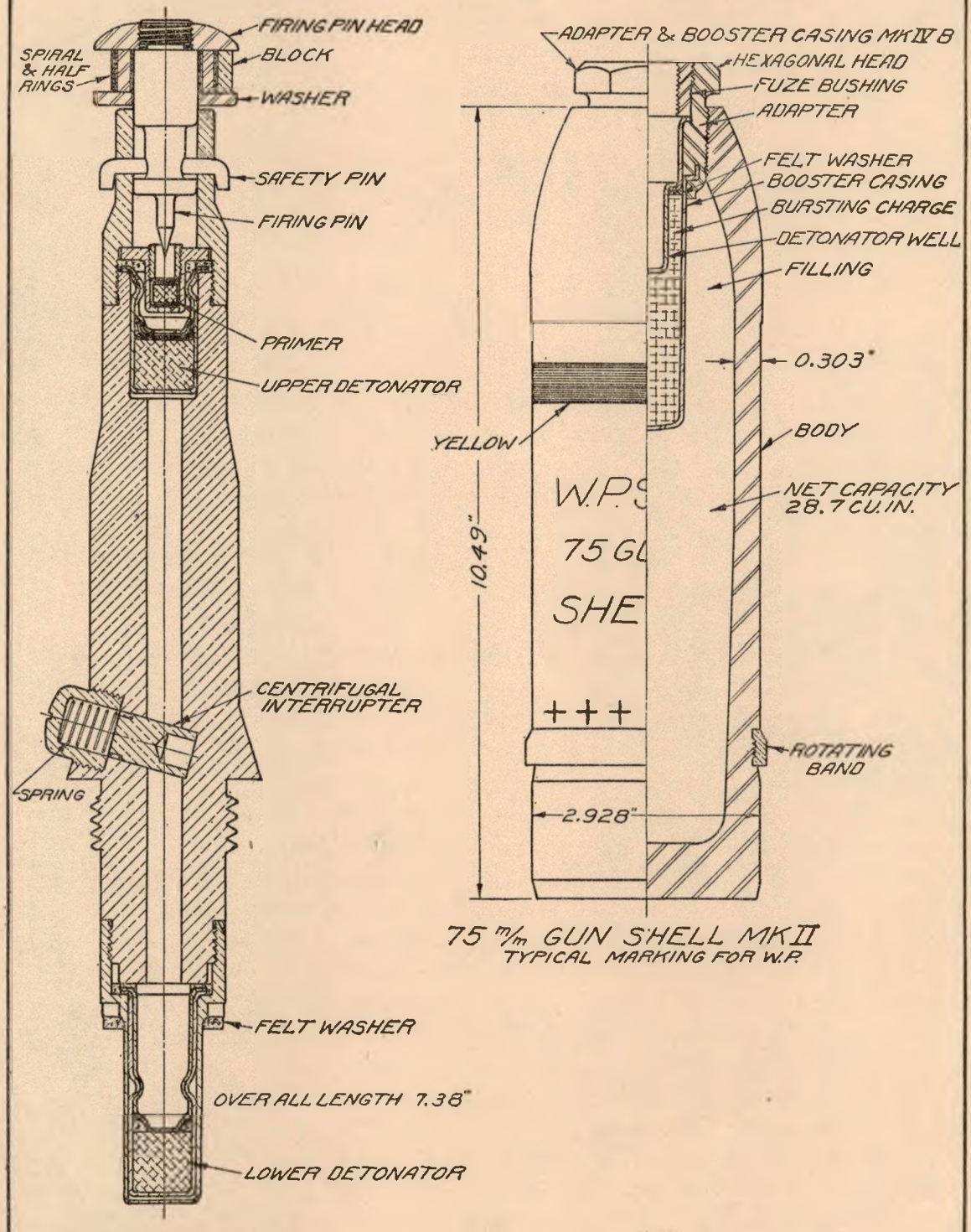

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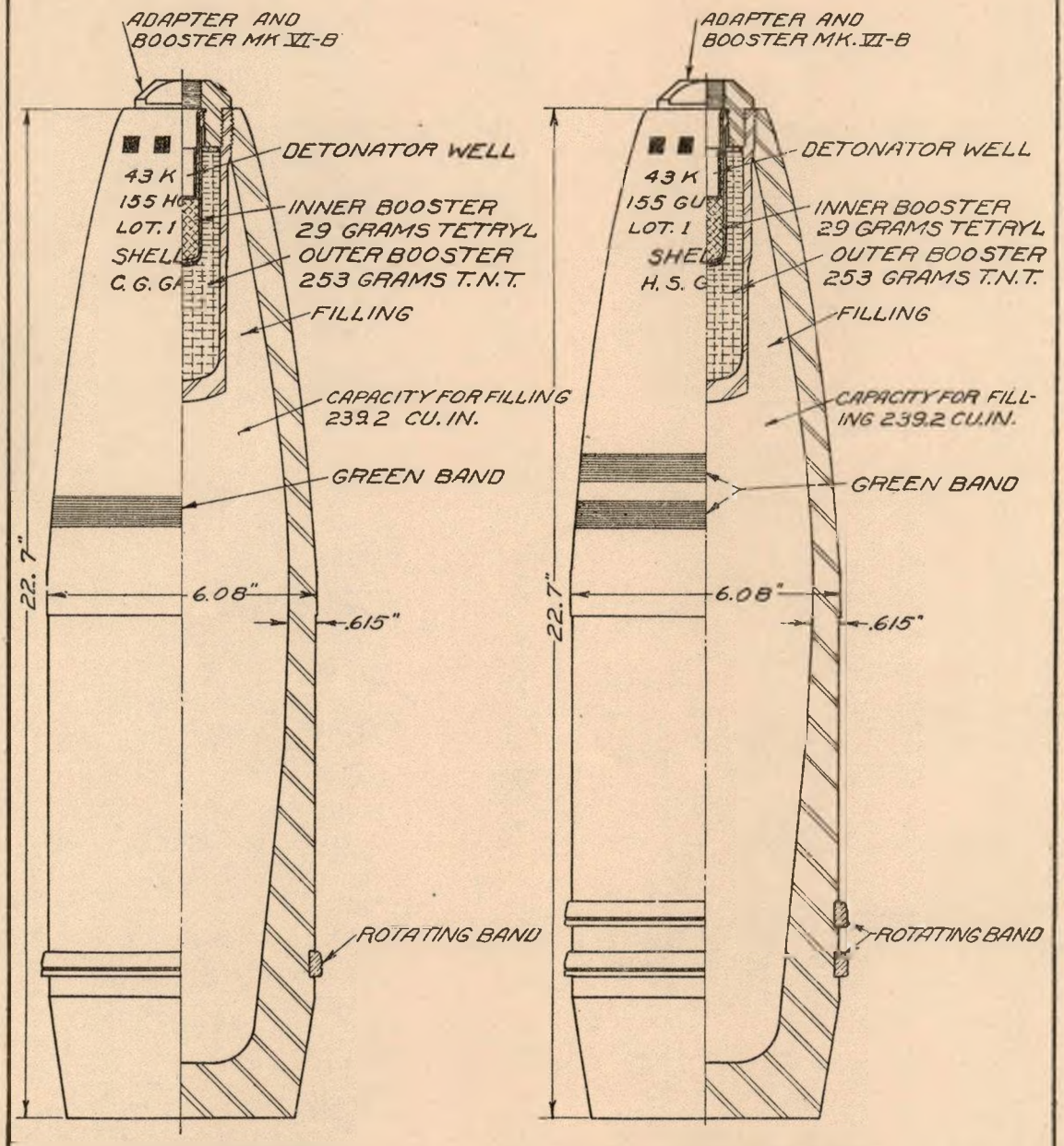
PLATE XV



SHELL, GAS MARK II
FOR 155 M.M. HOW.
TYPICAL MARKING FOR C.G.
TYPICAL MARKING FOR W.P. ONE YELLOW BAND

SHELL, GAS MARK VII
FOR 155 M.M. GUN
TYPICAL MARKING FOR H.S.

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PLATE XVI

The total capacity (net void) of the 75 mm shell is 29.14 cu. in., of the 155 mm shell, 249.8 cu. in.

