ORDNANCE MEMORANDA, NO. 21.

ERRATA.

INDEX, page iv.—"To case the fuse," read "To cast the fuze."
PAGE 31.—Line 3, for "one," read "end."
PAGE 37.—Line 10, omit "a," and for "plate" read "plates."
PAGE 52.—For "Figs. 1, 2 and 3, Plate I," read "Figs. 1 and 2, Plate XXI."
PAGE 56.—Lines 4, 5 and 7; for "columbiads," read "smooth-bore guns."
Line 4, insert "12″, 10″, 8″ and 4″.5 rifle guns."
Line 5, insert "12″, 10″, 8″ and 4″.5 rifle guns."
PAGE 57.—Line 26, omit, after the word "for," "the 8-inch canister, for siege howitzer and"
Last paragraph, in each line, for "columbiad" read "gun."
PAGE 104.—Line 11, for "powered" read "powdered."
PAGE 115.—Line 1, for "10 lbs. 5 oz." read "10.5 oz."
Line 4, for "44.14" read "14.14."

Corrections noted in this book

MAJOR JAMES M. adison WHITTEMORE, COMMANDING FRANKFORD ARSENAL,

AND

LIEUT. F. HEATH, ORDNANCE DEPARTMENT.

REVISED AND CORRECTED BY

THE ORDNANCE BOARD.

PUBLICATION AUTHORIZED BY THE SECRETARY OF WAR.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1878.

ORDNANCE MEMORANDA, NO. 21.

AMMUNITION, FUSES, PRIMERS, MILITARY PYROTECHNY, ETC.

PREPARED UNDER THE DIRECTION OF

BRIG. GEN. STEPHEN V. BENÉT,

CHIEF OF ORDNANCE, U. S. ARMY.

BY

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MAJOR JAMES M. WHITTEMORE, COMMANDING FRANKFORD ARSENAL,

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TABLE OF CONTENTS.

AMMUNITION AND MILITARY FIREWORKS.

BUILDINGS.

In large establishments for the preparation or breaking up of ammunition or military fireworks nine separate buildings are required:

No. 1. *Cartridge-house*, for making cases, and cannon cartridge-bags of all kinds.

No. 2. *Filling-house*, for filling cartridges.

No. 3. *Packing-house*, for putting up ammunition for transportation or storage.

No. 4. *Storehouse*, for materials and tools.

No. 5. *Driving-house*, for driving rockets, fuses, &c.

No. 6. *Mixing-house*, for mixing compositions.

No. 7. *Furnace-house*, for casting lead and making compositions requiring the use of fire. The floors are laid with brick or flagging.

No. 8. *Carpenter-shop*.

No. 9. *Magazine*, for powder, ammunition, &c.

All these buildings should be at a distance from dwellings, and about 100 feet from each other, and protected by trees and traverses. Those between which frequent transportation of material is necessary should be connected by a railway, protected from the weather by a light shed.

The size of the buildings should be regulated by the number of artificers to be accommodated. In small establishments the number may be reduced, as the same building may be used at different times for different purposes.

Those buildings in which explosives are handled should be constructed on the principle illustrated in Plates I and II.

These buildings (known, from their deviser, as the Laidley Laboratories) are designed to prevent the great loss of life which usually results from the demolition of a building, as ordinarily constructed, by the explosion therein of even a comparatively small quantity of powder.

The frames, rafters, and purlins are of wrought iron. The sheathing is of light wood, arranged to resist the pressure of winds from without, but to yield readily to slight pressure from within.

In case of an explosion, the roof and sides falling off at once, the iron frame remains standing, and the escape of the inmates from the *débris* is better secured. They have been severely and successfully tested by experiments and an accidental explosion.

The foundation should be of brick, stone, or wooden piles, according to circumstances.

The bed-plate is composed of 6″ Phœnix beams No. 8, joined at the middle and corners by $\frac{5}{8}''$ plates (Figs. 9 and 13), and secured to the foundations by bolts (Fig. 11). Upright posts are secured to the bed-plate by means of brackets riveted to the ends (Fig. 10). These posts are fastened in the same manner to a top-plate similar in size and material to the bed-plate. Rafters composed of T-iron, $3'' \times 3''$, No. 122, and braces, $3'' \times \frac{1}{4}''$ and $3'' \times \frac{1}{2}''$, fastened together by rivets, are secured to the top-plate, as shown in Fig. 6. Purlins of angle-iron are bolted to the rafters. The purlin A is of wood, to which, and the wooden portion B, the roof-boards are nailed.

The sides, ends, and roof are made in sections corresponding to the spaces between the posts and rafters respectively (Figs. 1 and 2). Wooden pieces are bolted to the posts. To these, cleats are nailed on the inner side (Fig. 8). Corresponding cleats are nailed to the sections on the outer side. A rebate is thus formed, enabling the sections to resist a great exterior force. For the sides, an interior force is resisted only by the tongues and grooves of the inner lining. For the roof, the pieces B are lightly held to the purlins by clamps of band-iron.

The peak of the gable is fastened to the end rafter by short wooden cleats. A ceiling may be formed by fastening, parallel to each other, strips of ⊥-iron, between which, and end to end, are placed light wooden frames, covered with canvas or cloth.

Bill of iron for a Laidley laboratory 50′ × 23′ 6″.

Names of parts.	No. of pieces.	Long.	Wide.	Thick.	Weight of each piece.	Total weight.	Remarks.
		Feet.	*Inches.*	*Inches.*	*Pounds.*	*Pounds.*	
Beams	8	25	6	2.75	333.3	2,666.4	For bed and top plates.
Do	4	23.5	6	2.75	313.3	1,253.2	Do.
Do	16	15.75	6	2.75	210.0	3,360.0	For posts.
Do	4	15.65	6	2.75	208.8	834.2	For corner posts.
T-iron	16	12.71	3	3	89	1,424	For rafters.
Plates for rafters	8	23.42	3	.5	120	960	For girders.
Do	32	1.92	3	.25	5.27	168.64	For braces.
Do	32	3.54	3	.25	9.74	311.68	Do.
Do	16	4.92	3	.25	13.5	216.0	Do.
Do	32	4.08	3	.25	11.23	359.36	Do.
Do	32	5	3	.25	13.75	440.0	Do.
Purlins	16	22.5	2.5 × 2.5	.312	115	1,840	Angle-iron.
Do	8	7	2.5 × 2.5	.312	35.77	286.16	Do.
Corner plates	8	.92	4.5	.625	10.5	84	
Brackets	80	4.5	3 × 3.5	.375	.3	240	For posts.
Foundation-bolts	18	3	1.25	Round.	15	270	
Plates for bolts	18	1	4.5	.5	9	162	
		Inches.					
Bolts	88	2	.75	Round	.75	66	For posts and corner plates.
Eye-bolts	12	3.5	.75	..do...	.85	102	For girders.
Do	4	7	.75	..do...	1.7	6.8	Do.
Bolts	16	2.25	6.25	..do...	.5	8	For eye-bolts.
Do	128	1.5	.438	..do...	.25	32	For purlins.
Do	60	3.5	.375	..do...	.2	12	For bolting wood to posts.
Rivets	160	1.25	.438	..do...	.2	32	For braces.
Do	80	1.25	.5	..do...	.225	18	For bolting brackets to posts.
Rafter	......	......	......	......	......	50	
Total	......	......	......	......	......	15,150	

FIXTURES AND FURNITURE.

1. *Cartridge-house.*—A table for making cartridges for small arms, 12 feet long and 2½ feet wide, for 12 men or boys to work at, and the length in that proportion for any greater number; tables for cutting paper and flannel, and for rolling cases on; choker for rocket-cases; press for rocket and port-fire cases; benches for cartridge-tables; stools. Closets should be partitioned off from these rooms and furnished with cases, drawers, racks, and shelves for materials and tools.

2. *Filling-house.*—A shelf, 2 feet wide, for weighing on; other shelves with closets under them; tables with raised borders for filling, folding, &c.; budge-barrels, or powder-barrels, with copper hoops and covers; stools for seats; footstools; a step-ladder; stands and gutters for emptying powder-barrels.

3. *Packing-house.*—Tables, benches, and stools; platform-balance.

4. *Storehouse.*—Shelf for weighing on, shelves, drawers, and closets; tables, scales, stools, seats, step-ladder.

5. *Driving-house.*—Blocks set in the ground or pavement; benches and stools. In favorable weather, a porch attached to the building, or a tent, may be used for a driving-room.

