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SEACOAST ARTILLERY AMMUNITION

and

INSTRUCTIONS FOR ITS PREPA- RATION, CARE, AND USE

(SIX PLATES)

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(Form No. 1572.)

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(2)

WAR DEPARTMENT,
OFFICE OF THE CHIEF OF ORDNANCE,
Washington, March 18, 1915.

This manual is published for the information and government of the Regular Army and Organized Militia of the United States.

By order of the Secretary of War:

WILLIAM CROZIER,
Brigadier General, Chief of Ordnance.

(3)

SEACOAST ARTILLERY AMMUNITION AND INSTRUCTIONS FOR ITS PREPARATION, CARE, AND USE.

AMMUNITION.

1. *Powder.*—All data for breech-loading guns in the service, as regards their elements, average weights of charges, and igniters, muzzle velocities, pressures, etc., will be found in Table of United States Army Cannon and Projectiles, Pamphlet No. 1676.

Each lot of powder or cartridges issued is marked for the weight of charge and proof velocity and pressure; these are to be considered the standard for that powder, unless subsequently changed in orders or by letter.

Linen tags attached to cartridge storage cases also give complete data descriptive of the powder contained in them.

Should any firings indicate a pressure has been obtained in excess of the maximum pressure in powder specifications as given in Pamphlet No. 1676, the use of the powder giving such pressures should be discontinued and all facts in connection with such firings should be immediately reported to the Chief of Ordnance (through the armament officer).

All seacoast breech-loading guns from 1.457 inches to 4 inches in caliber use fixed ammunition, which will not ordinarily be changed at posts. This also applies to 4.72-inch and 6-inch Armstrong guns in which the charge is inclosed in a brass cartridge case.

Detailed instructions for the care and test of smokeless powder and other explosive material are contained in Ordnance Department Pamphlet No. 1888.

2. *Cartridges.*—To avoid irregular and sometimes excessive pressures, the total length of charge for guns should be nearly equal to the length of chamber, with a minimum limit of nine-tenths that length; when reduction of the charge in prepared cartridges is required, firmness in the cartridge is to be secured by taking in the diameter of the bag uniformly over its length. The condition as to length need not be fulfilled for the mortars. The cartridge bags provided for service are made from special raw silk and are sewed with silk thread. The bags are made of somewhat larger diameter than is required for the charge to be contained.

Two lacing plaits are sewed lengthwise in the bag. In the case of bags of the latest model, the outer edges of these plaits are reinforced by a piece of lacing twine.

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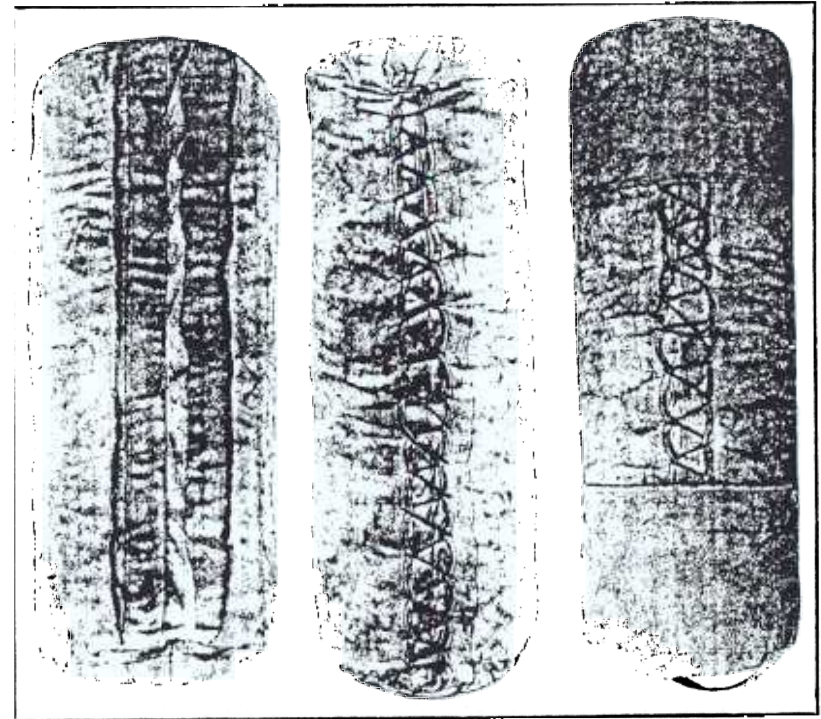
Twelve-inch and 14-inch bags will be provided with two sets of lacing plaits placed diametrically opposite, while 16-inch bags will be provided with three sets placed 120° apart.

In order to obtain rigidity in 12-inch, 14-inch, and 16-inch sections a cloth core joining the middle of the ends of the section is added. For the 12-inch and 14-inch sections this is made from a strip of cartridge cloth 8 inches wide folded into four thicknesses and stitched, making the core about 2 inches wide. For the 16-inch section this core is made in a similar manner except that the strip of cartridge cloth is 10 inches wide, making the core about 2½ inches wide. Each end of this core is split along both edges for about 2 inches and opened out, two thicknesses of cloth to each side. The tabs thus formed are then stitched to the middle of the inside face of the cartridge bag. Twelve-inch, 14-inch, and 16-inch bags are provided with a reinforcing band of one thickness of cartridge cloth on the inside of the body of the bag. It is placed in the middle of the body and is about one-third of the length of the bag.

Each end of each section of the charge is made up of two thicknesses of cloth, each thickness being of the same cloth as the body of the bag. The two thicknesses are cut in a circle about 2 inches larger than the bag when laced.

The black powder igniting charge is placed between the two pieces of cloth at each end, one-half of the igniting charge at each end, and quilted in in squares of about 2 inches, leaving the powder as uniformly spread over the surface as possible. Futuro issues of powder charges for 5-inch and 6-inch seacoast cannon will contain a core igniter. This consists of a single-thickness cloth tube made in the following manner (see Pl. II, figs. 1, 2, and 3): Two narrow strips of cartridge cloth (fig. 1) are cut, leaving a fan-shaped piece, A, A, on each end. The two strips are sewed together along both sides, *b—c*, except for a short space, *d—e*, along one side at the middle, which is left open for filling the core with igniting powder. In sewing up this core the raw edges of the seams are left outside. Gores (fig. 2) are set in, as shown, between the fan-shaped pieces, A, A, so that there is formed on each end of the core a flat circular disk of a diameter equal to that of the end piece of the bag (see fig. 3). The end igniter is then made up practically as described for the regular end igniter, using the circular disk on the end of the core as the inside thickness of cloth on the end igniter. The core is filled with igniting powder through the opening left at the middle and the opening sewed up. The diameter of the core must be such that, when the proper weight of igniting powder has been introduced, the igniter will form a continuous tightly packed string of powder from end to end. The dimensions of the core vary, of course, with the length of the finished charge and the amount of igniter used. The dimensions given on the

PLATE



One section, half charge, smokeless powder for the 10-inch gun, ready for lacing.

One section, half charge, smokeless powder for the 10-inch gun, showing lacing.

One section, half charge, smokeless powder for the 10-inch gun, showing lacing and priming protector caps.

figure are for a core for a cartridge having the dimensions given in Table I. The straight portion of the core is made 1 inch shorter than the length of the side of the bag, measured from seam to seam.

Data regarding igniters for guns.

Gun.	Number of sections.	Type of igniter.	Distribution of igniter in one section.				Total weight of igniter for charge.
			Rear igniter.	Front igniter.	Core igniter.		
					Ounces.	Ounces.	
5-inch, 1897.....		Core.....		2	2	6	6
5-inch, 1900.....		Core.....	2		3	7	7
6-inch, 1897-1908.....		Core.....		3	1	9	9
6-inch, 1900, 1903-1905.....		Core.....	3	3	1	10	10
8-inch, 1898.....	2	End.....	6	6		12	24
10-inch, 1894-1905.....	2	End.....	16	16		32	64
10-inch, 1900.....	2	End.....	16	16		32	64
12-inch, 1894-1905.....		End.....	14	14		28	112
12-inch, 1900.....		End.....	18	18		36	144
14-inch, 1907, 1909-1910.....		End.....	18	18		36	144
16-inch, 1895.....	6	End.....	22	22		44	264

The ends of the bag, finished as above described, are sewed in place to the body of the bag. A space is left at one end through which the bag can be filled with smokeless powder. After the proper weight of powder has been placed in the bag this opening is closed by hand. When necessary to open the bags for the purposes of blending charges they should be opened at this point, which is easily distinguishable by the overhand sewing. The section is then laid on a table and rolled to make it as compact and as uniform in diameter as possible. Before beginning the actual lacing temporary stitches are taken, about 10 inches apart, along the lacing plait. These stitches hold the bag in shape while lacing. The lacing is done in the following manner: Pass the needle through one of the lacing plaits near its outer edge; draw the twine through and tie it securely to the plait; lace the twine back and forth between the plaits and about one-fourth inch from their outer edges, taking stitches about $1\frac{1}{2}$ inches apart. After lacing about 6 inches of the length of the bag, draw the lacing taut and tie the twine, so that if the twine should break in handling at any time the section can not become unlaced throughout its whole length. After the section is fully laced there are about 2 inches between lacing plaits. If the bag is provided with another set of lacing plaits, roll the cartridge again and lace up the second set in precisely the same manner, lacing it as tight as possible. Next roll the cartridge once more, to give it a final shaping. If it becomes loose during this rolling, tighten the lacing once more. After placing the priming protector caps on each end the cartridge is ready for the cartridge storage case.

The lot of powder, in abbreviated form, is stenciled on the side of each section; for example, "P. A. Lot 185 D. P. Lot 6.08 12 G."

3. *Mortar charges.*—In order to provide for the exigencies of fire action, charges for mortars will hereafter be made up on the increment system, which is roughly described as follows:

The charge for any zone will be made up of a section or base section and one or more increments. The charge will be so made that by removing one increment it becomes the charge for the next lower zone; by removing two increments, the base section remaining, it becomes the charge for the second lower zone. The increments contain the weight of powder necessary to raise the corresponding base section, or corresponding base section and increment, to the next higher zone.

All zone charges except for 824 and 800 pound projectiles above the second zone are made up of a base section and one or two increments. The second zone has the base section corresponding to the first zone charge with a second zone increment. No first zone charges as such will be made up. Second zone charges will be issued or stored two charges to the cartridge storage case. All other charges will be issued or stored one charge to the case.

Knowing the number and weight of projectiles, and the zones in which the projectiles will probably be expended, the number of charges provided may be arrived at as follows:

700-POUND PROJECTILE.

MODELS OF 1890, 1890 MI, AND 1908, 12-INCH MORTAR.

For each projectile one eighth B zone section with a ninth zone increment.

MODEL OF 1912, 12-INCH MORTAR.

For each projectile one eighth B zone section with ninth and tenth zone increments.

824 AND 800 POUND PROJECTILES.

MODELS OF 1890, 1890 MI, AND 1908, 12-INCH MORTAR.

For each projectile one-eighth zone charge in one section.

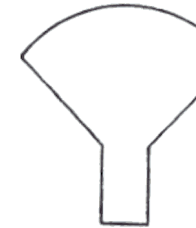
MODEL OF 1886 AND 1886-1890 MI, 12-INCH MORTAR.

For each projectile one seventh zone charge in one section.

1,046-POUND PROJECTILE, ASSIGNED TO THE EIGHTH A ZONE.

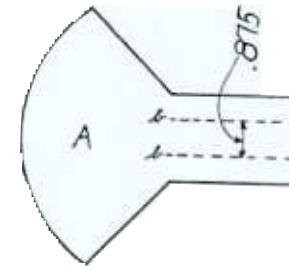
MODEL OF 1912, 12-INCH MORTAR.

For each projectile one and one-half charges comprising one sixth zone section, one seventh zone increment, and one eighth A zone increment.

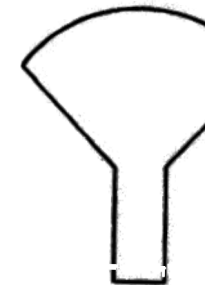


GORE

FIG II



CORE



GORE

FIG VI



ADDENDUM.

TO ORDNANCE DEPARTMENT PAMPHLET NO. 1872, "SEACOAST ARTILLERY AMMUNITION AND INSTRUCTIONS FOR ITS PREPARATION, CARE, AND USE."

