TM 3-3

WAR DEPARTMENT

TECHNICAL MANUAL

PORTABLE CHEMICAL CYLINDER MIA2

February 11, 1942

TECHNICAL MANUAL

PORTABLE CHEMICAL CYLINDER M1A2

CHANGES No. 1

WAR DEPARTMENT,
WASHINGTON, January 13, 1943.

TM 3–315, February 11, 1942, is changed as follows:

8. Equipment for firing cylinders electrically.

* * * * * * *

b. Blasting machine.

* * * * * * *

(1) *Description.*—The machine may be either of the magneto or dynamo type. The magneto type has a permanent magnet for a field. This machine has no commutator. The dynamo type shown in figure 17 has electromagnets for a field and is equipped with a commutator.

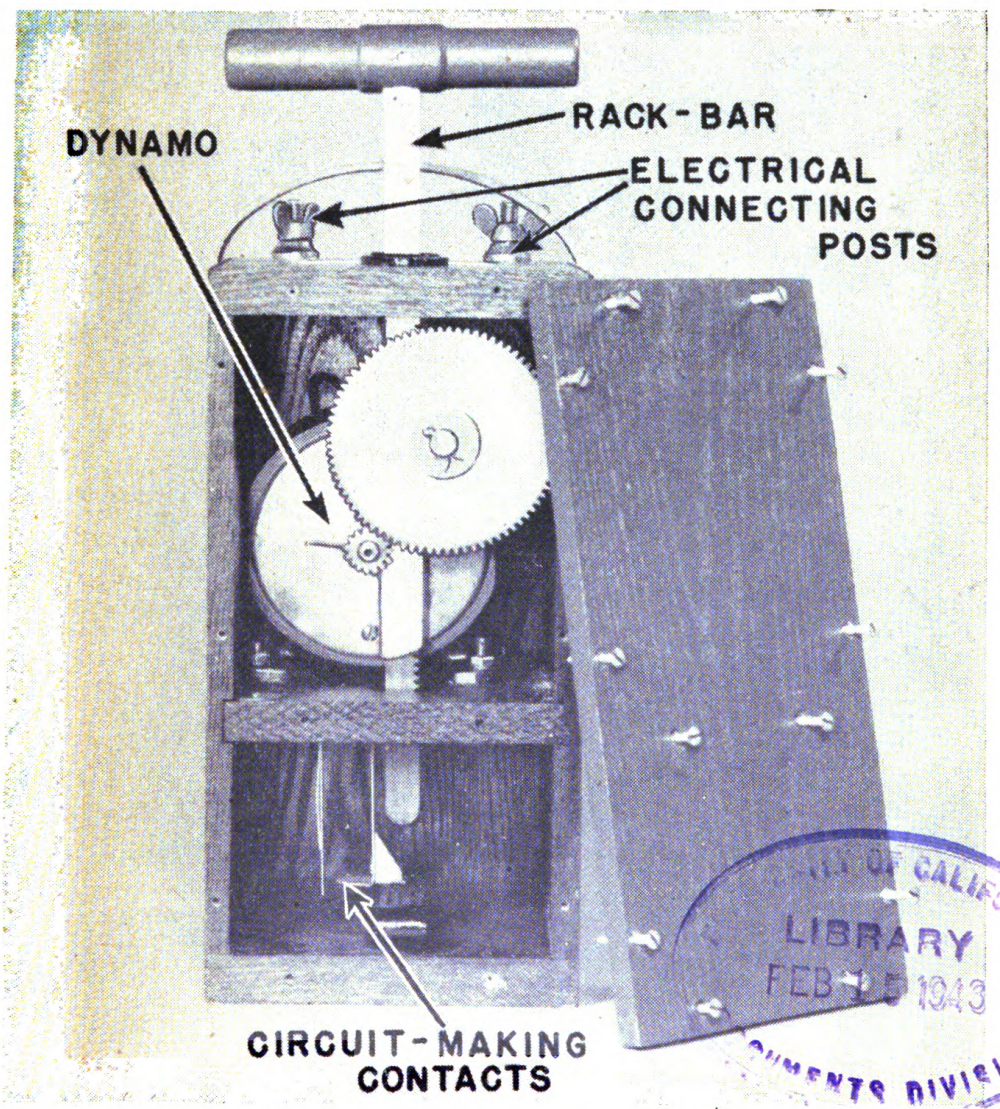

FIGURE 17.—Dynamo type blasting machine.

* * * * * * *

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(3) *Care.*—The machine should * * * upon the commutator. The circuit-making contact should likewise be kept bright and clean.

* * * * * * *

[A. G. 062.11 (12–21–42.] (C. 1, Jan. 13, 1943.)

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:
J. A. ULIO,
Major General,
The Adjutant General.

U. S. GOVERNMENT PRINTING OFFICE: 1943

TECHNICAL MANUAL

PORTABLE CHEMICAL CYLINDER MIA2

CHANGES No. 2

WAR DEPARTMENT,
WASHINGTON 25, D. C., 19 February 1944.

TM 3–315, 11 February 1942, is changed as follows:

3. General description. — *a. Cylinder MIA2.* — The portable chemical cylinder is a weapon of high mobility and chemical efficiency, but its combat use depends entirely upon opportunity, favorable weather, and terrain conditions. The MIA2 cylinder * * * is 22 pounds.

* * * * * * *

(5) (Added) *Special uses.*—The cylinder when modified by the removal of the nozzle, reducing coupling, nipple, and eduction tube may be filled with chlorine and used for training purposes. Such cylinders are usually filled at chemical warfare depots, the cylinders themselves serving as shipping containers.

* * * * * * *

c. Chemical filling.—The approved standard * * * a pressure within. **Cylinders modified for training purposes are filled with chlorine.**

* * * * * * *

(4) (Added) *Chlorine filling.*—Each filled cylinder contains about 30 pounds of chlorine.

d. Pressure charge.—The filled portable * * * from the cylinder. **No pressure charge is needed, however, for cylinders which contain only chlorine.**

* * * * * * *

[A. G. 300.7 (14 Dec 43).] (C 2, 19 Feb 44.)

5. Weights.

* * * * * * *

b. Chemical filling.—The weights of * * * are as follows:

	Pounds
Nonpersistent gas, CG	31
Nonpersistent gas, Cl	**30**
Smoke, FS	36

* * * * * * *

*The individual items in this change will be cut apart and pasted over the specific paragraphs or subparagraphs affected.

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c. Filled cylinder.—The weights of * * * are as follows:

Filling	*Charging agent*	*Approximate total weight (pounds)*
Nonpersistent gas, CG	Carbon dioxide	55
Nonpersistent gas, CG	Chlorine	57½
Nonpersistent gas, Cl (Nozzle, reducing coupling, nipple, and eduction tube are removed.)	**None**	**48**
Smoke, FS or FM	Carbon dioxide	60

* * * * * * *

[A. G. 300.7 (14 Dec 43).] (C 2, 19 Feb 44.)

9.1 Filling cylinders with Cl(Added).—*a. General.*—Chlorine is usually supplied in 1-ton containers. There is always sufficient chlorine vapor pressure to expel the liquid chlorine from the 1-ton containers. A simple vented filling line and scales are the only equipment required.

b. Procedure.—Figure 31.1 shows the usual method of filling a portable chemical cylinder with chlorine. Steps in filling are:

(1) Remove the cap from the lower outlet of the 1-ton container, first making sure that the valve is closed.

(2) Attach a filling line similar to, and in a manner as shown in figure 31.1.

(3) Remove the nozzle, reducing coupling, nipple, valve, and education tube from a portable chemical cylinder.

(4) Dry the cylinder, unless the previous filling was chlorine, and replace the valve. (The nozzle, reducing coupling, nipple, and education tube are not used.)

(5) Attach the cylinder to the flexible hose of the filling and place the cylinder on the scale platform, noting its weight.

(6) Close the filling-line vent valve and open the 1-ton container's lower valve, the filling-line valve, and the cylinder valve.

(7) Permit chorine to flow until the scales indicate that 30 pounds have been added.

(8) If the flow of chlorine stops before the cylinder has received 30 pounds, the filling-line valve should be closed and the vent valve opened to release excessive vapor pressure. The vent valve is then closed and the filling-line valve opened until the scales indicate 30 pounds of chlorine.

(9) To stop the flow of chlorine, close the filling-line valve and the cylinder valve.

(10) When a cylinder has been filled, the vent valve should be opened, the cylinder disconnected, and its cap tightly attached.

NOTE.—Cylinders that have been modified for and used with chlorine in training must not be used for other purposes until they have been emptied, dried, and had their eduction tubes replaced.

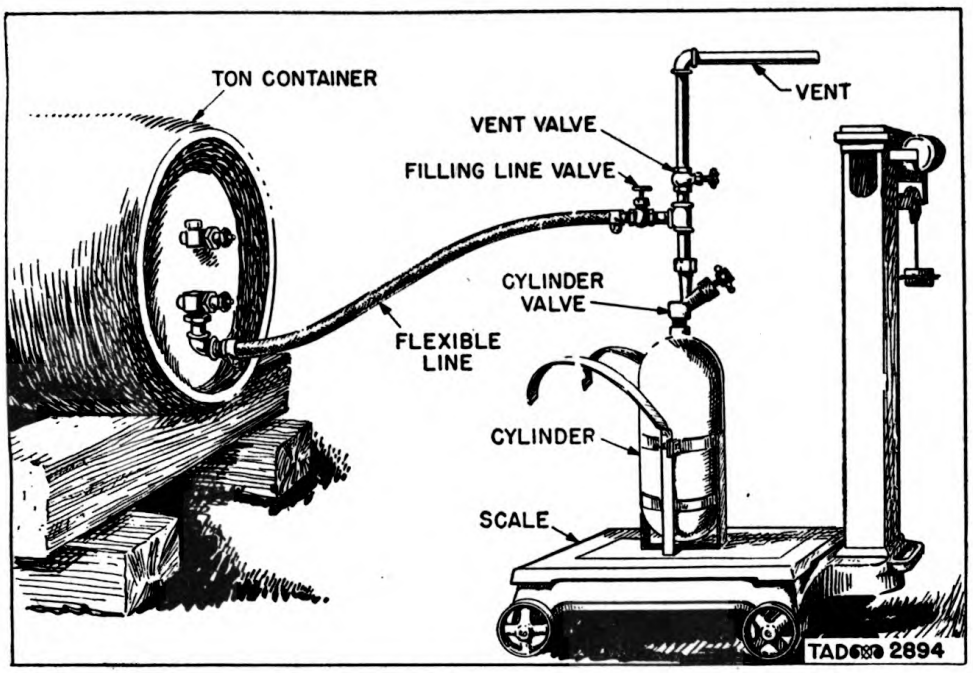

Figure 31.1—(Added) Improvised assembly for filling cylinders with chlorine.
[A. G. 300.7 (14 Dec 43).] (C 2, 19 Feb 44.)

c. Precautions.—(1) Immediately after charging operations are completed, the filling line should be vented, disconnected, thoroughly washed in a 5 percent solution of washing soda, rinsed in clear water, dried, and carefully stored.

(2) Persons engaged in charging cylinders with chlorine should work on the up wind side of the apparatus and should put on gas masks when sufficient chlorine is present to be irritating.

(3) Steps must be taken to see that no unprotected personnel are immediately down wind during filling operations.

[A. G. 300.7 (14 Dec 43).] (C 2, 19 Feb 44.)

16. Inspection.

* * * * * * *

c. Filled cylinders.—Filled cylinders should be inspected 24 hours after being placed in storage. Phosgene **and chlorine** leaks are detected by use of aqua ammonia fumes and are indicated by the formation of white smoke. FS or FM * * * use by personnel.

[A. G. 300.7 (14 Dec 43).] (C 2, 19 Feb 44.)

18. Disposal of leaky cylinders.

* * * * * * *

b. Leaking containers.

* * * * * * *

(2)

* * * * * * *

(*c*) (Added) *Transfer of chlorine.*—Chlorine may be transferred from one cylinder to another in the following manner: after the caps are removed, the cylinders are connected by the kind of filling line shown in figure 31.1. With the leaky cylinder inverted above the good cylinder, the vent valve is closed and the filling-line valve is opened. The pressure of the chlorine vapor will force the liquid chlorine into the good cylinder. Cylinder valves are then closed, the filling line vented and removed, and the cylinder caps replaced. The filling line is cleaned as prescribed in paragraph 9.1.

[A. G. 300.7 (14 Dec 43).] (C 2, 19 Feb 44.)

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
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U. S. GOVERNMENT PRINTING OFFICE: 1944

TECHNICAL MANUAL
No. 3–315

WAR DEPARTMENT,
WASHINGTON, February 11, 1942.

PORTABLE CHEMICAL CYLINDER M1A2

Prepared under direction of the
Chief Chemical Warfare Service

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SECTION I

GENERAL

1. Purpose and scope.—This manual is intended for the using services. It gives all necessary information regarding the construction, functioning, and identification of all standard matériel pertaining to the MIA2 portable chemical cylinder, with directions for operating such matériel. It also gives brief directions for conducting filling and charging operations to meet field filling requirements.

2. References.—All references to be used in conjunction with this manual are shown in appendix II.

SECTION II

DESCRIPTION AND DATA

3. General description.—*a. Cylinder MIA2.*—The portable chemical cylinder is a weapon of high mobility and chemical efficiency, but its use depends entirely upon opportunity, favorable weather, and terrain conditions. The MIA2 cylinder is shown in figures 1 and 2 and consists of five parts: container MII plus eduction tube (not shown); valve MIII; carrier MIA2; and nozzle MI. Its total weight empty is 22 pounds.

(1) *Range.*—The range of the cloud produced by a cylinder emplacement varies from 2,000 to 7,500 yards, depending upon weather factors, the spacing of cylinders, and length of front along which the gas cloud is released.

(2) *Efficiency.*—The filled cylinder weighs about 60 pounds, and carries approximately 31 pounds of nonpersistent gas or 36 pounds of smoke agent plus about 2 pounds of carbon dioxide; hence, chemical efficiency of this munition is 56 percent for nonpersistent agent and 60 percent for smoke agent.

(3) *Mobility.*—Due to the limited effective range of the cylinder, the time required for its emplacement, and its dependency upon favorable weather conditions, this weapon is useful only in stabilized or semistabilized operations.

(4) *Functioning.*—The standard method of releasing the contents of the cylinder is by a manually operated valve. One man can fire from three to five cylinders by hand. With the use of a special type

FIGURE 1.—Portable chemical cylinder MIA2 (front view).

valve, the cylinders can be fired in groups by an electric firing mechanism.

b. Limited standard cylinders.—The limited standard cylinders are the MI and MIA1, and are shown together with the MIA2 cylinder in figure 3. They differ from the standard MIA2 cylinder only in the method of construction of the container, and a slight difference in the carrier dimensions. Both the MI and MIA1 cylinder containers are 8 inches in diameter. The MI cylinder container is 19¾ inches and the MIA1 cylinder container 21 inches in height. The bottom of the MI cylinder container is a "lipped" metal cup inserted into the container and welded at its bottom edge. The bottom of the MIA1 cylinder container is convex in shape and welded to the extreme bottom of the container without insertion.

c. Chemical filling.—The approved standard fillings for the cylinder are the nonpersistent gas, phosgene, and the smoke agents, FS and FM.

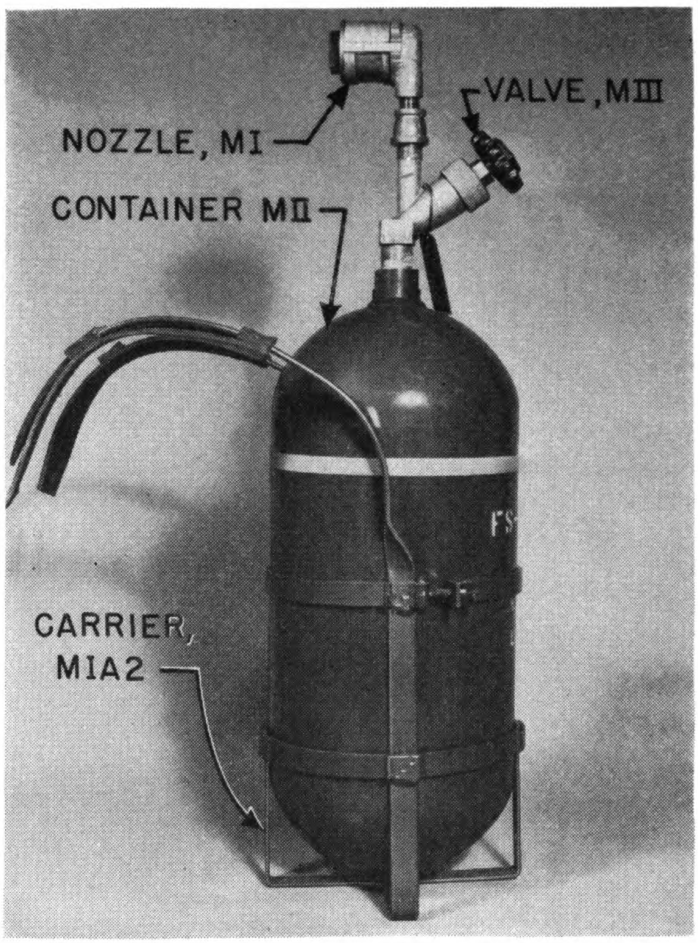

FIGURE 2.—Portable chemical cylinder MIA2 (side view).

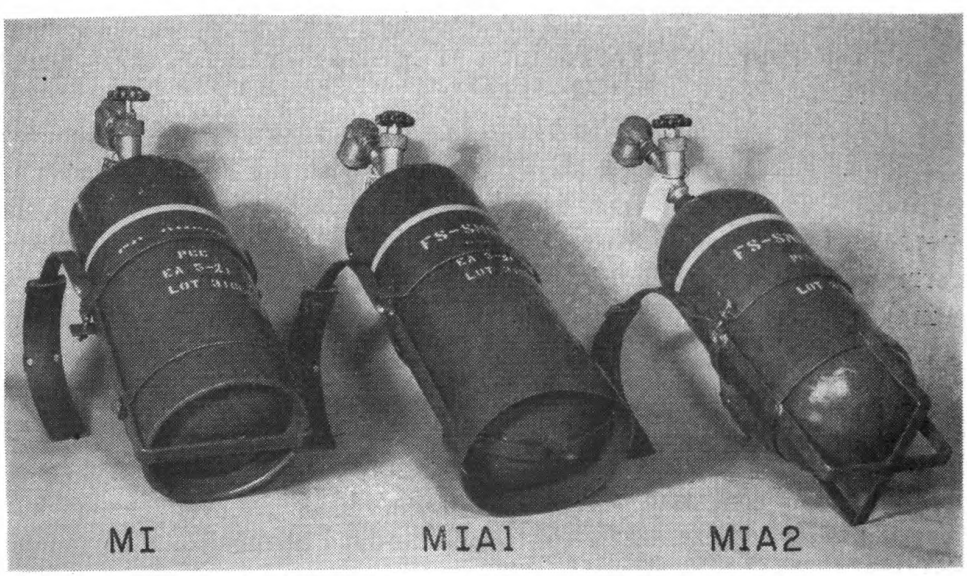

FIGURE 3.—Portable chemical cylinders MI, MIA1, and MIA2.

Liquid lacrimators, CNB and CNS, are authorized fillings for training purposes. In addition to the chemical filling, the cylinder is charged with a compressed gas to maintain a pressure within.

(1) *Phosgene gas filling.*—Phosgene is the only approved gas filling, and each filled cylinder contains approximately 31 pounds.

(2) *Smoke filling.*—(*a*) FS is the standard smoke filling, and each filled cylinder contains approximately 36 pounds.

(*b*) FM is the limited standard smoke filling, and each filled cylinder contains approximately 36 pounds.

(3) *Tear gas filling.*—(*a*) CNB is the standard tear gas filling for training purposes, and each filled cylinder contains about 23 pounds.

(*b*) CNS may be used as a tear gas filling, but it is much more powerful than CNB and is not generally used for cylinder filling in training. Each filled cylinder contains about 30 pounds.

d. Pressure charge.—The filled portable chemical cylinder contains a charge of compressed carbon dioxide or chlorine to maintain the pressure required to discharge the chemical agent from the cylinder.

(1) *Carbon dioxide.*—In all areas other than the Territory of Hawaii pressure is maintained within the cylinder by a charge of approximately 2.5 pounds of carbon dioxide. The pressure in the charged nonpersistent gas-filled cylinder is about 118 pounds per square inch, and the pressure in the charged smoke-filled cylinder is about 134 pounds per square inch at a temperature of 70° F.

(2) *Chlorine.*—For use in the Territory of Hawaii the gas-filled cylinder is charged with 5 pounds of chlorine.

4. Detailed description.—*a. Container MII.*—(1) *Construction.*—This container is a steel cylinder having a hemispherical top and bottom. The bottom half is joined to the upper half by a welded joint as shown in figure 4. The container has the following dimensions:

Outside diameter	$8\frac{5}{32}$ inches.
Height	19 inches.
Thickness of wall	0.078 inch.
Maximum thickness at bottom	$\frac{1}{4}$ inch.
Maximum thickness at top	$\frac{3}{16}$ inch.
Volumetric capacity	815 cubic inches.
Weight (including adapter)	$11\frac{3}{4}$ pounds.

The minimum physical requirements of the steel used in its construction are—

Tensile strength	55,000 pounds per square inch.
Elastic limit	37,000 pounds per square inch.
Elongation in 2 inches of steel	30 percent.

(2) *Adapter.*—A steel adapter is welded to a hole in the top of the container as shown in figure 4. The adapter is 1½ inches long and has an outside diameter of 1⅝ inches. At its base, the adapter has a collar 5/16 inch wide which fits along the inside surface and is welded to the container along the outside surface. A hole ¾ inch in diameter passes through the center of the adapter and is threaded with ¾-inch standard pipe threads to receive the valve. Two flat areas spaced 1¼ inches apart are on opposite sides of the adapter to provide a grip for an open-end wrench while the cylinder valve is being inserted in the adapter.

(3) *Eduction tube.*—The eduction tube is 19 9/16 inches long and consists of ⅜-inch standard black wrought-iron pipe. It is cut at its bottom at an angle of 45°, as shown in figures 4 and 5, to insure free flow of liquid, and is threaded at the top to screw into the valve body. (See also fig. 7.)