16. THE ADAPTER AND BOOSTER. - The adapter and booster contains the bursting charge of the shell, and forms the gas-tight closure. The adapter carries a hexagonal head and a long tapered (pipe) thread which screws into the nose of the shell. The steel booster casing is welded to its lower end. The booster for the 75 mm shell contains 35.4 grams of tetryl; the booster for both 155 mm shell,29 grams of tetryl and 253 grams of T.N.T. The bursting charge is held in place by a flanged copper tube which forms a well for the fuze, and which in turn is held in place by a small adapter - threaded externally to the adapter, and threaded internally to take the fuze.

17. THE FUZE. - (See Plate XV). The Mark III fuze now used for all chemical shell is a point detonating, super-quick, 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 and upper detonator on 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 bolt which is actuated by a small spring, and 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.

a. Arming. The plunger 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, unwinds the ribbon, releasing the inner half collars and freeing the plunger. The plunger is prevented from being forced to the rear during flight by a stout shear wire.

b. 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.

c. Safety. The arming mechanism is held in place by means of a gummed tape of oil cloth, and a tinfoil cover.

18. THE CARTRIDGE CASE AND CHARGE. - a. The cartridge case of the 75 mm shell is a brass casing containing the propellant charge of nitro-cellulose powder. The charge is ignited by a percussion cap and a small compressed flashing charge of black powder contained in 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 consequently the maximum angle of fall. This not only reduces the wear on the bore, but facilitates reaching behind slopes or other accidents of the terrain.

19. WEIGHTS OF SHELL. - The weights of individual shell vary appreciably within minimum and maximum allowable limits; and for purposes of accuracy of fire, shell are marked according to relative weights within those limits. In selecting shell for a single mission, those of similar weight are segregated and fired, a correction being applied when a lot of relatively heavier or lighter weight is used.

TABLES FOR HE SHELL

a. For the 75 mm (Mk I and MK II) Shell, the relative weights are designated by pluses (+), stenciled just above the rotating band, as follows:

From	To	Weight Mark
10 lbs. 11 oz.	11 lbs. 0 oz.	L
11 lbs. 0 oz.	11 lbs. 5 oz.	+
11 lbs. 5 oz.	11 lbs. 11 oz.	+ +
11 lbs. 11 oz.	12 lbs. 0 oz.	+ + +
12 lbs. 0 oz.	12 lbs. 5 oz.	+ + + +

b. For the 155 mm Howitzer (Mk I, Mk II) and Gun (Mk III and Mk VII) Shell, relative weights are designated by blocks around the nose of the shell, as follows:

From	To	Weight Mark
91 Lbs. 3 oz.	92 lbs. 5 oz.	☐ ☐
92 lbs. 5 oz.	93 lbs. 6 oz.	☐ ☐ ☐
93 lbs. 6 oz.	94 lbs. 8 oz.	☐ ☐ ☐ ☐
94 lbs. 8 oz.	95 lbs. 10 oz.	☐ ☐ ☐ ☐ ☐
95 lbs. 10 oz.	96 lbs. 12 oz.	☐ ☐ ☐ ☐ ☐ ☐

20. IDENTIFICATION MARKINGS. - In common with all chemical munitions, chemical shell are divided into two classifications based upon tactical employment, namely, non-persistent and persistent. (NOTE: A persistent gas is arbitrarily defined as one which will remain in the vicinity where released, in effective concentration, for at least ten minutes).

Non-persistent agents (gases and irritant smokes) are indicated by one green band around the shell; persistent gases by two green bands.

All screening smokes are indicated by one yellow band.

The words "Gas" or "Smoke" are stenciled on the body of the shell, followed by the symbol designation of the specific agent contained - all in the same color as the designating band.