Add following paragraph immediately after paragraph headed "To use testing sol" near top page 33:

In the future the covering piece for the test hole in cartridge storage cases will consist of a circular piece of metal $\frac{1}{2}$ inches in diameter, with a depression in the center $\frac{1}{2}$ inch in diameter and $\frac{1}{4}$ inch deep. This depression is intended to fit into and fill the test hole, thus obviating the possibility of hot solder working under the sealing disc, through the test hole, into the cartridge storage case. When testing storage cases, the new type of sealing disc should always be used for resealing the test hole. All of the new type discs which are serviceable should be used again, first burning off the old solder. A supply of the new type discs will be furnished Coast Defense Ordnance officers. These should be used when resealing storage cases now supplied with the old type test hole covers and to replace any of the new type which may become unserviceable. The new disc is applied by placing the depression in the center in the test hole and soldering the edges fast to the storage case. While doing this, hold the disc down in place by pressing on it with the stick of solder. After soldering in place, fill the depression in the disc with solder as a safeguard against the accidental pricking of a hole in the depressed portion of the disc.

ERRATA.

The last line on page 30 and the matter following on page 31 should be transposed so as to follow immediately after the last paragraph of the above addendum.

WAR DEPARTMENT,
OFFICE OF THE CHIEF OF ORDNANCE,
Washington, November 12, 1915.

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ADDENDUM TO ORDNANCE DEPARTMENT PAMPHLET NO. 1872,
"SEACOAST ARTILLERY AMMUNITION AND INSTRUCTIONS FOR
ITS PREPARATION, CARE, AND USE," REVISION OF MARCH 18,
1915.

The following instructions, with illustration, for adding supporting rods to base charges for 12-inch mortar charges now in service, should be inserted opposite page 12 of the pamphlet:

Base charges 1 and 2 for models of 1890, 1908, and 1912 12-inch mortars, and base charges 1 to 4, inclusive, for model of 1886-90 M1 mortar, now in service, should be modified at posts by attaching supporting rods. These supporting rods consist of 12-inch mortar powder grains, 14 inches long, running longitudinally along four elements of the cylindrical bag 90° apart.

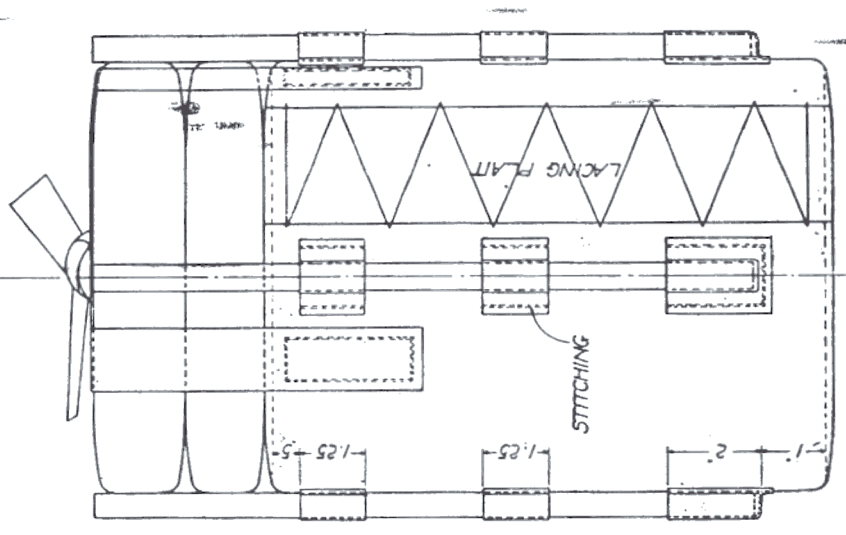
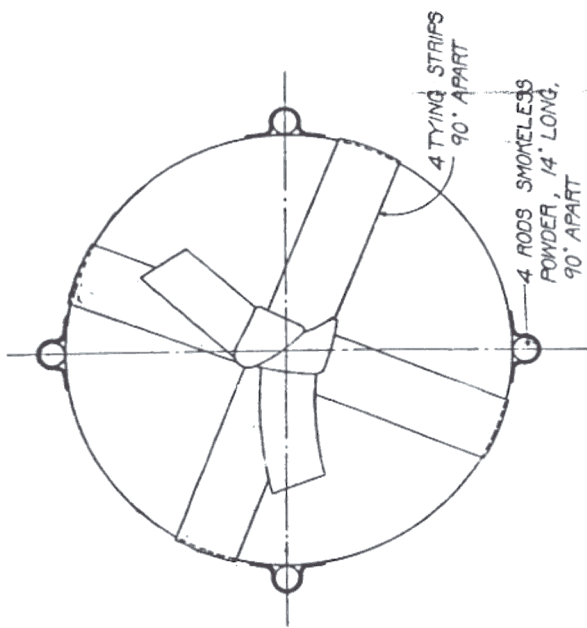
The rods should be attached to the bag so that they fall between the points at which the four strips of cloth for securing the increments are sewed to the bag.

Accompanying the rods, to be used in modifying the charges now in service, will be found ribbons of cartridge cloth hemmed on both edges and 1½ inches wide. These ribbons should be cut to the proper lengths and attached to the bag in the manner shown in plate. For each rod to be attached 3 pieces of this ribbon are required. Two are cut to a length of 1½ inches. One of these is sewed to the bag about ½ inch back of the seam at the front end of the body of the bag, so as to form a loop around the powder rod. The other one is attached in a similar manner at a point about midway between the first loop and the pocket at the rear end of charge. The third piece of ribbon should be cut 2½ inches long and sewed to the bag so as to form a pocket about 2 inches deep with the bottom of the pocket about 1 inch in front of the seam at the base of the powder bag. The powder rod is slipped through the two loops and the end rested in the pocket.

WAR DEPARTMENT,
OFFICE OF THE CHIEF OF ORDNANCE,
Washington, September 21, 1915.

20870-N/743-12-18.
Ed. September 21-15—2,500.

9303-15



POWDER CHARGES
FOR 12 INCH MORTARS.

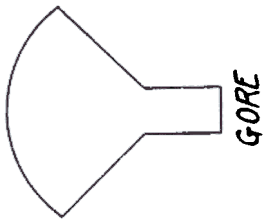
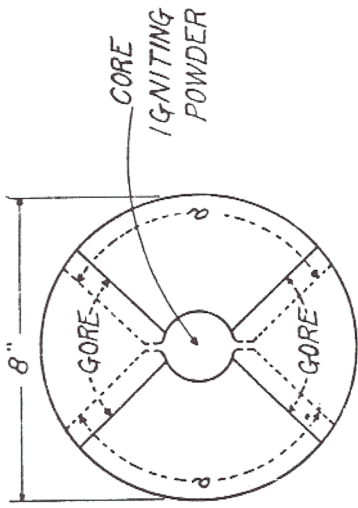


FIG II



END VIEW OF CORE

FIG III

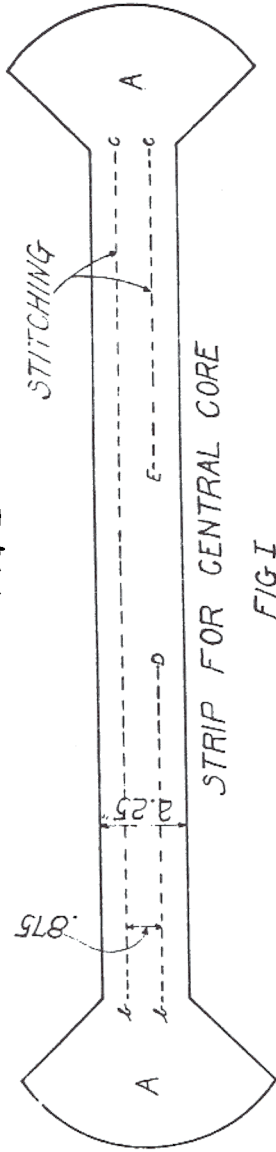


FIG I

CORE IGNITER FOR GINGH GUN MODEL 1897

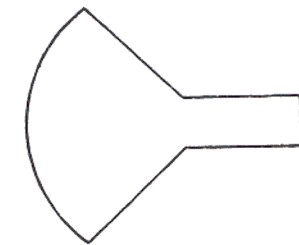
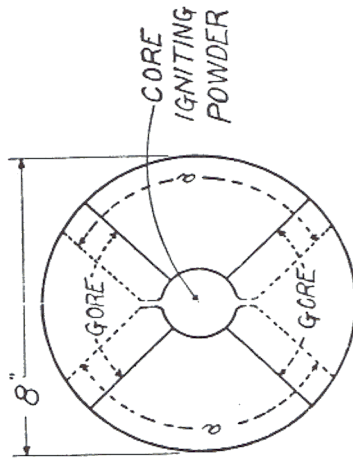


FIG IV



END VIEW OF CORE

FIG V

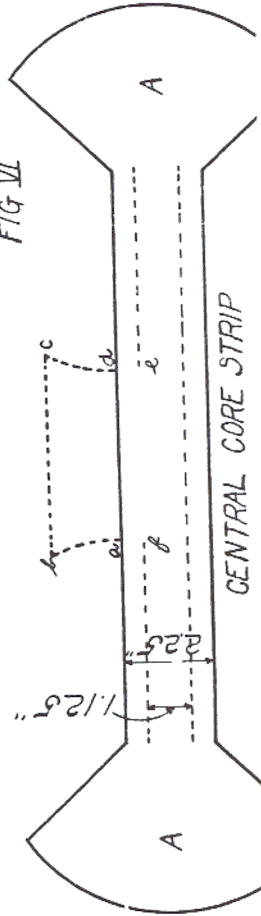


FIG VI

1,046 AND 1,000 POUND PROJECTILES, ASSIGNED TO THE SEVENTH ZONE.

MODELS OF 1890, 1890 M1, AND 1908, 12-INCH MORTAR.

For each projectile one and one-half charges comprising one fifth zone section, one sixth zone increment, and one seventh zone increment.

MODEL OF 1912, 12-INCH MORTAR.

For each projectile one charge comprising one fifth zone section, one sixth zone increment, and one seventh zone increment.

1,046 AND 1,000 POUND PROJECTILES, ASSIGNED TO THE SIXTH ZONE.

MODELS OF 1890, 1890 M1, 1908, AND 1912, 12-INCH MORTAR.

For each projectile one charge comprising one fourth zone section, one fifth zone increment, and one sixth zone increment.

MODELS OF 1886 AND 1886-1890 M1, 12-INCH MORTAR.

For each projectile one and one-half charges comprising one fourth zone section, one fifth zone increment, and one sixth zone increment.

1,046 AND 1,000 POUND PROJECTILES, ASSIGNED TO THE FIFTH ZONE, FOURTH ZONE, AND THIRD ZONE.

MODELS OF 1886, 1890, 1908, 1912, 12-INCH MORTAR.

For each projectile one charge for the zone to which assigned, comprising one zone section of the second lower zone, one increment of the next lower zone, and one increment of its own zone number.

1,046 AND 1,000 POUND PROJECTILES, ASSIGNED TO THE SECOND ZONE AND FIRST ZONE.

MODELS OF 1886, 1886-1890 M1, 1890, 1890 M1, 1908, AND 1912, 12-INCH MORTAR.

For each projectile one charge comprising one first zone section and one second zone increment.

The assignments to zones of the projectiles, authorized for each coast defense, was made after considering the recommendation of the coast-defense commander concerned at the time the assignment was contemplated.

It has been found advisable to introduce the central core igniter in mortar charges, and all base sections of mortar charges will have the core igniter. All the igniting charge, which for the core type igniter consists, for all zones, of 12 ounces of powder, is carried in the base section, one-third at each end and the remaining third in the

core. The core is made in the same way as that for the 5-inch and 6-inch guns previously described except for the dotted portion, a, b, c, d, Plate II, Figures IV, V, and VI. The portion, e, f, is not stitched until after the core has been filled. Owing to the fact that the core for mortars is relatively short and bulky it is necessary to leave this dotted portion for convenience in filling. After filling and stitching the dotted portion is cut off. The end igniter proper is 6 inches in diameter. The flat circular disk on each end of the core forms as before the inner thickness of the end igniter and is cut to a diameter of about 8 inches. This is stitched with a double row of stitching 6 inches in diameter to the middle of the outside thickness of the end igniter, which is cut to the proper diameter to form the end piece of the section. The inner thickness of the end igniter being only 8 inches in diameter, a ring outside of this is left having only a single thickness of cloth.

Each base section is laced in the same manner as other cannon charges. When base sections are more than 12 inches in length, the central third of the bag body is reinforced by one thickness of cartridge cloth sewed on the inside of bag. The increments of the eighth zone and above have two lacing plaits.

No igniter charges are placed in increment bags. These are made more rigid by sewing together the centers of the two ends. (See Fig. II.) They are composed of a body piece and two end pieces.