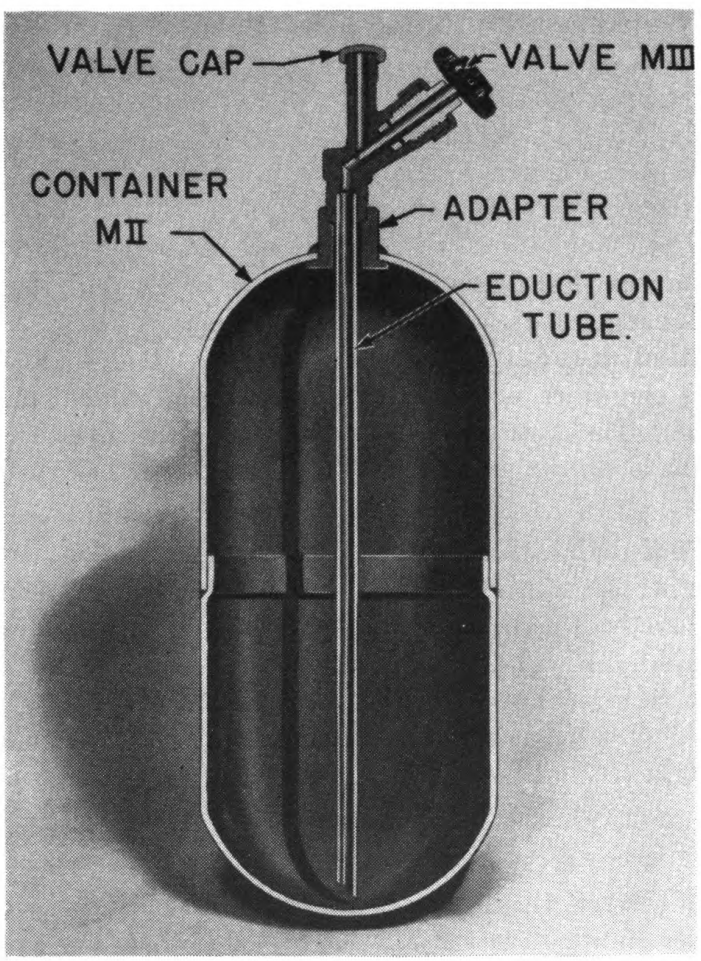

FIGURE 4.—Construction of portable chemical cylinder MIA2 (less carrier).

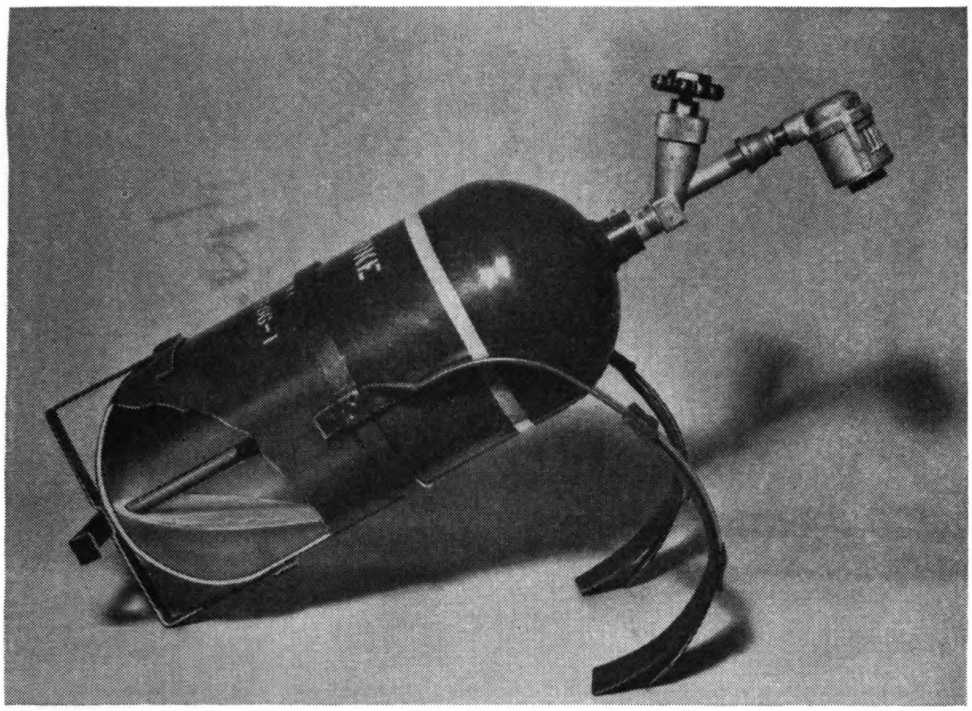

FIGURE 5.—Sectionalized view of portable chemical cylinder MIA2 showing chemical filling remaining in cylinder at end of discharge period.

(4) *Painting and marking.*—(*a*) The container is lacquered with an olive-drab enamel and marked as shown in figure 6.

(*b*) Containers filled with nonpersistent gas (CG) have a green band ½ inch wide painted around the container, 6½ inches below the adapter to indicate that the agent is a nonpersistent casualty agent. The symbol and type of agent (CG–GAS) are painted in ¾-inch green letters below the band. Underneath are additional data in ½-inch letters and numbers:

PCC
EA (loader's identification mark)
Lot number

(*c*) Containers filled with smoke carry similar markings. The identifying color band is yellow rather than green, to indicate that

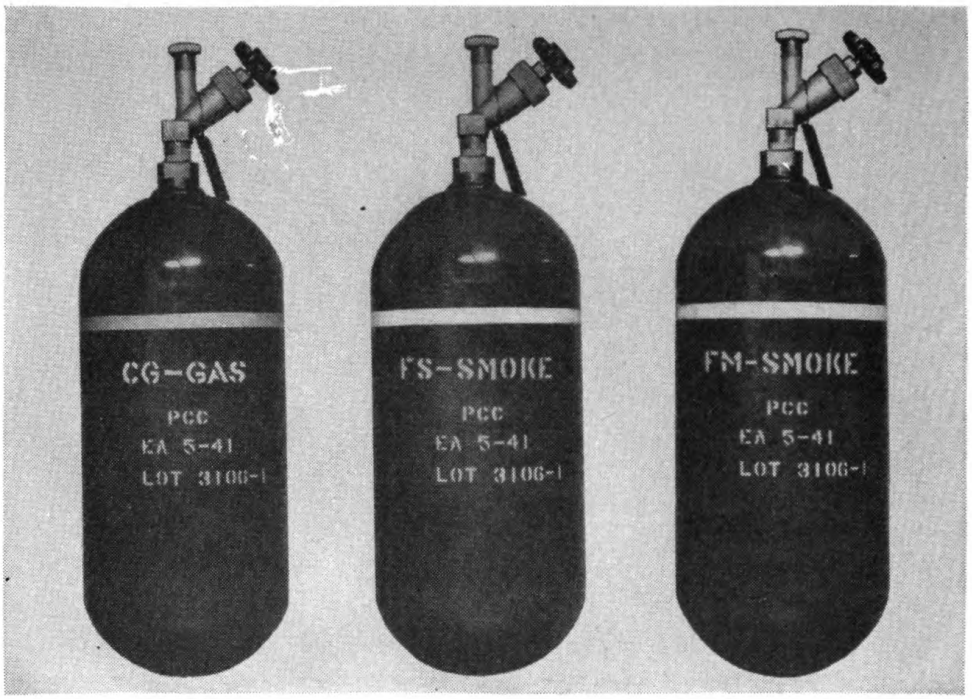

FIGURE 6.—Identification marking of portable chemical cylinder.

the filling is a nonpersistent screening agent, and the symbol and type of agent are marked "FS–SMOKE" or "FM–SMOKE."

(*d*) Containers filled with CNB or CNS are marked with one red band to indicate that the content is a harassing agent. The symbol and type of agent (CNB–GAS) or (CNS–GAS) are also painted on the container. All markings follow the system for the CG cylinder.

b. Valve MIII.—(1) *Construction.*—This valve is of the Y-type and is shown in figure 7. The brass body has the shape of an offset Y, and is provided with threads at the bottom to receive the eduction tube and to screw into the container adapter, and at the top to receive the nozzle or outlet cap. The copper nickel valve stem operates by a screw thread along the inside of a brass packing gland to open or close the valve. A gastight seal between the valve stem and valve body is maintained by a graphite impregnated braided asbestos packing. A brass washer is interposed between the packing and the packing gland, and another brass washer supports the packing at the bottom of the stuffing box. The packing gland carries left-hand threads which operate against the valve body to compress the packing. The brass check nut screws on the outside of the valve body with a right-

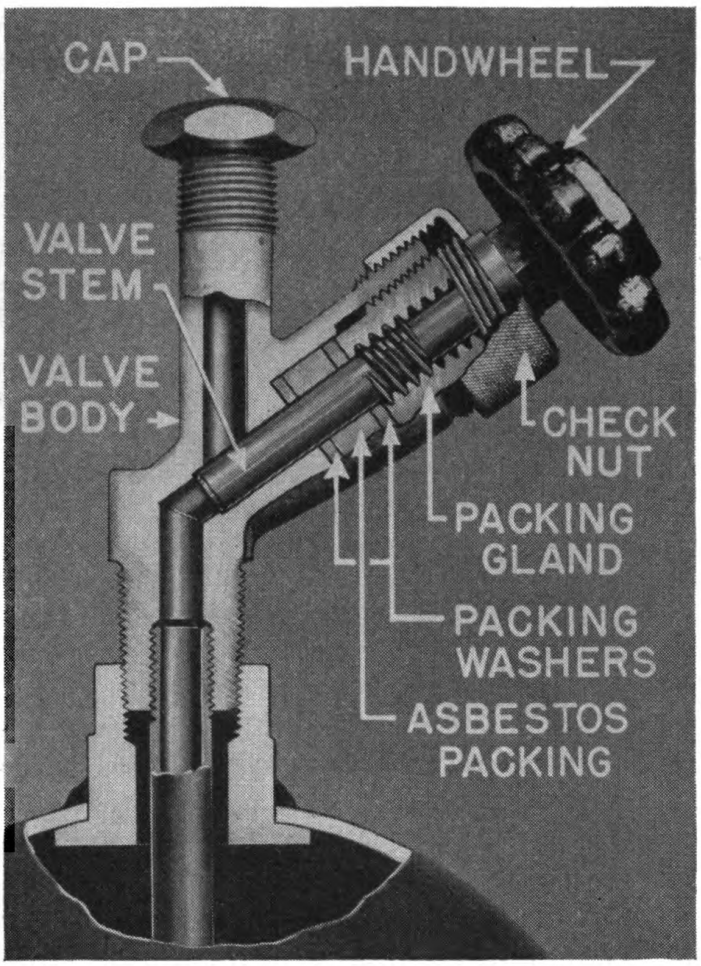

FIGURE 7.—Valve MIII, sectionalized view.

hand thread, and has a collar to press against the shoulder on the packing gland in order to prevent the gland from loosening during operation of the valve. The packing gland has a hexagonal top for use in tightening with a wrench. The cast-iron handwheel is provided with a hexagonal centerpiece so that a wrench may be used to tighten the valve. A brass tag is attached to the body of the valve by a steel wire and reads, "Tighten packing by turning nut TO LEFT—follow up with knurled check nut by turning TO RIGHT." The valve outlet is sealed by a valve cap and a hard fiber sealing disk as safety precautions for filled cylinders.

(2) *Corrosion prevention.*—The valve is lacquered with one coat of olive-drab enamel on all outside surfaces except threads and face of label.

c. Nozzle MI.—This nozzle is attached to the threaded end of the valve outlet, and is designed to decrease the loud hissing noise caused by a gas escaping under pressure. This nozzle is used only when the principle of surprise is to be utilized.

(1) *Construction.*—As shown in figure 8, the nozzle consists essentially of a cylindrical chamber, in one section of the wall of which are ten parallel slots. The brass base of the nozzle is attached to the valve by a brass coupling and nipple. The brass barrel has an outside diameter of 2 inches and a length of $1\frac{11}{16}$ inches. Its bottom is screwed into the base and the joint sealed with solder. The ten longitudinal slots in the barrel wall provide passage for the escaping gases, the slots being located over a range of 140° of the barrel circumference. (See fig. 9.) Each slot is $\frac{3}{4}$ inch long and $\frac{1}{16}$ inch wide, and the sides of the openings are V-shaped. A brass cap is screwed to the end of the nozzle barrel. This cap has a round core projecting into the center of the nozzle barrel to provide a circular passage for a rapid swirling motion of the escaping gases. The nozzle screen is made of four layers of copper-nickel wire mesh cloth and is held in place by a screen spring. Two pins are riveted flush with the outside of the barrel and extend inside to hold the screen and screen spring in position. A brass barrel cover fits over the barrel as shown in figure 9, and can be rotated so that its opening uncovers the nozzle openings. All outside surfaces other than the screen are lacquered with olive-drab enamel.

(2) *Functioning.*—Upon opening the cylinder valve, the contents of the cylinder pass at a tangent into the side of the nozzle base and rotate rapidly around the annular space of the nozzle. The mixture of gas and liquid then forms a fine spray in passing through the screened nozzle openings, and rapidly vaporizes upon being dispersed into the air.

d. Electrically fired nozzle E4.—This nozzle is attached to the threaded outlet of the MIII valve, and is electrically fired by means of a blasting machine. Thus far nozzle E4 has given the best results, and is shown in figures 10 and 11. This nozzle functions satisfactorily mechanically, but does not satisfy the military requirement of silent operation. The firing of the electric squib in the nozzle is accompanied by a distinct "pop," and the discharge of liquid produces a fairly loud hissing noise. This nozzle may be used to release all agents that are standard fillings for the portable chemical cylinder.

(1) *Construction.*—As shown in figure 11, the mechanism consists of a tapered bronze nozzle having a valve disk retained across its

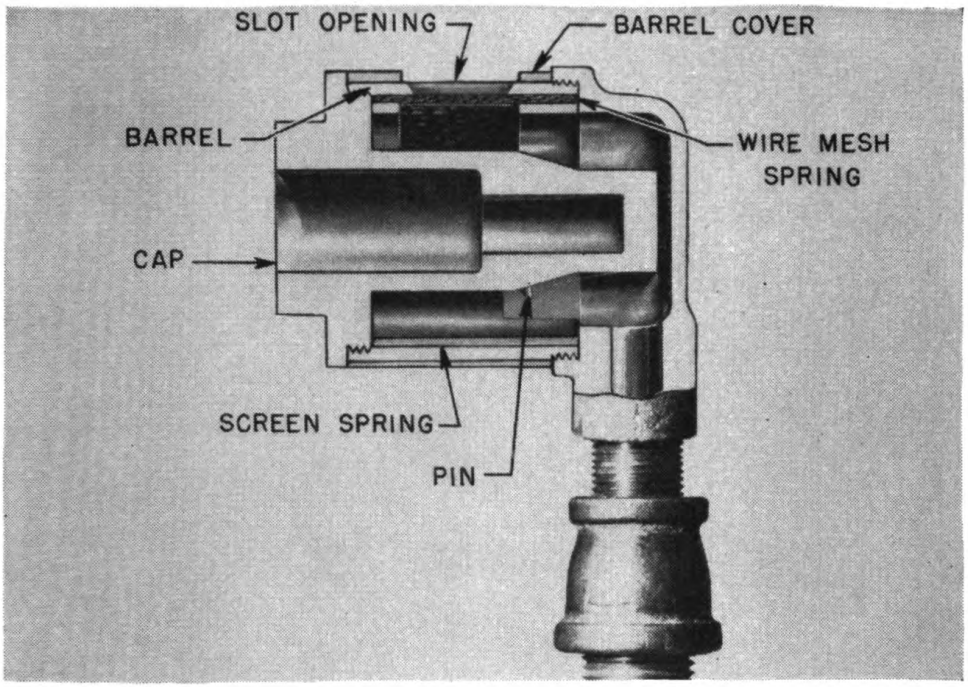

FIGURE 8.—Nozzle MI.

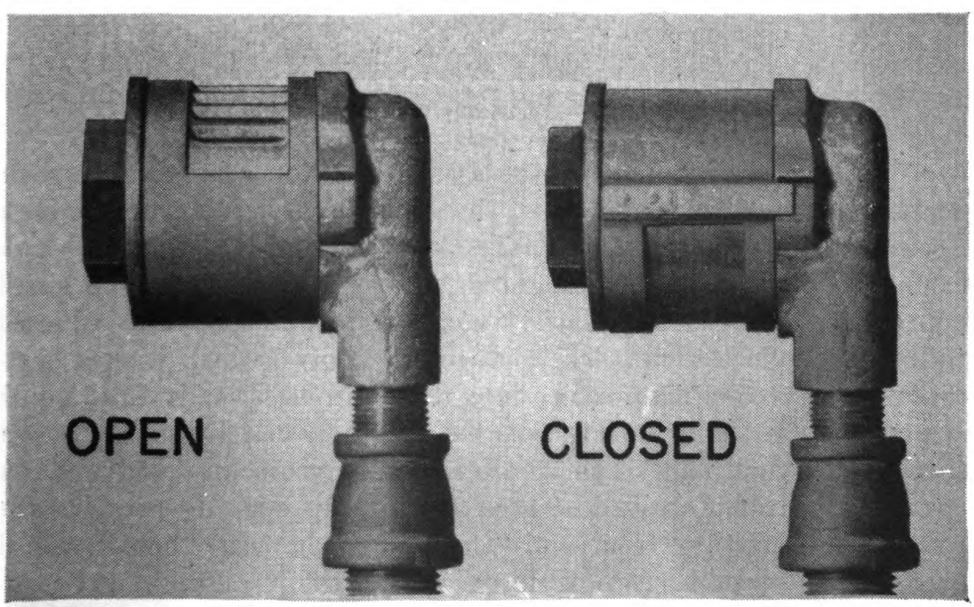

FIGURE 9.—Positions of barrel cover on nozzle MI.

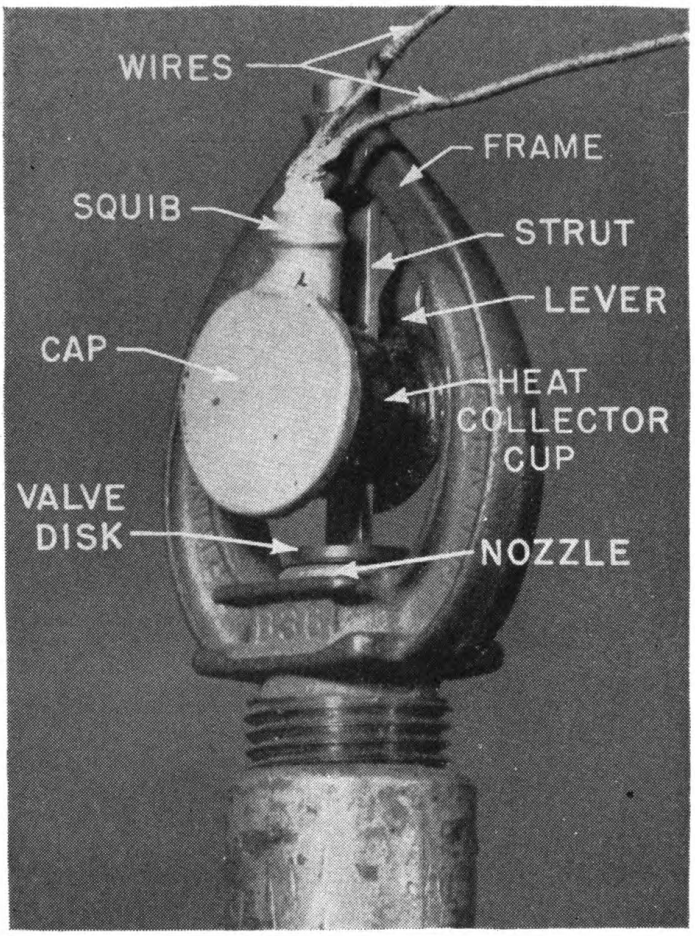

FIGURE 10.—Electrically fired nozzle E4.

opening by a strut which presses against the top of the valve disk. The strut is held in the frame of the nozzle by a hook lever which is released by application of heat. The hook lever presses against a fulcrum at the top of the frame, holds the top of the strut in a small depression, and is held in place by a cup-shaped key which is soldered to the heat collector cup. The heat collector cup is filled with a heat-producing pyrotechnic mixture into which an electrically fired squib is inserted. Cotton twine impregnated with fuze-match mixture passes through the vent holes of the squib into the pyrotechnic mixture. A coating of paraffin applied at the collector cup opening protects the pyrotechnic mixture from moisture, and a zinc cap then crimped over the heat collector cup opening protects the paraffin from breakage. (See fig. 10.) The nozzle is connected to the MIII valve by a

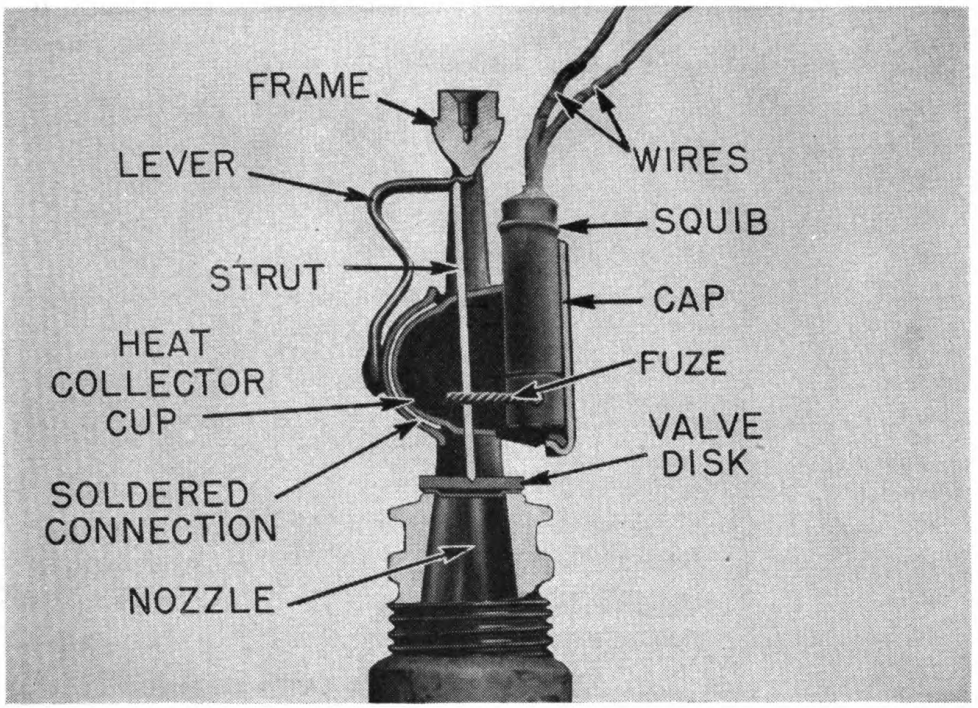

FIGURE 11.—Sectionalized view of electrically fired nozzle E4.

brass pipe coupling, and the squib is provided with insulated copper wire leads which are 6 feet in length.