6. *Mixing-house.*—Tables with raised edges; sieves, &c.

7. *Furnace-house.*—Furnaces; work-benches; platform-balance or large scales; a tinner's bench and tools, with a vise, an anvil, and a chest for tools, a smith's forge, shovel and poker, stools, &c.

8. *Carpenter-shop.*—Turning-lathe and tools; carpenter's benches and tools.

9. *Magazine.*—Shelves and frames for boxes and barrels.

FURNACES.

Two kinds of furnaces are used in a laboratory: In the first, the flame circulates around both the bottom and sides of the kettle; in the second, it comes in contact only with the bottom; the latter are used for compositions of which gunpowder forms a part.

Furnaces are built of bricks. The kettle is of cast iron, about 2 feet in diameter at the top, having a rounded bottom and a flange about 4 inches wide around the top, or else strong handles to set it by. The bottom is .75 inch thick, and the sides .5 inch. By setting it in an iron plate pierced with holes, encircling the bottom, a furnace of the first kind may be converted into one of the second kind by stopping the holes.

Furnace for reducing the oxide of lead or dross: This furnace is built in the open air, on a stone or brick foundation. It is composed of a cylinder of sheet-iron, 16 inches by 30 inches, lined with refractory clay from 2 to 3 inches thick.

The interior has a form of an inverted frustum of a cone, terminating below in a basin, the bottom of which is inclined toward a tap-hole. The fire is made in a furnace, and the draught supplied by a bellows, the nozzle of which enters at the top of the reservoir. The dross and the charcoal intended for its reduction, are thrown on the fire from the top of the furnace. The metal, as it is reduced, flows into the basin, and escapes through the tap-hole into an iron vessel and is cast into bars or pigs as desired.

In the field, furnaces may be built with sods, or sunk in the earth, if bricks cannot be readily procured.

Furnace built with sods.—Let the kettle rest on a trivet, the feet of which may stand on any piece of flat iron, such as the bottom of a shot-canister, or stand for grape, the bottom of the kettle about 1 foot from the ground; build round it with sods. The door of the furnace is 10 inches square; the flue of the chimney, opposite to the door, 6 inches square, and commencing about 6 inches from the ground; the first part of the flue inclined at an angle of about 15°, the rest vertical, and placed, if circumstances permit, against a wall; the top of the door and of the flue may be supported by small bars of iron.

Furnace sunk in the earth.—The edge of the kettle should be about 1 inch above the ground, and the bottom 12 to 15 inches above the hearth of the furnace; the earth is dug down vertically 1 foot from the kettle for the front of the furnace, and the door is cut out 10 inches square. The earth is removed and sloped out, so as to give access to the door; the flue is bored out on the opposite side with a crowbar; it commences 6 inches above the hearth and comes out of the ground 18 inches from the furnace, whence it is carried horizontally about 13 feet.

In furnaces of the second kind mentioned above, the trivet may be omitted, and the kettle may rest on the sod or earth for about 1 inch all round, and the earth rammed in against the sides of the kettle.

PRECAUTION AGAINST ACCIDENTS.

Avoid as much as possible, the use of iron in the construction of the buildings, fixtures, tables, benches, boxes, &c., of the laboratory; sink the heads of iron nails, if used, and fill over them with putty, or paste several thicknesses of paper over them. Before the men go to work cover the floor with carpets or paulins, which are taken up carefully, after the men leave, and carried at least 50 yards from the building and there shaken thoroughly and swept. During the work have the carpets frequently swept.

Place the stores in cloth bags in the windows exposed to the sun. Prevent persons from entering with sabers, swords, or canes, &c., or with matches about their persons. Direct all who work where there is powder to wear moccasins or socks, and to take them off when they leave. Direct the men not to drag their feet in walking.

Make the doors and windows to open and close easily, without friction; keep them open whenever the weather permits.

Never keep in the laboratory more powder than is necessary, and have the ammunition and other work taken to the magazine as fast as it is finished.

Let powder-barrels be carried in hand-barrows made with leather, or with slings of rope or canvas, and the ammunition in boxes. Let everything that is to be moved be lifted, and not dragged or rolled on the floor.

Never drive rockets, port-fires, &c., or strap shot or shells in a room where there is any powder or composition except that used at the time.

Loading and unloading shells, driving rockets, pulverizing materials, the preparation of compositions requiring the use of fire, and in which the components of gunpowder enter, ought to be done in all cases, when possible, in the open air or under a tent far from the laboratory and magazine.

Never enter the laboratory at night, unless it is indispensable, and then use a close lantern, with a wax or oil light carefully trimmed. Allow no smoking of tobacco near the laboratory.

In melting lead, be sure that it contains no moisture; put the pigs in carefully, and do not use more than will fill the pot two-thirds full.

Use the same precautions in melting fatty substances.

APPLICATION FOR BURNS.

Exclude the air by applying to the burn fresh lard, or bathe the part burned, and cover it with linen soaked in a mixture of eight parts of sweet oil and one of hartshorn well beaten together; or paint the parts burned with white lead and cover with lint; or cover the injured part with lint or other soft fabric, spread thickly with vaseline containing 1 per cent. of carbolic acid.

MATERIALS.

Laboratory materials are classified as follows, viz:

1st. Those for producing light, heat, and explosion.

2d. Those for coloring flames and producing brilliant sparks.

3d. Those used in preparing compositions.

4th. Those used in making tools, cases, cartridge-bags, and for miscellaneous purposes.

MATERIALS FOR LIGHT, HEAT, AND EXPLOSION.

Potassium nitrate (*niter*), KNO_3.—For use in the laboratory, niter should be freed from all foreign substances and be reduced to a fine powder or else to very minute crystals. It is best pulverized in the rolling-barrels at the powder-mills; but it may be pulverized by hand in the laboratory as follows: Put into a *rolling-barrel* 50 pounds of dry, refined niter and 100 pounds of bronze balls; turn the barrel for two hours and a half at thirty revolutions a minute, striking it at the same time with a mallet to prevent the niter from adhering to the sides. Separate the balls by means of a brass-wire screen and the foreign substances with a hair sieve.

Niter may also be pulverized by pounding it in a brass mortar, or by solution as follows: Put 14 pounds of refined niter with 5 pints of clear water, in a broad and shallow copper pan, over a slow fire, and as the niter dissolves skim off the impurities; stir the solution with a wooden spatula until the water is all evaporated, when the niter will be very white and fine. Should it boil too much, the pan must be lifted from the fire and set upon wet sand or earth, and the niter should be stirred until it dries, to prevent it from adhering to the pan.

Potassium chlorate, $KClO_3$, is a white salt; crystallized in white scales; anhydrous; not altered by exposure to the air; soluble in water, more in warm than in cold; insoluble in alcohol; density, 1.989; decrepitates and fuses at about 500°; at about 720° it is decomposed into oxygen and potassium chloride.

This salt is one of the most energetic of oxidizing bodies, because it parts with its oxygen readily, of which it contains a great quantity (.3915 of its weight). Thrown on burning coals, it melts quickly. It explodes by simple contact with sulphuric acid; mixed with a combustible body, the mixture may be exploded by friction or by a blow. It should be purchased crystallized, and should not contain more than one-thousandth of its weight of chloride of sodium or potassium. Its purity is tested by means of the nitrate of silver dissolved in distilled water, 73½ grains in one-quarter of a pint. Dissolve 77 grains of the chlorate in 300 grains of warm water, and let the solution get cold; the chlorate will be precipitated in crystals. Add to the liquid about two drops of the solution of the nitrate of silver. After filtering, the liquid ought not to give a precipitate by the addition of more nitrate of silver.

Mercury fulminate, $CNC(NO_2)Hg$. is a gray salt, crystallized in fine silky needles; soluble in water, more so in warm than in cold water. It is an extremely dangerous substance to operate upon in a dry state, owing to the readiness and violence with which it explodes. It detonates strongly when struck by a hard body; but sometimes trifling friction may serve to produce this effect, even when in a moist state. Heated to 300° it explodes, evolving a bright flame. It is decomposed, with explosion, by the electric spark, and contact with strong nitric and sulphuric acids. The products of detonation are carbonic acid, nitrogen, and vapor of mercury. It should always be manipulated moistened with at least 30 per cent. of water.