To insure that mortar charges will be inserted in the mortar with the proper end to the rear, red cloth will, in future, be used to cover the rear igniters of all base sections for 12-inch mortars.

The increments are secured to the base section by means of four tying straps of cartridge cloth, which are strongly sewed to the base section. They are made amply long to allow a strong knot to be tied, so as to hold the increments securely. These straps, therefore, are easily untied to remove or add increments and can be tied as tightly as the rigidity of the charge requires. (See Fig. I.)

The sections and increments are to be marked to indicate the zones with 1½-inch figures as follows:

Each base section three times on the side, 120° apart, and once on each end. (See Fig. I.)

Each increment three times on the side 120° apart, and three times on the front end.

The numbers on the ends of the increments will be so placed in assembling as to avoid being covered by the tying straps.

Nos. 6 and 9 will be underscored, 6 and 9 to prevent confusion. The numbers indicate in the case of the base section the zone in which it gives the required charge. In the case of the increments, they indicate the zone to which the increment will raise the base section or the

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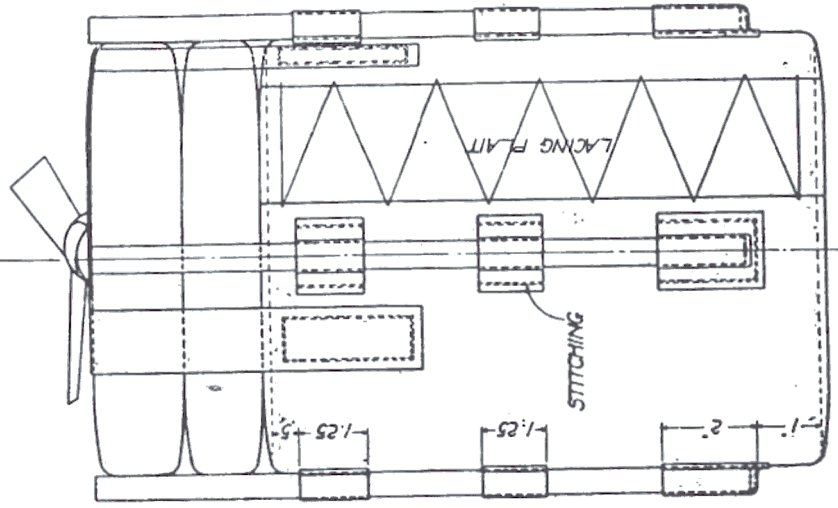
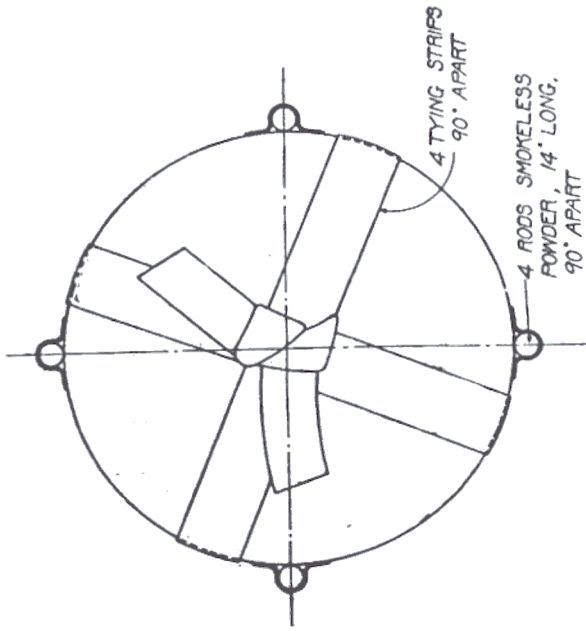
Base charges 1 and 2 for models of 1890, 1908, and 1912 12-inch mortars, and base charges 1 to 4, inclusive, for model of 1886-90 M1 mortar, now in service, should be modified at posts by attaching supporting rods. These supporting rods consist of 12-inch mortar powder grains, 14 inches long, running longitudinally along four elements of the cylindrical bag 90° apart.

The rods should be attached to the bag so that they fall between the points at which the four strips of cloth for securing the increments are sewed to the bag.

Accompanying the rods, to be used in modifying the charges now in service, will be found ribbons of cartridge cloth hemmed on both edges and 1½ inches wide. These ribbons should be cut to the proper lengths and attached to the bag in the manner shown in plate. For each rod to be attached 3 pieces of this ribbon are required. Two are cut to a length of 1½ inches. One of these is sewed to the bag about ¼ inch back of the seam at the front end of the body of the bag, so as to form a loop around the powder rod. The other one is attached in a similar manner at a point about midway between the first loop and the pocket at the rear end of charge. The third piece of ribbon should be cut 2½ inches long and sewed to the bag so as to form a pocket about 2 inches deep with the bottom of the pocket about 1 inch in front of the seam at the base of the powder bag. The powder rod is slipped through the two loops and the end rested in the pocket.

WAR DEPARTMENT,
OFFICE OF THE CHIEF OF ORDNANCE,
Washington, September 21, 1915.

26870-N/748-12-18.
Ed. September 21-15-2,500.



POWDER CHARGES
FOR 12 INCH MORTARS

zone to which the increment will raise the base section and the intermediate increment.

But one primer protecting cap of the standard form will be furnished with each charge. It will be used to protect the primer at the rear end of the base section.

A tag giving the necessary ballistic data, etc., will be attached to each base section, to the outside of each cartridge storage case, and to each crate containing cartridge storage cases. The manufacturer and lot number of the powder is stamped on the side of each base section and on the end of each increment.

4. *Priming protector caps.*¹—These caps are made in three pieces, viz: (1) A circular piece about $1\frac{1}{2}$ inches larger in diameter than the section in which it is intended to be used; (2) on the outside and across the center of the circular piece is a strip of cloth about 1 inch in width and strong enough to take hold of in order to pull off the cap without untying the draw string; (3) a third piece $6\frac{1}{2}$ inches wide and long enough to pass loosely around the section on which it is to be used.

The ends of the last-named piece are sewed together and the circular piece is sewed on it to form a cap. A hem is made on the opposite edge of the third piece, through which passes a strong twine that is used as a draw string.

A circular piece of felt is cut of the size of the section of the cartridge on which it is to be used. This felt is placed in the bottom of the cap; the latter is then pulled over the end of the section of the cartridge and is tied firmly by the draw string. The primer protector cap prevents dampness from reaching the priming powder. It also protects the ends of the sections of cartridges from wearing through. This wearing would allow the priming powder to fall out in handling or during transportation.

Primer flame baffles of bronze have been issued for use on the mushroom heads of all 5, 6, 8, 10, 12, 14, and 16 inch guns and 12-inch mortars to prevent scorching the dummy powder charges by firing of primers during drill.

The bronze plates are burned through after about 50 rounds by the hot gases from the primer. Nickel-steel plugs are furnished for insertion in the center of the baffles. All bronze baffles should be plugged by the ordnance machinist when they have become worn. Deeply eroded nickel plugs should be driven out and replaced to prevent scorching the dummy charge.

5. *Dimensions of sections.*—The weights of charges for different lots of smokeless powders vary, but the dimensions of the sections

¹ Plate I shows a cartridge bag ready for loading, and also the same bag, loaded, and with priming protector cap in place.

of cartridges of smokeless powder made up with the average charges of powder are as follows:

TABLE

	Charge (approximate), including igniter.	Cartridge (or section)		
		Number of sections.	Diameter.	Length, including igniter.
	Pounds.		Inches.	Inches.
5-inch gun, model of 1907.....	10.50		8.25	27.00
5-inch gun, model of 1900.....	22.50		8.00	32.00
6-inch gun, models of 1907, 1907 M1, 1908, 1908 M1, 1908 M2	28.75		8.25	31.00
6-inch gun, models of 1900, 1903, and 1905.....	32.00	1	8.25	40.00
8-inch gun.....	53.50	2	8.25	24.00
10-inch gun, models of 1905.....	182.00	2	10.25	30.00
10-inch gun, model of 1901.....	182.00	2	10.50	31.75
12-inch gun, models of 1888 and 1905.....	279.00	4	12.25	18.25
12-inch gun, model of 1901.....	324.00	4	13.25	24.25
12-inch mortar, models of 1888 and 1905.....	34.25		11.00	15.25
12-inch mortar, model of 1901.....	45.00		11.50	17.50
12-inch mortar, model of 1901.....	50.00		11.50	24.00
14-inch gun, model of 1907 M1, 1908-1910.....	349.00		15.00	18.00
16-inch gun, model of 1905.....	687.50		16.50	17.00

I Dimensions of zone charges for inch mortars.

OF 1880 AND 1888, U. S. POWDER, OTHER

Gas	Diameter.	Length.	Increment.	Length.	+ Increment.	Length.
1...	8.5	9.		10.5	No. 3..	12
2...	8.5	11.	No. 3.	13.5	No. 4..	15.25
3...	8.5	13.	No. 4.	15	No. 5..	18
4...	8.5	14.	No. 5.	17.5	No. 6..	20.5
5...	10	12		15	No. 7..	18.5
8A.	11	19.				
8B.	11.75	16.				

MODELS OF 1888 AND 1895 M1.

	Length.	Increment.	Length.
1...	14	No. 3...	16.25
2...	16.25	No. 4...	18.25
3...	18.2	No. 5...	20.75
4...	18.7	No. 6...	17
5...	14	No. 7...	21.5
6...	17	No. 8A.	21.5
8B.	19	No. 10..	25

H MORTARS, MODELS OF 1886 AND 1890 M1

Base.	Diameter.	Length.	+ Increment.	Length.	+ Increment.	Length.
1.	8.	9.5	No. 2.	10.5	No. 3..	11.75
2.	8.	11.75	No. 2.	13.5	No. 4..	15.75
3.	10.	9.5	No. 4.	12	No. 5..	14
4.	11	9.5	No. 5.	12.5	No. 6..	18
7	12	15.75				

NOTE.—Increment given in column 6 is added to base, column 1 and increment, column 4, to make total sectional charge.

The sections of the cartridges for the 8-inch, 10-inch, and 12-inch guns are made of uniform weight and dimensions unless the weight of the charge is so great as to require one section to be specially made to fit the forward end of the powder chamber.

Table of dimensions of powder chambers.

Cannon.	Type.	B	D	Cubic inches.
5-inch gun, model of 1907.....	CY	7.595	5.5	5.5
5-inch gun, model of 1900.....	YGON	8.395	6.7	6.0
6-inch gun, model of 1907 M1.....	CY	8.1	7.0	7.0
6-inch gun, models of 1900 and 1903.....	YGON	8.1	8.0	7.2
6-inch gun, model of 1905.....	CY	8.1	8.0	8.0
6-inch gun, models of 1908, 1908 M1, 1908 M11.....	CY	8.1	7.0	7.0
8-inch gun, models of 1888, 1888 M1, 1888 M11.....	CY			8.5
10-inch gun, models of 1888, 1888 M1, 1888 M11, 1895, and 1895 M1.....	CY		11.8	11.8
10-inch gun, model of 1900.....	YGON		13.75	12.0
12-inch gun, models of 1888, 1888 M1, 1888 M1-1, 1888 M11, 1888, and 1895 M1.....	CY		14.2	14.2
12-inch gun, model of 1900.....	YGON		16.5	14.5
12-inch mortar, C. I., Hoop, model of 1886.....	CY	16.05	12.4	12.4
12-inch mortar, steel, model of 1880-1890 M1.....	CY	16.05	12.4	12.4
12-inch mortar, models of 1880, 1890 M1, and 1908.....	CY	21.13	12.5	12.5
12-inch mortar, model of 1912.....			12.5	12.5
14-inch gun, models of 1907, 1907 M1, 1909, and 1910.....	CY	38.915	16.8	16.8
16-inch gun, model of 1905.....	CY	46.24	19.0	19.0

The chambers of 14-inch guns, model of 1909 and 1910, will be enlarged by extending the cylindrical section forward 19 1/2 inches, thereby increasing the capacity to 19.72 cubic inches, the charge to approximately 430 pounds, the muzzle velocity approximately 2,300, and maintaining the pressure at less than 28,000 pounds per square inch.

6. *Charges to use.*—Propelling charges of smokeless powder both for the reserve supply and for target practice, except for guns using cartridge cases, are issued to the service in hermetically sealed cartridge storage cases.

Unless there are instructions to the contrary, the charges to be used during each target season will be taken from those lots of powder of earliest date of manufacture on hand in the Artillery district, no matter whether they be marked for reserve or for target practice. These instructions apply to fixed target-practice ammunition as well as to that of separate loading.