(2) *Functioning.*—The electrically fired nozzle is wired in series with other nozzles and a blasting machine. An impulse from the blasting machine fires the electric squib and ignites the impregnated cotton twine, which in turn ignites the pyrotechnic mixture. Heat generated by the mixture melts the solder joint between the heat collector cup and the cup-shaped key, freeing the hook lever. Pressure against the bottom of the valve disk then acts to throw off the hook lever, strut, and valve disk, permitting the chemical filling to flow freely through the nozzle opening.

e. Carrier.—Portable chemical cylinder carrier MIA2 is constructed of steel strips as shown in figure 12. The steel strips are approximately $\frac{1}{8}$ inch thick and $\frac{7}{8}$ inch wide. Upper and lower rings are spot-welded to the shoulder hook and support. The upper ring is open at one side and provided with eyebolt and wing nut so that the ring may be clamped firmly about the cylinder. Leather shoulder pads are slipped over the carrier hooks and held in position by rivets which fit loosely into holes located in the carrier hooks. The ends of the shoulder hooks (obscured by pads in fig. 12) are pointed to facilitate suspension of the cylinder on a parapet wall.

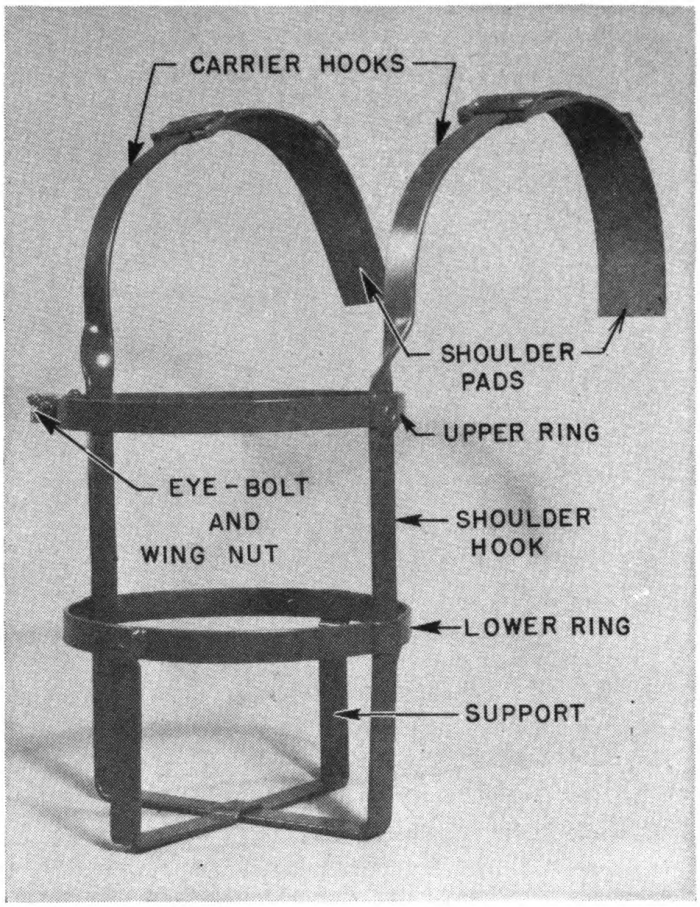

FIGURE 12.—Portable chemical cylinder carrier MIA2.

5. Weights.—*a. Cylinder.*—The weights of the component parts of the portable chemical cylinder are as follows:

	Pounds	*Ounces*
Container MII	11	12
Carrier MIA2	4	8
Pads, shoulder, leather	--	2½
Nozzle MI (not including coupling and nipple)	1	8
Coupling, reducing	--	3
Nipple	--	⅗
Tube, eduction	--	14½
Valve MIII	2	8
Total weight of unfilled cylinder	21	8⅗

b. Chemical filling.—The weights of the chemical agents and compressed gases used in filling the cylinder are as follows:

	Pounds
Nonpersistent gas, CG	31
Smoke, FS	36
Smoke, FM	36
Tear gas solution, CNB	23
Tear gas solution, CNS	30
Compressed gas, carbon dioxide, approximately	2½
Compressed gas, chlorine	5

c. Filled cylinder.—The weights of the cylinder filled and charged with the various chemical agents and compressed gases are as follows:

Filling	*Charging agent*	*Approximate total weight (pounds)*
Nonpersistent gas, CG	Carbon dioxide	55
Nonpersistent gas, CG	Chlorine	57½
Smoke, FS or FM	Carbon dioxide	60
Tear gas solution, CNB	Carbon dioxide	48
Tear gas solution, CNS	Carbon dioxide	55

6. Packing and shipping.—*a. Portable chemical cylinder.*—Two complete portable chemical cylinders are packed together in a wooden box for shipment. Figure 13 shows the manner in which the cylinders are packed, and figure 14 shows the components which are packed in each box. The dimensions of the packing box permit the portable cylinders to be packed with the valves and eduction tubes assembled with the containers. The standard MI nozzles are packed separately in the box. One engineer's wrench, having 1.27-inch and 0.83-inch openings, is packed in each box for use in the operation and maintenance of valve MIII. The components of the portable chemical cylinder are sometimes packed in an unassembled condition, in which case a shipping plug is screwed into the opening of the container. The shipping plug is a die casting of zinc-aluminum-magnesium alloy. The eduction tube is screwed into the base of the shipping plug and hence is within the container. An ammunition data card is placed in each box.

(1) *Packing box.*—(*a*) The packing box is constructed of wood. Its lid opens on hinges and is fastened by two steel hasps. Partitions

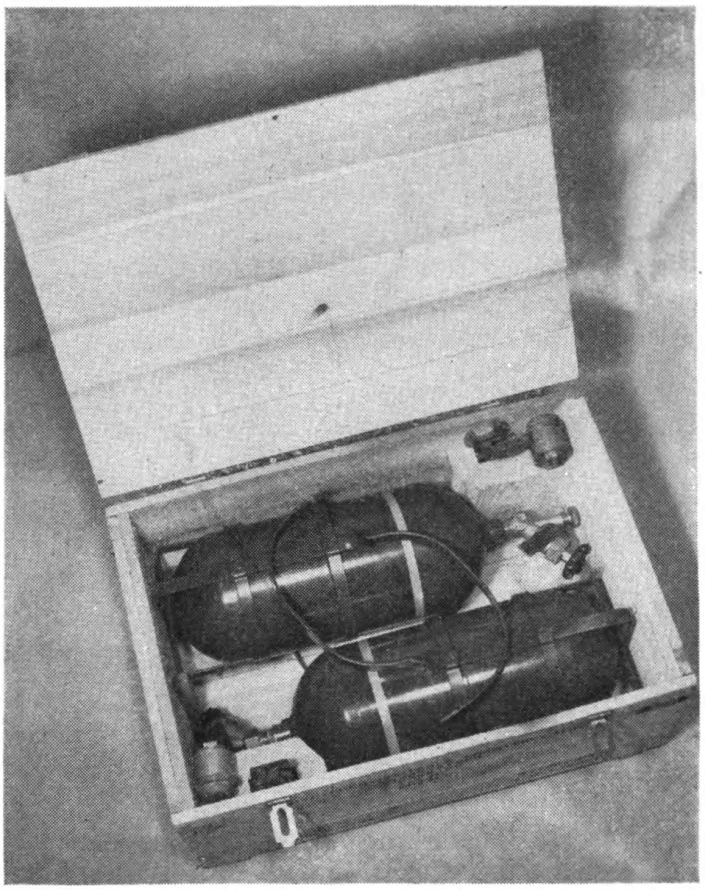

FIGURE 13.—Method of packing portable chemical cylinder.

and supports are arranged to hold the cylinder components in shipping position. Shipping data on the box are as follows:

Length	28¼ inches
Width	19⅛ inches
Height	12 13/16 inches
Weight, empty, approximately	33 pounds
Weight, with empty cylinders, approximately	77 pounds
Displacement of box, approximately	4 cubic feet

(*b*) *Marking.*—The packing box is marked as shown in figure 15. On one side of the box is stenciled the following information:

Quantity and kind of cylinder.
Total weight with empty cylinders.
Lot number.
Month and year of packing.
Chemical Warfare Service insignia and letters.

Shipping name as prescribed by Interstate Commerce Commission regulations, and the shipping container specification number.

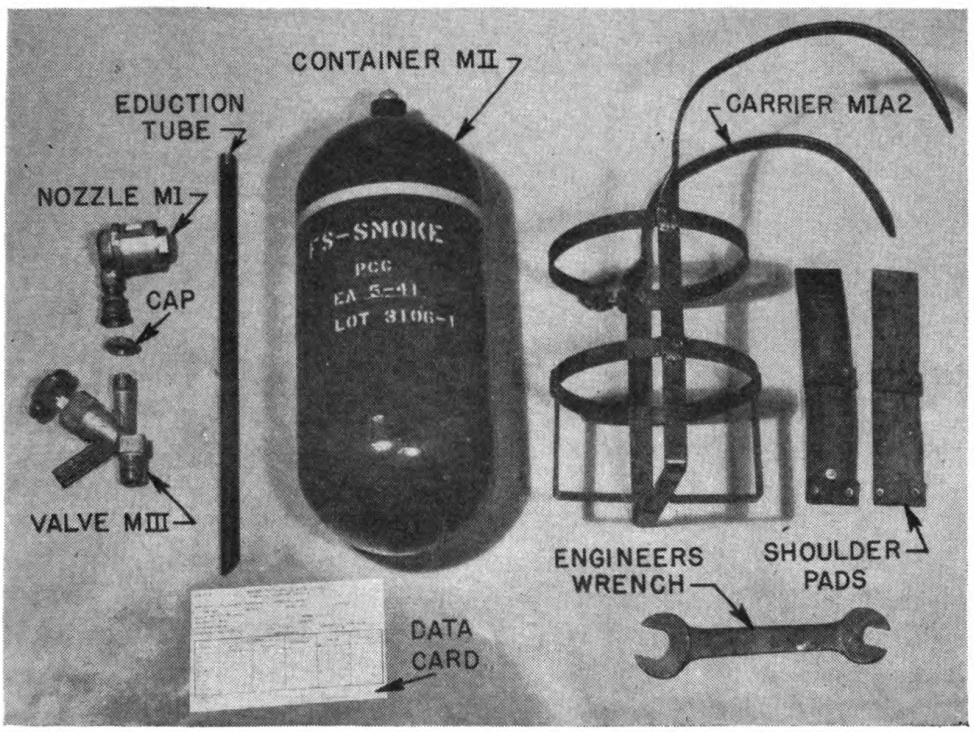

FIGURE 14.—Components of portable chemical cylinder MIA2, together with engineer's wrench and data card.

On both ends of the box the following information is given:

Quantity and kind of cylinder.
Name of place where packed.
Chemical Warfare Service letters.
Lot number.
One ½-inch colored band painted on the lower portion of the right batten, between two blue-gray bands, each ¾ inch wide. (A green band is used for phosgene-filled cylinders, a yellow band for smoke-filled cylinders, and a red band for CNB or CNS filled cylinders.)

(2) *Interstate Commerce Commission regulations.*—For cylinders filled with phosgene (CG), paragraphs 59, 327, 330, 333, and 334 of the Interstate Commerce Commission regulations apply. Paragraphs 59, 240, 243, and 254 of the same regulations apply for smoke-filled

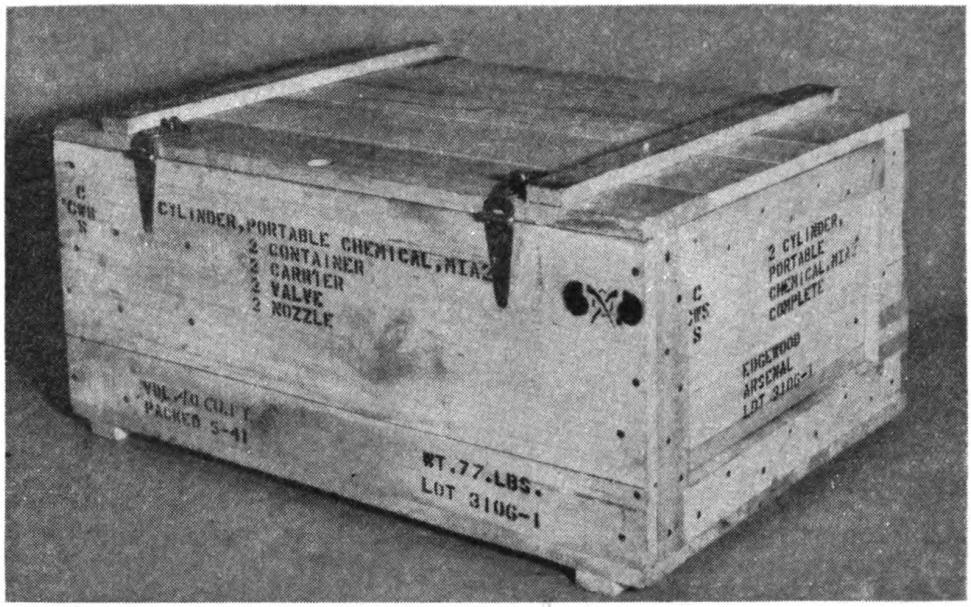

FIGURE 15.—Marking of packing box for portable chemical cylinder.

(FS) cylinders. These regulations do not permit shipment of filled and charged portable chemical cylinders.

(3) *Shipping names.*—Cylinders filled with phosgene are shipped under the name, "Phosgene in steel cylinder." Cylinders filled with FS smoke agent are shipped under the name, "Acids N. O. I. B. N., liquid in steel cylinder."

b. Nozzle E4.—This nozzle is not a part of the standard portable chemical cylinder, and is usually packed in a separate box containing 100 nozzles.

(1) *Packing.*—(*a*) Each nozzle is prepared for packing by having the lead wires securely wrapped about a carton protector, as shown in figure 16. The nozzle is then placed in an individual packing carton which has inside dimensions of about $4\frac{3}{16}$ by $2\frac{3}{16}$ by $1\frac{11}{16}$ inches. One hundred nozzles in cartons are packed in a wooden box fastened with nails and steel straps. One data and instruction card is included in each box. Shipping data on the packed box are as follows:

Length	21 inches
Width	$13\frac{7}{16}$ inches
Height	$10\frac{5}{16}$ inches
Weight, empty, approximately	17 pounds
Weight, with 100 nozzles, approximately	80 pounds
Displacement of box	1.69 cubic feet

(b) *Marking.*—On one side of the box is stenciled the following information:

100 nozzles E4 for portable chemical cylinder.
Lot number.
Month and year of packing.
Chemical Warfare Service insignia and letters.
Shipping name to comply with Interstate Commerce Commission regulations.

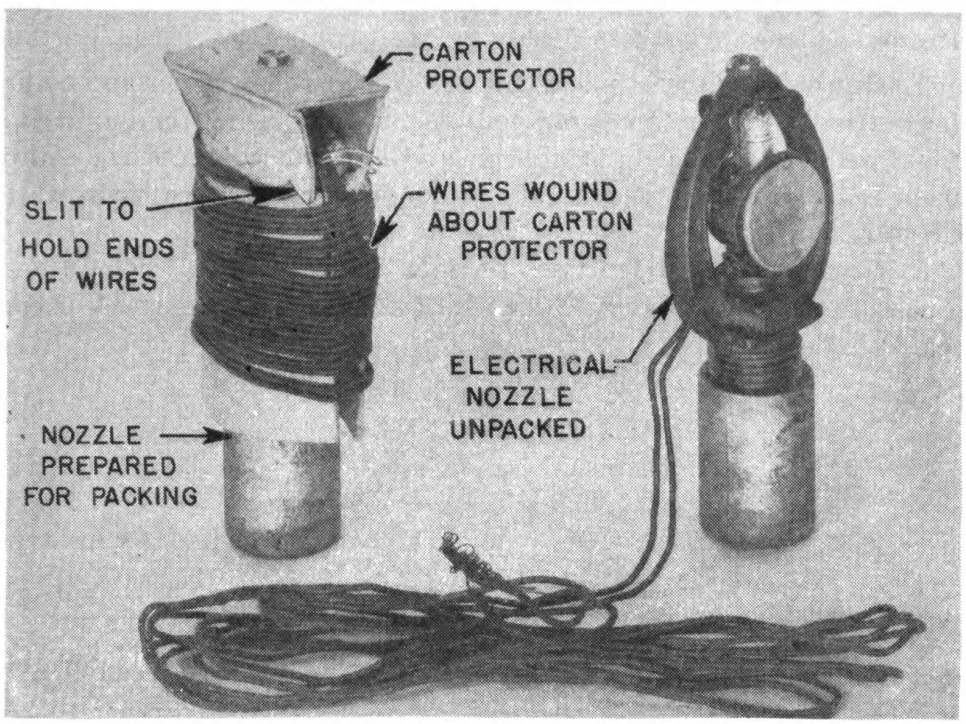

FIGURE 16.—Electrically fired nozzle E4 prepared for packing.

On both ends of the box is given the following information:

100 nozzles E4 for portable chemical cylinder.
Name and place where packed.
Lot number.
Chemical Warfare Service letters.

(2) *Interstate Commerce Commission regulations.*—For electrically fired nozzle E4, paragraphs 70, 152, 154, and 173 of the Interstate Commerce Commission regulations apply.

(3) *Shipping name.*—The shipping name is "delay electric igniters with inflammable solids, N.O.I.B.N."

SECTION III

ACCESSORY EQUIPMENT AND OPERATIONS

7. General.—Operations to fill and charge the cylinder and to fire it electrically require accessory equipment which is not regularly supplied with the standard portable chemical cylinder. Accessory equipment is also used to test cylinders of doubtful safety with hydrostatic pressure.

8. Equipment for firing cylinders electrically.—*a. General.*—The equipment required by a unit to fire electrically 500 portable chemical cylinders is as follows:

500	electrically fired nozzles.
10	blasting machines, 100-cap.
4	rheostats.
4	galvanometers.
1,000 yards	firing wire, double-lead No. 14 (telephone wire, type W40, may be used).
20 rolls	friction tape.

b. Blasting machine.—The blasting machine is a small, portable electric generator used for firing the electrically fired nozzles.

(1) *Description.*—The machine may be either of the magneto or dynamo type. The magneto type shown in figure 17 has a permanent magnet for a field. This machine has no commutator. The dynamo type has electromagnets for a field and is equipped with a commutator. Each type functions by means of a plunger, and each has a rated capacity of 100 electrically fired nozzles, provided not more than 1,000 yards of standard double-lead No. 14 wire are used in the circuit. To insure dependability of fire, only 50 electric nozzles (two circuits) are fired at each operation of the blasting machine.

(2) *Operation.*—(*a*) In operation, the blasting machine is set on a solid level place and the lead wires connected. The rack bar is then withdrawn by the handle to its full extent and with one quick, hard, two-handed stroke is plunged to the bottom of the box. As the rack bar nears the bottom it becomes more difficult to plunge because of

the build-up of the electric current. The speed of the thrust should not be diminished as the finish of the operation is just as important as the start. No fear should be had of plunging the rack bar down too hard, as the machine is constructed to stand hard thrusts and this is the only way it is correctly operated. ***Caution:*** The main lead wires to the blasting machine should not be connected until the moment the cylinders are to be fired. During a thunderstorm, no long wires should be connected to the cylinders.

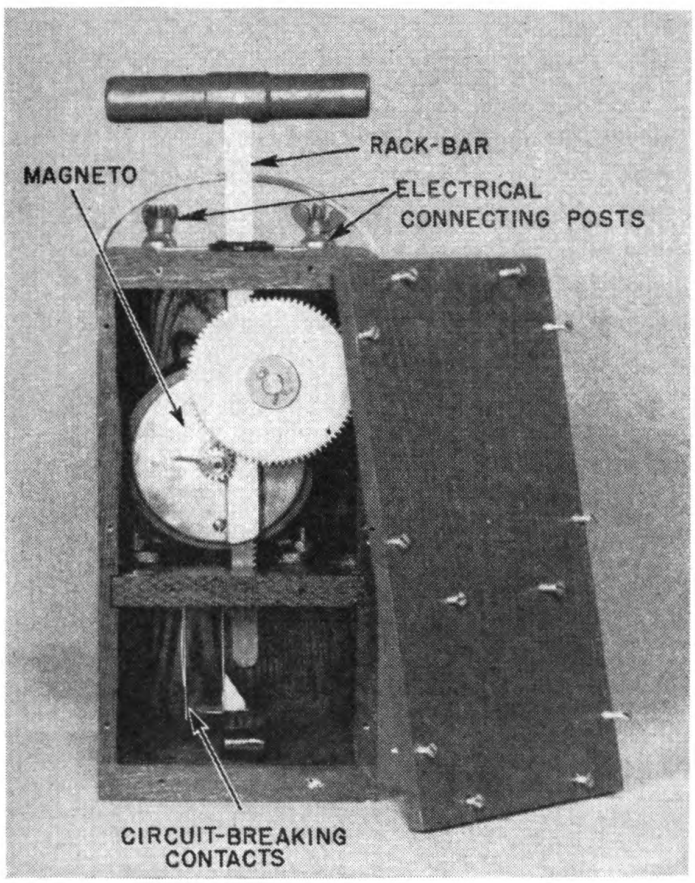

FIGURE 17.—Magneto type blasting machine.

(*b*) Care should be taken that wire is clean and bright (the metal may be scraped lightly, if necessary), before any connections are made.

(*c*) All wire connections should be firmly twisted together and covered with friction tape.

(*d*) The circuit should be tested with a blaster's galvanometer (circuit detector) to make certain it is complete (see FM 5–25). Each circuit should consist of not more than 25 electric nozzles.

(3) *Care.*—The machine should be stored in a cool, dry place. During use it should not be permitted to remain exposed to wet weather or lie in the mud. Occasionally the bearing and gearing should be lightly oiled. In the case of the dynamo type machine, no oil should be allowed on the commutator, which is a small, copper-covered wheel on the end of the armature shaft. A little graphite, however, may be used for lubrication. The two slots cut in the copper part of the commutator should be kept clean and free of any material that might cause a short circuit. The copper brushes should be kept clean, and care should be taken to see that they bear firmly upon the commutator. The circuit-breaking contacts should likewise be kept bright and clean.

(4) *Test.*—(*a*) A blasting machine may be tested by connecting to it, in series, the proper number of electric blasting caps or squibs such as are used in electrically fired nozzles, and actually trying it out. This method is expensive, and the procedure with a rheostat as given below will provide the same results.