To prepare fulminate of mercury.—Dissolve, in a glass retort capable of holding about a half-gallon, 10 ounces of pure mercury in 5 pounds nitric acid (aqua-fortis), of the specific gravity of 1.40. The solution is made by placing the retort in a water or sand bath of about 120°, or exposed to the sun's rays on a warm day. The vapors which come over are very deleterious, and should not be inhaled. It requires about eight hours to thoroughly dissolve the mercury. When the solution is complete, pour the liquor into a wide-mouthed glass vessel capable of holding 8 to 10 gallons, into which 5.675 pounds of alcohol (ethyl), about 6½ pints, of the specific gravity of .85 have been previously poured. Care must be taken to *pour the nitrate of mercury on the alcohol*, as the reverse mode of mixing is dangerous. Great heat is evolved during the effervescence which ensues from the mixture, and the glass vessels used should be well annealed, and of a form to bear a high heat without breaking. Carboys of thin flint-glass, without mouth-rings or any abrupt change in thickness, are best. The operation should be performed at a safe distance from the fire, as the vapors of ether disengaged are highly inflammable. When reddish fumes begin to appear, they must be reduced by adding alcohol in small quantities.

The proportion of alcohol used in the whole operation varies according to the strength of the acid and alcohol, and also with the state of the weather. The proper quantity is that which is just sufficient to keep down the reddish fumes, and is determined by trial with the materials used.

When the effervescence has ceased, the fulminate of mercury is found at the bottom of the vessel as a brownish precipitate. A small quantity of water is poured in, and the contents transferred to the washing-tub, where it is repeatedly washed in soft water, until the water no longer reddens litmus-paper.

The fulminate is in the form of very small crystals, of a light gray color and brilliant surface. If the operation be well performed, no metallic mercury will be reproduced. The weight of the fulminate when dried is about 14 per cent. greater than that of the mercury used.

If the proper proportions be not used (or if the materials be not of good quality), the product will be, instead of fulminate, an impalpable yellow powder, which is incombustible. When this is observed, the result may generally be corrected by varying the proportion of alcohol in the mixture.

The fulminate of mercury is kept under water, in stone jars, which should be preserved from frost.

A day's work.—In a warm clear day, one master and two assistants can make, and partially wash, 100 pounds of fulminate in ten hours.

Charcoal. (See *Gunpowder.*)

Roll brimstone is used for melting, and flowers of sulphur may be used instead of roll sulphur pulverized. The purity of the flowers is more to be depended upon than that of the roll sulphur. When mixed with potassium chlorate, however, it should be washed to remove free sulphuric acid. Sulphur facilitates the ignition and combustion of compositions to which it is added.

Gunpowder.—For compositions, gunpowder is *mealed*, either by rolling it for two hours with once and a half of its weight of balls, or by beating it an equal length of time in a leather bag, or by grinding it with a muller on a mealing-table.

Mealed powder, and pulverized saltpeter, charcoal, and sulphur, are generally obtained from the powder-mills.

Antimony (regulus of antimony) is a grayish-white metal, very brilliant, with a highly lamellated structure. Specific gravity, 6.7; melting point, 809°. It is easily reduced to powder, and by its combustion with sulphur produces a strong light and heat, with a blue or white flame. Antimony is never found pure in the shops; that which is sold under the name of regulus of antimony always contains a little sulphuret of antimony, arsenic, and sometimes sulphuret of iron.

Lampblack is the result of the incomplete combustion of resinous substances. It is composed of 80 parts of carbon and 20 of impurities. It is employed to quicken the combustion of certain substances; but before it is used it should be washed with a hot alkaline solution, to remove all traces of empyreumatic oil.

Coloring materials.—A flame is colored by introducing into the composition which produces it a substance, the particles of which, being interspersed through the flame and rendered incandescent, give it the required color. Coloring substances do not generally take part in the combustion, and their presence more or less retards it. It is for this reason that potassium chlorate, a more powerful oxydizing agent than niter, is used in lieu of it in compositions for colored fires.

There are a great variety of substances which give color to flames, the principal of which are strontium nitrate and sulphate for red, barium nitrate for green, the bicarbonate of soda for yellow, copper sulphate for purple, copper carbonate and acetate for blue. Lampblack is employed to give a train of rose-colored fire in the air, and powdered flint glass for white flames.

Sparks are produced by introducing into the composition filings or thin chips of wrought or cast iron, zinc, steel, copper, or fragments of charcoal.

Iron.—Filings and thin chips give very brilliant sparks and stars, the effects of which depend on the size of the particles used. The filings must be made when wanted, or be very carefully preserved from rust.

Cast iron.—Pulverized, it gives very large white sparks, in fireworks (Chinese fire). Select the white cast iron, or take the pieces of utensils with thin sides. To pulverize it more easily, heat it to a red heat and throw it into cold water.

Steel.—In fireworks, filings and small pieces give the most brilliant sparks.

Zinc is a bluish-white, metal, usually brittle, and its fracture shows a crystalline structure. Specific gravity, 6.9; melts at 680°; is volatilized at a red heat, and takes fire in the air, burning with a light flame. At 400° it is easily reduced to a powder in a mortar. Granulated zinc is used to produce a bluish flame. An alloy of zinc and antimony pulverized gives beautiful blue drops. The oxide of zinc (*flowers of zinc*) produces the appearance called gold rain. It ought to be purchased in scales, not in a powder, as in this latter case it may be mixed with foreign substances.

Copper filings are used to give reddish sparks and a greenish blue flame.

PREPARING COMPOSITIONS.

Turpentine, spirits of turpentine, Venice turpentine, tar, pitch, and rosin, are chiefly employed in the preparation of compositions for producing light.

Alcohol, whisky, brandy, or vinegar is used in mixing compositions into which niter enters, as it does not dissolve niter. It should be strong. To prevent it being drunk, mix a little asafetida with it.

Beeswax and mutton tallow are employed in mixing compositions intended to produce heat and light.

Gum arabic should be transparent, yellowish-white, brittle, insipid, inodorous, soluble in water and vinegar, insoluble in alcohol. It is used in solution to give body and tenacity to compositions, or to make them burn more slowly. It should be prepared as required, for when in solution it undergoes a decomposition.

Copper is a red, brilliant metal, possessing great tenacity, ductility, and malleability. Specific gravity, 8.9; fusible at about 1980°. Copper, being but slightly acted on by saltpeter, is employed for powder measures, utensils for refining saltpeter, &c. Copper vessels should not be exposed to a great heat, or used for heating compositions containing sulphur, as the copper would be rapidly oxidized.

Bronze is used in the laboratory for utensils and implements which receive blows or act by percussion, and replaces steel and iron wherever there is danger of an explosion from a blow or from friction.

Brass is an alloy of about two parts of copper and one of zinc. Brass wire is used for ligatures, for screens and sieves.

Sheet-iron.—Select the softest and most pliable. When it is substituted for tin, in strapping projectiles, it should be first annealed by heating it to a dull red heat and letting it cool gradually under warm ashes, not exposed to the air.

Lead is a bluish-white metal, bright, but tarnishes quickly in the air. Specific gravity, when pure, 11.48; melts at 600°, and volatilizes at a red heat. The purity of lead is judged of by its specific gravity. To determine this, after having weighed the pig, suspend it with a wire in a vessel of water, so that it shall be completely immersed, without touching the sides, and weigh it again. The weight in the air, divided by the difference between the weight in air and water, will give the specific gravity, which ought to be 11.35 for lead of commerce.

Lead melted in contact with air is soon covered by a coat of gray oxide, which rapidly increases in thickness. The formation of this oxide, or dross, is prevented by covering the lead with powdered charcoal or rosin.

To reduce the oxide of lead.—Put in a kettle about 50 pounds of lead, with $\frac{1}{10}$ of its weight of powdered charcoal or grease; cover the kettle, and raise to a red heat; stir the mass, and add gradually more coal, as it assumes a yellow color, using in all $\frac{1}{6}$ of the weight of oxide; dip out the lead with an iron ladle, and pour it into iron molds or pans. After having obtained in this way two-thirds of the weight of oxide, in lead, throw the dross into a tub of water, and wash it, to separate the ashes and coal; dry the remaining oxide and grains of lead, and put them in a ladle with $\frac{1}{20}$ of their weight of rosin; raise it to a red heat, set fire to the rosin, shake the ladle, and pour off the lead. A further addition of rosin will produce more lead; $\frac{1}{14}$ of the weight of dross is generally used. Tallow may be used in place of rosin.