When the number of charges of separate-loading ammunition from any lot of powder which remains on hand in an Artillery district is less than the number required for the annual practice of an organization, steps will be taken in the Office of the Chief of Ordnance for the issue or transfer of additional charges of that lot or instructions given for its blending with other lots.

The slightly different interior ballistics of the 1888 and 1895 models of 10-inch and 12-inch guns are not considered in making issues of powder charges. Ten-inch charges for these models rated at 2,250 feet per second may be expected to give under normal conditions 2,250 feet per second in the model of 1888 gun and 2,265 feet per

second in the model of 1895 gun. Twelve-inch charges are expected to give 2,235 feet per second in model of 1888 guns and 2,250 feet per second in model of 1895 guns.

7. *Temperature variations.*—For a given weight of propelling charge of smokeless powder the muzzle velocity increases with the temperature of the powder at the instant of firing, and for a given increase of temperature this increase in velocity varies with the muzzle velocity.

The powder charge will not be left in the gun for any considerable length of time before firing. If a number of rounds have just been fired from the gun, the temperature of the charge might thereby be increased several degrees.

The propelling charges for all lots of smokeless powder that have been tested in recent years, except those given in Table III, have been adjusted to give the prescribed muzzle velocities when fired at the standard temperature of 70° F. In a few cases the firings were made at temperatures varying from 70° F. ± 3° F.

Table II indicates the corrections to be applied to the assumed muzzle velocity when firings are made with the powders listed and for the temperature of any powder when fired.

TABLE II.

Initial muzzle velocities.

		1220				250				2400				2000																																				
21	24	18	41	62	83	104	125	146	167	188	209	230	251	272	293	314	335	356	377	398	419	440	461	482	503	524	545	566	587	608	629	650	671	692	713	734	755	776	797	818	839	860	881	902	923	944	965	986	1007	
17	19	15	38	59	80	101	122	143	164	185	206	227	248	269	290	311	332	353	374	395	416	437	458	479	500	521	542	563	584	605	626	647	668	689	710	731	752	773	794	815	836	857	878	899	920	941	962	983	1004	
13	14	11	34	55	76	97	118	139	160	181	202	223	244	265	286	307	328	349	370	391	412	433	454	475	496	517	538	559	580	601	622	643	664	685	706	727	748	769	790	811	832	853	874	895	916	937	958	979	1000	
9	10	7	30	51	72	93	114	135	156	177	198	219	240	261	282	303	324	345	366	387	408	429	450	471	492	513	534	555	576	597	618	639	660	681	702	723	744	765	786	807	828	849	870	891	912	933	954	975	996	1017
5	6	3	26	47	68	89	110	131	152	173	194	215	236	257	278	299	320	341	362	383	404	425	446	467	488	509	530	551	572	593	614	635	656	677	698	719	740	761	782	803	824	845	866	887	908	929	950	971	992	1013
1	2	0	22	43	64	85	106	127	148	169	190	211	232	253	274	295	316	337	358	379	400	421	442	463	484	505	526	547	568	589	610	631	652	673	694	715	736	757	778	799	820	841	862	883	904	925	946	967	988	1009

To be deducted from normal muzzle velocity.

To be added to normal muzzle velocity.

ATE IV.

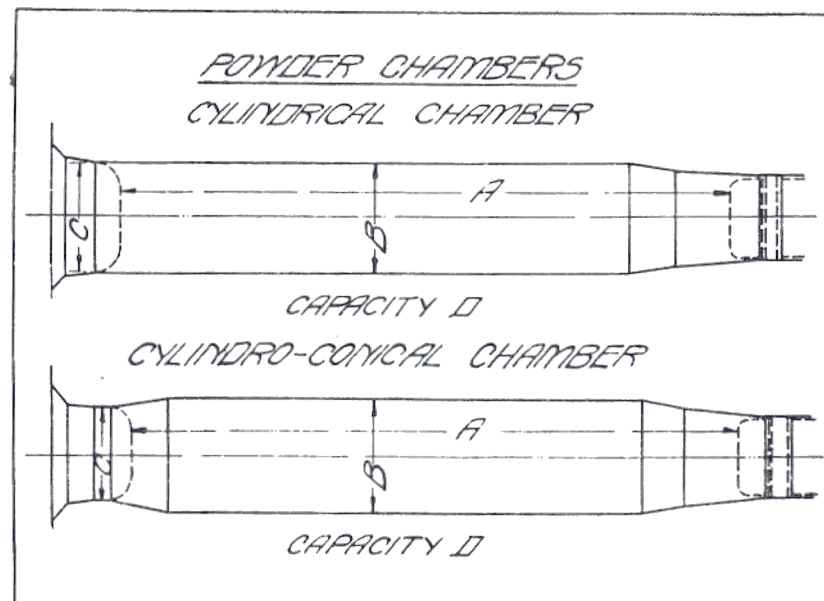


TABLE III.

List of smokeless powders tested at temperatures other than 70° F. ± 5° F.

[See paragraph 7.]

Gun.	Lot of powder.	Weight of projectile.	Temperature of atmosphere.	Temperature of charge.	Charge without igniter.	Muzzle velocity.	Maximum pressure.	Date of test.
5-inch gun, model of 1897.	L. & R. No. 2, 1901..	Lbs. 58	48	42	Lbs. 16.25	<i>ft. per sec.</i> 2,600	<i>Lbs. per sq. in.</i> 35,500	Mar., 1904
	Du Pont No. 4, 1900..	58	81	74	14.875	2,600	36,750	May, 1900
	No. 5, 1900..	58	82	74	14.709	2,600	35,100	Do.
5-inch gun, model of 1897 M1.	Int. No. 2, 1901..	106	77	47	29	2,600	34,500	Apr., 1904
5-inch guns, models of 1900, 1903, and 1905.	Int. No. 0, 1906..	106	68	62	38.625	2,600	27,600	Aug., 1907
	L. & R. No. 7, 1906..	106	82	66	39.6	2,600	27,300	Aug., 1906
	C. P. W. No. 3, 1900, for 6-inch gun, mod. of 1897.	106	38	.....	41.562	2,600	27,900	Mar., 1907
	Du Pont No. 3, 1906..	106	73	75	36.125	2,600	21,400	Aug., 1906
	No. 4, 1906..	106	75	74	37.1	2,600	22,700	Do.
5-inch gun, model of 1888.	L. & R. No. 1, 1901..	318	24	29	76.25	2,200	35,500	Jan., 1904
	Int. No. 1, 1901..	316	56	.....	79	2,185	38,500	Apr., 1903
10-inch guns, models of 1888 and 1895.	No. 2, 1901..	316	68	62	81.5	2,200	35,500	Aug., 1907
	C. P. W. No. 10, 1904..	610	41	65	155.5	2,250	35,700	Nov., 1904
	Du Pont No. 1, 1900..	575	74	.....	143.75	2,250	35,200	July, 1902
	(a).....	604	.....	.....	142	2,235	.....	.....
	(a).....	604	.....	.....	152	2,235	.....	.....
2-inch guns, models of 1888 and 1895.	L. & R. No. 1, 1901..	575	82	.....	159	2,250	34,300	May, 1901
	(a).....	604	.....	.....	152	2,235	.....	.....
	C. P. W. No. 8, 1902..	1,046	59	.....	259	2,240	36,380	June, 1903
	Du Pont No. 10, 1901..	1,000	63	63	258	2,250	34,500	Do.
	Int. No. 5, 1906..	1,052	43	65	274.75	2,250	35,400	Mar., 1906
(a).....	No. 6, 1906..	1,048	43	65	275.25	2,250	35,300	Do.
	No. 8, 1907..	1,046	74	65	266.75	2,250	34,500	Aug., 1907
	L. & R. No. 2, 1901..	1,000	65	.....	272.5	2,250	31,900	Oct., 1901
(a).....	1,046	.....	.....	271	2,230	.....	.....
12-inch gun, model of 1900.	L. & R. No. 2, 1907.. [See Table V.]	1,046	32	74	346.6	2,250	27,700	Feb., 1907

* Reduced to this charge by General Orders, No. 77, 1903.

In some of the tests of lots of smokeless powder given in the table, only the temperature of the air, and not that of the powder, at the time of firing, was recorded. To enable the proper correction to be determined from the foregoing table in such cases, the temperature of the powder may be assumed to have been the same as that of the air. For example, if a lot of powder was originally tested at 60° F., and the propelling charge was fixed corresponding to 2,250 feet per

second, the proper correction to be applied to the muzzle velocity, if fired at a temperature of 80° F., would be $24 + 19 = 43$ feet per second.

8. *Precautions to be observed in preparing for firing.*—The conditions for each shot should be as uniform as practicable. To secure this uniformity, the bore, including the powder chamber, should be cleaned thoroughly before firing the first shot, since the presence of the lubricant used for protecting the bore gives a material reduction in the velocity.

Care will be exercised to see that only powders of the same lot are blended together, except in cases where the blending of two or more lots together has been authorized by the Chief of Ordnance. Charges for a given zone, weight of projectile, or model of gun, will not be used for any other zone, weight of projectile, or model of gun, except when specially authorized.

The weight marked on a charge, or a section of a charge of smokeless powder, as issued, is the weight of the smokeless powder only. It does not include the weight of the igniter or of the bags.

The percentage of moisture and solvent in powder has a marked effect upon the muzzle velocity, and any exposure which would tend to change the percentage present will be avoided.

Smokeless powder will not be exposed to the direct rays of the sun, or to excessively moist air.

Pressure gauges are issued for use in taking pressures in all guns above 5-inch. Instructions for using these gauges are contained in Ordnance Pamphlet No. 1738. These instructions should be carefully followed, as the pressures obtained are filed as a record of the powder used and indicate its serviceability.

The pressures should be measured immediately after the trial shots are fired, as they will greatly assist in determining the muzzle velocity to be used in record shots.

9. *Cartridge storage cases, care of, etc.* Cartridge storage cases containing propelling charges should normally be piled on end with skids under the first tier and each succeeding tier. This arrangement may be departed from in case special facilities for piling the cases in some other manner are provided or in case the length of the storage case is so great relative to the diameter that there is danger of tiers falling down. If cases are piled on the side for any reason, particular care should be taken to separate them by skids rounded out to fit the contour of the case, as experience has shown that the piling of cases on their sides, either without skids or with ordinary skids, has a tendency to break the seals of the cases, causing them to leak.

Cartridge storage cases will be carefully handled, and when emptied will be returned promptly to the depot or arsenal from which they were received. A reasonable number of the crates in which storage

cases are received will be preserved for use in making shipments of powder and return shipments of empty cases.

The protector caps found on the sections of the cartridges will be left in the storage cases for return shipment to the depot or arsenal from which received.

Strawboard liners are, in future, to be omitted from cartridge storage cases.

10. *Rescaling opened cases.*—Whenever it may be necessary on account of weather conditions or for other adequate reasons to delay target practice, the following method of temporarily rescaling cartridge storage cases that have been broken open at posts for blending the powder is prescribed for the proper protection of the smokeless powder charges:

Support the cartridge storage case in a horizontal position on a table or bench, and after pressing the lid firmly on the case apply melted paraffin with a brush to the joint between the lid and the cartridge storage case, at the same time turning the latter rather rapidly at first, but more slowly as the paraffin sets. Continue this operation until a thick coat, entirely covering the joint, has been formed. Each layer should be allowed to set before applying the next one. Before putting on the lid the joint between it and the cartridge storage case should be made clean and dry.

No special skill is required in this work, and if the paraffin is kept hot and thoroughly liquid and care is used in applying it, the joint will be waterproof and will stand ordinary handling. In turning the cartridge storage case while applying the paraffin care should be exercised not to allow the powder charge to strike against the lid, as any severe jar or blow is liable to crack the coat of paraffin, especially after it has set and become brittle.

Cartridge storage cases should be handled as little as possible after scaling in the manner herein described and should be stored where other articles will not be placed upon them.

In reopening the cartridge storage cases the paraffin may readily be removed by striking it lightly with a hammer or an iron bar and then scraping the joint with a chisel.

To carry out the foregoing instructions, the following material will be issued to ordnance officers of artillery districts:

2.75-inch brushes.

1 2-quart enamel saucepan.

20 pounds of paraffin.

Paraffin will be replaced as expended upon requisitions submitted in the usual manner.

If conditions are such that the powder charges contained in cartridge storage cases that have been broken open and rescaled in the

manner herein described may not be used within a considerable period from the date of opening the cases, report will be made to the district armament officer, who will take steps to provide for the resealing of the cases by soldering.