(*b*) A rheostat is substituted for all but two of the electric squibs, as indicated in figure 18, with the wires *X* and *Y* connected to the proper posts to give a resistance equal to the number of squibs desired. If both squibs fire when such a connection is made and the blasting

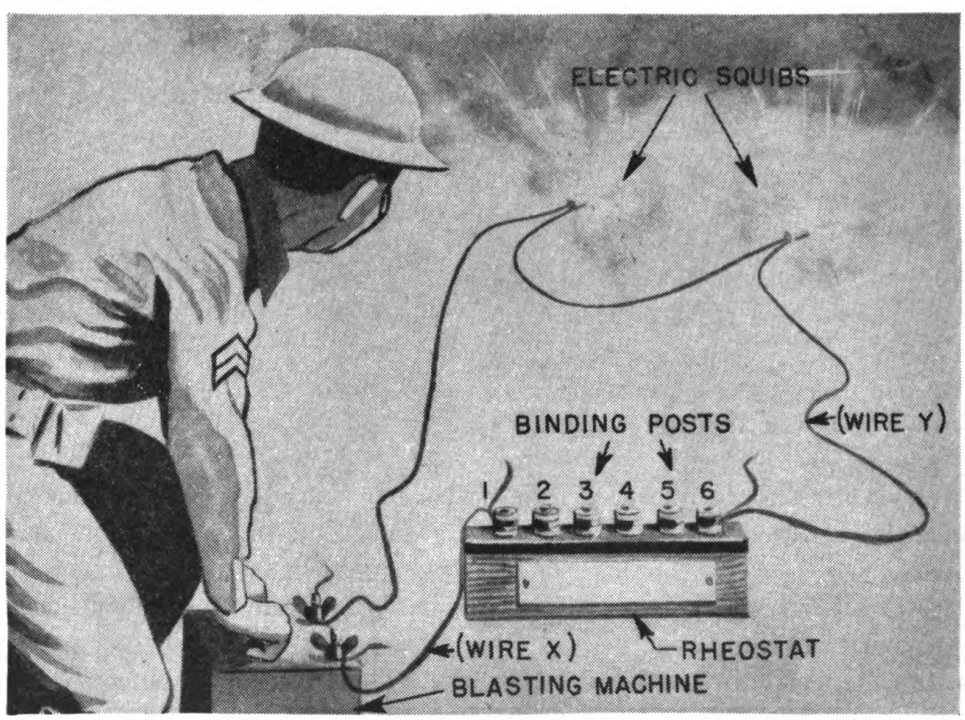

FIGURE 18.—Method of testing capacity of blasting machine.

machine operated, it indicates that the machine is working properly. If both squibs fail, or if one fires and the other does not, the machine is not functioning correctly.

(*c*) In case the blasting machine is not working properly, it should be sent to the nearest Corps of Engineers' shop company for repair or if this is not feasible, to the nearest engineer depot company for exchange.

FIGURE 19.—Rheostat.

c. Rheostat.—The standard rheostat is shown in figure 19. It is an arrangement of coils (not shown) of high resistance wire, each of a definite length, with binding posts 1 and 6 attached to its ends, and binding posts 2, 3, 4, and 5 attached to it at intermediate points. The entire length of the resistance wire in the rheostat has a resistance sufficient to represent a test of 100 electric squibs, with a factor of safety to allow for the lead wire, connecting wire, and all connections in the circuit. The binding posts 1, 2, 3, 4, 5, and 6 are not attached to the resistance wire at equal distances. The purpose of this is to afford different resistances between different binding posts, each representing a test of a certain number of electric squibs. If wires *X* and *Y* are attached to binding posts 1 and 2, the check represents a test of 5 squibs; if to posts 2 and 3, of 10 squibs; if to posts 3 and 4, of 20 squibs; or if to posts 4 and 5, of 25 squibs. The wires *X* and *Y* need not be attached to adjoining posts. If, for instance, they are attached to posts 1 and 4, the test represents the sum of the intervening numbers, 5, 10, and 20, or a total of 35 squibs.

d. Galvanometer.—The galvanometer, sometimes called a circuit detector, is used to check each electric nozzle and the entire circuit for proper firing condition.

(1) *Description.*—This instrument consists of a graduated scale and indicator hand or pointer on its face; two nonremovable electric terminals or contact studs in its bottom; and one "Dahi" silver chloride battery. These are contained in a moisture-proof metal or bakelite case measuring approximately 4⅜ by 3⅛ by 1¾ inches, to which is attached a descriptive name plate. The galvanometer is further inclosed in a leather carrying case provided with leather flap and shoulder straps, as shown in figure 20. The instrument should be tested before use by having a short piece of copper wire placed mo-

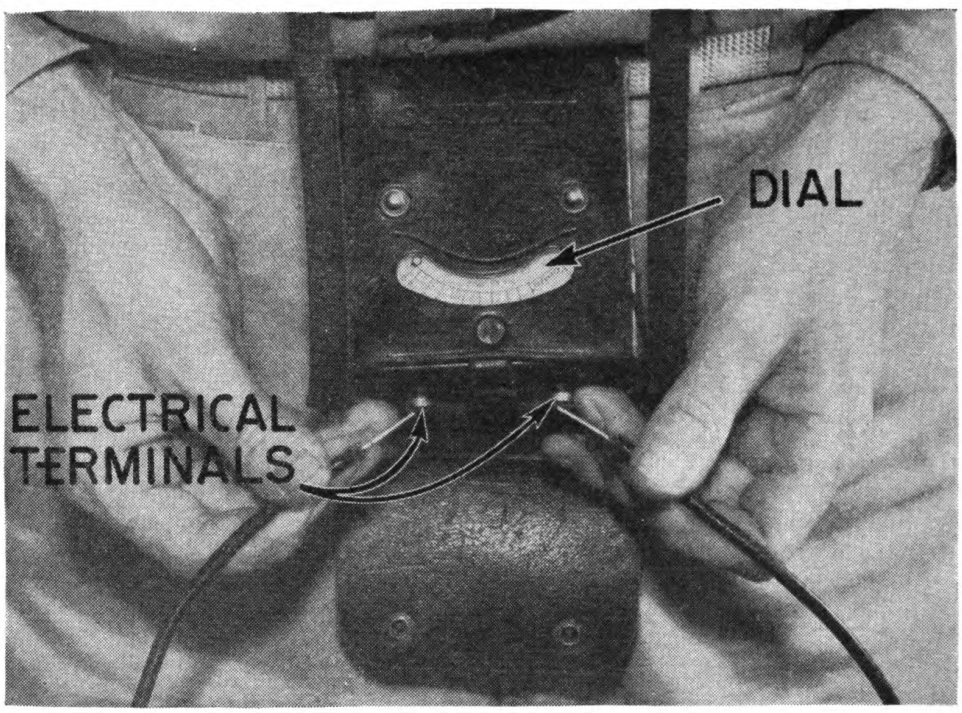

FIGURE 20.—Galvanometer.

mentarily across the two contact studs. If the pointer does not move across the scale the battery should be replaced, but *only* with another chloride of silver cell.

(2) *Use.*—To test a circuit, the ends of the lead wires are placed in contact with the electric terminals of the galvanometer. A normal movement of the galvanometer pointer indicates that the circuit is complete and ready for firing. If the pointer reads very low or very high, the firing circuit should be checked by comparing the reading on the galvanometer with the reading that the galvanometer gives when connected to a properly adjusted rheostat resistance. The rheostat resistance used in this check reading should be approximately twice the calculated total resistance of the electric nozzles to be fired. Abnor-

mally low readings of the galvanometer on the firing circuit indicate poor connections; abnormally high readings indicate short circuits (see FM 5-25).

9. Apparatus for filling cylinder with phosgene.—*a. General.*—The volatile nature of phosgene requires filling into the portable chemical cylinder by a method that will prevent its vaporization during the filling process. A particular apparatus, making use of dry compressed air, is used for filling the cylinder by pressure displacement of phosgene from a ton container. The arrangement of the filling apparatus eliminates the necessity of venting phosgene vapor into the atmosphere.

(1) *Filling process.*—(*a*) *Procedure.*—The procedure of filling the agent into the cylinder without venting of phosgene vapors depends entirely upon the ability to supply CG at a pressure higher than that which will be generated in the cylinder during the filling operation.

(*b*) *Nature.*—In filling the cylinder, several events occur during the process. When the first portion of phosgene enters, a part of the liquid will undergo flash vaporization, and its vapors enter the vapor space of the cylinder. As the liquid phosgene continues to enter, it will compress the phosgene vapor and other gases ahead of it, thereby gradually building up an ever increasing pressure within the cylinder which tends to oppose the inflow of the liquid. When the pressure of the phosgene vapor becomes greater than its equilibrium pressure with liquid phosgene, a portion of the vapor will be recondensed to liquid. The carbon dioxide gas with which the cylinder has previously been purged is partially dissolved in the liquid phosgene during the filling process. The condensation of phosgene vapor and the dissolution of the carbon dioxide gas both tend to reduce the pressure which is built up in the cylinder during the filling process.

(2) *Air in portable chemical cylinder.*—(*a*) *Undesirability.*—The presence of air in a cylinder which is to be filled with phosgene is detrimental both to the filling operation and the efficacy of the discharge of the agent during field service. The undesirability of air is due to its very low solubility in phosgene, which results in building up a high back pressure during the filling process and causing a rapid pressure drop during the discharge period of the cylinder. New cylinders should therefore be purged with carbon dioxide prior to filling with phosgene. Carbon dioxide is moderately soluble in liquid phosgene, and, moreover, the filled cylinder is subsequently to be charged with carbon dioxide.

(*b*) *Removal by purging.*—Cylinders containing mostly air require purging with carbon dioxide before being filled. The air may be

purged by introducing this gas and subsequently releasing the mixture of carbon dioxide and air. Upon release of the pressure built up by the introduction of the carbon dioxide, a large portion of the air will be vented in the escaping mixture. This operation is ordinarily unnecessary on cylinders previously filled with phosgene and used in service, for the prior filling will already have removed the air.

(3) *Refilling discharged cylinders.*—Cylinders returned for refilling with phosgene contain a residue of liquid phosgene and carbon dioxide gas. The carbon dioxide should be released before refilling with phosgene. (See *e* below.)

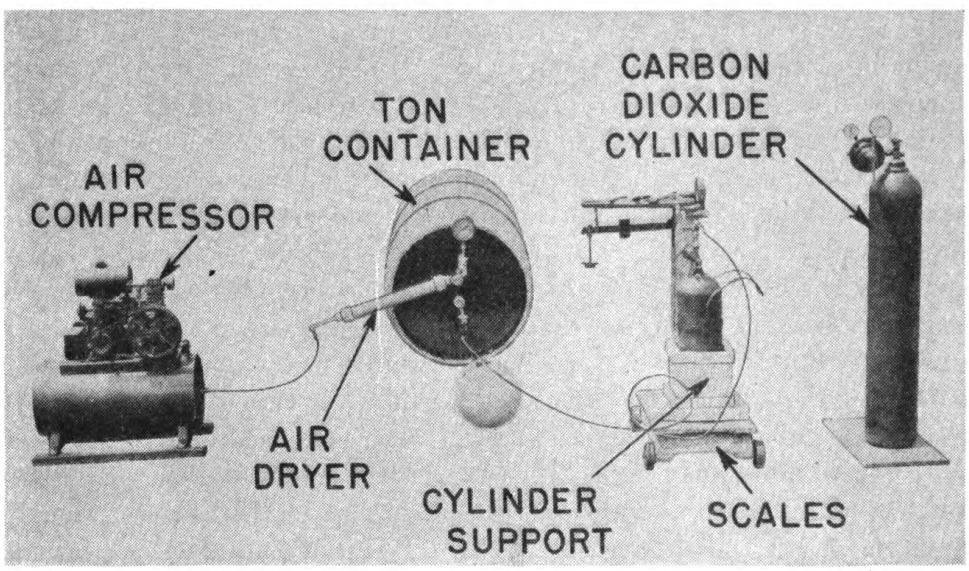

FIGURE 21.—Apparatus for filling portable chemical cylinder with phosgene.

b. Description.—The apparatus used for filling the cylinder with phosgene is shown in figures 21 to 26, inclusive. This apparatus utilizes phosgene supplied in ton containers and liquid carbon dioxide supplied in steel cylinders. With the exception of one item, a special adapter used to make connection with the ton container, the mechanism is constructed of standard commercial material.

(1) *Filling head.*—This assembly is shown in figure 22, and serves to connect the phosgene and carbon dioxide lines with the filling-head adapter. It is constructed of the following materials:

4 ¼-inch brass gate valves.
1 pressure gage, 0 to 300 pounds per square inch.
3 ¼-inch standard iron tees.
7 ¼-inch iron pipe nipples, close.
1 ¼-inch malleable iron union, brass-to-brass seat.

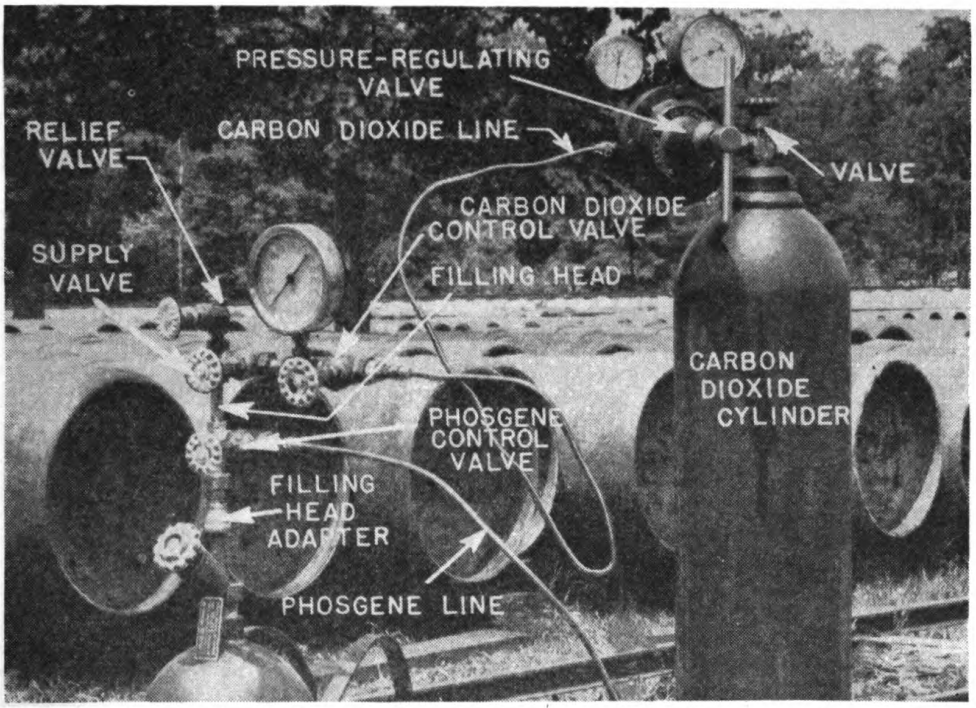

FIGURE 22.—Filling-head arrangement on phosgene filling apparatus.

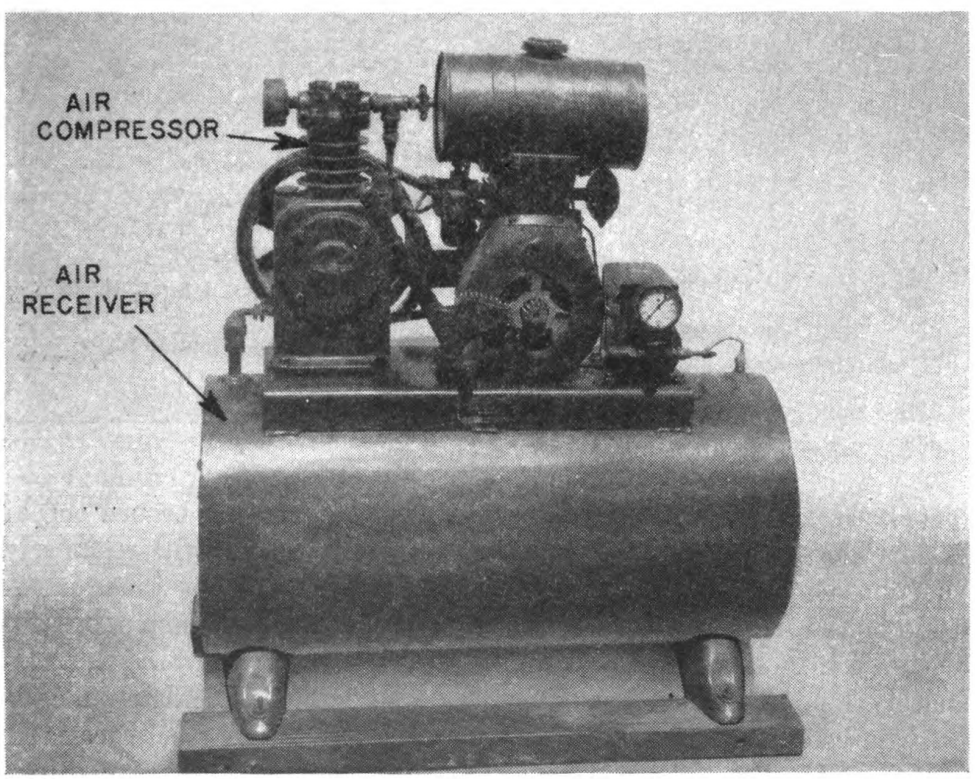

FIGURE 23.—Air compressor.

(2) *Filling-head adapter.*—This part connects the cylinder with the filling head. It consists of a brass ½-inch by ¼-inch reducer coupling, a ¼-inch iron pipe short nipple, and the male half of the union specified for the filling head.

(3) *Air compressor.*—This is a portable gasoline engine air compressor of the type shown in figure 23. The compressor should be of the two-stage type, having a displacement of approximately 5 cubic feet of free air per minute, and should deliver air at a pressure of 200 pounds per square inch. It should be equipped with an interstage cooler and an air receiver. A compressor of this capacity will furnish compressed air sufficient to supply three phosgene filling apparatuses.

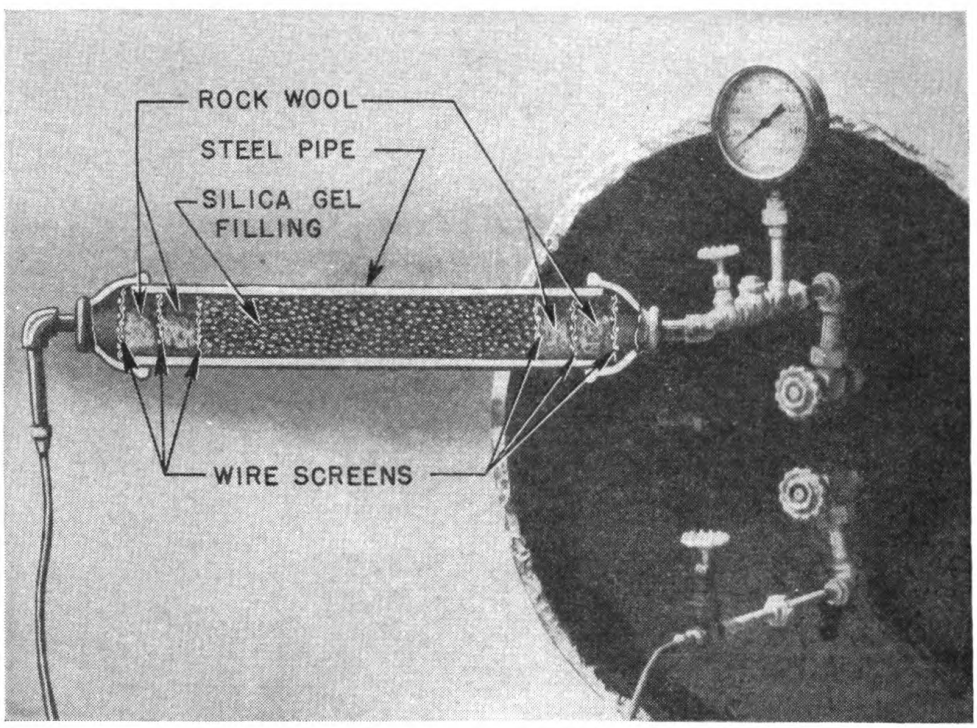

FIGURE 24. Air dryer.

(4) *Air dryer.*—This unit dries the compressed air before the air is introduced into the ton container, since moist air will react with the phosgene or the smoke agents. The dryer is shown in figure 24. It is constructed of an 18-inch length of standard 2-inch iron pipe and two 2-inch by ¼-inch reducer couplings. It contains approximately 1 pound of silica gel drying agent which is held in place by wire screens and rock wool. The air dryer unit has a capacity sufficient to dry the air introduced into one ton container during

the filling operation. A fresh unit should be used with each ton container.

(5) *Portable platform scale.*—This scale should have a capacity of 500 pounds and should be provided with a double or a single beam. Its use is shown in figure 21.

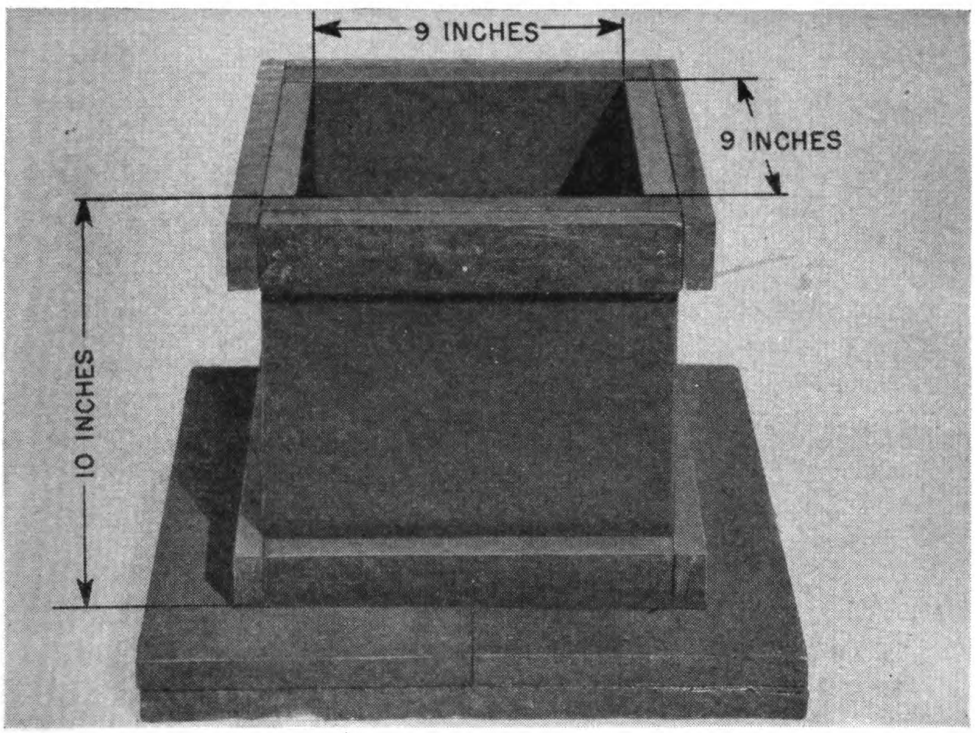

FIGURE 25.—Support for portable chemical cylinder.

(6) *Cylinder support.*—The support is shown in figure 25. It consists of a square wooden box, open at the top, with an inside width of 9 inches and a height of 10 inches. It is attached to a wide wooden base for stability.

(7) *Reducing valve.*—This is a standard pressure reducing valve used to reduce the pressure of the carbon dioxide to a range of pressures from 0 to 300 pounds per square inch.