21. FILLINGS. - The following represent the type agents appropriate for the different calibers.

a. 75 mm

Gas Shell - Mustard Gas (HS - persistent)
- Chloracetophenone (CN in solution - persistent)
Smoke Shell - White Phosphorus (WP - non-persistent).

b. 155 mm Howitzer

Gas Shell - Mustard Gas (HS - persistent)
- Chloracetophenone (CN in solution - persistent)
- Phosgene (CG - non-persistent)
Smoke Shell - White Phosphorus (WP - non-persistent).

c. 155 mm Gun

Gas Shell - Mustard Gas (HS - persistent)
Smoke Shell - White Phosphorus (WP - non-persistent).

d. Pertinent data on chemical agents and certain weapons employed by Artillery:

PERTINENT DATA ON CHEMICAL AGENTS AND WEAPONS USED BY ARTILLERY

WEAPONS	RATES OF FIRE Rounds per Min.		TYPE AND APPROXIMATE WEIGHT IN POUNDS OF CHEMICAL AGENTS USED IN EACH WEAPON				RANGE (e)		
	Short Bursts	Prolonged	HS Mustard Gas (a)	CG Phosgene (b)	CNS Tear Gas (c)	WP Smoke (d)	Extreme	Maximum Accurate Fire	Effective Area Fire
75 mm Gun	6	3	1.3		1.5	1.8	8,800	7,000	8,000
155mm How	3	1	11.0	11.1	13.0	15.4	12,400	10,000	11,200
155mm Gun	3	1	11.0			15.4	18,000	14,400	16,200

NOTES:

Identification Marks -

(a) "HS Gas", and two bands, all in green

(b) "CG Gas", and one band, all in green

(c) "CNS Gas", and two bands, all in green

(d) "WP Smoke", and one band, all in yellow

(e) Ranges given are approximate only. Important factors are accuracy of corrections applied, previous adjustment, nature of target, and facilities for observation.

SECTION IV

CHEMICAL SHELL, FIRING

22. GENERAL CONSIDERATIONS. - a. Altho the general principles which govern the firing of chemical and HE shell are identical, special technique based upon the properties of the specific agents is demanded, and a knowledge of the behavior of agents upon release are essential, to make the most effective use of chemical ammunition. For example, chemical shell range shorter and have a greater dispersion than HE. Such factors must be considered in firing a non-persistent lethal agent such as phosgene, for too great 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, due to 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 HE shell bursts on the ground the effect is principally lateral, 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 non-persistent agents, the liquid spattered on the ground is rapidly converted into a vaporous cloud which immediately moves away from the point of burst under the influence of the speed and direction of the wind. The concentration of the cloud is greatest at the point of burst; but as the cloud travels, it spreads and heightens and tends to rise, 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 of the cloud. In the case of persistents, a large portion of the agent splatters on the ground. That in the air acts as a non-persistent 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 rays, 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.

c. In considering the relative casualty producing value of gas shells and high explosive shells, it may be said that either will make a casualty of anyone in immediate vicinity of its burst.

(1) Let us assume for the sake of argument that gas shells and high explosive shells, as single projectiles, have approximately equal value against personnel in the immediate vicinity of their bursts. Small gas shoots then are approximately equal in value to small HE shoots, but, as the number of shells fired increases, the gas shell bombardment becomes relatively more effective. This is due to the cumulative effect of gas shells in building up a lethal cloud which drifts down-wind -- a property not possessed by high explosive shells. In other words, the effect of 100 high explosive shells may be said to be 100 times the effect of one high explosive shell, but the effect of 100 gas shells is more than 100 times the effect of one gas shell, by an amount indicated by the area covered by the drifting cloud of gas.

(2) The idea that gas shoots are of no value except when a very large number of shells is fired is incorrect. The fallacy seems to be based on the idea that gas shells have no value except as their clouds join to set up a concentration which drifts down-wind and gets casualties as it goes. As has been indicated above this is merely the additional value of gas shells over high explosive shells. The gas shells have already done the work of high explosive shells when they set up their original individual clouds.

(3) Personnel in deep trenches and dugouts are immune from casualties due to high explosive shell fire except in the case of a direct hit. If the target is not accurately located and accurately adjusted upon no amount of shelling with high explosive will have any effect. If, on the other hand, gas shell are used, the gas will roll into the 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 gas shells burst upwind from the target. Accuracy is not so necessary. The gas itself will seek out its target. The fragments of a high explosive shell are effective for perhaps one second. The particles of mustard gas from a gas shell are effective for days.