11. *Powder blending.*—The powder issued to a company for its annual service practice will, if practicable, be of the same lot. Battery commanders will blend the powder to be used for the annual service practice of their companies. Before blending, each section will be weighed and if the weights of any sections differ appreciably from the markings on the tags the latter will be forwarded to the Chief of Ordnance with a special report. After blending, each section of each charge will be carefully made up under the personal supervision of the battery commander, who will see that the powder is not exposed at any time to the direct rays of the sun or, if it can be avoided, to excessively moist air. In filling, sewing, and lacing sections, special care will be taken to obtain equal weights in corresponding sections of the several charges and in securing such rigidity and uniformity of length and diameters as may be possible. To this end great care will be taken in lacing sections in connection with such kneading and rolling as may be necessary.

The weights of powder charges will be verified by the battery commander.

One of the following methods shall be used in blending:

(a) Select a suitable floor space and cover it with paulins. Take all the powder to be blended from the boxes or storage cases and place it in a single pile at the center of the space covered by the paulins. Improvise 10 wooden shovels and let 10 men shovel at the same time from the center pile to 10 piles arranged in a circle around the center pile. To prevent the powder from scattering off the paulins, boards supported on edge by brackets may be placed around the edge.

Shovel with care from the bottom of the center pile to the top of the circumferential piles. After the powder is all in the circumferential piles the operation is reversed, i. e., the powder is shoveled from the bottom of the circumferential piles to the top of the center pile. Each shovelful should be scattered as much as possible over the center pile. Shoveling from the center pile to the circumferential piles and back again forms one cycle. About five cycles should give a very thorough blend of the powder. Charges should then be remade.

(b) With any convenient measure, remake the new charges so that each section shall contain an equal volume from each of the original sections. This is accomplished with facility by means of the ordinary tin cups. The transfer of a few grains from section to section will be necessary at the end to make the sections of identical weights.

(c) Counting grains, so that each new section will contain an equal number of grains from each of the original sections. If necessary, finally adjust the weights as in (b).

When the new charges are made up they should be weighed carefully, the exact weights being verified by an officer.

The provisions of this paragraph do not apply to fixed ammunition.

Battery commanders may, if they desire, submit a report to accompany Form 819 containing information concerning the blending additional to that called for by the form.

12. *Compound blending.*—The following instructions will govern compound blending or blending together powder of two or more lots:

The governing principle in blending powder of different lots is that each composite charge should contain an equal amount of the powder of each lot used.

In order that the records in the Office of the Chief of Ordnance may accurately show the status of powder in the service, composite blending will be resorted to only on authority from that office.

The form following, which should be prepared at posts, is suggested for use in compound blending:

Powder blending.

Artillery District of Chesapeake Bay. Fort Monroe, Va. Battery G. A. De Russy. Caliber and model of gun or mortar, 12-inch guns, model of 1895. June 5, 1911.

Lots.	2		3		4		5		6		7		8		9		10		11	
	Number of charges.	Number of sections.	Weight of each charge.		Total weight of powder of each lot.		Expected weight of each lot for each new section.		Preliminary weight of each lot to be placed in each new section.		Total weight of remnants.		Weight of remnants to be placed in each new section.		Actual weight of powder in each section.		Actual weight of powder in each charge.			
			Lbs.	Lbs.	Lbs. oz.	Lbs. oz.	Oz.	Oz.	Lbs. oz.	Lbs. oz.	Oz.	Oz.	Lbs. oz.	Lbs. oz.	Oz.	Oz.	Lbs. oz.	Lbs. oz.		
Int.—22-'00.....	9	36	282	2,538	39 10½	39 8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Du Pont—31-'08.....	6	24	268	1,608	25 2	25 0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Du Pont—33-'10.....	1	4	273	273	4 4¼	4 2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total.....	16	64	.....	4,419	69 ½	68 10	120	1½	68 11¼	274	15¼	.....	.....	.....	.....	.....	.....	.....

NOTE.—Blend each lot separately and place equal amounts of each lot in each new section. Weights are in pounds and ounces of smokeless powder, net.

To illustrate the use of the above form: It is filled out as for blending 16 charges of 3 different lots of powder for 12-inch gun. All the data except that in the last four columns should be entered on the form before blending is begun.

Explanation.

Enter the names of the lots and number of charges of each.

Compute number of sections of each lot and total number of charges and sections.

Enter the weight per charge of each lot.

Compute the total weight of powder of each lot and the total of these weights.

Compute the expected weight of each new section—total weight of powder divided by the total number of sections.

Compute the weight of powder of each lot for each new section—each number in column 5 divided by the total number of sections.

Assume and enter the preliminary weights of powder of each lot to be placed in each new section.

In practice it is advisable to use amounts slightly less (column 7) than those computed and entered in column 6.

If the amounts given in column 6 be used, it will often happen that the portion of a lot to be placed in the last section will be less than required, due to losses in handling or other causes.

The actual blending should then take place as follows:

Blend separately the powder of each lot.

Weigh out the preliminary amount of each lot of powder (amounts shown in column 7) and place it in each section.

The small amounts of the different lots can then be mixed, weighed, and divided equally among all the sections. (See columns 8 and 9.) The figure in column 9 plus the total of column 7 will then give the total amount of smokeless powder, net, in each section, and this quantity multiplied by the number of sections in a charge will give the weight of smokeless powder per charge.

It is well to number serially in pencil the powder bags at the beginning for checking purposes as the blending proceeds.

If the expected muzzle velocities and pressures of the various lots are known, they can be computed for the composite charge by the ordinary methods of proportion.

For instance:

Name.	Lot.	Number of charges.	Pressure.	Velocity.
Int.....	22-'09	9	34,000	2,210
Du Pont.....	31-'08	6	30,000	2,235
Du Pont.....	42-'10	1	33,000	2,250

$$\text{Expected pressure} = \frac{9 \times 34000 + 6 \times 30000 + 1 \times 33000}{16} = 34,687 \text{ pounds per square in.}$$

$$\text{Expected velocity} = \frac{9 \times 2210 + 6 \times 2235 + 1 \times 2250}{16} = 2222 \text{ f. s.}$$

13. *Instructions for adjusting and testing powder scales.*—1. Scales for weighing powder charges should not only give an accurate total weight, but should be sensitive enough to record a small change in weight, such as results from adding a single grain of powder to a charge on the scales. To facilitate the adjustment of scales that may be used for weighing powder, at least one set of the following standard weights, packed in a suitable box, will be issued to each Artillery district: One 25-pound weight, one 5-pound weight, one 0.5-ounce weight.

2. Assuming that it is desired to make up powder sections weighing 78 pounds, the method of adjusting the scales would be substantially as follows:

(a) Level the scales as accurately as possible.

(b) Place the 25-pound weight on the scales and move the slide along the scale beam to the 25-pound reading and carefully balance the scales so that the scale beam is accurately poised in its middle position.

(c) Remove the test weight and place a pail of sand on the scales; add or remove sand until the scale beam again balances in its middle position.

(d) Repeat operation (c) with another pail of sand.

(e) Place the 25-pound weight, the 5-pound weight, and both pails of sand on the scales, move the slide along the scale beam to the 80-pound reading, and again carefully balance the scales, which should now be accurately adjusted for weighing weights of approximately 80 pounds.

(f) Test the sensitiveness of the scales by placing the 0.5-ounce weight thereon, in addition to the 80 pounds of weight, and note whether the beam is thrown out of balance, as it should be in case the scales are reasonably sensitive.

(g) The scales being adjusted to weigh 80 pounds correctly, may be assumed to weigh with a negligible error weights a few pounds above or below 80, such as the 78-pound charge to be prepared.

14. The weights of projectiles, powder charges, muzzle velocities, and pressures for seacoast guns and mortars will be found in Ordnance Pamphlet No. 1676. The following powders—D. P., 2-1905 and L. R., 1-1907 for 10-inch guns, model of 1900, and Int., 2-1907, L. R., 1-1906, and L. R., 2-1907 for 12-inch guns, model of 1900—were originally tested in and the charges established for guns without fixed chamber trays. Charges of these powders issued prior to October 1, 1910, are of greater weight than those issued subsequently, but may be used with safety in guns with fixed chamber trays giving a normal muzzle velocity of approximately 2,300 feet per second. Charges issued since October 1, 1910, are estimated to give the standard velocity of 2,250 feet per second under normal conditions.

15. *Zones, muzzle velocities, zone limits, etc., for 12-inch mortars.*—The number of zones, muzzle velocities corresponding thereto, zone limits, widths of zones, and overlaps for the 12-inch mortar, cast-iron, steel-hooped, and the 12-inch mortar, steel, are as shown by the following table:

No. of zone.	12-inch mortar, cast-iron, steel-hooped, models of 1886 and 1896-1890 Ml.					12-inch mortar, steel, models of 1890, 1890 Ml, and 1908.				
	Muzzle velocity.	Weight of projectile.	Zone limits.	Width of zone.	Overlaps.	Muzzle velocity.	Weight of projectile.	Zone limits.	Width of zone.	Overlaps.
	F. S.	Lbs.	Yds.	Yds.	Yds.	F. S.	Lbs.	Yds.	Yds.	Yds.
1.	500	1,046	2,225-3,000	775	400	550	1,046	2,810-2,070	760	370
2.	610	1,046	2,690-3,480	880	400	600	1,046	2,600-3,421	831	361
3.	670	1,046	3,080-4,110	1,030	400	690	1,046	3,070-4,030	960	390
4.	743	1,046	3,710-5,000	1,280	400	725	1,046	3,631-4,800	1,160	371
5.	837	1,046	4,000-5,240	1,640	400	810	1,046	4,429-5,040	1,511	420
6.	910	1,046	5,840-7,319	1,470	504	915	1,046	5,820-7,478	1,956	449
7.	1,050	824	6,725-9,225	2,500		1,050	1,046	7,027-9,250	2,223	492
8.						1,300	824	8,758-12,010	3,261	1,165
9.						1,500	700	10,854-15,201	5,437	

12-inch mortar, steel, model of 1912.

	Muzzle velocity.	Weight of projectile.	Zone limits.	Width of zone.	Overlaps.
	F. S.	Lbs.	Yds.	Yds.	Yds.
1...	550	1,046	2,214-2,028	714	341
2..	600	1,046	2,587-3,438	851	375
3..	690	1,046	3,063-4,086	1,023	477
4..	725	1,046	3,069-4,834	1,225	370
5..	810	1,046	4,455-5,976	1,521	412
6..	915	1,046	5,564-7,492	1,928	585
7..	1,050	1,046	6,907-9,387	2,480	780
8A.	1,200	1,046	8,607-11,754	3,137	3,140
8B.	1,250	700	8,614-11,927	3,313	1,073
9..	1,500	700	10,854-15,201	4,437	2,295
10..	1,800	700	12,996-19,319	6,323	

Zone limits will probably be so arranged that the same battery will not use both the 700 and 824 pound projectile. The use of the 700-pound projectile with the model of 1886 mortar is being considered.

PROJECTILES.

16. *Preservation and care of projectiles.*—Proper precautions will be taken by those responsible to see that the rotating bands of projectiles are not burred or deformed in handling. To prevent this, projectiles will be packed in wooden boxes whenever necessary to ship them from place to place. When wooden boxes are not available, the rotating bands will be protected by rope grommets or other efficient means.

When stored in magazines after removal from the wooden packing boxes, projectiles will be placed on skids or rails in such a manner that the rotating band does not support the weight of the projectile.

If necessary to pile projectiles, the layers will be separated from each other by a wooden frame, in such a manner that the rotating bands do not support any weight.

Projectiles will be repainted from time to time, in accordance with Ordnance Department Form No. 1868, "Paints for Projectiles." In case the magazines or galleries in which they are stored are wet, the projectiles will be slushed after painting.

The packing boxes in which target-practice projectiles are received will be carefully preserved until the projectiles are expended. These boxes may be found useful for properly repacking projectiles when necessary to transfer them from place to place.

17. *Projectiles for Coast Artillery target practice.*—Unless otherwise specified, cast-iron shot or shell of service weight and form will be used in target practice. When necessary, sand will be inserted in the cavities of shell to bring them up to the proper weight. Sawdust may be mixed with the sand to fill the cavities completely, or water or metal may be added to secure the desired weight.

Narrow-banded projectiles, if on hand, should be expended before broad banded, except in the case of batteries specially authorized to fire broad-banded projectiles only, and instructions requested for the disposition of small lots for which there is no probable use.

18. *Reserve projectiles—Systems of lot numbering.*—(a) Continental United States only: In view of the difficulties which arose under the system of lot numbers previously assigned to projectiles and fuzes of the reserve ammunition supply for seacoast guns and mortars, a new and simpler system was recently adopted. Under the new system all projectiles of the same type, regardless of caliber, prepared for the same kind of fuze, have the same lot number, thereby eliminating one of the most confusing features of the previous system.