(8) *Ton-container connections.*—These connections are shown in figure 26. The special adapter used to make connection with the ton-container valves is shown in figure 27. To the lower valve of the ton container are attached the phosgene line connections, which consist of a ½-inch iron pipe ell, a bushing, a gate valve, and ¼-inch pipe connections. To the upper valve are attached the compressed air connections, which consist of a ½-inch iron pipe ell, a bushing, a pressure gage, a check valve, a gate valve, and ¼-inch pipe connec-

tions. The pressure gage should have a capacity of approximately 200 pounds per square inch.

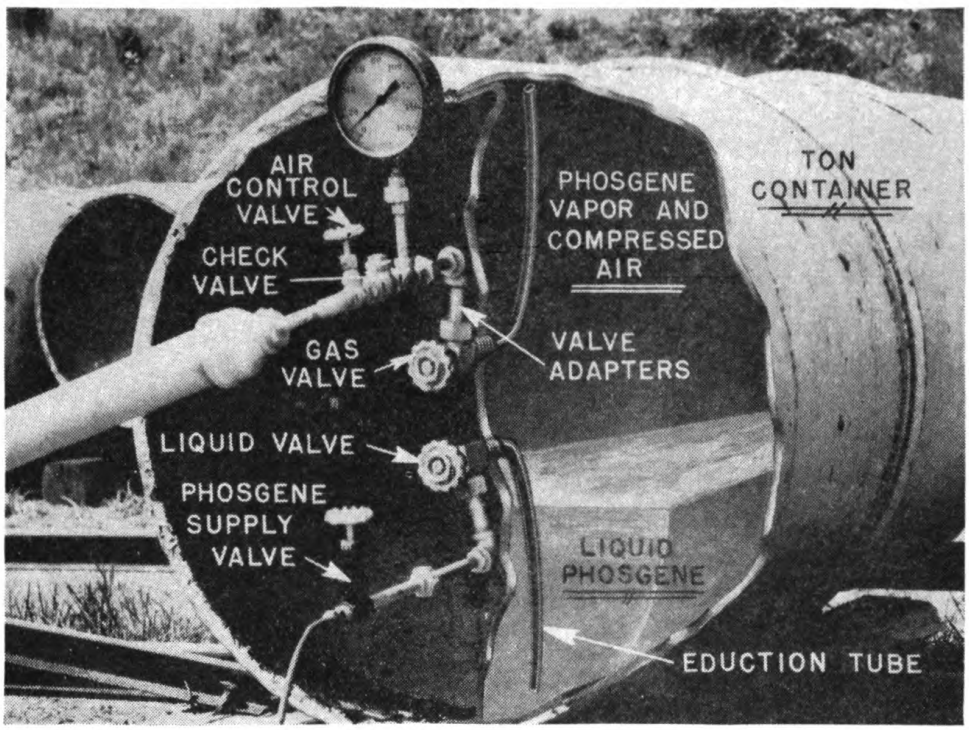

FIGURE 26.—Ton-container connections on phosgene filling apparatus.

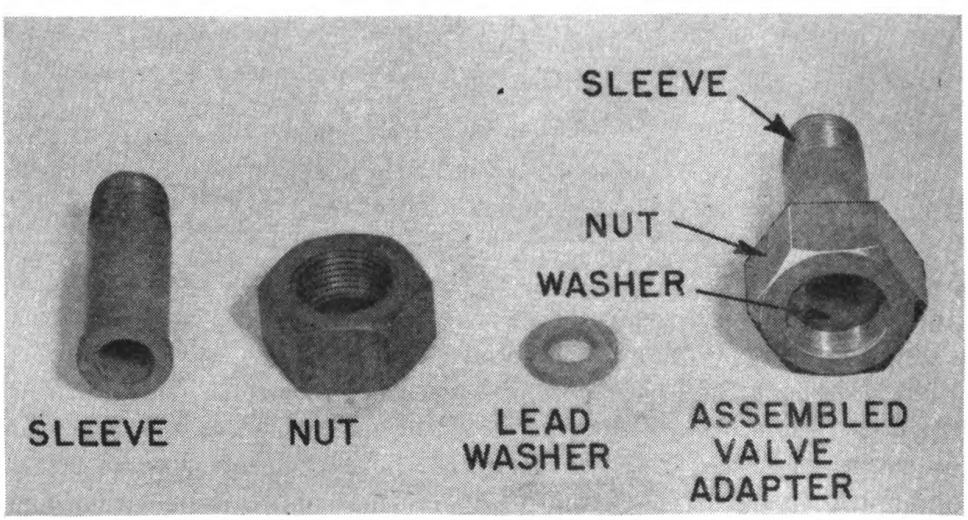

FIGURE 27.—Valve adapter for valves used on ton containers (chlorine institute valve).

(9) *Copper tubing lines.*—The lines for phosgene, for carbon dioxide, and for compressed air are constructed of $\frac{5}{16}$-inch annealed copper

tubing having a 20-gage (0.035-inch) wall thickness. Flared copper tube fittings, 5/16-inch copper tubing to 1/8-inch iron pipe size, and 1/4-inch by 1/8-inch iron pipe bushings are used to make connections between the copper tubing and the iron pipe. Three 10-foot lengths of copper tubing are required for each phosgene filling apparatus.

(10) *Wet cloth.*—This cloth is used to wrap around the top of the cylinder to keep it cool when the filling operations are conducted in hot weather. The cloth consists of thin cotton material and is approximately 1 yard square.

(11) *Assembly.*—The filling apparatus should be maintained in the form of subassemblies until it is needed for filling. The filling head, filling head adapter, ton container connections, air dryer, and lengths of copper tubing should be assembled as individual units pending their use as a working assembly.

c. Preparation for use.—(1) *Assembly.*—The apparatus is assembled as shown in figures 21, 22, and 26. The ton container is positioned so that its valves are in vertical alinement. The air line is connected to the upper (gas) valve, and the phosgene line is connected to the lower (liquid) valve of the ton container. All valves should be closed when the apparatus is first assembled.

(2) *Compressed air supply.*—The air compressor is then started and allowed to come to its full working pressure. The ton container gas valve is then opened, and the air control valve is opened until the pressure gage on the ton container indicates a pressure of 150 pounds per square inch. The air control valve is opened only when the compressor is supplying its full working pressure, and is kept closed except when it is necessary to adjust the pressure in the ton container.

(3) *Carbon dioxide supply.*—The pressure regulating valve on the carbon dioxide cylinder is regulated in the following manner: The pressure regulating valve handle is turned counterclockwise until its stem exerts no pressure on the valve diaphragm. The carbon dioxide cylinder valve is then opened and the pressure regulating valve adjusted to supply carbon dioxide at a pressure of 175 pounds per square inch, as indicated on the pressure gage of the pressure reducing valve. This pressure is then checked against the filling head pressure gage by momentarily opening the carbon dioxide control valve.

(4) *Phosgene supply.*—The ton container liquid valve and the phosgene supply valve are opened. The phosgene control valve on the filling head is checked to make certain that it is tightly closed before the phosgene supply valve is opened.

d. Operation.—This apparatus is used to fill cylinders which are clean and empty or to refill cylinders which were discharged in service. The following procedure describes the operation of filling cylinders which have contained no phosgene prior to being filled. The air purging operation is omitted when refilling cylinders which have been discharged in service and which contain residual amounts of phosgene. Figures 28 and 29 illustrate the filling process.

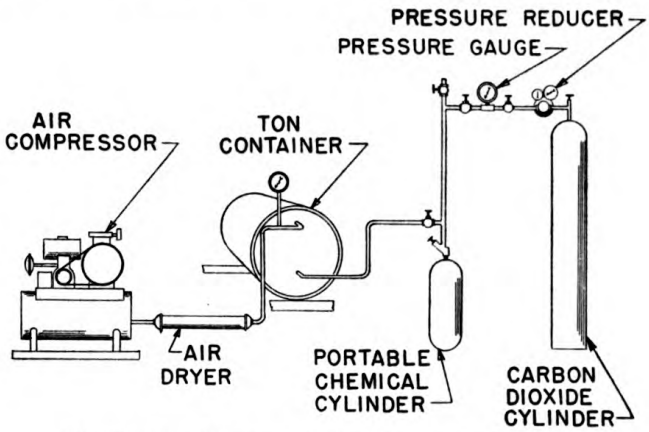

FIGURE 28.—Phosgene filling process—apparatus.

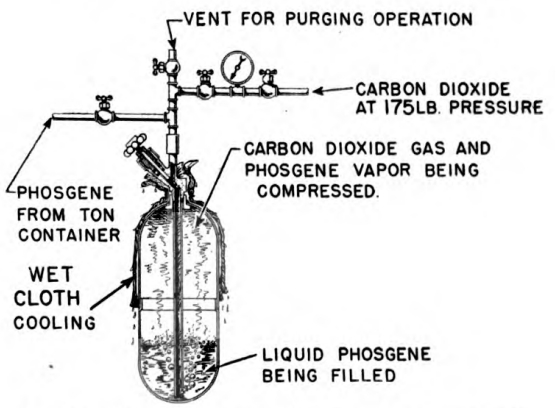

FIGURE 29.—Phosgene filling process—method.

(1) *Connection of filling head adapter.*—The adapter is connected to the cylinder valve as shown in figure 22. A pipe thread lute such as red lead in oil should be used on the threads in making the connection. The cylinder with its carrier is then placed in the cylinder support on the platform scale, as shown in figure 21.

(2) *Connection of filling head.*—The filling head is connected to the filling head adapter by means of the half-unions of the two parts.

(3) *Wet cloth.*—The wet cloth is then wrapped about and pressed into close contact with the upper portion of the cylinder, as indicated

in figure 29. The cloth should extend downward at least one-third of the length of the cylinder, and is of thin material so that the evaporative cooling effect at its outside surface can be readily transmitted to the surface of the cylinder.

(4) *Purging of air with carbon dioxide.*—The portable chemical cylinder valve is opened and the cylinder purged with carbon dioxide. To perform this operation, the carbon dioxide supply valve is opened and allowed to remain open during the entire purging operation. The carbon dioxide control valve is opened until the filling-head pressure gage indicates a pressure of 50 pounds per square inch; then it is closed. The vent valve is opened to release the pressure from the portable cylinder; then it is closed. Again the carbon dioxide control valve is opened until the pressure in the cylinder reaches 50 pounds per square inch. Both the carbon dioxide control valve and the carbon dioxide supply valve are then closed. The vent valve is opened, then tightly closed after the pressure has been released from the cylinder. During the purging operation the carbon dioxide should be introduced rapidly in order to secure an efficient mixing action of the carbon dioxide with the air. This whole purging process normally takes about 1 minute per cylinder.

(5) *Balancing scale.*—The tare weight of the cylinder on the scale is determined by balancing the scale beam. The beam rider is then adjusted to give a gross weight 31 pounds heavier than the tare weight.

(6) *Filling cylinder with phosgene.*—The cylinder is then filled with phosgene by opening the phosgene control valve and allowing phosgene to enter the cylinder until the balancing of the scale beam indicates that 31 pounds of phosgene have entered the cylinder. The phosgene control valve is then tightly closed and the cylinder valve allowed to remain open.

(7) *Displacement of phosgene from filling head.*—The filling head is cleared of phosgene before it is disconnected. This is done by passing carbon dioxide through the filling head into the portable chemical cylinder. The carbon dioxide control valve is opened a few turns, then the carbon dioxide supply valve is opened to pass carbon dioxide into the cylinder at a moderate rate. Carbon dioxide is allowed to flow through the filling head into the cylinder for a period of about 15 seconds; then the cylinder valve, the carbon dioxide supply valve, and the carbon dioxide control valve are closed in the order named. The vent valve is opened to release the carbon dioxide pressure from the filling head and is then closed.

(8) *Disconnection of filling head.*—The filling head is removed from the cylinder by disconnecting the union which joins the filling head with the filling head adapter. The cylinder valve and all the filling head valves *must* be closed before performing this operation.

(9) *Removal of filling head adapter.*—The cylinder is removed from the cylinder support and the filling head adapter removed from the cylinder valve. The valve cap is replaced and tightened on the cylinder valve.

(10) *Inspection of filled cylinders.*—The filled cylinder should be inspected for leakage, and therefore is allowed to stand for 30 minutes after the cylinder valve has been tightly closed and the valve cap replaced. It is then tested for leaks by the use of fumes from ammonium hydroxide solution (aqua ammonia). The cylinder to be tested is placed in such a position that when the bottle of ammonium hydroxide is opened the fumes will come in contact with the connection to be tested. Leakage is indicated by the appearance of a white smoke.

e. Notes.—(1) *Refilling portable chemical cylinder.*—Cylinders which are to be refilled usually contain small amounts of liquid phosgene and carbon dioxide which were not discharged in the firing operation. The pressure of the carbon dioxide should be released before the cylinder is connected with the phosgene filling apparatus, inasmuch as a high initial pressure of carbon dioxide in the cylinder will hinder the filling operation. The weight of phosgene remaining in the cylinder must be taken into consideration when the cylinder is refilled.

(*a*) *Release of carbon dioxide pressure.*—This operation is conducted, as shown in figure 30, by inverting the cylinder and releasing its pressure through a short length of rubber hose into a water slurry of slaked lime or a solution of caustic soda. The end of the hose is closed by means of a wooden plug, and several slits cut in its side near the end in order that the gas will be introduced into the solution, as shown in figure 31, in the form of small bubbles.

(*b*) *Weight of phosgene introduced into cylinder.*—The amount of phosgene introduced into the cylinder should be sufficient to bring the total weight of the agent in the cylinder up to 31 pounds. Since the amount of phosgene initially in the cylinder is unknown, the cylinder is filled to a gross weight which is 31 pounds heavier than the weight of a similar empty cylinder. A cylinder which is known to be completely empty is first placed on the scale, connected with the filling apparatus, and weighed. The gross weight of the properly

filled cylinder connected to the filling apparatus will then be 31 pounds greater than the tare weight of the empty cylinder connected in the same manner.

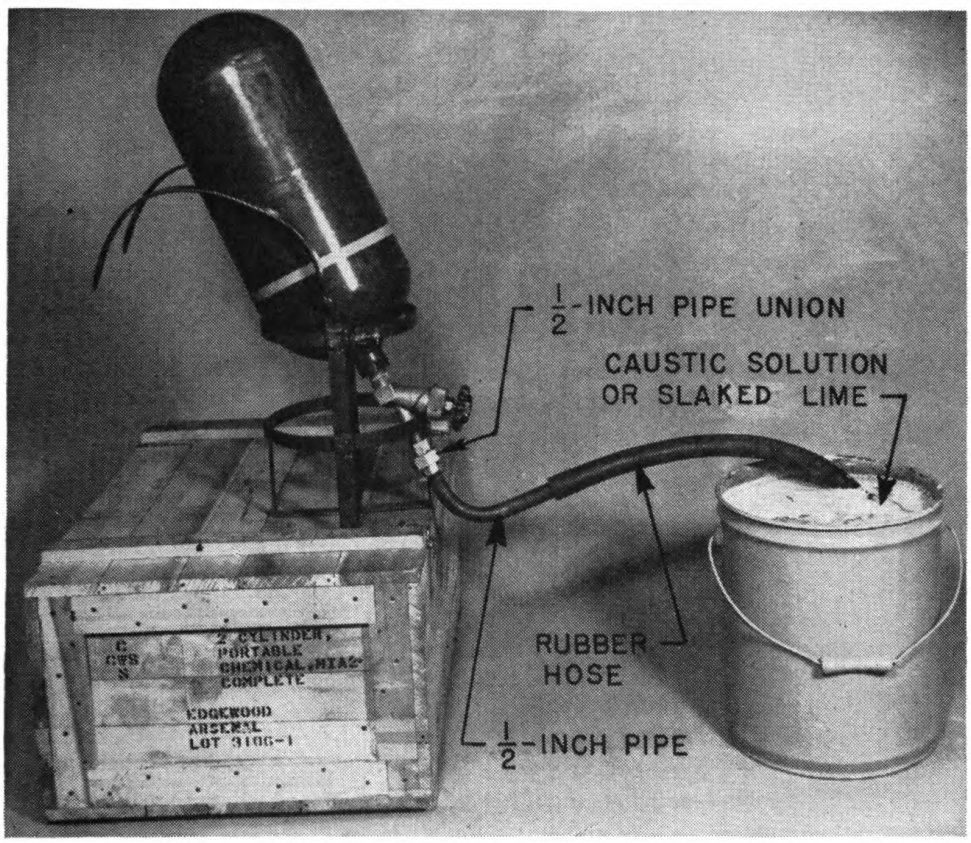

FIGURE 30.—Method of venting carbon dioxide from cylinder.

(2) *Extra filling head adapters.*—Several extra filling head adapters should be available for use during extensive filling operations. Considerable time can be saved in filling by having cylinders ready for immediate connection to the filling head.

(3) *Marking of ton containers.*—After a ton container is emptied of phosgene its condition should be indicated by painting or stenciling on the valve end of the container the word EMPTY.

f. Safety precaution.—(1) *Leaks.*—All connections and valves of the apparatus should be carefully inspected to prevent leakage of phosgene during the filling operation.

(2) *Safety equipment.*—All personnel engaged in these operations should have gas masks available for immediate use at all times. Masks need not be worn at all times, but each individual should carry his mask in the carrier, properly adjusted to his person, and ready for

instant use, if required. They should be worn whenever the odor of phosgene is detectible. Rubber gloves should be worn by all personnel when breaking pipe connections where liquid phosgene might be present.

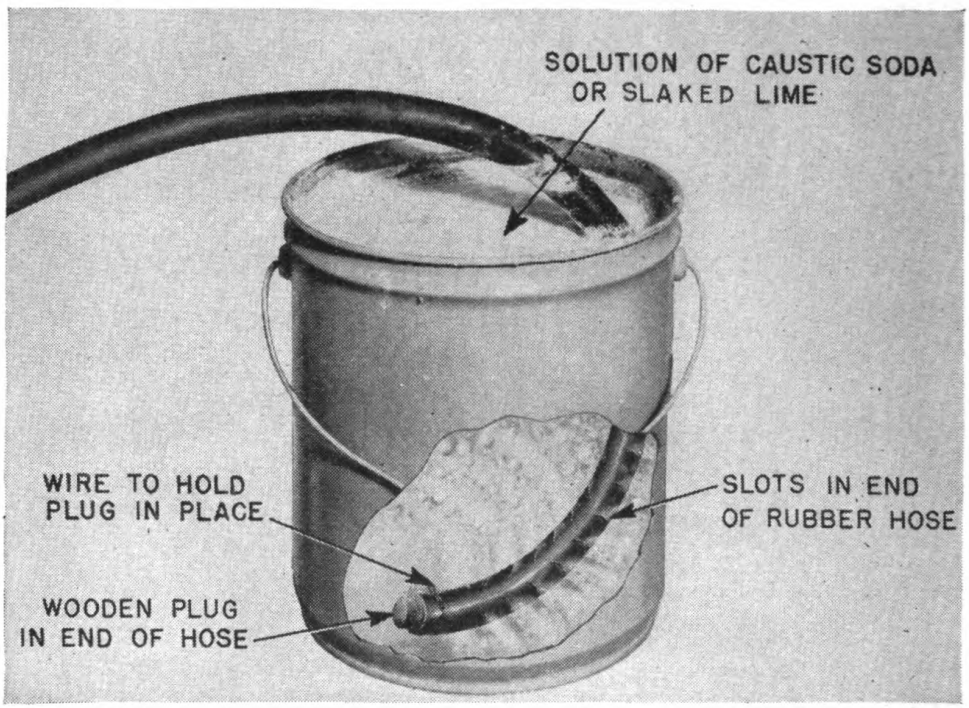

FIGURE 31.—Method of neutralizing phosgene vapors in solution of slaked lime or caustic soda.

10. Apparatus for filling cylinder with FS or FM.—*a. General.*—The smoke agent is usually supplied in a 55-gallon drum, and is most easily transferred to the cylinder by means of a hand-operated pump. An alternative method is to raise the drum to a point above the cylinder and allow the agent to flow into the cylinder by gravity. The valve and eduction tube assembly is removed from the cylinder and the smoke agent passed through a flexible metal hose into the open container. Smoke agents, FS and FM, are liquids of relatively low volatility and are easily filled into the cylinder.

b. Description.—The apparatus to fill the cylinder by use of a hand-operated pump is shown in figure 32. Figure 33 illustrates the method by which the cylinder is filled by gravity flow.

(1) *Pump.*—This is a rotary hand-operated pump as shown in figure 32. Its construction should be of the all-iron type. The pump should be provided with a suction pipe and a bung adapter threaded for a 2-inch steel drum opening. The bung adapter is a metal collar attach-

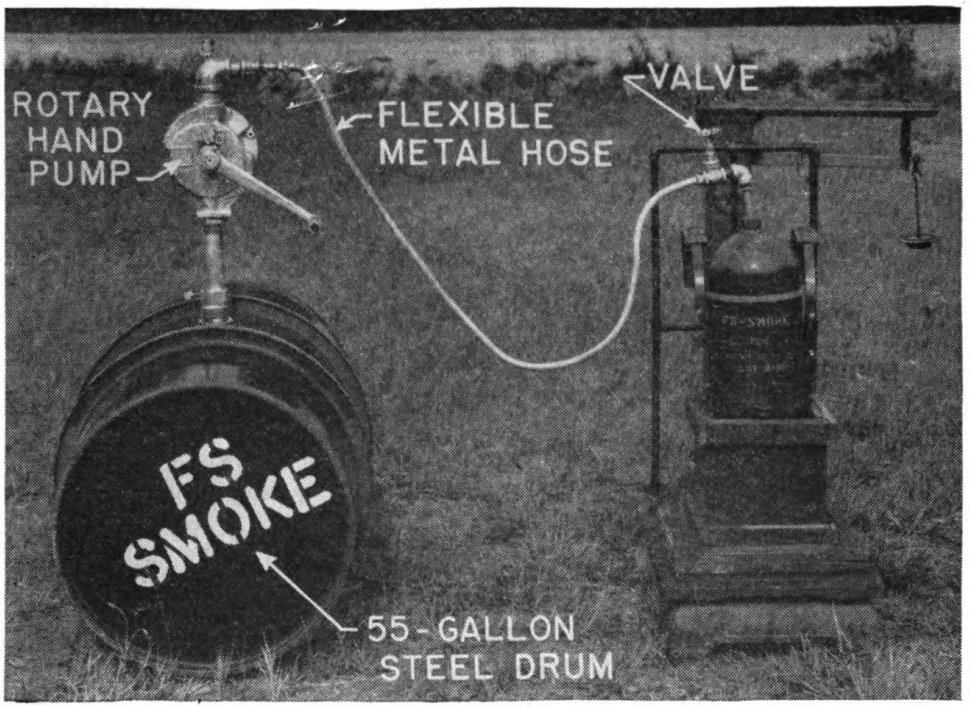

FIGURE 32.—Method of filling FS or FM into portable chemical cylinder by use of hand-operated pump.