When the quantity of dross is considerable, it may be reduced, in a similar manner, in a small cupola-furnace.

Plumbers' solder is an alloy of lead and tin, in the proportion of two parts of the former to one of the latter.

Paper.—Paper for cartridge-box wrappers should be homogeneous and without any trace of stalks; well sized, even, pliable, with a good body without being too thick, free from folds or rents.

The sheet when moistened ought to present a uniform hue, without spots or marblings. Taken out of the water and suspended a moment by the extremities of the short sides, it ought not to tear from its own weight. The sheet, crumpled in the hand or pinched with the nails, ought not to tear in the folds, and when torn the rent should be fibrous.

A strip of paper 4 inches wide ought not to break under a weight of 40 pounds, in the direction of its least strength.

In testing the strength of paper, the two ends are held by two vises of hard wood. Each vise is composed of two rectangular jaws, which can be brought against each other and held firmly by means of screws, or by tenons on one jaw passing through the other and keyed firmly to it. A strip of paper 4 inches wide is cut and inserted in the vises, so that the length between them shall be exactly 12 inches. The jaws are closed tightly, and one vise is suspended from a fixed point by means of a cord or hook, and to the other is made fast the pan of a balance. It is loaded gradually, with care, until the paper gives way. The strips should not be taken from the edges of the sheets only, but from all parts, and from the length and breadth successively, for in these two directions the strength is very different.

Five sheets are generally taken from each ream, in which only one sheet can have less strength than that allowed. If this condition be not fulfilled, the ream is rejected.

The other papers are tested in the same way, and should possess the same general characteristics.

Size and weight of paper.

	Inches.	Weight, pounds.	Proof weight, pounds.
No. 1. For musket-cartridges	13 ×16½	....	40
No. 2. For musket-cartridge wrapper	18 ×20	36	101
No. 3. Cartridge-box wrappers	16 ×14	21	30
	18 ×16	27	
	20 ×20	37½	
	24 ×20	45	
No. 4. Port-fires and rockets	19 ×28	65	180
No. 5. Fixed ammunition	23½×24	60	225
No. 6. Cannon-cartridges	19 ×23	70	315
No. 7. Fireworks	13 ×16½	20	85

The several kinds to be packed in bundles; No. 3 in bundles of 1,000 sheets each, the others in bundles of 500 sheets; all without folding. The dimensions given above are such as the sheets are required to have when trimmed for use.

Tow should be entirely of hemp or flax, clean, dry, sound, free from stalks and foreign substances.

Merino or *serge,* for cartridge-bags, should be made entirely of wool; it should be strong, closely woven, twilled, and not frayed; the width should be even in the same piece; that ¾ yard wide is convenient and the most common. The colors are to be preferred in the following order: green, gray, yellow, blue, red, white; reject black, which is almost always burnt and weak.

Canvas.—Take the strongest and closest woven; used for sacks for fire-balls.

Twine should be strong, smooth, and well twisted, .03 inch thick for sewing fire-balls, &c.; from .06 inch to .08 inch for fixing ammunition, &c.

Rope should be even and well twisted, pliant without being soft, made of hemp of good quality, water-rotted, and entirely freed from stalk. Its size should be uniform throughout its whole length. That most commonly used in the laboratory is white-hemp rope, from 1 inch to 1.5 inch in girth.

Thread.—Saddlers' thread, of flax, three strands; used with paper boxes for revolver cartridges.

Woolen yarn is used to sew cartridge-bags.

Glue should be hard, dry, transparent, of a brownish-red color, and free from smell.

TO PREPARE PASTES AND GLUE.

Flour paste.—Sift the flour and mix it with $8\frac{1}{2}$ times its weight of water; heat it gently, stir it, and let it boil for three-quarters of an hour; when it becomes ropy pour it into bowls and pass it through a sieve before it is quite cold. The flour yields 7 times its weight of paste. Time required to make it, one hour and a half. It is best made of rye flour.

Starch paste.—Mix wheat starch with twice its weight of water, pour it gradually into $6\frac{1}{2}$ times its weight of boiling water and let it boil for ten minutes, stirring it all the time; then proceed as before. Starch yields 8 times its weight of paste. Time required, one hour.

Paste for pasteboard.—Mix the flour or starch with 12 times its weight of water; this yields 9 times the weight of flour and 11 times the weight of starch.

Paste mixed with glue.—The addition of $\frac{1}{16}$ of glue makes the paste fit for pasting sheets of parchment together or for pasting paper on wood. Dissolve the glue separately and pour it into the cold water with which the flour or starch is mixed.

Cheese paste is made of fresh white cheese and quicklime. Pound the cheese in a mortar with boiling water; let it stand and decant it; repeat this operation three or four times. Pound together 3 parts of this cheese thus prepared and one part of quicklime, moistening it with pure water till the paste ropes like honey. Prepare only a little at a time. It is used in pasting parchment and parchment-paper.

These different kinds of paste should be used cold. A supply for not more than two or three days should be made at one time; but it may be preserved longer by adding alum in the proportion of $\frac{1}{10}$ of the weight of flour. The depredations of rats may be prevented by dissolving a like proportion of colocynth in the water with which the paste is made.

Glue is dissolved in its own weight of boiling water. A glue-pot with a water-bath should be used to avoid burning the glue. Remove the pot from the fire as soon as the glue is entirely dissolved.

SIEVES.

Sieves are made of brass wire, hair, or silk, and may be square or round in shape.

Hair sieves for mixing compositions.	No. 1.	50 meshes in 1 inch, or 2,500 in a square inch, a single hair in one direction, 2 in the other.
	No. 2.	25 meshes in 1 inch or 625 in a square inch, 2 hairs side by side in each direction.
	No. 3.	12.5 meshes in 1 inch or 156 in one square inch, 3 hairs side by side in each direction.
	No. 4.	180 meshes in a square inch, brass wire.

Brass sieves ought to be used only for dry materials.

A silk sieve of 120 meshes to the linear inch in used in preparing glass dust for priming-compositions.

PAPER AMMUNITION FOR SMALL-ARMS.

There are two kinds of cartridges used in service, the ball-cartridge, made with a single elongated ball, and the blank cartridge.

BALL-CARTRIDGES.

MAKING BALLS.

Lead balls are made by compression, by means of machines for that purpose. Balls thus made are more uniform in size and weight, smoother, more solid, and give more accurate results than cast balls.

The lead is first cast into round cylindrical bars, .58 inch in diameter for the caliber .58, and 21 inches long, and then rolled to .46 inch in diameter; length, 25 inches. These bars are fed to the machine, which cuts off a part sufficient for one ball and transfers it to a die, in which the ball is formed, with cavity and rings, the surplus metal being forced out in a thin belt around the ball in the direction of its axis. The balls are trimmed by hand, with a knife, and are then passed through a cylinder-gauge of the proper size.

A day's work.—One man can make with the machine 30,000 balls in 10 hours, the bars of lead being prepared for him. One man can cast 1,500 bars in 10 hours, and can trim and roll 2,000 bars in 10 hours. A boy can trim and gauge 5,000 in 10 hours.

Bullet-molds are provided to cast balls where the pressed balls cannot be had.

The mold is so constructed as to trim the balls by a single operation before they are taken from the mold.

TO GREASE THE BALLS.

Place them on their bases on a tin frame capable of holding about 50 balls, and immerse it in a melted mixture of one part of tallow and eight of beeswax, kept warm, until the cylindrical part of the ball is covered. Remove the frame and let it stand till the grease hardens. Three frames are required for each boy.

TO CUT THE PAPER.

WORKMAN.—1 *cutter.*

MATERIALS.—*Paper* and *pencil.*

IMPLEMENTS.—1 *cutting-board*, 30 inches square; 1 *iron ruler*, 33 inches long; 1 *lever*, 1 *cord*, 1 *large knife*, 1 *sandstone*, 1 *trapezoid*, of *hard wood* or *iron.*

Cut the paper first into strips of a width equal to the length of a trapezoid, and then into trapezoids, using the pattern as a guide.

The paper and ruler are kept from moving by means of a lever, one end of which is fixed and the other is moved by the foot by means of a cord and treadle.

The knife is held in both hands.

From 6 to 8 reams may be cut at a time in this way.

A cutting-machine like that used by book-binders facilitates the operation when many hands are employed.

When only a knife and ruler are used, about 12 sheets are cut at a time.