The following table gives the new system of lot numbers:

Fuze.	Delay or non-delay primer.	Projectile.	Lot No.
Medium caliber, base detonating.....	Delay.....	Shot, Ordnance Department design.....	1
	Non-delay.....	Shell, Ordnance Department design.....	4
	do.....	Shot, Armstrong design.....	10
	do.....	Shell, Armstrong design, strong head..	6
M-M caliber, base percussion.....	do.....	Shell, Armstrong design, cast-steel....	3
	do.....	Shell.....	2
Siege detonating, modified Peirce stack.	do.....	Shell, mortar, 800-pound.....	20
	do.....	Shell, mortar, 1,000-pound.....	22
	do.....	Shell, mortar, 1,046-pound.....	5
	do.....	Shell, gun.....	12
A. P. detonating, modified Peirce stack.	do.....	Shell, gun.....	3
	Delay.....	Shot.....	9
	do.....	Shell, mortar, 700-pound.....	11
	do.....	Shell, mortar, 824-pound.....	13
Major caliber, base detonating.....	do.....	Shell, mortar, 1,046-pound.....	14
	do.....	Shell, gun.....	16
	do.....	Shell, mortar, 800-pound torpedo.....	18
	do.....	Shell, mortar, 1,000-pound torpedo....	18

It will be noted that under the system outlined above all projectiles using a delay-action primer in the fuze have been assigned odd numbers, while those using the nondelay-action primer have been given even numbers. No siege detonating fuzes, modified Poirce stocks, have been assigned to shot.

Where the lot numbers now stamped on the rotating bands of projectiles conflict with the above scheme they will be canceled and the new lot numbers substituted. The lot numbers on the boxes containing fuzes will similarly be changed to agree with the numbers on the projectiles to which they pertain. Metal labels for marking the fuze boxes are to be obtained from Frankford Arsenal and furnished to posts by the armament officers.

(b) *Philippine and Hawaiian Islands:* The following table shows the system of lot numbers previously adopted for projectiles and fuzes in the insular possessions. While this system is not so simple as that adopted for the continental United States, it will be adhered to, in view of the fact that there are fewer types of projectiles involved and that they and the fuzes are already marked:

		Projectile.		
P. deton.	Nondelay	{	Delay.....	1
			Nondelay	
P. de stock.	Nondelay	{	Delay.....	2
			Nondelay	
P. de stock.	Nondelay	{	D. P. shell, 1,046-pound.	3
			Delay.....	
P. de stock.	Nondelay	{	A. P. shell.....	4
			Delay.....	
P. de stock.	Nondelay	{do.....	5
		do.....	

19. *Amount of reserve ammunition to be kept on hand.*—1. Original issues of reserve ammunition are ordinarily made when requested. As, however, many of the components, such as powder charges, may be used for target practice, as well as for reserve purposes, it is incumbent upon the proper coast-defense authorities to see that the proper supply of ammunition is kept up by requisition, unless there is information at hand indicating that issues of supplies to fill deficiencies have been already ordered.

2. Reserve seacoast ammunition is issued as funds become available after a consultation with the office of the Chief of Coast Artillery. Every round of this ammunition should be complete at all times and coast-defense commanders should see that fuzes, bursting charges, base covers, propelling charges, etc., are on hand for each separate loading projectile. If any reserve ammunition is expended in target practice, requisition for its replacement should be made. One electric primer should be on hand for each powder charge and one-half as many friction primers, emergency type, as electric primers.

friction primers this type of primer may be counted as either an electric primer or a friction primer. One sectional mortar charge, the zones to be as recommended by the coast-defense commander and approved by the Chief of Coast Artillery, is provided for each reserve projectile and in addition thereto a number of charges for the outer zone, 1,046-pound projectile, equal to 50 per cent of the number of charges prescribed for that zone. Powder charges, etc., should be kept on hand for any projectiles which have been issued in excess of the normal full allowance.

While a rather large target-practice reserve—i. e., ammunition for special target practice in case of imminent hostilities—is contemplated, for the present it will be possible to have on hand at all times only sufficient ammunition for one year's target practice by the regular troops and any Coast Artillery reserve which there may be. Ammunition for each year's target practice should be requisitioned for in ample time.

20. *Dummy projectiles.*—These conform as closely as possible to service weight and shape, and are intended to enable the loading of the gun with service ammunition to be closely simulated. The construction of the type of projectile now in use is shown in the sketch.

A portion of the base plug is conical, and on this conical surface is a movable bronze band which is cut through at one point. The width of the band is narrower than the length of the conical surface, which leaves a space between the body of the projectile and the bronze band when the band is held to the rear by the plungers and the plunger springs shown on the sketch. The base plug, bronze band, plungers, etc., can be readily disassembled by screwing out the base plug, and reassembling is accomplished by placing the parts in their proper positions and screwing in the base plug. A tit wrench which will fit the holes in the base plug is provided for each Coast Artillery post, but if not on hand a suitable wrench can be improvised. The slope of the conical portion of the base plug, the exterior dimensions of the bronze band, and the strength of the plunger springs are so designed that the projectile should not rebound at the time of ramming but at the same time should not stick so tightly but that the projectile can be drawn to the rear with the hand extractor and upon coming in contact with the bronze band knock the same loose. There is, however, a very small working margin in any of the above elements between rebounding and sticking, either of which is very annoying in use. The exterior dimensions of the band become changed, due to continued use, and also the surface of the gun against which the band bears changes with the number of rounds fired and the conditions of lubrication of this surface change. The slope on the base plug does not change, but

dirt and rust on this surface changes the ease with which the surface will slip through the band and therefore has practically the same effect that changing the slope would have. The springs vary somewhat as manufactured, and more extensive variations are due to becoming weakened in service or to improper assembling. From this it will be apparent that the primary requirement in the successful use of dummy projectiles is to so adjust the projectile that it will neither rebound nor stick, and hereafter to see that the conditions are not changed. Several practical tests at Artillery posts have shown the soundness of this conclusion and the projectiles have operated satisfactorily, while at many places where such precautions were apparently not taken unsatisfactory results have been obtained.

The following rules should insure satisfactory action:

A. See that the rotating band is fairly round and that the rear of the band bears evenly against the front of the rear flange of the base when the latter is removed from the projectile, i. e., a portion of the strength of the springs should not be wasted in forcing a band to the rear which does not properly fit the base.

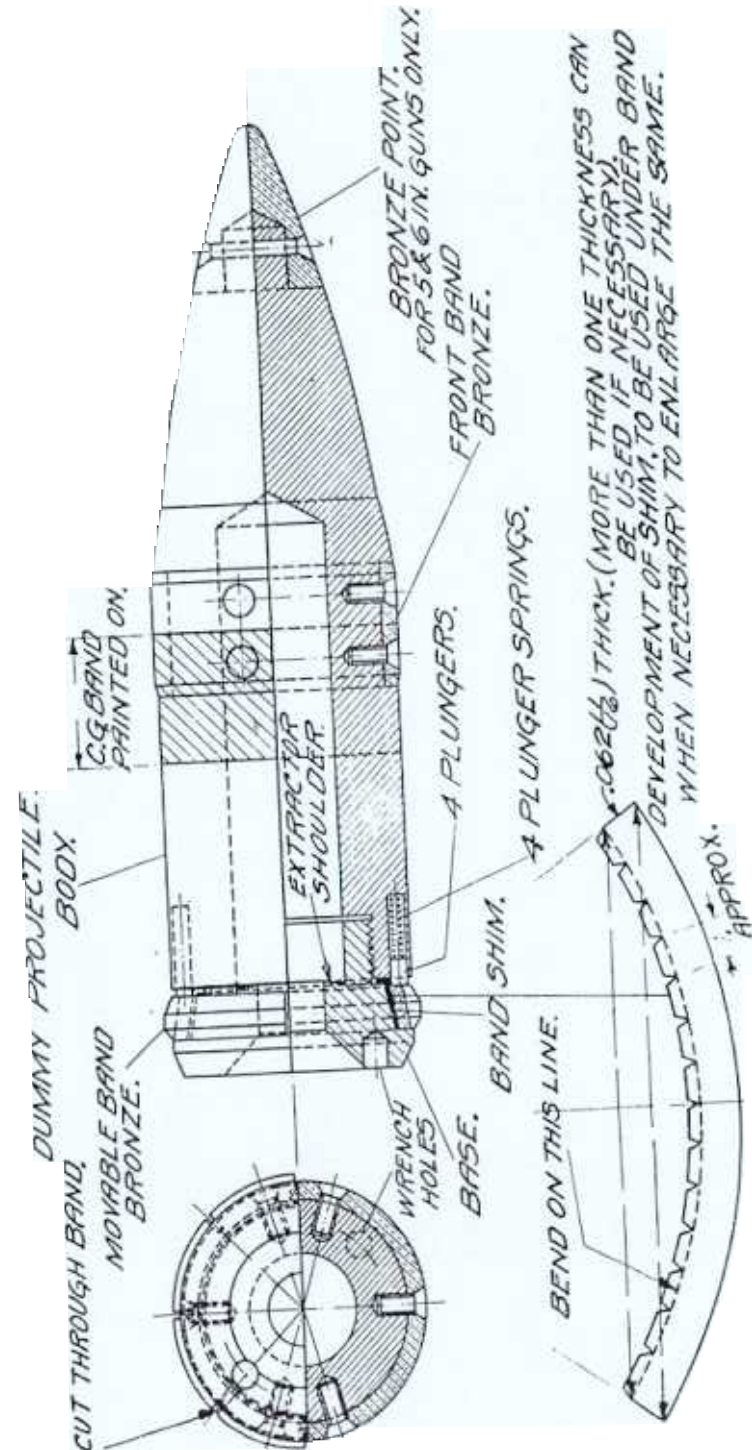
B. See that the band is large enough so that when the projectile is pushed in the gun, the band bears on the centering cone at the front end of the powder chamber and does not enter the rifled portion of the gun. If the diameter of the band is not large enough, it can be increased by placing one or more shims underneath, as indicated in the sketch.

C. See that the springs are strong enough to hold the band to the rear when the projectile is rammed. See that the band is made of such diameter as to bear on the centering cone. This can readily be determined by ramming the projectile and then looking into the breech of the gun. If the slot through the band is closed up, the band has moved to the front on the base plug and the springs are not strong enough. Some improvement can be made by placing washers under the plungers, or very simply by placing leather washers under the springs. In this case, the washers should be threaded on a nail or wire to permit removing them later on. Care should, however, be taken that the assembled height of the springs is not so reduced that they will become solid when the body of the projectile is pulled toward the band in extracting.

D. Immediately before every drill pour a small quantity of kerosene in the space around the band so that in operation any rust which may have formed under the band will be promptly cut and the conditions under which the projectile was adjusted not disturbed.

E. In some cases, improvement will result by not screwing the base plug entirely home, which leaves a wider space between the band and projectile, and hence increases the ramming action of the latter when withdrawn.

PLATE V



F. Should the projectile operate badly during drill, the temporary expedient of inserting a small block of wood in the cut which goes entirely through the band of the projectile will prevent the band from closing up when the projectile is rammed and prevent sticking until the wood is broken up. It takes only a short time to replace the wooden block. After drill the projectile should be overhauled and put in condition.

21. *Subcaliber practice with 12-inch mortars.* The propelling charges of the ammunition for this practice are adjusted to permit of zone firing and the number of the zone for which each round is prepared is stenciled in white on the projectile.

The muzzle velocities, zone limits, etc., are as follows:

No. of zone.	Muzzle velocity.	Zone limits.	Width of zone.	Overlaps.
		Yds.	Yds.	Yds.
	550	1,002-2,711	719	237
	625	2,474-3,312	838	344
	700	2,988-4,142	174	

22. *Subcaliber ammunition for 6-pounder and 15-pounder guns.*—The service-rifle caliber .30 ammunition will not be used in the subcaliber cartridges for cannon, its primer not being adapted for the blow of the firing pins of these pieces and being so small that the back pressure tends to force it into the firing-pin cavity in the front of the block. A special caliber .30 cartridge is made for this purpose, and requisition will be made for "subcaliber cartridge, caliber .30," for use with cannon.

23. *Subcaliber ammunition for 1/4 to 16 inch guns.*—The 1-pounder fixed ammunition used in guns of these calibers is prepared with the 20-grain igniting primer, except that for the 4-inch D. S. and 4.72 and 6-inch Armstrong guns, which is prepared with 20-grain percussion primer.