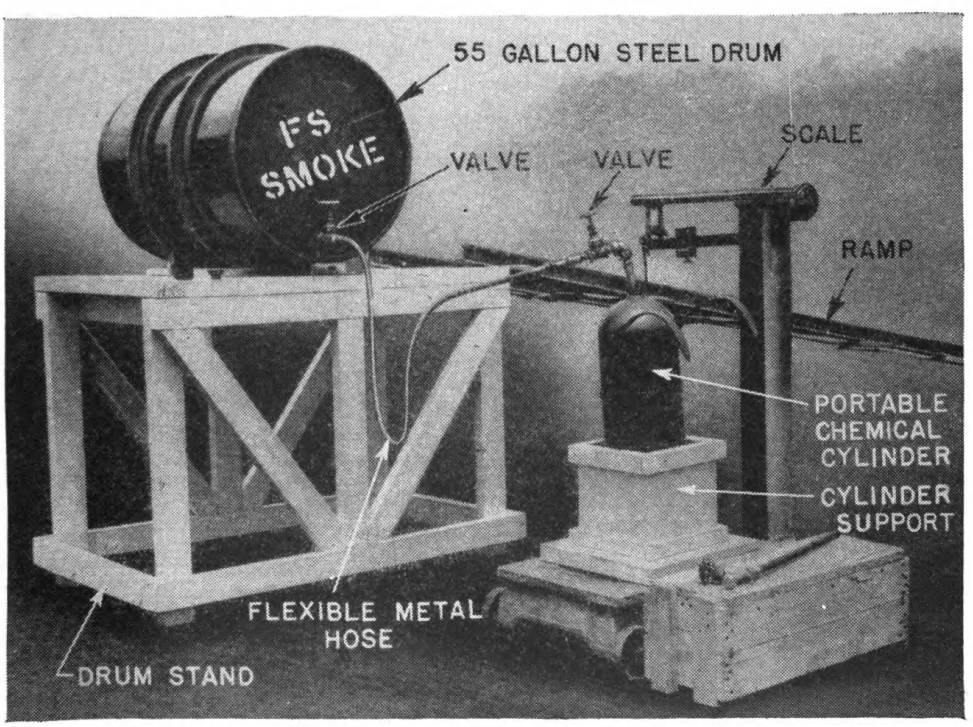

FIGURE 33.—Method of filling FS or FM into portable chemical cylinder by gravity flow.

ment which can be screwed into the bung, and is provided with a set-screw to clamp the suction pipe of the pump into place. The discharge of the pump should be equipped with a ⅜-inch iron pipe size threaded connection.

(2) *Filling line.*—The filling line consists of a 6-foot length of seamless flexible metal hose equipped with a valve and iron pipe fittings. The metal hose has an inside diameter of ⅜-inch and is provided with a ⅜-inch iron pipe size soldered male coupling at each end. The valve should be of all-iron or stainless steel construction. A ⅜-inch iron pipe nipple serves as a filling nozzle.

(3) *Platform scale.*—The scale should have a capacity of 500 pounds and should be provided with a double or single beam.

(4) *Cylinder support.*—The support is shown in figure 25. It consists of a square wooden box, open at the top, having an inside width of 9 inches and a height of 10 inches. It is attached to a wide wooden base for stability.

(5) *Drum stand.*—This stand is used to support the steel drum containing the supply of FS or FM. It is constructed of 2-inch by 4-inch wood, as shown in figure 34.

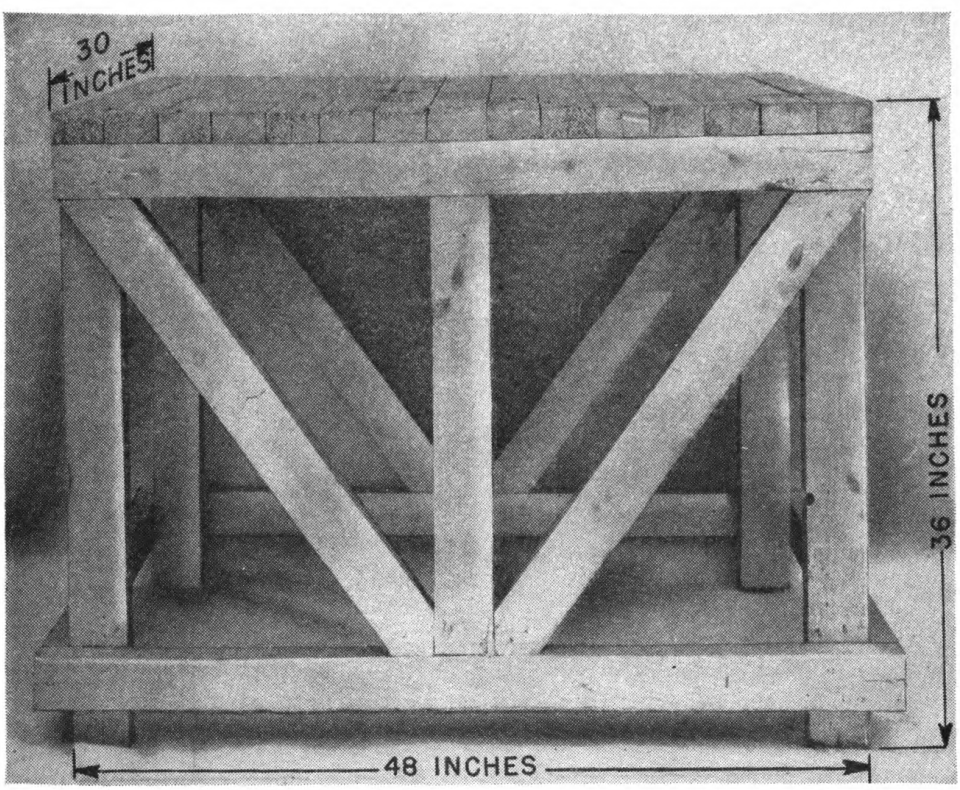

FIGURE 34.—Drum stand.

c. Connection of steel drum container.—(1) *For use with pump.*—The drum is positioned on its side in such a manner that its side bung is uppermost. Wooden chocks are placed beneath the drum to keep it in position, and the plug removed from the side bung of the drum. The suction pipe of the rotary hand-operated pump is inserted through the side bung until the end of the pipe reaches the opposite side of the drum. The special bung-fitting is then screwed tightly into the bung, and the setscrew of the bung-fitting tightened securely against the suction pipe of the pump. This assembly is shown in figure 32.

(2) *For use with drum stand.*—If the smoke agent is to be drawn from the end bung of the drum, the connection must be made before the drum is placed on the drum stand. The drum is placed on end with the end bung at the top. The plug is removed from the bung and a ¾-inch by ⅜-inch iron pipe bushing inserted. A ⅜-inch valve is connected to the bushing by means of an iron pipe nipple and the valve is tightly closed. The drum is then turned over on its side and rolled up a ramp and positioned on the drum stand as shown in figure 33.

d. Procedure for filling cylinders.—(1) *Preparation.*—(*a*) New or empty cylinders are prepared for filling by removing their valve and eduction tube assemblies, and should be inspected to see that they are clean and dry before being filled.

(*b*) Cylinders which are to be refilled may contain a residue of smoke agent and some carbon dioxide gas remaining from previous firing operations. Prior to the removal of the valve and eduction tube assembly, these cylinders should be placed in a horizontal or vertical position with the valve down and the carbon dioxide released by opening the cylinder valve. When the pressure is released in this manner practically all of the smoke agent remains in the cylinder. This operation should be conducted in such a manner that personnel will not be endangered by any small amounts of smoke agent that may escape. The cylinder is then placed in an upright position and the valve and eduction tube assembly removed.

(2) *Filling.*—The cylinder, with its valve and eduction tube assembly removed, is placed in the cylinder support on the portable scale as shown in figure 32 or figure 33. The tare weight of the empty cylinder and cylinder support is determined by balancing the scale, and the beam rider is then readjusted to give a gross weight 36 pounds greater than the tare weight. When refilling cylinders which contain some residual smoke agent, the tare weight should be ascertained previously by placing a similar but empty cylinder in the support on the scale. The smoke agent is then filled into the cylinder until

the balanced beam indicates that the cylinder contains 36 pounds of the agent. Care should be taken not to permit the filling line to rest on the cylinder, as this would interfere with the proper operation of the scales.

(3) *Closing.*—Before the filled cylinder is removed from the scale, the valve and eduction tube assembly is inserted into the container opening and made handtight. Kaolin pipe thread cement should be used on the pipe threads to make a leakproof connection. The cylinder assembled with its valve and eduction tube is then removed from the scale, and the connection between the valve body and the cylinder container tightened by use of a wrench until a leakproof connection is made.

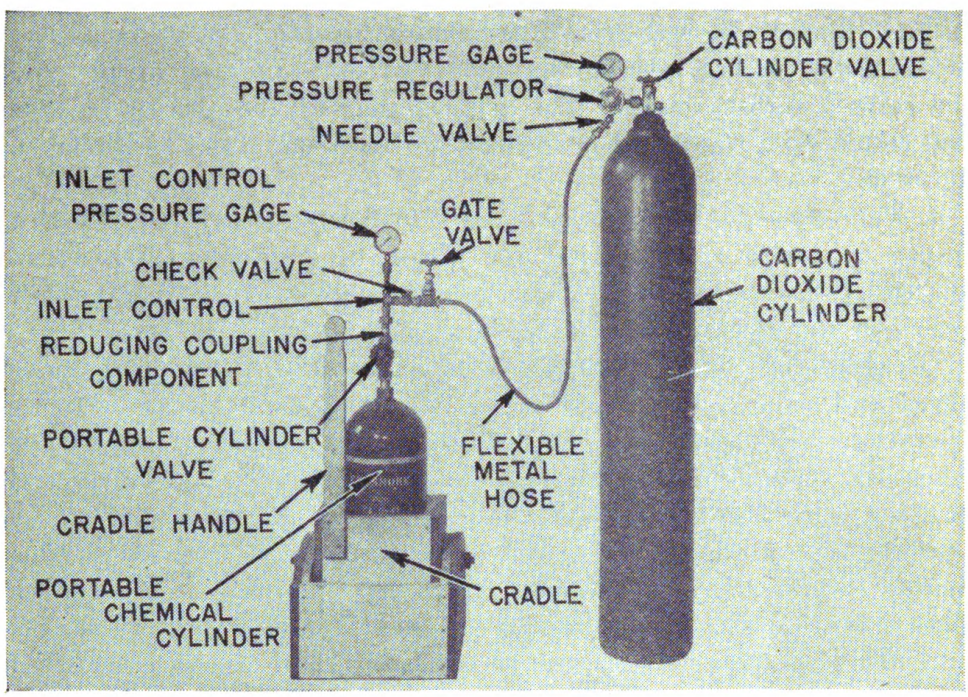

FIGURE 35.—Assembly of charging apparatus M1.

(4) *Inspection.*—The filled cylinder is placed on its side and allowed to remain in this position for 1 hour, during which time it will be observed for leaks. Leaks will be indicated by the appearance of white fumes. If a leak is indicated, the connection should be tightened.

e. Maintenance of apparatus.—Immediately after use, all parts of the filling apparatus should be washed thoroughly with a 5 percent solution of soda ash, rinsed with water, and dried. The hand-operated pump should be disassembled, and all metal parts washed thoroughly, dried, and given a light coating of grease to prevent rusting.

f. Safety precautions.—Personnel engaged in filling the cylinder with smoke agents should be provided with a good grade of heavyweight coveralls, goggles, respirators, rubber gloves, and rubber boots. Every possible care should be exercised to prevent contact of FS or FM with the body. If, in spite of every precaution, any liquid should come in contact with the body, it should immediately be wiped off with a piece of dry cloth or waste, the affected part then washed with an *abundance* of water, and lastly with a weak solution of sodium bicarbonate. Should any appreciable quantity of FS or FM touch the clothing, the garment should be removed immediately. No water should be put upon the garment while it is being worn, as the heat of reaction may cause severe burns.

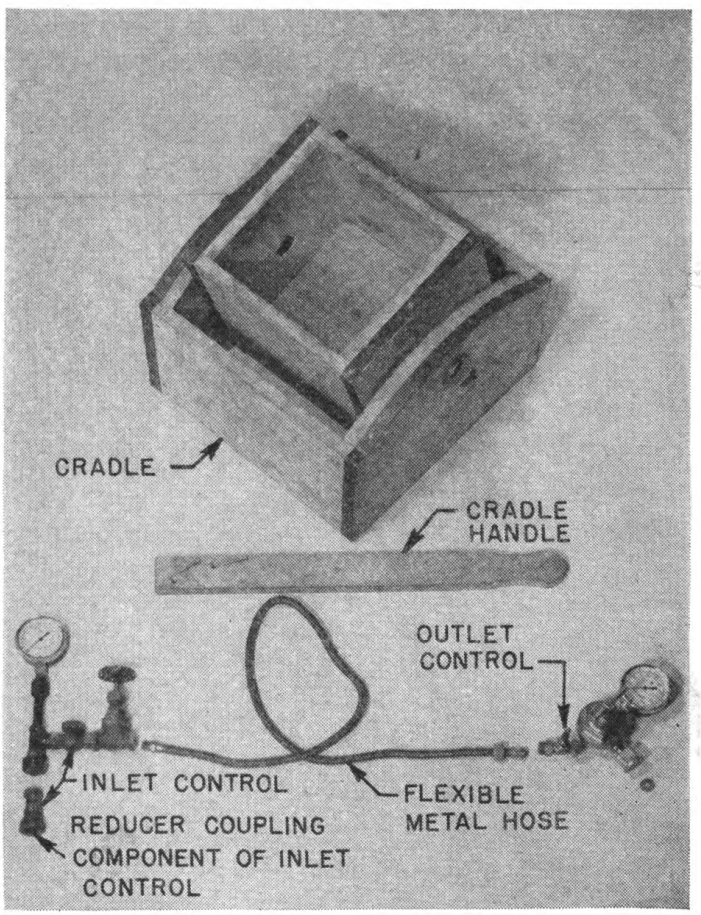

FIGURE 36.—Components of charging apparatus M1.

11. Charging apparatus M1.—*a. General.*—This is a standard hand-operated apparatus used in charging the filled cylinder with carbon dioxide gas. The M1 charging apparatus is portable and

may be used for field charging operations. In use, it charges one cylinder at a time, and approximately 10 minutes is required for each cylinder.

b. Description.—The apparatus assembled for operation is shown in figure 35. The components of the apparatus are shown in figure 36, and consist of an outlet control, an inlet control, a length of connecting hose, and a cradle in which the portable chemical cylinder is rocked. The outlet control is connected to the carbon dioxide cylinder and the inlet control to the portable chemical cylinder.

(1) *Outlet control.*—The outlet control is a pressure regulator. It consists of a pressure reducing valve provided with a pressure gage to indicate the reduced pressure of the carbon dioxide gas, and a needle outlet valve.

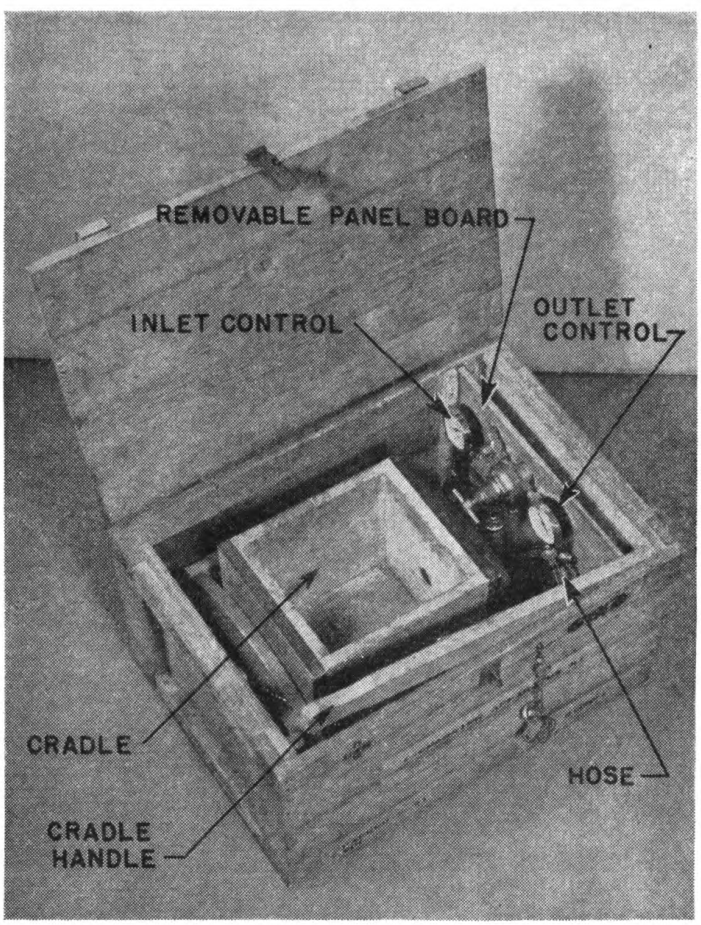

FIGURE 37.—Method of packing charging apparatus M1.

(2) *Inlet control.*—The inlet control is an assembly comprising a gate valve, a pressure gage to indicate the pressure in the portable

chemical cylinder, and a check valve to prevent the chemical filling from backing up into the charging apparatus. The control is connected to the valve of the portable chemical cylinder by means of a reducer coupling and a union, both of which are components of the inlet control.

(3) *Hose.*—A flexible bronze hose connects the inlet and outlet controls of the apparatus. The hose is provided with a union at one end and a male coupling at the other end.

(4) *Cradle.*—The cradle is constructed of wood. It consists of a cylinder holder and a base. The cylinder holder is supported on pinions so that it may be rocked to agitate the contents of the cylinder.

(5) *Packing.*—The charging apparatus is packed in a wooden box as shown in figure 37. The inlet control, the outlet control, and the metal hose are clamped to a removable panel board. Wooden retainer strips hold the panel board in position in the packing box. The weight of the packed charging apparatus is 66 pounds, and its volumetric displacement is 4.2 cubic feet. The packing box is shown again in figure 38.

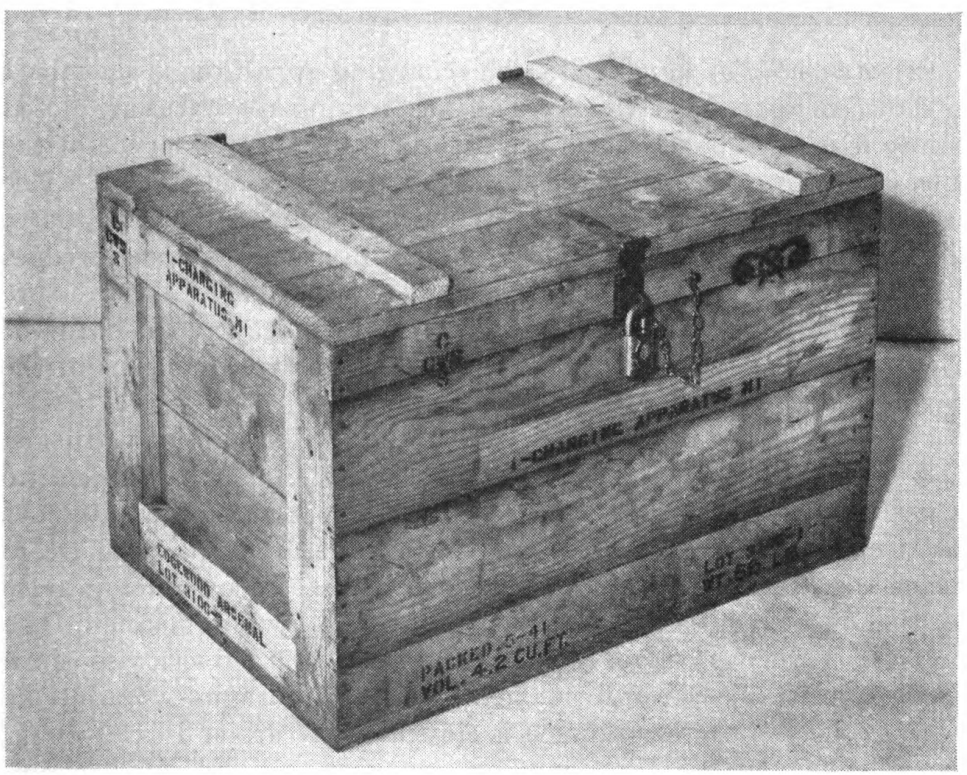

FIGURE 38.—Packing box for charging apparatus M1.

than the pressure to which the cylinder is to be charged. For example, in charging a phosgene-filled cylinder at a temperature of 70° F., the pressure to which the cylinder is to be charged is 118 pounds per square inch, and the pressure reducing valve is adjusted to supply carbon dioxide at a pressure of about 143 pounds per square inch. The needle valve of the outlet control is opened and the carbon dioxide supply pressure checked with the inlet control pressure gage by opening the gate valve of the inlet control. If the two gages are not in agreement, the pressure reducing valve is readjusted until the correct carbon dioxide supply pressure is indicated upon the inlet control pressure gage, whereupon the gate valve of the inlet control is closed. All connections should be inspected for leaks.

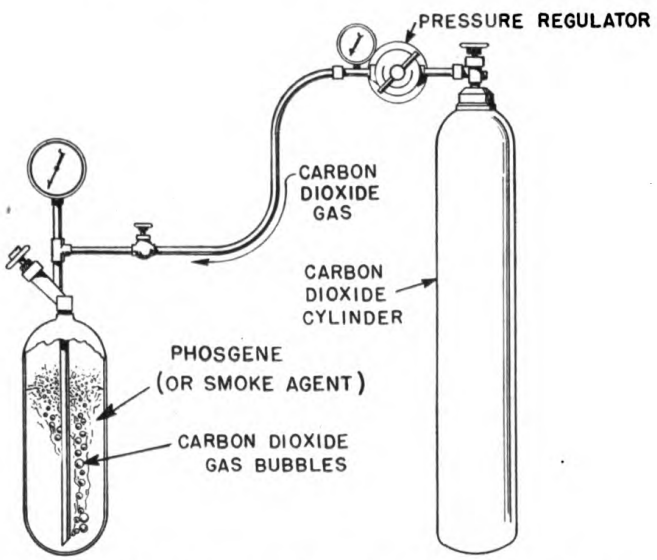

FIGURE 39.—Method of charging portable chemical cylinder with carbon dioxide.