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 bursts on any up-wind point of impact will cover the target. However, the greatest effectiveness is possible only under conditions of precision firing, with chemical agents as well as HE or shrapnel.

e. Future Possibilities. Experimentation since the World War indicates that the present power of mustard gas may be greatly increased by equipping the shell with a time fuze, adapted to burst the shell above ground. With an adequate booster, mustard gas would thus be showered as a fine mist having qualities approaching those of a volatile vesicant.

23. CALIBERS BEST SUITED TO THE VARIOUS TYPES OF AGENTS. - a. In general, low caliber shell are best suited for persistent agents, and large shell for non-persistents.

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 infected spots. The low capacity of the 75 mm shell (1.3 lbs. 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 nine times as many infected spots as the 155 mm Howitzer or gun firing the same quantity of agent. Of course, the 155 mm Howitzer and gun must be used for mustard gas beyond the range of the 75 mm gun.

c. The reverse is true for non-persistent 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 2 minute burst. The large capacity of the 155 mm shell (11.1 lbs. per round) makes this munition suitable for phosgene.

d. Smoke is used in the 75 mm shell and in both the

155 mm Howitzer and 155 mm Gun shell. Although the necessarily high 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 WARFARE WEAPONS USED BY THE AIR CORPS

SECTION I

GENERAL

1. INTRODUCTION. - a. Chemical agents were not disseminated by airplane during the World War, and what little development work was done was confined largely to drop bombs containing incendiary substances. A smoke bomb was developed by the French, but it was used for training (bombing) purposes only, to mark the registration of hits. White phosphorus was used as an incendiary but not a smoke substance.

b. Incendiary bombs were of two types, the intensive and scatter types. The intensive type was designed to penetrate and set fire to buildings or heavy construction and to bring the incendiary agent in direct contact with materials to be damaged. The fillings generally used were special thermite and metallic sodium. The scatter type was designed to set fire to light construction or objects easily ignited. The fillings were white phosphorus and solidified oils. Incendiary air munitions have such a highly specialized and restricted use that they are now obsolete.

2. POST-WAR DEVELOPMENT. - a. The development of chemical warfare as applied to aircraft has kept apace with general progress in aviation. The effectiveness of the airplane as a means of projecting chemical agents has outstripped expectation; and it has been demonstrated that the following types of agents are

suitable for such dispersion: HS, CNS, FM and WP. It has further been demonstrated that the effectiveness of certain agents has been increased to a point far beyond that yet obtained by other weapons.

b. The wide radius of action and potency of the effects now possible with aircraft introduce conditions into warfare hitherto unknown, and radically change the aspect of chemical warfare from the defense or protective standpoint. The taking of warfare into the air is certain to increase the depth of attack generally, and to make installations and movements in rear areas much more important as local or strategical objectives, and far less invulnerable to attack than hitherto; and is likely to exert an influence on the organization of the theater of operation.

3. PRESENT STATUS. - a. The projection methods now being considered for gas and smoke are as follows:

Pressure apparatus - sprinkling
Non-pressure apparatus - spraying
Chemical-filled standard type bombs
Special chemical bombs.

b. Altho the development of projection apparatus and of air chemical tactics are still in an experimental stage, the work has been carried sufficiently far to demonstrate the physical, chemical and military feasibility of the projects; and one standard bomb has been approved.

c. All special 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 APPARATUSES

4. GENERAL. - a. In projecting a liquid from a fast moving airplane where the liquid is intended to fall to the ground as drops of rain, or in drops relatively large compared with the product of the atomizing apparatus, it is necessary to expel the liquid at a rate of speed equivalent to the air speed of the plane, otherwise the agent becomes so completely atomized as to hang in the air as a very fine mist and fail to reach the ground, if released from high altitudes.

b. The size of the drops is principally a matter of pressure and design of nozzle. The drift of the particles, and the extent of the area covered, varies with the altitude of the plane and the velocity of the wind.

c. Two general types of apparatus have been developed, the pressure apparatus (sprinkling) and the non-pressure apparatus (spraying or atomizing).