TO MAKE THE CARTRIDGE.

WORKMEN.—1 *master*, 10 *boys*.

IMPLEMENTS FOR EACH BOY.—2 *boxes* to hold cylinders, 20 inches long, 8 inches wide, and 4 inches high, in the clear, made of $\frac{1}{2}$-inch boards, without a cover; they are placed on their sides, their backs inclined against the partition in the middle of the cartridge-table, the front resting on cleats nailed to the table; 1 *former*, cylindrical, of hard wood, of the same diameter as the ball, 6 to 7 inches long, one end pointed almost as much as the ball, and marked with a shallow groove 4 inches from the end; 1 *sabot or frame*, tacked to the table, to hold balls, placed at the left hand of the boy; 1 *spool of thread*, turning on a vertical spindle fixed in the table near the balls; 1 *choking-string*, made of four or five cartridge-threads twisted together, about 9 inches long, with a wooden toggle at the end, fastened to the edge of the table at the right hand of the boy; 1 *knife blade*, $1\frac{1}{2}$ inch long, hooked, driven into the front of the table below and near the choke-string.

TO FORM THE CYLINDER.—Lay the trapezoids on the table with the sides perpendicular to the bases, toward the workmen, the broad end to the left. Take the former in the right hand and lay it on a trapezoid, the groove in the former against the right edge of the paper, bringing the pointed end $\frac{1}{2}$ inch from the broad end of the paper; envelop the former with the paper; then, with the fingers of the left hand laid flat upon the paper, turn the former and roll all the paper upon it; hold it with the left hand and, with the choking-string in the right, take one turn around the cylinder at about $\frac{1}{2}$ inch from the end; hold the former firmly in the left hand and draw gently upon the choking-string, pressing at the same time with the left forefinger upon the projecting end of the cylinder, thus folding it neatly down upon the end of the former. Having choked the cylinder close, carry it to the right side, and with the thread in the right hand, take two half-hitches firmly around the part that has been choked; cut the thread on the knife-blade and press the choke in a cavity in the table; place the former, with a cylinder on it, on a second trapezoid; put a ball over the end of the former; roll the paper on the former and the ball; hold the cylinder in the left hand and choke and tie it as just described for the inner cylinder; withdraw the former, pressing the cylinder with the left hand, and place it in the box.

A day's work.—A boy can make 800 cylinders in 10 hours.

TO FILL THE CYLINDER.

IMPLEMENTS.—1 *charger*, made of a cylinder of wood or brass pierced with two holes through its length, holding the exact charge of powder; a funnel attached to one end of the cylinder, and a discharge-pipe to the other. The holes in the cylinder are made to communicate and shut off, alternately, from the funnel holding the powder, and the discharge-pipe at the lower end, by a reciprocating motion given to the cylinder by the hands.

Fill the funnel with powder; insert the discharge-pipe in a cartridge, holding the charger in both hands, and turn the cylinder; the charge of powder is deposited in the cartridge; insert the pipe in the next, and turn the cylinder in the opposite direction, and continue in the same way for all the rest.

Cartridges may be filled with a copper charger made to hold the exact charge, pouring the powder by means of a small funnel, which is inserted in the cartridge.

TO PINCH THE CARTRIDGE.—Take the cartridge in the right hand, strike it lightly on the table to settle the powder; flatten the empty part of the cylinder and bend it flush with the top of the powder at right angles to the cartridge, the oblique side of the trapezoid on top, the cartridge standing vertical on the table; fold the flattened part in the direction of its length, with two folds from the exterior, meeting in the middle; bend this folded end back on itself and strike it on the table to set the folds.

TO BUNDLE CARTRIDGES.

UTENSILS.—1 *box* without ends or top, width equal to five times the diameter of the ball, height equal to twice that diameter, and length that of the cartridge. It is tacked to the table, the sides parallel to and near the edge of the table.

Put a wrapper in the box, the long side perpendicular to the edge of the table, the middle of the paper in the middle of the box; place, parallel to the sides of the box, two tiers of cartridges of 5 each, the balls alternating; bring the short ends of the paper together and fold them twice close down on the cartridges; insert a package of caps in the end of the bundle next to the ends of the lower tier; fold the wrapper on the ends and tie the bundle, first in the direction of the length, then its breadth, with the twine fastened in a single-bow knot.

CASES FOR PERCUSSION-CAPS.—These are rolled on a former, .54 inch in diameter, choked at one end and tied. Twelve caps are put in, and the case is closed by twisting the open end of the case.

PACKING CARTRIDGES.—Cartridges are packed in boxes containing 1,000 each. Five tiers of bundles are laid flat in a single row along one side of the box; the rest are placed on edge, the caps alternately up and down.

Blank cartridges are packed in boxes containing 2,000 each; the bundles are placed on end, the caps alternately up and down.

PACKING-BOXES.—The boxes are made of white pine boards, dovetailed and nailed together, and are furnished with wooden brackets or handles nailed to the ends with wrought nails clinched on the inside; the lids fastened with six 1.75-inch screws. They are painted different colors, to indicate the kind of cartridges. The boxes should be lined with strong paper, and the bundles of cartridges must be packed closely, so as not to shake in transportation. Each box should be marked on each end with the number and kind of cartridges, and on the inside of the cover with the place and date of fabrication.

BLANK CARTRIDGES.

MATERIALS.—*No. 2 paper; paste; powder.*

Cut the paper into trapezoids, as for ball-cartridges; roll the trapezoid on the former one turn; fold down this much of the paper on the head of the former with the left hand; roll the rest of the paper; fold down the rest of the paper; touch the fold with a little paste on the finger; press the end of the former on a ball imbedded in the table for the purpose; remove the cylinder from the former; place it in a box to dry.

Fill the cylinders, as described, for ball-cartridges.

A day's work.—One boy can make 2,000 cylinders in 10 hours.

PACKING MUSKET-BALLS.

Balls are packed in boxes with tow or saw-dust, to prevent their bruising. The boxes are made of 1-inch boards, and contain 1,000 balls.

They are marked on both ends with the number and kind of balls, and on the inside of the cover with the place and date of fabrication. The cover is fastened with six 2-inch screws, and the boxes must be hooped with iron for transportation. They are not painted.

Cartridges for small-arms.

Kind of cartridge		Expanding-ball.		Blank.	Elongated ball.			
Kind of arm		Musket and rifle (1855).	Cadet musket (1857).	Musket and rifle (1855).	Pistol, carbine.	Revolver, Army.	Revolver, Navy.	Sharp's carbine.
Caliber ... inches		.58	.58	.58	.58	.44	.38	.54
Ball	Diameter ... inches	.5775	.5775	....	.5775	.46	.39	.56
	Weight ... grains	500	450	....	450	216	145	475
Charge of powder ... do		60	50	60	40	30	17	50
Trapezoid	Height ... inches	4.12	4.12	3.75	4.1	2.75	2.4	3
	Long base ... do	4.0	4.0	4.16	4.0	3.25	2.5	3.25
	Short base ... do	2.5	2.5	2.5	2.5	1.6	1.6	2.25
Number of trapezoids in one sheet		16	16	24	16	30	40	24
Wrapper	Length ... inches	9	9	....	9	8	7.5	10
	Width ... do	6.5	6.5	....	6.5	6.5	4.9	6.8
	Number in one sheet	6	6	....	6	6	12	4
	Color	Ordinary color.	Red ...	Ordinary	Blue ...	Ordinary	Blue ...	Ordinary
Thread for 1,000 ... ounces		.5	.5	....	.5	.5	.5	.5
Weight of 10 cartridges ... do		13.5	13	....	12.5	6	5	13.5
Bundles of 10	Length ... inches	2.6	2.5	....	2.4	2.3	2.20	2.6
	Width ... do	2.9	2.9	....	2.9	2.0	1.9	2.5
	Depth ... do	1.15	1.15	....	1.15	.85	.85	1.1
Size of packing-boxes *for 1,000 cartridges.*	Length ... do	14.75	....	*15.5	....	†13.1	†10.5	14.75
	Width ... do	10.75	....	11.0	....	4.6	3.8	8.9
	Depth ... do	6.38	....	6.25	....	3.5	3.25	5.2
Weight of box packed ... pounds		98	....	....	....	28.5	16.5	78
Color of box		Olive ...	Gray ...	Olive ...	Yellow ..	Olive ...	Blue ...	Olive ...
Packing-boxes for 1,000 balls.	Length ... inches	8.25	8.25	....	5.25	....	....	....
	Width ... do	8.25	8.25	....	5	....	....	....
	Depth ‡ ... do	5	4.25	....	4.25	....	....	....
	Weight ... pounds	73	59.5	....	59.5	....	....	....