(4) *Charging procedure.*—The method of charging is illustrated in figure 39. With the carbon dioxide supply pressure properly adjusted, carbon dioxide is introduced into the cylinder by partly opening the inlet control gate valve and fully opening the portable chemical cylinder valve. Carbon dioxide is introduced at a moderate rate and the cylinder rocked in the cradle of the charging apparatus during the operation. The rocking hastens the solution of carbon dioxide in the contents of the cylinder. The introduction of carbon dioxide is continued until the inlet control pressure gage indicates a pressure 10 pounds per square inch greater than the final pressure desired in the charged cylinder. After the pressure in the cylinder has reached this value, the gate valve is closed and the rocking continued for a period

of 3 minutes. During this 3-minute period, the pressure in the cylinder is maintained at 10 pounds per square inch above the desired final pressure of the charged cylinder by opening the gate valve as necessary. The gate valve is then kept closed and the rocking continued for an additional period of 5 minutes. If the pressure in the cylinder remains constant or does not drop below the specified final required pressure of the charged cylinder as indicated in table I, the cylinder is fully charged and ready for use. If, during the 5-minute rocking period, the pressure in the cylinder falls below that specified in table I, more carbon dioxide is introduced as outlined above until the cylinder retains its proper pressure.

(5) *Inspection.*—Cylinders which are not to be fired within 24 hours after charging should be inspected for maintenance of charging pressure. They should be inspected by use of the charging apparatus after being allowed to stand 24 hours. The cylinder is connected to the charging apparatus and the gate valve of the inlet control closed. The portable chemical cylinder valve is opened and the cylinder pressure read as indicated on the inlet control pressure gage. If the pressure in the cylinder is within 10 pounds per square inch of the specified pressure of the cylinder as shown in table I, the cylinder has been satisfactorily charged. If the cylinder pressure is lower than 10 pounds per square inch below the specified pressure, the cylinder should be recharged as outlined in the charging procedure. Recharged cylinders will not require further inspection. In the inspection of cylinders which show satisfactory maintenance of charging pressure, a small amount of carbon dioxide gas should be passed through the inlet control connection and into the cylinder before disconnecting the cylinder from the apparatus. This operation is necessary to force back into the cylinder the small amount of phosgene or smoke agent that may have entered the inlet control connection during the inspection.

d. Safety precautions.—Personnel engaged in charging phosgene-filled cylinders should have gas masks available for immediate use at all times. Personnel engaged in charging FS or FM filled cylinders should be provided with gas masks and rubber gloves. A 10-gallon open tank (or at least two or three 10-quart buckets) filled with water should be immediately available when handling FS or FM.

e. Maintenance of apparatus.—After the charging operations have been completed, the apparatus should be dismantled and stored in a dry place. The carbon dioxide cylinder valve must be closed before dismantling the apparatus. Parts of the apparatus which were ex-

posed to phosgene or to the smoke agent should be washed with a 5 percent solution of soda ash, rinsed with water, and thoroughly dried.

12. Charging apparatus type A.—*a. General.*—This is a gasoline engine-driven apparatus used to charge filled cylinders with carbon dioxide. By its use, cylinders previously filled with the proper amount of phosgene, FS or FM, are charged with carbon dioxide gas to provide an expellant for discharging the contents of the cylinders in the field.

(1) *Capacity.*—The type A charging apparatus has a charging capacity of 30 cylinders per hour. The cylinders are charged in groups of 10, and approximately 20 minutes are required to charge each group.

(2) *Use.*—The type A charging apparatus is suitable for use in the zone of the interior and in army depots.

b. Description.—The charging apparatus is illustrated in figures 40, 41, 42, and 43, and consists of three principal parts: the stand, rocking cradle, and operating mechanism.

(1) *Stand.*—The stand is a structural steel frame consisting of a base, two upright end sections serving as end bearings, ten upright center sections serving as intermediate bearings, and a bedplate for the motor-drive unit.

(2) *Rocking cradle.*—The rocking cradle is a structural steel oscillating member and consists of a frame with eleven compartments, ten of which are for the portable chemical cylinders and one for either a 50- or 75-pound carbon dioxide cylinder. The rocking of this cradle is accomplished by means of a connecting rod attached to a crank on the operating mechanism.

(3) *Operating mechanism.*—The operating mechanism consists of a one-horsepower gasoline motor, a 75 to 1 ratio reducing gear, and a hand-operated friction clutch. This unit is designed to give 30 complete oscillations per minute.

c. Operation.—(1) *Placing carbon dioxide cylinder.*—The carbon dioxide cylinder is placed in the compartment provided at the end of the apparatus, the adjusting screws tightened, the rocking cradle swung to a horizontal position, and the cradle locked in this position by means of the locking pin, as shown in figure 40.

(2) *Starting engine.*—The gasoline engine is started and allowed to warm up for a few minutes prior to starting the charging operation. The engine is started in the conventional manner by means of a rope starter. The choke lever should be turned to a horizontal position when starting the engine, and to a vertical position as soon as the engine is started.

(3) *Preparing portable cylinders.*—Ten cylinders are prepared for charging. They are removed from their carriers and their valves

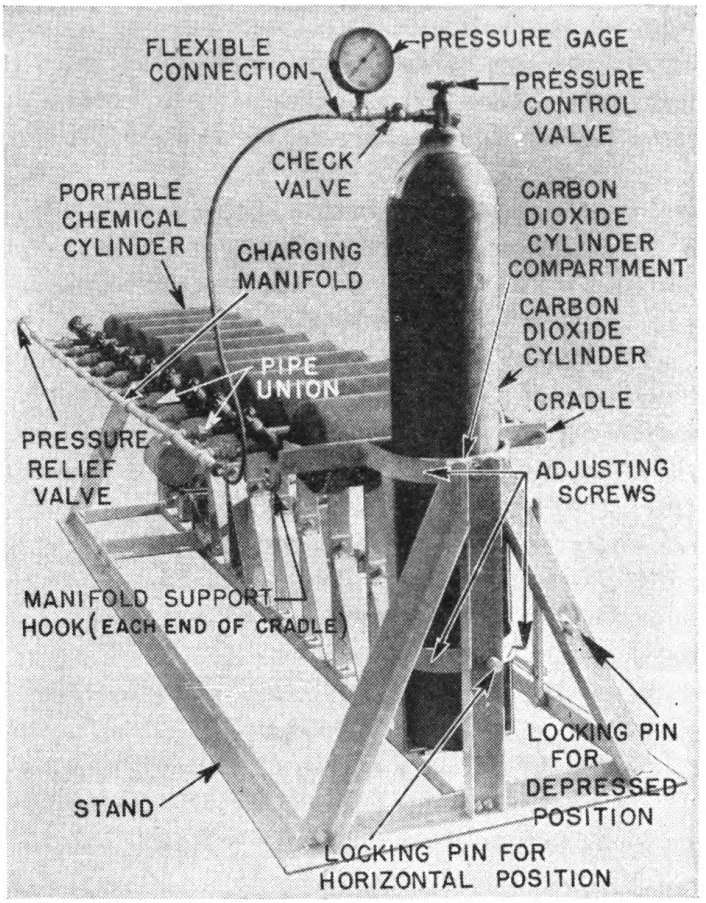

FIGURE 40.—Charging apparatus type A in horizontal position.

checked to insure that they are tightly closed. The valve caps are then removed and unions assembled tightly to the cylinder valves.

(4) *Connecting portable chemical cylinders.*—The cylinders are placed in the rocker compartments with valve handles up, and the free ends of the pipe unions connected to the charging manifold, as shown in figure 40.

(5) *Connecting carbon dioxide cylinder.*—The flexible connection provided with a pressure gage and check valve is attached to the carbon dioxide cylinder and to the charging manifold as shown in figure 40.

(6) *Testing for leaks.*—The pressure relief valve on the manifold is closed and the system tested for leaks by manipulating the pressure control valve until a pressure of 200 pounds per square inch is indi-

cated on the gage. Spiral-wound flexible metal hose frequently leaks slightly until it adjusts itself to the pressure. If the hose is in good condition and has retained its flexibility this leakage should not be serious.

(7) *Depressing cradle.*—In this operation the locking pin shown in figure 40 is released, and the cradle swung to the depressed position and locked there, as shown in figure 41.

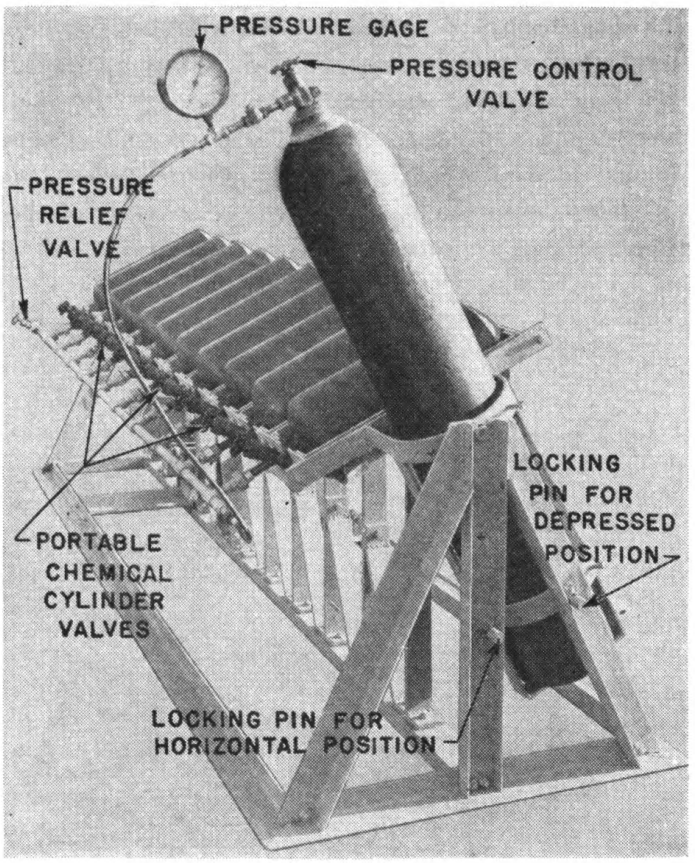

FIGURE 41.—Charging apparatus type A in depressed position.

(8) *Opening portable cylinder valves.*—All cylinder valves are fully opened and at the same time and as far as practicable a carbon dioxide pressure of 25 pounds per square inch is maintained on the gage.

(9) *Starting operating mechanism.*—The locking pin shown in figure 41 is released and the pressure control valve manipulated until a pressure of about 150 pounds per square inch is indicated on the gage. The clutch is engaged by pulling the operating lever to the rear until it locks, and the operating mechanism regulated to a rocking speed of 30 complete oscillations per minute.

(10) *Charging cylinders.*—The rocking and charging of the cylinders should be continued until the pressure reaches the gage point specified in table I for the temperature of cylinders at the time of charging. Approximately 5 to 10 minutes are required to bring the cylinder pressure up to the specified degree. Care should be taken to allow the pressure in the cylinders to reach a constant value with the pressure control valve closed before assuming that the desired pressure has been reached. During the charging operation the pressure control valve should be closed momentarily at frequent intervals in order to note the pressure which has been built up in the cylinders. This may be done without stopping the cradle. It is desirable to start the charging at a pressure of 50 to 100 pounds per square inch higher than the desired final pressure, and to reduce this excess as the final pressure is approached. Charging should not be done at a pressure greater than 250 pounds per square inch.

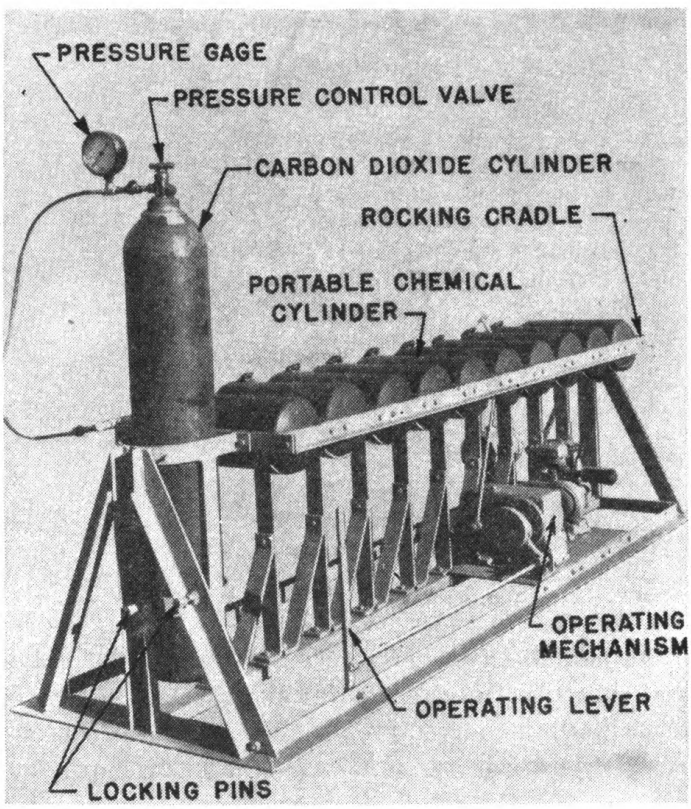

FIGURE 42.—Charging apparatus type A showing operating lever and operating mechanism.

(11) *Halting operating mechanism.*—When the pressure remains constant after 5 minutes of continued agitation with the pressure control valve closed, the clutch is disengaged by pushing the operating

lever forward until it stops. The operating cradle is then locked in the depressed position.

(12) *Increasing manifold pressure.*—The pressure control valve is opened and the pressure in the manifold allowed to rise 20 pounds per square inch above the charging pressure. The valve is then immediately closed. This operation is intended to force the phosgene or smoke agent remaining in the manifold and cylinder eduction tubes back into the cylinders.

(13) *Closing portable cylinder valves.*—All portable chemical cylinder valves are closed tightly by the use of a hand wrench on the handwheels to insure complete closure.

(14) *Clearing manifold.*—An extension of pipe is placed on the connection attached to the pressure relief valve and this valve opened until the pressure indicated on the gage reaches zero. The clearing of the manifold is completed by manipulating the pressure control valve until the line has been blown free of phosgene or smoke agent. This final operation should be conducted with extreme care. The extension pipe should carry the phosgene or smoke agent where unprotected personnel will not be endangered.

(15) *Removing cylinders.*—After the charging operation has been completed and the manifold cleared, the manifold is removed and placed on hooks provided on the apparatus for its support. The cylinders are removed from the rocking cradle and replaced in their carriers. The sections of unions are removed from the cylinder valves and placed upon other cylinders awaiting charging. The valves on the recently charged cylinders are inspected for tightness and immediately sealed with valve caps.

(16) *Stopping engine.*—After all operations have been completed, and it is desired to stop the engine, the metal stop switch is pressed against the end of the spark plug and held there until the engine stops turning.

d. Care and maintenance.—(1) *Inspection.*—A careful inspection should be made before using the apparatus to ascertain if all valves are in operating condition and if the flexible metal hose is free from the corrosive effects of chemical agents. Excessive loss of flexibility of the metal hose is an indication of undue corrosion. At no time should the charging line assembly comprising the charging manifold and the flexible metal hose and component parts be used if it is not in first-class condition. Necessity for frequent replacement of parts subjected to the action of phosgene or smoke agent is not necessarily an indication of defective material or carelessness on the part of the operating personnel. Phosgene and smoke agents are very corrosive

substances, and frequent inspection and test should be made of all metal parts coming into contact with them.

(2) *Cleaning.*—Immediately after use, if the equipment is to stand idle for more than 6 hours, the charging manifold and flexible metal hose assemblies should be disconnected and separated. Each of these parts should then be washed thoroughly with a 5 percent solution of soda ash, rinsed with clear water, dried, and carefully stored for future use.

(3) *Lubrication.*—(*a*) *Engine.*—The oil reservoir of the engine should be filled to the level of the filler plug opening shown in figure 43 after every 5 hours of operation. After every 25 hours of operation the old oil should be drained completely from the crankcase and replaced with fresh oil. An oil having an SAE 20 body should be used for lubrication. After every 25 hours of operation the air cleaner should also be removed, washed with gasoline, and thoroughly dried; and the felt filter pad should be saturated with lubricating oil and replaced in the air cleaner. In the event of difficulty, the book of instructions accompanying the engine should be consulted.

(*b*) *Reducing gear.*—An occasional check for depth of lubricant should be made through the filling hole shown in figure 43, and a sufficient quantity of grade 600W oil added to keep the lower gears covered.

(4) *Clutch mechanism.*—The clutch mechanism requires occasional lubrication and adjustment. Lubricating oil of the grade used in the engine crankcase (SAE 20) should be added to the operating ring when required. The bearing-pin of the clutch-housing should be lubricated occasionally by the addition of 3 or 4 drops of oil through the oil hole in the clutch driveshaft. The connecting rod bearings and the clutch control lever bearing require occasional lubrication. In the event of clutch slippage, the adjusting ring screw should be loosened and the adjusting ring advanced slightly. The adjusting ring should be secured in this position by tightening the adjusting screw. Care should be observed to prevent oil from coming into contact with the clutch plates. If this should occur, the clutch must be dismantled and the plates cleaned with gasoline.

e. Safety precautions.—(1) Personnel engaged in charging phosgene-filled cylinders by use of charging apparatus type A should observe the safety precautions outlined in paragraph 9*f*, and those engaged in charging cylinders filled with FS or FM should observe the precautions outlined in paragraph 10*f*. In addition, personnel engaged in charging smoke-filled cylinders should be equipped with gas masks for use in the event of an excessive amount of fumes.

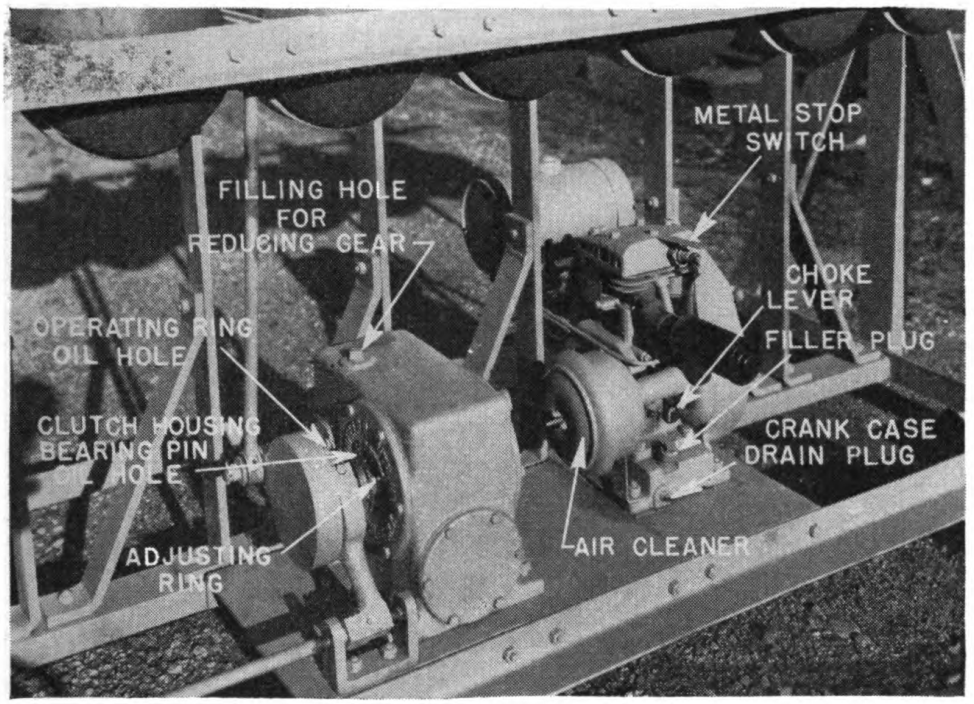

FIGURE 43.—Charging apparatus type A operating mechanism.

(2) If charging operations are conducted indoors, proper draft ventilation should be provided. If the operations are conducted out of doors, personnel should keep upwind or out of the fumes.

13. Apparatus for charging cylinder with chlorine.—*a. General.*—This is a standard apparatus used to charge phosgene-filled cylinders with chlorine. The apparatus utilizes chlorine supplied in a ton container, and a definite weight of chlorine is charged into each cylinder. It is shown in operation in figure 44. Since each apparatus has two chlorine charging lines, two cylinders may be charged simultaneously.

(1) *Capacity.*—This apparatus is estimated to have a charging capacity of 50 cylinders per hour.

(2) *Accessory equipment.*—Two portable platform beam scales are required in the operation. Each of the scales should have a capacity of about 500 pounds.

b. Description.—The apparatus, exclusive of the chlorine ton container and the platform scales, consists of two sections of ½-inch flexible metal hose together with special fittings. Each section of metal hose is 4 feet in length and is connected at one end through a special fitting to the lower outlet valve of the ton container. On the other end of

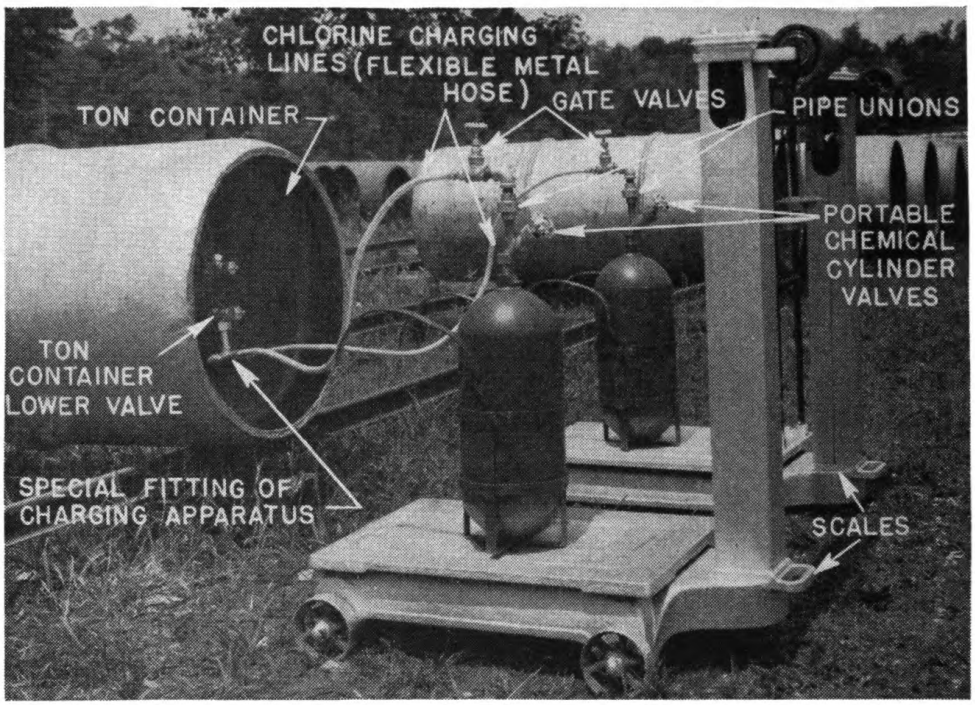

FIGURE 44.—Apparatus for charging cylinder with chlorine, shown in use.

each section is a gate valve, an ell, and a union for attachment to the cylinder.

c. Assembly of apparatus.—The chlorine ton container is so placed that its valves are in vertical alinement. The special fitting of the chlorine charging apparatus is then connected to the lower valve of the ton container. The gate valve on each of the filling lines is tightly closed, and the valve of the ton container to which the apparatus is connected is opened. The platform scales are rolled into positions where the charging lines may later be connected without tension to cylinders on the scales.

d. Charging operation.—(1) *Connecting cylinders.*—A cylinder with its carrier is placed on each scale, and the ends of the charging lines are connected to the cylinder valves by means of the unions provided with the charging line assembly. All connections should be checked for tightness.