24. *Statement as to interchangeability of subcaliber guns.*

Type.	Caliber.	Standard for—	Adaptable for—
2-A	1.457	4-inch D. S.	6'05, 8, 10, 12, 14, and 16 inch sea-coast.
2-B	1.457	4.72-inch Armstrong	Do.
2-C	1.457	6-inch Armstrong	10, 12, 14, and 16 inch sea-coast.
2-D	1.457	6-inch model of 1897	6'05, 8, 10, 12, 14, and 16 inch sea-coast.
2-E	1.457	6-inch model of 1900	Do.
2-F	1.457	6-inch model of 1897	10, 12, 14, and 16 inch sea-coast.
2-G	1.457	M1 1908. 6-inch model of 1900, 1903.	6'05, 8, 10, 12, 14, and 16 inch sea-coast.

The 4-inch Driggs-Chroeder, 6-inch models of 1897 and 1908, and 6-inch Armstrong subcaliber guns should have adjusting wrench holes, if not already provided, drilled in the breech face, if these guns are ever mounted in 10 or 12 inch guns.

With few exceptions, each caliber and model of gun requires a special adapter which can not be used in any other model of gun.

The 2.95-inch subcaliber guns for 12-inch mortars, model of 1886, are not interchangeable with those for

25. *Care of empty metallic cartridge cases and primers.*—After the expenditure of ammunition in target practice with guns using metallic cartridge cases the empty cases will be taken up on the property return of the post or battery as "empty metallic cartridge cases," under the heading provided for that purpose. Immediately after firing the cases will be decapped, well cleaned by washing inside and out, and dried.

Upon the accumulation of convenient lots of such cases they will be packed in the boxes in which received and shipped from posts in the Eastern and Central Divisions to Frankford Arsenal; in the Western Division to Benicia Arsenal; in the Philippines Division to the Manila Ordnance Depot.

All service primer bodies will be cleaned immediately after firing, and turned in to the post ordnance officer for shipment to the ordnance establishments specified above.

26. *Misfires.* Rounds of fired ammunition, or primers which have missed fire, will, unless ordered returned to an arsenal, be held for inspection by the armament officer.

27. *Cameras and photographic supplies.*—To each Artillery district, except the Potomac and New Orleans, there have been issued two cameras, and to each of the excepted districts, one camera, for photographing the fall of shots in target practice and the splash in submarine mine practice, and the necessary equipment for developing and printing. The annual allowance of films and developing and fixing powders will be issued to the ordnance officers of Artillery districts without requisition on or about the following dates:

To all Artillery districts in the Department of the East, the Department of California, and the Department of the Columbia, May 1.

To all Artillery districts in the Department of the Gulf, January 1.

To all Artillery districts in the Philippine Islands, January 1.

The films, developing paper, developing powders, and fixing powders, issued for a given practice, may be dropped at the conclusion of that practice on the next property return.

28. *Drill primers.*—Two drill-primer outfits are authorized for each Coast Artillery post. The post ordnance officer is charged with the duty of supervising the resizing and reloading of these primers and with the responsibility for withdrawing from use any primer bodies which become greatly weakened or otherwise unsuitable for use.

The authorized supply of drill-primer bodies is 150 for each company assigned to guns and mortars requiring their use. Unserviceable drill-primer bodies will be disposed of as provided for empty cartridge cases and primers in paragraph 21. (Reference Ordnance Department Pamphlet No. 1986.)

Hold air in case for at least three minutes.

After the test is completed the hole in the cover will be closed by soldering the small piece of tin or zinc over it again.¹

Any cases without the small hole in the lid should be provided with it at the time of the first test of the case.

Upon receipt of the testing set, all cartridge-storage cases containing powder should be tested and any leaks closed by soldering. In future all cases and metal-lined boxes of fixed ammunition, except those whose contents will be used in a short time for target practice, should be tested upon receipt at the post and all necessary repairs made. Tests of cases other than those mentioned above will be required only under special circumstances, such as when transferred from one magazine to another or otherwise subjected to rough handling. The necessity for testing at such times is left to the discretion of the local authorities. Tests with this apparatus need not be made of cartridge-storage cases sealed with paraffin during the short period between blending and target-practice firing.

Every leaky case found, besides being resealed, should be marked, put aside, and the powder in it used in the next target firings if practicable.

In order that the Ordnance Office may be kept informed as to the suitability of the designs of cartridge-storage cases in service, report should be made of all leaky cases found, giving the type of the case, description of the leak, and any circumstances which will enable the cause of the leak to be determined or which will enable remedial action to be taken.

MAXIMUM AND MINIMUM THERMOMETERS.

29. *Thermometers.*—A thermometer is an instrument for measuring temperature, founded on the principle that changes of temperature in bodies are accompanied by proportional changes in their volumes or dimensions.

Thermometers consist essentially of a glass tube of capillary bore, terminating in a bulb, and containing mercury or alcohol, which, expanding or contracting according to the temperature to which it is exposed, indicates the degree of heat or cold by the amount of space occupied, as shown by the top of the liquid column on the graduated scale.

Thermometers of the best grade have the graduated scale engraved or etched directly upon the glass stem or tube of the thermometer. Thermometers issued by the Ordnance Department will be so graduated, and in addition thereto the graduations and corresponding numbers will also be stamped on the metal backs. In case of any discrepancy between the two readings, due to movement of the thermometer in its metal back, the reading on the glass tube is to be taken as the true reading.

APPARATUS FOR TESTING CARTRIDGE STORAGE CASES.

[Plate V.]

30. The testing set shown on O. O. Drawing 24-12-1, of November 6, 1911 (Pl. VI), is composed of four principal parts, namely: Wood base, air pump, mercury column, and compression connector.

The wood base is of oak $1\frac{1}{2}$ inches thick, 11 inches wide, and 30 inches long. Footing pieces are screwed on bottom to prevent rocking on uneven floors. The air pump is of the double-acting plunger type with 13-inch stroke. The mercury column is an ordinary plumber's gauge. The hand compression connector is a combination of small parts to allow of convenient hose connection to a storage case.

The outfit is shipped partly assembled in a box, the parts cleated and screwed to wood base.

To assemble.—After the cover is removed, lift the entire set from the box. Unscrew all unpainted cleats.

(a) Screw the iron stand on base over unpainted spot about 3 inches in diameter, using the screws furnished (four No. 10 wood screws 1.5 inches long) for the purpose. The mercury column will now be found hanging down. Place a monkey wrench on nut D and turn a half revolution to the right until the column is in an upright position. Do not turn too far, as any turn backward would probably cause a leak.

(b) Screw air pump over unpainted spot in center of wood base, using two No. 10 wood screws 1.5 inches long, being careful to get hose side of pump toward column and stand.

(c) Put on brace A, securing ends to slots in sides of wood base, using No. 8 wood screws 0.75 inch long.

(d) Attach pump hose C to union joint B, making certain that faces are clean before closing joint.

(e) Remove the black guard from lower end of mercury column and put in its place the mercury pot E. See that pot E is screwed up tight against washer J. When removing cap from pot E hold in vertical position to prevent loss of the charge of mercury which is shipped in the pot.

To test set before using.—Each set has been assembled and tested before issue, but as some joints are disturbed in "knocking down," a retest of the final assembling is advisable.

Proceed as follows:

Place compression connector under test clip L and seat set screw E over nipple G. The lower end of set screw K contains a lead washer for making air-tight joint.

Open needle valve F.

Pump slowly until mercury is about 3 inches from top of column.

Cease pumping and close valve F.

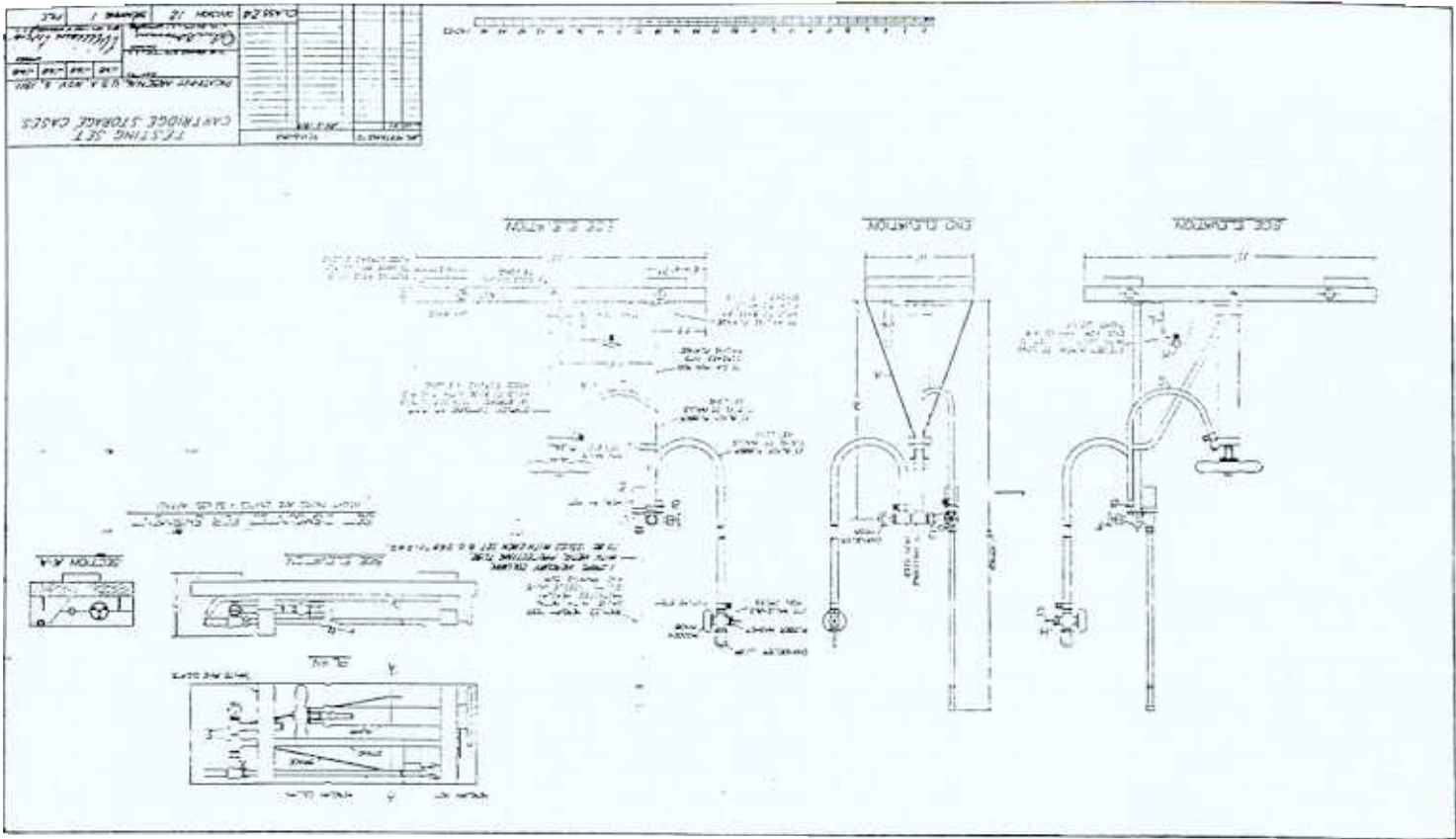


PLATE VI

ADDENDUM.

TO ORDNANCE DEPARTMENT PAMPHLET NO. 1872, "SEACOAST ARTILLERY AMMUNITION AND INSTRUCTIONS FOR ITS PREPARATION, CARE, AND USE."

Add following paragraph immediately after paragraph headed "To use testing set" near top page 38:

In the future the covering piece for the test hole in cartridge storage cases will consist of a circular piece of metal $1\frac{1}{2}$ inches in diameter, with a depression in the center $\frac{1}{4}$ inch in diameter and $\frac{1}{4}$ inch deep. This depression is intended to fit into and fill the test hole, thus obviating the possibility of hot solder working under the sealing disc, through the test hole, into the cartridge storage case. When testing storage cases, the new type of sealing disc should always be used for resealing the test hole. All of the new type discs which are serviceable should be used again, first burning off the old solder. A supply of the new type discs will be furnished Coast Defense Ordnance officers. These should be used when resealing storage cases now supplied with the old type test hole covers and to replace any of the new type which may become unserviceable. The new disc is applied by placing the depression in the center in the test hole and soldering the edges fast to the storage case. While doing this, hold the disc down in place by pressing on it with the stick of solder. After soldering in place, fill the depression in the disc with solder as a safeguard against the accidental pricking of a hole in the depressed portion of the disc.