* For 2,000 cartridges. † Contains 600 cartridges; box made of .75-inch boards.
‡ If the balls be packed in tow add ½ inch to the depth of the box.

PERCUSSION-CAPS FOR SMALL-ARMS.

The cap for small-arms is made of copper. It is very slightly conical, with a rim or flange at the open end; it has four slits, extending about half the height of the cap.

The cap is charged with *fulminate of mercury*, mixed with half its weight of niter, the object of the *niter* being to render the fulminate less explosive and to give body to the flame. To protect the percussion-powder from moisture, and also to secure it from falling out, it is covered over, in each cap, with a drop of pure shellac varnish.

The copper for making the caps is obtained in sheets 48 inches long and 14 inches wide, weighing 3 pounds; a variation of 4 ounces, more or less, is allowed. The copper should be pure, free from seams, holes, or blisters, well annealed, and as evenly rolled as possible, with straight and smooth edges.

The copper is cleaned by immersion in a pickle made of one part (by measure) of sulphuric acid and forty parts of water; it is scoured with fine sand and a hand-brush, and washed clean in running water; after which it is well dried in clean saw-dust and rubbed over with a cloth slightly oiled; it is then ready for the machine.

The fulminate of mercury is prepared in the same manner as described under the head of metallic ammunition for small-arms, and 2 assistants can make and partially wash 100 pounds of fulminate in 10 hours.

To PREPARE THE PERCUSSION-POWDER.—Take about 2 pounds of the wet fulminate in an earthen dish, drain the water from it, and spread it on sheets of blotting-paper until it is sufficiently dry to assume the granular form and retain only 20 per cent. of moisture. In this state add to it 60 per cent. of its weight of refined pulverized niter, and thoroughly mix the ingredients on a wooden table with the hand and a wooden spatula, and pass it several times through an iron sieve, No. 3; spread it on sheets of paper in quantities of ½ pound each, and dry it in the sun or in a room warmed by flues. When quite dry, pass the ½-pound parcels through a fine hair sieve by rubbing it with the hand, and put each parcel in a separate box made of paper varnished on the inside and outside with shellac varnish and having a loosely-fitting over. The boxes should be kept in a small magazine standing apart from other buildings, upon shelves covered with cloth to prevent friction in moving, and be issued one at a time to the person having charge of the cap-machine.

MAKING AND FILLING THE CAPS.—Both of these operations are performed by the same machine. The sheet of copper is adjusted on the table of the machine. The hopper is filled with the percussion-powder, and the machine put in motion. The star or blank is cut by a punch and transferred to a die, where it is formed into a cap by a second punch. The cap is caught in the notches of the revolving horizontal plate, and carried first under the hopper containing the percussion powder, where it receives its charge of ½ grain, and then under a punch, which presses the charge firmly into the cap, and lastly to the drop-hole, where it falls into the receiving-drawer.

The hopper is supplied from time to time from the ½-pound box, while the machine is at rest, using a small copper scoop for the purpose, and the box returned to its special loset, at least one yard from the machine and above its level, before the machine is put in motion.

As a cap is occasionally exploded under the punch in charging, all dust of percussion-powder should be frequently removed, and only a small quantity of percussion-powder kept in the hopper. The receiving drawer should be emptied after each sheet of copper is completed; 2,314 are made from each sheet 48 inches long and 14 wide.

A day's work.—The average work of 10 hours, including all necessary stoppages, is 31,000 caps for each machine.

To PREPARE THE VARNISH.—Dissolve 1 pound of the best gum shellac in 1 quart of rectified alcohol containing 95 per cent. of pure spirit. The solution is made most eadily at a temperature of about 120°. It must be stirred frequently until all the gum is dissolved. It is made and fit for use in four hours.

The varnish is best made and kept in glass vessels. One quart of alcohol and 1 pound of shellac make 1.46 quart of varnish. A small quantity of alcohol is occasionally added to thin the varnish when it is used. Eighteen quarts of varnish are required for 1,000,000 caps. Two quarts of alcohol are required for thinning the varnish.

To VARNISH THE CAPS.—The caps are put into holes in counting-plates made of sheet-brass, 15 inches by 12 inches, .05 inch thick, held in a frame of brass rods .35 inch square. This is quickly done by taking a parcel of caps on the plate and shaking it sidewise; the caps settle themselves in the holes. When the plate is filled, the defective caps and those which have lost their charge are easily detected by the eye, and are replaced by perfect ones. The plate is placed in its bed in the varnishing-machine, which is worked by hand, and each row of caps is brought in turn under a row of wires, which are alternately dipped into a pan of varnish and then into the caps, leaving in each a drop of varnish.

The quantity of varnish placed in each cap can be regulated by the size of the wires, or by the depth to which they enter the varnish. The caps remain in the plate 30 to 40 minutes, when the varnish is sufficiently set to allow of their being turned into a tray for drying. These trays are of wood, 18 inches long, 12 inches wide, and 1 inch deep, and contain 2,500 caps. The caps remain in the trays for 3 days in a room heated to about 100°. They are then put into bags, and kept at the same temperature for 10 days longer before they are packed in boxes.

A day's work.—One boy can count and varnish 7,000 caps per hour.

PACKING.—The caps are put in bags of strong cotton duck, 10,000 in a bag, and ten bags are packed in a wooden box. The box is lined with thick paper, the bags are packed in tow, and the cover is fastened with six 2-inch wood screws.

BAGS AND PACKING-BOXES.—The bags are 6 inches in diameter and 13.5 inches deep. They are made with circular bottoms, like cartridge-bags for field-service. They are marked with the number of the bag, the contents, the place and date of fabrication.

The packing-boxes are made of 1-inch white pine, dovetailed; they have brackets for rope handles on the ends, are painted olive color, and marked on the ends with the number and kind of contents, and on the inside of the cover with the place and date of fabrication.

Interior dimensions.—Length, 28.75 inches; width, 12 inches; depth, 8.5 inches.

Weights.—Of 1,000,000 caps, 994 pounds.
Of bag with 10,000 caps, 9.625 pounds.
Of packing-box, 25 pounds.
Of box packed with 100,000 caps, 1 7 pounds.

MATERIALS REQUIRED FOR 1,000,000 CAPS.

For the caps.—1,300 pounds of sheet copper, of which about one-third is returned in scraps.

For the powder.—42 pounds mercury.
336 pounds nitric acid.
382 pounds alcohol.
24 pounds niter.

For the varnish.—10 pounds gum shellac.
12 quarts alcohol.

For bags.—31 yards of cotton duck, .75 yard wide.

For boxes.—150 feet white-pine boards.

NOTE.—Experience has shown that it is not safe to try to wash the percussion-powder from partly filled caps. A lot of unvarnished caps, imperfectly filled, being soaked in water for several days became coated with a substance much more explosive than the original fulminate.

The percussion-powder must be burned out, and the cap polished by rolling in a dust-barrel.

MANUFACTURE OF METALLIC AMMUNITION AND CANNON PRIMERS.

BUILDINGS.

For the manufacture of metallic ammunition for small-arms and friction and electric primers for cannon on a large scale, the following buildings are required:

No. 1. *Fire-proof factory* with L, the basement being provided with machinery adapted to the manufacture of primers, &c., with a separate room containing necessary grindstones, emery-wheels, &c., and tumbling-barrels.

The first story being fitted up with all the machines, tools, and benches of a first-class machine-shop, for manufacture and repair of the machines and tools employed in the works, with necessary office and engine rooms, and well furnished with presses and cabinets for surplus tools, standard gauges, specimens, &c. A room in L, with all appliances for washing cases, and a large and conveniently arranged drying-room over the engine-boiler.

The second story contains all the machinery necessary for drawing, trimming, heading, and forming cartridge-cases, with a separate room in L provided with machines and tables for making paper packing-boxes; printing-presses, type-fonts, &c., for printing.

No. 2. *Fire-proof factory* for manufacture of bullets, with separate rooms for charging cases and inspecting and packing finished ammunition.

No. 3. *Blacksmiths' shop* and stacks for forgings and small castings, and annealing furnaces for tools, &c., with a separate room for annealing and pickling cases.