(2) *Charging cylinders.*—The cylinder valves are opened but the valves on the charging lines are allowed to remain closed. The scales are balanced and note taken of the tare weights of the cylinders connected to the charging lines. The rider on each scale is moved to a position which indicates 5 pounds more than the tare weight. The charging line valves are gradually opened and 5 pounds of chlorine per-

mitted to flow into each cylinder, as indicated by the balancing of the scale beams. When this amount of chlorine has been added to the cylinder, the valve on its charging line is closed, and after a lapse of about 15 seconds the valve on the cylinder is closed. Care should be taken to insure that nothing touches the charging lines or the cylinders while their weights are being checked.

(3) *Disconnecting cylinders.*—The cylinders are disconnected from the charging lines by unscrewing the unions. They are then taken from the scales, the union sections remaining on their valves removed, and valve caps securely tightened on the valves.

e. Care and maintenance.—Before use, a careful inspection should be made to ascertain if all valves are in operating condition, and if the flexible metal components are free from the corrosive effects of chlorine. Immediately after charging operations are discontinued, the charging line assembly should be disconnected, thoroughly washed with a 5 percent solution of soda ash, rinsed with clear water, dried, and carefully stored for future use.

f. Safety precaution.—Personnel engaged in charging cylinders with chlorine should wear gas masks.

14. Hydrostatic pressure test for cylinders.—*a. General.*—Cylinders of doubtful safety should be tested with hydrostatic pressure before they are filled. Cylinders which upon test withstand a hydrostatic pressure of 400 pounds per square inch without giving any sign of leakage or distortion may safely be filled and charged. The test procedure described herein is intended only for checking the condition of used or old cylinders, and should not be employed by the manufacturer as an acceptance test on new cylinders.

(1) *Inspection of cylinders.*—All cylinders should be visually inspected before they are filled. If there is any irregularity in the contour, any excessive corrosion or rusting, or any evidence of corrosion in the welded joint at the middle of the cylinder, the above hydrostatic pressure test must be made.

(2) *Manufacturer's acceptance test.*—New cylinders are tested by the manufacturer. The portable chemical cylinder container MII is required to withstand an internal hydrostatic test pressure of 400 pounds per square inch without showing a permanent increase in volume of more than 10 percent of the total volumetric expansion, and to withstand an internal air pressure of 300 pounds per square inch with no leakage. The finished cylinder is required to withstand an internal air pressure of 200 pounds per square inch without leakage when the cylinder valve is closed.

b. Apparatus.—The apparatus used to test the cylinder with hydrostatic pressure is shown in figure 45. It consists of a hand-operated pump, flexible metal hose, and a pressure test head.

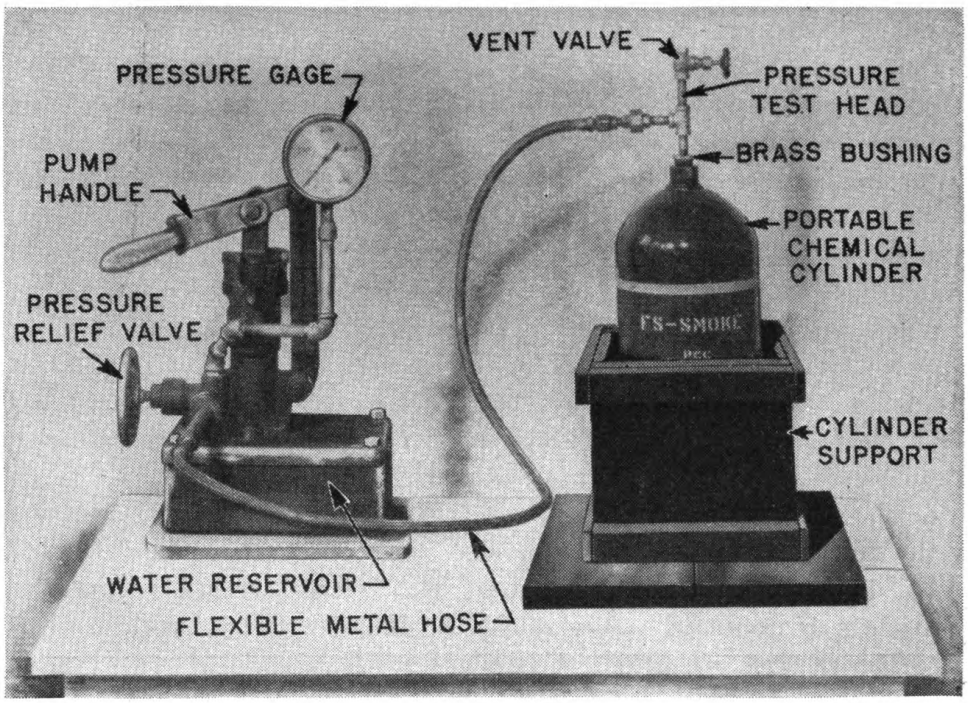

FIGURE 45.—Apparatus for testing cylinder with hydrostatic pressure.

(1) *Pump.*—This is a hand-operated plunger pump which has a working pressure of about 1,000 pounds per square inch. The base upon which the pump is mounted is provided with a water reservoir. A pressure gage having a range of 0 to 600 pounds per square inch is connected to the pump outlet.

(2) *Pressure test head.*—The pressure test head serves to connect the flexible metal hose to the cylinder. The head consists of an assembly of a ¼-inch valve, a T, a union, and iron pipe nipples, and is connected to the cylinder by means of a ¾-inch by ¼-inch brass bushing.

(3) *Flexible metal hose.*—The flexible metal hose is of the seamless type and has an internal diameter of ¼ inch. One end of the hose is provided with a union and the other end with a soldered male coupling.

c. Conditioning cylinders.—The cylinder must be thoroughly cleaned of any chemical agent before it can be submitted to a hydrostatic pressure test. After it has been tested and found to be satisfactory, it should be dried thoroughly.

(1) *Cylinders containing phosgene.*—Discharged cylinders which contain a residue of phosgene must be emptied and cleaned before they are tested. This operation is conducted as shown in figure 30 by inverting the cylinder and releasing phosgene vapor through a short length of rubber hose into a water slurry of slaked lime or a solution of caustic soda. Application of heat to the cylinder may be necessary to vaporize all of the liquid phosgene. After all the agent has been vaporized and the pressure in the cylinder released, the valve and eduction tube assembly is removed and the cylinder filled with water to displace the phosgene vapor. The quantity of vapor displaced into the atmosphere by the water can be minimized by the alternative of introducing 2 quarts of a 10 percent caustic soda solution into the cylinder and rocking the cylinder upon its side for about 1 minute, after which it should be emptied and rinsed with water.

(2) *Cylinders containing smoke agent.*—Discharged cylinders which contain a residue of a smoke agent must be cleaned before they can be tested. The pressure due to carbon dioxide gas remaining in the cylinder should first be released by laying the cylinder upon its side and opening the valve. Small amounts of the smoke agent may be discharged with the carbon dioxide, and this operation should be conducted in such a manner that unprotected personnel will not be endangered. After the pressure has been released, the valve and eduction tube assembly is removed, and the remaining smoke agent poured out. The empty cylinder should be rinsed with water to remove the last trace of the smoke agent.

(3) *Drying cylinder.*—The cylinder should be dried thoroughly after it has been tested and found satisfactory. It is treated first by having live steam introduced into it, after which the steam condensate is allowed to drain and the cylinder dried by injecting air into it. The cylinder must be completely dry when it is to be filled with phosgene, as the presence of moisture in phosgene produces hydrochloric acid which will corrode the steel container.

d. Procedure for testing cylinder.—(1) The cylinder is inspected to insure that the valve and eduction tube assembly has been removed and that the cylinder is clean. The cylinder is removed from its carrier and placed in a suitable support, such as the support shown in figure 25, so that it will remain in an upright position. It is then connected to the pressure test head as shown in figure 45, and the pressure test head connected to the flexible metal hose of the apparatus by means of the union. A pipe thread lute, such as white lead in oil, is used on all threaded connections to prevent leakage.

(2) The vent valve is opened on the pressure test head, and water pumped into the cylinder until a free overflow of water through the vent valve indicates that all of the air has been displaced from the cylinder and the pressure test head. The water supply in the reservoir of the pump should be checked and replenished if necessary.

(3) The vent valve is then closed and the pump operated until the pressure gage indicates a pressure of 400 pounds per square inch, which is maintained for a period of 1 minute. Meanwhile, the cylinder should be watched for leakage or deformation. After the test has been completed, the pressure is released from the cylinder by means of the pressure relief valve provided on the pump, and the cylinder disconnected from the apparatus.

(4) If no deformation or leakage of the cylinder occurred during the hydrostatic pressure test, the cylinder is acceptable for filling and charging. The cylinder must then be thoroughly drained and dried (*c*(3) above) before it is connected with its valve and eduction tube assembly.

SECTION IV

CARE AND MAINTENANCE

15. Storage.—*a. Empty cylinders.*—Empty cylinders are stored and transported in their packing boxes. It is advisable to leave them in the original packing until required for filling and charging. They should be stored in a suitable warehouse or shed. If this is not possible, the cylinders in their boxes should be stored neatly and protected from the weather by use of tarpaulins or other available means.

b. Filled cylinders.—(1) Filled cylinders should be stored in a dry, well-ventilated building, removed from flammable material.

(2) All filled cylinders should be stored unpacked and in an upright position, and separately as to type of filling. The manner of storage should be such that leaky cylinders may easily be detected and removed.

(3) Filled cylinders which have been charged should be protected from heat. If stored in the open during warm weather, they should be protected against continuous direct rays of the sun.

16. Inspection.—*a. New cylinders.*—New cylinders should be inspected before they are filled and charged. The valve and eduction tube assembly is removed and the interior inspected for cleanliness and dryness.

b. Used cylinders.—Cylinders which previously have been filled and discharged should be inspected for proper operation of the valve, the condition of the fiber sealing disk under the valve cap, and for signs of mechanical injury or excessive corrosion of the container. If the cylinder shows signs of mechanical injury or excessive corrosion, it should be submitted to a hydrostatic pressure test before it is again filled.

c. Filled cylinders.—Filled cylinders should be inspected 24 hours after being placed in storage. Phosgene leaks are detected by use of aqua ammonia fumes and are indicated by the formation of white smoke. FS or FM leaks are indicated by the spontaneous formation of a white smoke when those agents come into contact with the air. After this initial inspection, frequent checks should be made for leakage or signs of valve or cylinder failures. Gas masks, rubber gloves, rubber aprons, and rubber boots should be available at all times for use by personnel.

17. Maintenance of valve and nozzle.—*a. Valve.*—The parts of the valve requiring attention are the valve packing and the valve seat.

(1) *Valve packing.*—Leakage around the valve stem may usually be corrected by increasing the pressure on the valve packing by means of the packing gland. If this is insufficient, the valve should be dismantled and the packing replaced with new graphite impregnated braided asbestos packing. Since the valve must be dismantled to replace the packing, this operation cannot be performed on valves which are installed on cylinders under pressure. Leakage about the valve stem will not occur when the valve seat is in good condition and the valve tightly closed.

(2) *Valve seat.*—Minor leaks about the valve seat may be corrected by grinding. The valve is dismantled, a small quantity of medium grinding compound placed on the closure end of the valve stem, and the valve stem ground against the valve seat. If the valve seat is badly scored it should be machined and ground to a smooth finish.

b. Nozzle.—After use in firing operations, the nozzle should be inspected by removing the brass cap and examining the interior for foreign matter or evidence of corrosion. If the screen requires cleaning, remove the screen spring and the screen and wash the screen in gasoline. Dry the screen thoroughly after washing. Upon reassembly, the threads of the brass cap should be luted with an acidproof black paint.

18. Disposal of leaky cylinders.—*a. Leaking valves.*—(1) Leaking valves can usually be remedied by tightening the valve with a hand wrench. The wrench is placed upon the hexagonal portion of the valve handle. The tightness of the valve cap should also be checked, and it may be necessary further to tighten the packing gland.

(2) If the valve leak cannot be repaired, and the contents of the cylinder have been charged with carbon dioxide, the contents of the cylinder should be discharged in a locality where unprotected personnel will not be endangered. If the contents of the cylinder have not been charged with carbon dioxide, the valve should be replaced. Cylinders containing uncharged phosgene should first be cooled in the manner outlined in *b*(2)(*b*) below, before the valve is replaced. Valves on cylinders containing uncharged smoke agents may be directly replaced, for such cylinders are not under pressure.

b. Leaking containers.—(1) Charged cylinders which develop a leak in the container should have their contents discharged in a locality where unprotected personnel will not be endangered. No attempt should be made to salvage chemical agents which have been charged with carbon dioxide under pressure, for the tendency of the carbon dioxide gas to come out of solution would make this a decidedly dangerous operation. To reduce contamination of the atmosphere by the escaping chemical agent before the contents of the cylinder can be disposed of, the cylinder may be temporarily stored in a tank containing a 10 percent solution of caustic soda.

(2) Cylinders which are not charged and which develop a leak in the container should have their contents transferred to another cylinder.

(*a*) *Transfer of smoke agent.*—Uncharged smoke agents may be transferred directly from one cylinder to another in the following manner: The valve and eduction tube assembly is removed from the leaky cylinder, and an iron pipe bushing, to which a ⅜-inch iron pipe nipple is attached, is screwed into the cylinder opening. The valve and eduction tube assembly of the new cylinder is removed and the new cylinder positioned over the leaky container so that the iron pipe nipple projects into the new cylinder. The relative positions of the cylinders are then reversed so that the leaky cylinder is above the new cylinder, the iron pipe nipple meanwhile being kept in the opening of the new cylinder. The smoke agent will then pass downward from the leaky cylinder into the new cylinder.

(*b*) *Transfer of phosgene.*—Uncharged phosgene may be transferred from one cylinder to another in the following manner: The

pressure in the leaky cylinder is released in the manner shown in figure 30, and as described in paragraph 9*e*(1) (*a*), until the phosgene has cooled to its boiling point of 46° F. As an alternative, the cylinder may be cooled by packing it in ice. After the phosgene has been cooled, it is transferred to the new cylinder in the same manner as that used in the transfer of the smoke agent.

SECTION V

TRANSPORTATION

19. General.—*a. Empty cylinders.*—Clean and empty cylinders are best shipped in their packing boxes. There are no Interstate Commerce Commission regulations applicable to empty cylinders. They are shipped with the designation, "Cylinders, steel, for liquid gas N. O. I. B. N. new, other than coppered or nickeled."

b. Filled and uncharged cylinders.—Cylinders which have been filled, but not charged, are shipped in their packing boxes. The applicable Interstate Commerce Commission regulations, shipping names and consolidated freight classifications are listed in the Chemical Warfare Service Supply Catalog. Interstate Commerce Commission regulations do not authorize shipment of phosgene in the portable chemical cylinder.

c. Filled and charged cylinders.—Cylinders which have been filled and charged are transported in their packing boxes. Prior to transportation, all cylinders should be inspected for leakage. Containers showing any sign of leakage should not be offered for transportation until rendered leakproof. Interstate Commerce Commission regulations do not authorize shipment of the charged portable chemical cylinder.

20. Transportation to emplacement position.—Filled and charged cylinders are transported by motor truck to a point as near as possible to their emplacement position, and by man-carry for the remainder of the distance. For transport to their emplacement position, the cylinders are removed from their packing boxes, assembled with the MI nozzle, and loaded in an upright position in the vehicle. If electrically-fired nozzle E4 is to be used in place of the MI nozzle, the E4 nozzle is shipped separately and attached to the cylinder valve at the emplacement, or firing position. The cylinders are usually carried to their emplacement positions under cover of darkness, and with as little noise as possible.

APPENDIX I

FILLING CYLINDER WITH CNB OR CNS

1. General.—CNB and CNS are not standard fillings for the portable chemical cylinder. However, these agents may be dispersed by the cylinder and are authorized for training purposes. CNB is generally used because it is less powerful than CNS.

2. Filling cylinder.—*a. Preparation of cylinder.*—The cylinder is removed from the packing box. The valve (with eduction tube) is removed from the cylinder and placed in a convenient spot so that the cylinder may be closed immediately after filling. All valves are examined to insure that they close tightly and that the packing nuts are drawn down against the packing.

b. Filling cylinder with CNB or CNS.—(1) The cylinder is placed, with its valve and eduction tube assembly and carrier removed, in the cylinder support on a portable scale. The tare weight of the empty cylinder and support is determined by balancing the scale; the beam rider is then readjusted to give a gross weight, which is 23 pounds for CNB and 30 pounds for CNS greater than the tare weight. The material is now transferred to the portable cylinder by means of a hand-operated pump, passing through a flexible metal hose until the correct weight is obtained (fig. 32).

(2) If a hand-operated pump is not available, the container is raised to a point above the cylinder and the material permitted to flow into the cylinder by gravity (fig. 33).

(3) If a portable scale is not available, approximately 2½ gallons of the material are placed in a dry bucket and transferred to the cylinder by means of a funnel.

c. Closing filled cylinder.—As soon as the cylinder has been filled with the proper amount of agent, the valve and eduction tube assembly is inserted in the cylinder opening and made handtight by using kaolin pipe cement to insure a leakproof connection. The filled cylinder is placed on its side and stationed in this position for 1 hour, observed meanwhile for leaks, which will be indicated by the presence of a deposit of CN about the place of leakage. If a leak is indicated, the valve is tightened with a wrench.

3. Charging filled cylinder with carbon dioxide.—*a.* After the cylinder has been filled with the chemical agent, it is charged with carbon dioxide by use of the apparatus shown in figure 35.

b. Charging operation.—(1) All valves are closed and the apparatus connected as shown in figure 35.

(2) The pressure regulator handle is turned counterclockwise until the diaphragm is free and the pressure regulator closed. The carbon dioxide cylinder valve is then slowly opened approximately one-half turn.

(3) The pressure regulator is moved down by turning the handle clockwise until the pressure gage indicates a working pressure of 200 pounds per square inch.

(4) The needle valve and gate valve are then opened. The inlet control pressure gage must be observed to ascertain that it registers the same pressure as the carbon dioxide cylinder pressure gage. Should it not, the flexible metal hose must be checked for kinks and hose fittings checked for stoppages or leaks. The portable cylinder valve is opened and the carbon dioxide permitted to bubble through the CNB or CNS in the cylinder for 3 minutes. A 200-pound working pressure is meanwhile maintained. The gate valve is closed and the cylinder rocked as vigorously as possible for about 10 minutes by means of the cradle handle. If the inlet control pressure gage then indicates that the pressure in the cylinder has dropped below 180 pounds per square inch, the charging operation is continued until the pressure in the cylinder remains above 180 pounds per square inch during the time specified (10 minutes). When the cylinder is fully charged, the portable cylinder valve and the gate valve are closed and the cylinder disconnected from the charging line. (See par. 7 for pressure-temperature allowance.) Since the rate of absorption of the carbon dioxide in the CNB or CNS depends largely upon the degree of agitation, particular attention should be directed to this step in the charging operation.

4. Inspection.—Cylinders which are not to be fired within 24 hours after charging should be inspected for maintenance of charging pressure. They should be tested with the charging apparatus after being permitted to stand for 24 hours. The cylinder is connected to the charging apparatus and the gate valve of the inlet control closed. The portable cylinder valve is opened and the cylinder pressure read as indicated on the inlet control pressure gage. If the pressure in the cylinder is less than 150 pounds per square inch, the cylinder must be recharged in accordance with the requirement set forth in paragraph 3 above. If the pressure is 150 pounds per square inch or more, no further inspection is required.

5. Safety precaution.—Personnel engaged in filling and charging cylinders with tear gas solution and carbon dioxide should wear gas masks and rubber gloves.

6. Maintenance of apparatus.—After the charging operations have been completed, the apparatus should be dismantled and stored in a dry place. The carbon dioxide cylinder valve must be closed before dismantling the apparatus. Parts of the apparatus which were exposed to CNB or CNS should be thoroughly cleaned with carbon tetrachloride or benzene.

7. Effects of temperature.—The pressures specified for charging CNB or CNS filled portable chemical cylinders are based on average temperature conditions. If the charging operations are carried on during freezing temperature, all pressure specified should be reduced by 50 pounds per square inch.

APPENDIX II

LIST OF REFERENCES

1. FM 3–5, Tactics and Technique (now published as Chemical Warfare Service Field Manual, Volume I).

2. FM 5–25, Explosives and Demolitions.

3. Chemical Warfare Service Supply Catalog.

4. Standard Nomenclature and Price List of Chemical Warfare Matériel.

5. TM 3–305, Use of Smokes and Lacrimators in Training.

6. Chemical Weapons and Ammunition, The Chemical Warfare School, Book 3.

7. Directive for the Care and Use of Portable Chemical Cylinders, MIA1 and MIA2, July 29, 1937.

8. Manufacturing Process Method No. 33A, Process Method for Filling Portable Chemical Cylinders MIA1 or MIA2, with FM or FS and Charging with Gaseous CO_2, November 24, 1941.

9. Manufacturing Process Method No. 34, Method of Charging Phosgene Filled Portable Chemical Cylinders, E3 with Chlorine, in the Hawaiian Department, November 16, 1936.

10. Manufacturing Process Method No. 35A, Process Method for Filling Portable Chemical Cylinder, MIA1 or MIA2, with CNS or CNB, and Charging Filled Cylinders with Gaseous CO_2, November 24, 1941.

11. Manufacturing Process Method No. 44, Method for Charging FS or FM Filled Portable Chemical Cylinder, MIA1 and MIA2, with CO_2. Using Chemical Cylinder Charging Apparatus, E2, June 16, 1937.

12. Manufacturing Process Method No. 49, Method of Using Chemical Cylinder Charging Apparatus, E2, for Charging Phosgene-Filled Portable Chemical Cylinder, MIA1 and MIA2, with CO_2, April 29, 1937.

13. Munitions Filling Directive No. 52, Directive for Filling Portable Chemical Cylinders and Livens Projector Shell with Phosgene, Using Salt and Ice for Refrigeration.

14. Munitions Filling Directive No. 53. Directive for Filling Portable Chemical Cylinders and Livens Projector Shell with Phosgene without Refrigeration, Sept. 26. 1938.

15. Blaster's Handbook, E. I. DuPont De Nemours & Co., Inc.

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BY ORDER OF THE SECRETARY OF WAR:

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The Adjutant General.

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