ERRATA.

The last line on page 30 and the matter following on page 81 should be transposed so as to follow immediately after the last paragraph of the above addendum.

WAR DEPARTMENT,
OFFICE OF THE CHIEF OF ORDNANCE,
Washington, November 1916.

If set is tight the mercury should not fall more than 1 inch in one hour.

If set leaks prepare a soapy water solution and apply with brush.

A bubble will indicate location of leak.

Test the set about once a month.

To use testing set.—There is a small hole in the lid of each cartridge-storage case, over which a piece of tin or zinc has been soldered. Remove this piece of tin or zinc, and insert nipple G, being careful to see that washer H is in its proper position. Press firmly with the hand on the connector while pumping up the desired pressure. As soon as pumping ceases, close valve F and watch the gauge—if mercury falls, the case leaks; if mercury stands at a constant height, case is tight.

A register thermometer, or self-registering thermometer, is one that automatically registers either the maximum or minimum of temperature occurring in the interval of time between any two consecutive settings.

The complete self-registering set issued by the Ordnance Department consists of one maximum and one minimum thermometer mounted on the wooden base and brass supports adopted as a standard.

Maximum thermometer: The maximum thermometer is always filled with mercury.

All maximum thermometers have a round, brass, hub-shaped projection fastened to the metallic back at the top.

The most distinctive peculiarity of the maximum thermometer, however, is not so easily seen as those mentioned above. If the thermometer is held vertically, with the bulb down, it will be noticed that the mercurial column does not extend entirely into the bulb. A very close examination of the thermometer at the point just above the bulb, where the mercurial column stops, will show that the hole in the glass tube has been almost closed at that point, and the passage-way for the mercury is so fine that it will go through only with some difficulty. If the hand is held around the bulb, the mercury in it becomes warm and is forced to pass the constricted portion of the tube, flowing through in little spurts. When the hand is removed from the bulb the mercury below the constriction withdraws toward the bulb, but none of the mercury above the constriction will go back, and the length of the column remains just the same as it was when the bulb was warmest. In this way the maximum temperature is registered.

Minimum thermometer: This thermometer, as issued by the Ordnance Department, is always filled with alcohol and is, therefore, at once distinguished from mercurial thermometers. Besides the alcohol

there is also inside the thermometer a small black object having a rounded head on each end. This object is called the index and is the prime characteristic by which this kind of minimum thermometer is distinguished from other thermometers.

If the thermometer is held vertically while the bulb is warmed by contact with the hand, and then turned upside down, it will be noticed that the index glides along the tube until it strikes the top of the column, where it will at once stop. This operation of bringing the index to the top of the column is called "setting" the thermometer.

If the thermometer is next held horizontally and the bulb cooled, it will be noticed that the index is dragged backward toward the bulb, remaining always at the end of the column of alcohol, while the temperature is decreasing. However, if the temperature increases, the column will go up, the alcohol flowing around the index and leaving it at the lowest point. In this way the minimum temperature is registered.

Generally the index will slide freely up and down the thermometer tube when the latter is turned upside down or right side up. Sometimes, however, and especially after the thermometer has been shipped through the mails, the alcohol in the tube becomes broken up into short, detached columns, and the index is frequently caught and held. Until this is remedied the thermometer can not be used.

On account of the extreme delicacy of construction of the instrument the greatest care should be used in endeavoring to reunite detached columns of alcohol or in trying to free the index.

(1) The mount consists of a wooden base, 16 inches long by 4 inches wide, which should be secured by a screw at either end to a wall or other substantial support.

(2) A brass standard, $3\frac{1}{2}$ inches long by $\frac{1}{4}$ inch diameter; its lower end threaded to screw into a corresponding threaded hole in the wooden base; its upper end turned down to form a spindle and shoulder for the hub of the maximum thermometer; and above this, $\frac{1}{4}$ inch of the extreme end turned down to $\frac{1}{2}$ inch in diameter and threaded for a nut that holds the thermometer in position on the standard. A hole of proper diameter to receive the bent wire pin when used as a wrench, is drilled through just below the shoulder.

(3) A bent wire pin, inserted in a hole near the left end of the board and serving as a support or rest for the left end of the maximum thermometer. This pin is also used as a wrench to screw the brass standard firmly in place.

(4) A bronze strip, screwed to the base and serving as a support for the minimum thermometer, which is secured to it by a small thumbscrew.

To set the thermometers:

(a) The maximum—Remove the brass wire pin that passes through

observe that the nut at end of standard is properly secured by means of the split pin; then whirl the thermometer from right to left (clockwise) until the proper setting has been obtained.

After being set see that the thermometer is held in its former position by the brass pin passing through hole in clip, its end being forced into hole in support.

(b) The minimum—This thermometer is "set" in place by elevating the bulb or lower end of the thermometer until the index moves down to the end of the column of alcohol, and then carefully lowering it into the notch at the left of the brass support.

To read the thermometers:

(a) The maximum—First carefully remove the wire pin and slowly lower the thermometer to a vertical or nearly vertical position. This will cause the mercury in the tube to flow toward the bulb until stopped by the constriction. The thermometer must not be lowered to the vertical suddenly, especially in warm weather, as the weight of the long column of mercury is likely to force some portion through the constriction and cause an erroneous reading. The maximum temperature is read at the top of the column of mercury.

(b) The minimum—This thermometer is read in place by observing the number of degrees on the scale at the end of the index farthest from the bulb. A reading taken at the end of the column of alcohol will give the temperature at time of reading. If at any time the column should be found to be broken and bubbles are observed in the tube, the instrument should be taken off the supports and the column united.

THE WET AND DRY BULB THERMOMETER SET (PSYCHROMETER).

This set consists of two thermometers mounted in a vertical position on a varnished pine base. Each thermometer consists of a glass tube, a glass bulb, an aluminum back, and a bronze strip support $\frac{1}{2}$ inch wide. The wet-bulb thermometer has in addition a metal water reservoir, a support for the reservoir, a muslin cover for the bulb, and a tube of cotton wicking leading from the muslin cover into the reservoir.

The tubes and bulbs of the wet and dry bulb thermometers are alike, each being about 10 inches long and $\frac{1}{4}$ inch in diameter, graduated in F° from -10° to $+120^{\circ}$, with every fifth division longer than the rest and every tenth degree numbered. It has a strip of enamel on the rear side against which the degree divisions and mercurial column may be seen. The maximum allowable error of graduation between $+12^{\circ}$ and $+112^{\circ}$ is 0.3° , and below $+12^{\circ}$, 0.6° .

The bulb is cylindrical, not more than $\frac{1}{8}$ inch in diameter and $\frac{1}{2}$ inch in length.

The tube is held in a semicylindrical recess in the aluminum back

in the metal back for additional security. The cylindrical bulb projects $1\frac{1}{2}$ inches below the end of the metal back. The back is made of aluminum $\frac{3}{8}$ inch thick, $9\frac{1}{2}$ inches long, and $\frac{1}{16}$ inch wide.

The wet and dry bulb thermometers stand vertically and about $\frac{3}{4}$ inch from the common base to which they are attached by means of bent bronze strips and by thumb screws through the two holes in each aluminum back. On the wet-bulb thermometer the water reservoir is attached to the lower end of the bronze strip by the support.

A small tube of cotton wicking extends from the water reservoir to the muslin cover on the bulb of the wet-bulb thermometer. The function of the wicking is to keep the muslin uniformly moistened with water from the reservoir, but as explained subsequently neither the wicking nor anything except the muslin should touch the bulb.

ACTION OF WET AND DRY BULB THERMOMETER SET.

The wet and dry bulb thermometers are taken together to determine relative humidity. The principle upon which the method is based is as follows: One thermometer, the dry bulb, has no other function than to register accurately the temperature of the surrounding air. The wet-bulb thermometer is mounted beside the dry bulb and under as nearly the same conditions as possible, except that the bulb is kept moist with the moisture as freely exposed to the air as possible to facilitate evaporation. The amount of evaporation which varies inversely as the amount of moisture in the air is measured by the sinking of the mercury column in the wet-bulb thermometer. Tables have been published giving the relative humidity corresponding to any difference in readings between the wet and dry bulb thermometers (depression of the wet-bulb thermometer) for any actual temperature of dry air. (Reading of dry-bulb thermometer.) The standard covering for the bulb of the wet-bulb thermometer is one thickness of moist muslin, and it is obvious that any other covering will result in a rate of evaporation at the surface of the bulb different from the standard, a reading of the wet-bulb thermometer differs from the standard and an erroneous determination of the relative humidity.

THE MUSLIN COVER OF THE WET-BULB THERMOMETER.

There is ordinarily issued a combined cover and wick which requires no adjustment other than to slip the hollow end over the bulb and place the other end in the reservoir, a muslin tube being woven about a core of wicking. A suitable length of this is cut off and the wicking pulled out far enough at one end to have about 1 inch of the other end of the tube empty. This empty section is slipped

In case this special tubing and wicking is not available there is little difficulty in properly fitting up the thermometer provided the elementary requirements that there must be a single thickness of muslin over the bulb and a suitable wick to supply it with water are borne in mind. Detailed instructions are given in the next paragraph.

The muslin, thoroughly washed in hot water before it is placed on the bulb to remove the starch usually found in it, is cut in a rectangular piece about $\frac{3}{4}$ inch greater in length than the bulb, and a trifle greater in width than its circumference, so that when wrapped about the bulb it will cover it completely, the edges overlapping only enough to secure perfect covering. After cutting, wet the cover and attach it smoothly and tightly to the bulb, making sure that it is covered completely by one thickness of the cloth. While the cloth is wet tie it tightly both above and below the bulb with fine thread. Divide one end of the wicking and tie it to the portion of the muslin below the bulb so as to secure good contact with the muslin.

Should it be found that the cover has become loose or does not completely cover the bulb, thread may be wound around the bulb and tied securely. The muslin over the bulb should always be kept perfectly clean, and to that end should be replaced when necessary. A slight coating of foreign substance on the muslin seriously retards free evaporation and conduction. If the muslin becomes dry, then wet the wicking freely by direct application of a few drops of water. Keep the cistern well supplied with pure rain water or distilled water when the temperature of the air is above the freezing point.

TO READ WET THERMOMETERS WHEN THE TEMPERATURE IS BELOW THE FREEZING POINT.

Remove the cup of water from its position in the shelter and keep it full of cold water as near the temperature of freezing as possible. The wicking should not be removed from the thermometer, but its free end should be passed over the bronze support behind the thermometer, leaving the bulb with its muslin cover as before. At least half an hour before time for making an observation bring the cup of water underneath the thermometer and wet the muslin by lifting the cup until the muslin cover is completely immersed, then quickly lower it; the drop of water which will gather on the bottom of the bulb should be removed by touching it with the edge of the cup. In order to secure a film of ice over the whole bulb so thick that it will not be wholly evaporated before the time of observation, it may be necessary to repeat the wetting once or twice, especially if there be a high wind. In case the bulb already has a thin coating of ice left from a preceding observation, the wetting should be

wholly omitted. The aim is to have a thin film of ice upon the bulb for a sufficient length of time before the observation to insure that the thermometer has fallen to its lowest point and is stationary at the time of making the observation. It may sometimes happen that when the air is stagnant and near the freezing point that the water takes an hour or more to freeze and that the mercury remains at the freezing point of water instead of sinking to the temperature of evaporating ice. The freezing in this case may be hastened by fanning the bulb. When a thaw occurs care must be taken that the ice is wholly melted and a film of water substituted; at such times the covered bulb and its attached wicking should be immersed in warm water to melt the ice at least an hour before the observation is made.

GENERAL REMARKS.

It should be kept in mind that the thermometer is to measure the temperature of the surrounding air. Errors in readings may be caused by allowing the sun's rays to fall directly upon the thermometer or by mounting it near a wall or other object which radiates heat. If the thermometer is mounted in a corner where there is little circulation of air it is likely to be influenced by local conditions. Except in the case of the wet-bulb thermometer the bulb should be perfectly dry and should not be touched just before a reading nor should the hand be held very near to it.

Especial care must be taken to mount the wet-bulb thermometer where it will not be affected by radiation and where it will be in contact with the moving air. A suitably located shelter similar to the standard thermometer shelter used by the United States Weather Bureau should be used.

The tubes and bulbs should be kept clean, but care taken not to remove the black pigment from the numbering and division lines. The aluminum surfaces should be kept well lacquered to prevent corrosion, which is otherwise caused by the action of salt air.

Special reference is made to the following:

Weather Bureau Pamphlet No. 347, "Instructions for Cooperative Observers."

Artillery Circular D, 1893.

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