No. 4. *Carpenter-shop*, for making boxes, tools, &c.

No. 5. *Paint-shop.*

No. 6. *Retort-house*, for manufacture of fulminate of mercury.

No. 7. *Magazine*, for powder.

No. 8. *Small magazine*, for fulminate of mercury and friction-powder.

No. 9. *Storehouse*, for storing cartridges, primers, etc.

METALLIC AMMUNITION FOR SMALL-ARMS.

The modern center-fire metallic cartridges may be divided into three classes: the solid attached head, the solid head, and the folded head.

There are two varieties of folded-head cartridges, the reinforced and non-reinforced.

As regards priming, the above-named classes are divided into outside and inside primed cartridges, and may be designated respectively as reloading and non-reloading cartridges.

They are generally made from sheet-copper or brass, the latter material having more elasticity and the former more uniformity and durability.

Manufacture.—Sheet metal of the required thickness, from .025″ to .09″, is used for the various kinds of cartridges. This is fed to a double-acting die and punch, which cuts out a disk and forms it into a cylindrical cup at one operation. The cup is reduced to a cylinder of the required length in from four to six operations by dies and punches, and is called drawing or reducing.

The cylindrical shell is trimmed to a standard length in a machine called the case-trimmer.

After washing, the shells or cases have a flange formed at the closed end by pressure in a special machine called the header.

The headed case is tapered to a standard size. The open end is made cylindrical for the length the bullet enters it, so as to inclose the latter snugly; and if it be inside-primed, like the present service cup-anvil cartridge, the anvil is inserted and fastened at the same time by crimping the case around its edge.

Priming is done in a machine called the primer. For outside priming a percussion-cap is used, made in the ordinary way. Priming of fulminate of mercury should not be deposited on brass, as it forms an amalgam and deteriorates the metal and priming. Shellac varnish is used to protect the surface of brass. No injurious deterioration from this cause has been noticed in the use of copper.

Bullets are made in a bullet-machine from a cast slug or rolled bar; the last is considered the best; they are trimmed by a machine called the bullet-trimmer. The diameter is required to be up to standard with no minimum allowance, and they are sized at the lubricating machine by passing through a die. The form, width, and depth of grooves must conform to the standard with very little variation. The weights should not vary more than two grains from the standard of 405 grains.

The lubricant should be free from acid reaction, and of vegetable origin as bayberry or Japan wax, and filled into the grooves by a machine.

Loading, or assembling the case, powder, and bullet, is done in a machine called the loader, by one operation (as in the Frankford arsenal loader), or by several operations known as plate-charging. The bullet should be perfectly concentric with the case at the time of insertion. The charge of powder should be as uniform as possible, with not more than two grains variation from the standard weight of 70 grains.

Inspection.—All cartridges should be wiped clean and gauged as to diameter, length, and diameter and thickness of head. Those should be rejected showing any defects in material, or bad workmanship. Each cartridge should be weighed to detect loss of parts or deficiency in weight of powder. A special automatic weighing machine is used at Frankford arsenal.

DETAILS OF THE MANUFACTURE OF THE CENTER-FIRE METALLIC-CASE CARTRIDGE, CALIBER .45″.

The successful invention of the self-primed metallic-case cartridge has greatly simplified the construction of breech-loading small-arms. Prior to its introduction and use, the prevention of the escape of flame through the joint of the breech was of difficult if not impossible accomplishment, and complicated arrangements of the breech mechanism had to be resorted to, with, at best, unsatisfactory results. The metallic cartridge overcomes this difficulty, being itself a perfect gas-check renewed at every round, prevents foulness and wear of the mechanism, and exercises the most vital functions in the life of the arm. So important an element is it, that it may be said that with a perfect cartridge the most indifferent breech arrangement can be used with safety and efficiency.

Its advantages, other than that already indicated, are many: Its completeness and simplicity, being self-primed and used as a whole in loading; its strength and safety, withstanding the roughest usage and thoroughly protecting the powder and fulminate; its accuracy, because of the coincidence of the axes of the bore and bullet; and, added to these, the absolute impossibility of using more than one cartridge at a time.

That adopted by the Ordnance Department is known as the center-fire. The superiority of this system over the rim-fire is so marked as will undoubtedly lead to its universal adoption. By concentrating the percussion composition in the center of the head, the quantity used is reduced to a minimum, to less than one-fourth of what is required to prime the entire circumference in the rim-fire, and this smaller quantity is so much better protected as not to be at all liable to accidental explosions. The central portion of the head has more elasticity than the rim, and is better able to resist the strain upon it from the sudden action of the fulminate, besides having the additional advantage of permitting the reinforcing of the rim, thus strengthening the weakest portion of the cartridge-case.

The United States regulation center-fire metallic cartridge consists of the following parts, viz.:

The case.
The cup anvil.
One-half grain of percussion composition.
Seventy grains of musket powder, and
A lubricated (lead 16, *tin* 1) *bullet*, weighing 405 grains.

The caliber is .45″ for the Springfield rifle and carbine, the revolvers, pistols, and small Gatling guns of late models. The .50″ caliber is used with the 10 barrel .50″ caliber Gatlings; and 1″ caliber with the larger Gatlings.

The case is the copper tube which forms the receptacle for the powder charge, the percussion composition, and the bullet. Its exterior conformation is designed to facilitate its ready extraction from the chamber of the gun after firing. Besides the rim at the closed end, which is intended primarily to assist extraction, the case is tapered from the rear to a point where it seizes the bullet, whence it merges in a right cylinder.

The cup-anvil is a small metallic cup, of sufficient rigidity to resist the blow of the hammer communicated by the firing-pin, and of such form as to insure the passage of the flame to the powder charge upon the explosion of the percussion-composition. It is provided with a circular recess or cavity into which the percussion composition is deposited. Two little vents at the extremities of a diameter of this recess direct the flame to the charge. The cup, when charged with the composition, is placed within the copper case, pressed snugly against its closed end, and crimped firmly into position. Cups were formerly made of sheet-iron tin-plate, but they are now made of copper.

The bullet enters more than half its length into the case, in order that the lubricant in its grooves may be entirely covered and protected. To render the cartridge water-proof the edge of the case is crimped hard against the bullet.

THE CASE.

THE COPPER.

The sheet-copper for making the cases is No. 22, wire gauge, obtained in strips $35\frac{1}{4}$ inches long, 3.3 inches wide, and .03 inch thick. The ends of these strips are cut at an angle to avoid waste, and each strip gives material for 40 cases. One pound of copper will make 40 cases, $\frac{1}{3}$ scrap. In the selection of sheets for making the cases, such only should be chosen as appear to have been rolled in a careful manner. They must be free from the slightest seams, blisters, or flaws, and of an even thickness throughout, well annealed, and trimmed to the foregoing dimensions.

The best copper ores are mined on the shores of Lake Superior. The Minnesota mines and the most approved brands of Detroit smelting should be selected in preparing metal for cartridge purposes. It is not pure as received from the mills, being alloyed with 5 per centum of spelter.

DOUBLE-ACTION PRESS.

The first operation in drawing the tubes is performed by the double-action press.

The strips of copper are prepared for the press by straightening their ends and edges, if necessary, with a hand mallet, and oiling both surfaces. The strips are then fed to the press by hand, a small stop on the die-plate regulating the length of feed.

The first shape given to the future cartridge-case is that of a flat circular disk, 1.63 inch in diameter, cut from the copper strips fed under the double punch of this press. This punch is essentially a punch within a punch, the exterior one cutting the disk clear from the strip, while the interior one descends and forces it through a tapered die, giving it a shallow, cup shape, about 1 inch in diameter and .5 inch deep. After passing through and beyond the tapered die, the cup expands slightly and is stripped from the interior punch as the latter ascends.

Two rows of disks are cut from each strip, one disk at a time. They are cut and cupped at the rate of 65 a minute. Experience has proven that a width of strip giving only two rows of disks is better than a width giving three or more rows, the former being rolled to a more uniform thickness and subject to less percentage of waste.

SINGLE-ACTION PRESSES.

In order to draw the cups to the dimensions required for the finished cases, they are subjected to the action of four additional punches and dies of decreasing sizes, so as to gradually elongate the cups while reducing their diameters. These draws are made by single-action presses, having each a single punch and die.

The first press elongates the cup from .92 to .95 of an inch, and reduces its diameter to (according to the maximum thickness of copper and wear of tools) about .7 of an inch.