5. PRESSURE APPARATUS (SPRINKLING). - a. This was the first means developed for the sprinkling of chemical agents. It consists essentially of a tank containing the agent, a tank of carbon dioxide gas, to provide pressure for forcing out the agent, an outlet pipe with the nozzle at the tail of the plane and the necessary control valves, gauges and connections. It is designed for attachment to the bomb rack. Due to the weight involved it is only suitable for use with the large weight carrying plane, such as the bomber.

b. The capacity of this type of apparatus is limited, as its weight is large in comparison with that of the agent contained. Also, the amount of expellant (CO_2) carried, and the proper control of pressure, handicaps efficient operation and adaptation.

c. Agents of the mustard type and lacrimators may be used. Liquid smokes (i.e., FM - Titanium Tetrachloride) may be used for screening purposes in the smoke curtain form. This method may be efficiently employed up to altitudes of 2000 feet with mustard gas and up to 600 feet with FM.

d. The fall of the liquids is directly affected by the drift due to the winds; consequently, the main difficulty in sprinkling from high altitudes lies in being able to compute the course to be flown over in order to cover the objective. For

altitudes up to two thousand feet this is a fairly simple proposition and can be classed as fairly accurate. For higher altitudes the system can be used only under the most favorable air conditions such as might be encountered at night.

e. Using this system of sprinkling at nine hundred feet altitude with an average wind velocity of thirty miles per hour an area approximately 300 yards wide by 1400 yards long can be covered by 700 pounds of liquid agent. The width of the area increases directly with the altitude from which the liquid is dropped and with the wind velocity. The persistency of the gas decreases as the area increases.

6. NON-PRESSURE APPARATUS (SPRAYING OR ATOMIZING). - a. This apparatus utilizes the normal pressure generated by the speed of the plane to atomize the agent. It consists of a stream-lined tank, a control valve, vent, and connections. Pressure is supplied to the liquid in the tank by means of the vent. The discharge nozzle reduces the liquid to a fine spray or mist. The particles are very minute and drift with the wind. Two types of this apparatus have been designed; a fuselage tank which is attached on the reserve gasoline tank rack and a stream-lined wing tank which is attached to the wing bomb rack.

b. In this type of apparatus the rate of release of the agent is a function of the speed of the plane. It is the most economical and effective method yet developed, and is particularly adapted to fast, low-flying planes. Vesicants, lacrimators and smokes may be used.

7. VALUE OF SPRAYING AND SPRINKLING. - a. The effectiveness of chemicals projected from planes, especially in spraying, lies in the enormous effective concentrations that can be accurately put down on targets of large area under conditions approaching complete surprise, and in the inadequacy of any practical protection against them.

b. The high concentrations arise from the minute state of atomization and resulting high dispersal of the agents, released instantaneously and in quantity over the area. In such a state, a highly persistent agent (such as mustard gas) becomes less persistent; the concentration in the air is probably increased beyond that obtained by any other method now known; the ultimate physiological potentiality of the agent is more fully

realized; and the effects are more rapidly produced.

c. Using this type of apparatus at an altitude of 50 feet and a wind of 10 to 12 miles per hour, an area approximately 300 yards wide and 1500 yards long can be covered by 330 pounds of liquid agent. The width of the area increases directly with the altitude from which the liquid is released and with the wind velocity. The persistency and concentration of the gas decrease as the area increases.

d. The dispersion of chemicals by aircraft facilitates the supply of chemicals due to the location of air fields in rear of the front lines.

8. TACTICAL USES. - a. Smokes are used for screening effect, either as ground smoke or as smoke curtains. The former are laid on the ground or target, either to screen or blanket; the latter are suspended in the air for screening purposes.

b. Lacrimators are used for harassing or demoralizing effect.

c. Vesicants when used in sprays may be employed for direct casualty effect, for harassing or for interdiction. Ground smoke may be laid on a target, such as a column of troops, to prevent aimed fire, and chemicals sprayed down thru the smoke for casualty effect.

9. USES OF CHEMICALS BY TYPES OF AIRCRAFT. - a. Bombardment. Bombing airplanes are adapted to the use of either chemical bombs or to the sprinkling device. The latter system requires fairly heavy equipment which practically limits its use to bombing aircraft.

b. Attack. Attack airplanes, which are designed for relatively low flying together with a fairly high speed and weight carrying ability, can be equipped with either chemical bombs or spray tanks.

SECTION III

STANDARD TYPE BOMBS

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 have been attempts in the past to use the bodies of standard demolition bombs for chemical fillings. As a general rule, these demolition bodies have not been found practical for such use. Also, aircraft bombs in general are not considered a practicable means of putting down concentrations of non-persistent gases. One chemical bomb has been developed for HS filling, has gone thru full service tests, and has been approved by the War Department as standard for manufacture and issue. This is known as the Bomb, Chemical, 30 lb. M-I.

11. DESCRIPTION OF THE M-I, 30 LB. CHEMICAL BOMB. - This bomb is a standard stream-line design for true flight, and consists of a body, filling, booster, fin assembly and fuze. The body weighs about 19 lb. and is drawn from seamless steel tubing. It carries a little less than 10 lb. of mustard filling. It will be noted that the ratio of weight of filling to weight of body does not show the same efficiency as the drum of the Livens projector. This is due to the limitations in design imposed by the demand for a bomb having true flight. The bomb does not require special filling holes, but is filled thru the fuze opening at the nose of the bomb, and is closed after filling by screwing in an outer booster casing or well tube which runs the whole length of the bomb. A pipe threaded joint insures the seal. Booster and fuze are shipped separate from the bomb and are assembled just before use. Chemical bombs have the same general appearance as demolition bombs, except that they are painted after the same system of marking as other chemical filled munitions. They are released from the same type of bomb racks as other bombs. Moreover, since bombs do not rotate in

the air like artillery shell, the difference in ballistic properties between a liquid-filled bomb and a solid-filled bomb becomes negligible, whereas in artillery shell the difference between the two types is considerable.

12. FUZE. - a. The Mark XIV Fuze now used is a direct impact fuze consisting of a firing pin, sleeve, arming vane and cup, eight steel balls, shear wire and safety pin. The firing pin is suspended in the sleeve by the shear wire, and a circle of 8 steel balls placed between the flange of the firing 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 to the extremity of the firing pin. When in position on the bomb in the bomb rack, a safety pin, which is attached to the rack by means of a wire, passes thru an eye on the side of the fuze and thru a small hole in the vane to preclude rotation. An additional safety pin passes thru the body and firing pin for safety during transportation.

b. Operation. When the 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. After 13 turns, the arming vanes and cup drop off, releasing the steel balls and arming the fuze. On impact, the shear wire is sheared and the firing pin penetrates the primer.

13. USE OF FILLINGS OTHER THAN HS. - Fillings other than HS are suitable for use in the chemical bomb (30 lb. M-I). In addition to the HS, two other fillings are now standard. These comprise CNS (lacrimator) and WP (smoke). The use of the latter filling in bombs as a casualty producer is still being investigated.

SECTION IV

SPECIAL CHEMICAL BOMBS

14. FLOATING SMOKE BOMB. - 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 reaction of the components of the HC 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, non-toxic smoke of great obscuring power is released thru the check valve. The bomb continues to burn for 5 minutes.

15. STATUS OF DEVELOPMENT OF SPECIAL CHEMICAL BOMBS. - a. There have been many suggestions for special chemical bombs which would give air-burst with HS fillings and a wide radius of dispersion of the contents. In general the problem coincides with that considered for many years in fragmentation bombs. Most of the suggestions have proved impractical, including long fuze extrusions and various adjustable time fuzes. One type, the Davis-Woodberry Expulsion Bomb, designed in the Ordnance Office at Edgewood Arsenal, has reached a higher development stage than any other schemes of the sort to date and has given some promising results in preliminary local tests. Any such special bomb before adoption, however, must show reasonable manufacturing costs, high certainty of functioning under a wide variety of conditions and simplicity in assembly, as well as high weight efficiency and efficiency in dispersion of contents. It is still too early to make any reasonable prediction on the success of a bomb of this type.

b. The efficiency of the present chemical bomb (ratio of agent to total weight) is lower than desired, being approximately 30%. Experiments are being conducted in view of developing chemical bombs, both 30 pound and 100 pounds with a higher efficiency.