The second press elongates it from 1.15 to 1.2 inch, and reduces the diameter to about .65 of an inch, thus lengthening out the cup into a tube. These tubes at this stage are annealed after a process to be presently described.

The third press elongates the tube from 1.75 to 1.8 inch, and reduces its diameter to .55 of an inch.

The fourth press brings the tubes to the required exterior diameter of

.501 minimum and .503 maximum of an inch, the extreme permissible variation of which is .002 of an inch; but they are left of unequal lengths and with ragged edges.

These presses are fed at the rate of 65 tubes a minute, by placing them upright on a revolving horizontal plate provided with guides and stops.*

ANNEALING.

The tubes are annealed after the second draw, as stated above, to restore to the metal its ductility, the previous operations having rendered it hard and brittle. The number of annealings required during the entire process of manufacture, will depend on the quality of the metal used; with the best copper, only one is necessary. The annealing is done by placing the tubes in a perforated iron cylinder, heating them red hot in a charcoal fire, revolving the cylinder meanwhile to equalize the heat, then plunging them into a solution of one part of sulphuric acid and fifteen parts water, and, afterward, thoroughly washing in several changes of water to remove all trace of acid. The acid solution (pickle) is intended to cleanse the metal from any scale, or oxide, occasioned by the annealing. They should be kept in a slightly acid bath until ready for use, when they are washed and oiled.

TRIMMING MACHINE.

The finishing draw having left the tubes of unequal lengths and ragged edges, it is necessary, in order to facilitate the subsequent steps of manufacture, and to insure uniformity in the finished cartridges, to remove the ragged edges and reduce the tubes to an uniform length.

This is done by means of the trimming machine. The tubes are placed in the trough of this machine, whence they are taken up by a revolving mandrel, against which, and just inside of a shoulder upon the

*Great care must be taken in the preparation of the dies and punches for these presses. The dies should be made with as hard and smooth a surface as possible, otherwise they will turn out inferior work and wear very rapidly. To prevent them from splitting, they are made hard inside and soft outside by imbedding them in powdered charcoal in a cast-iron box, heating them in a furnace to a cherry red, then passing a stream of salt water through them until cold (½ bushel salt to 20 gallons water). The inner surfaces are afterward smoothed with a lead mandrel, and thoroughly polished with crocus cloth. The very best steel should be used; flat bars of Hobson's steel for dies, and best Sanderson's steel, in octagon bars, for punches.

The punches are made by being brought to a cherry red in a charcoal fire; Nos. 1 and 2 being then dipped in water Nos. 3 and 4 in sulphuric acid, and all cooled in oil. The temper is afterward slightly drawn to permit them to be straightened if necessary.

same, the edge of a circular cutter is pressed. The tube, when brought to position by the mandrel, is cut clean and even by the cutter, a stripper removing the tube and scrap after each operation.

To allow for the metal that is used for forming the head or rim, the tubes are cut a little longer (about .13″) than the headed case.

The tubes are trimmed by this machine at the rate of 80 a minute.

REMOVING THE OIL.

In all the operations previous to and succeeding the annealing, lard oil of the best quality is the lubricant used. But as the smallest particle of oil will impair the efficiency of the percussion composition, it is of the last importance that all vestiges of it be removed from the interior of the tube before the percussion composition is inserted.

The flattening of the closed end of the tube by the next operation would, if the oil were not previously removed, retain a greater or less quantity of it in the interior fold of the rim, from which no subsequent process could entirely remove it, and from which it would be liable to exude in the finished cartridge, to the destruction of the percussion composition.

The present unheaded condition of the tube, therefore, affords the most favorable opportunity for removing the oil, which is done by washing the tubes in a solution of 1½ pounds potash, 1½ pounds soda, and 5 gallons of water, temperature 120°, for seven minutes, and afterwards rinsing them thoroughly in clean warm water, using a revolving wire barrel partially immersed in it.

HEADING MACHINE.

The head or rim of the cartridge-case is next formed by the heading machine. This machine consists of a horizontal die, countersunk at one end for sizing (diameter and thickness) the head, a feed-punch to insert the tubes into the die, and a heading punch to flatten the closed end of the tubes into the countersink. The bumper may be reversed, and the die left without countersink. This plan has been recommended.

The tubes, which are a little longer than the headed case, are fed into the inclined trough of the heading machine, whence they are taken up on the feed-punch. A shoulder on this punch, at a distance from its extremity equal to the inner depth of the headed case, prevents it from extending to the full depth of the tube, and a surplus of metal is thereby left at the closed ~~one~~ end of the tube for the formation of the head.

The feed-punch inserts the tube into the die, and holds it there, while the heading punch moves forward by a powerful cam, and presses and folds the unsupported projecting portion of the tube into the countersink of the die or recess of bumper, as the case may be, forming and accurately sizing and shaping the head or rim.

The headed case being left in the die as the feed-punch recedes, is pushed out by the succeding tube and thrown by a flipper into the receptacle below.

No oil is used in this operation, the moisture of the tubes from the recent washing sufficing as a lubricant.

The machine is fed at the rate of 65 per minute.

The cases are now finished; but to be certain that the oil is entirely removed from them, they are again washed in the alkaline solution and dried thoroughly in a drying-room, at a temperature of about 125° Fahrenheit.

THE CUP-ANVIL.

THE DOUBLE-ACTION PRESS.

The cup-anvil is made of copper, by a double-action press, similar to the one for cutting and cupping the disks for the copper cases.

Copper sheet-metal strips, 25 inches long, 2.5 inches wide, and .045 inch thick is used. One pound will make 176 cups, $\frac{1}{3}$ scrap.

The sheet-metal for cups must be free from all defects, with a bright, smooth surface, and uniform in thickness throughout, and unannealed.

The cups are cut and formed by this machine at the rate of 45 a minute.

CUP-TRIMMING MACHINE.

The cup anvils, as they come from the double action press, are of the right diameter, but too long, and with ragged edges. The cups are reduced to an uniform height by cutting off the ragged edges in the cup-trimming machine, which consists of a revolving rose cutter, made of a number of small cutters, that can be changed and sharpened at pleasure.

The cups are fed to the cutters through a vertical trough, and are trimmed at the rate of 30 a minute.

CUP-VENTING MACHINE.

The vents are punched in the trimmed cups by the cup-venting machine, which is provided with a two-pointed punch and corresponding dies.

The cups are fed by hand on a revolving circular plate, at the rate of 70 per minute.

CUP-IMPRESSION MACHINE.

The circular depression in the bottom of the cup, which serves as the receptacle for the percussion composition, is formed by the cup-impression machine.

The cups are fed through a vertical trough at the rate of 90 per minute. The trough has a flat pan at the top, into which the cups in quantities are emptied, and where they are arranged so as to present the proper end to the punch in passing through the machine.

This machine not only forms the recess, but gauges the cup at the same time.

The cups thus completed are well washed in an alkaline solution, to remove all traces of oil, and then thoroughly dried.

THE PERCUSSION COMPOSITION.

The percussion composition consists of—

Fulminate of mercury, by weight	35 parts.
Chlorate of potash, by weight	16 parts.
Glass dust, by weight	45 parts.
Gum arabic, by weight	2 parts.
Gum tragacanth, by weight	2 parts.

These are mixed without danger by using the fulminate in a moist state, the water having been entirely drained from it. The chlorate of potash being well triturated, and the glass dust properly prepared, the ingredients are put into a China bowl and thoroughly mixed, using a small steel spatula for the purpose. The dissolved gums will contain sufficient water to reduce the composition to a thick paste, it being used in the machine of this consistency.

Glass dust for the percussion composition is prepared for use in the following manner: Broken French plate-glass only is used. The glass is washed clean and dried; it is then broken into small pieces, put into an iron mill or rolling-barrel, running from twelve to fifteen revolutions per minute, and ground for a time; after which it is sieved by shaking through hair sieves of 50 meshes to the inch to remove the lumps, and what remains is sifted on hair sieves of 120 meshes to the inch to remove the impalpable powder. What is left on this sieve is free from dust and lumps, and is of good grit and ready for use.

PRIMING MACHINE.

The percussion composition, of the consistency of thick paste, is deposited in the recess of the cup by the priming machine, a very ingenious piece of mechanism, which performs this important operation with the greatest accuracy and certainty, and with perfect safety.

Its principal parts are, first, the central revolving spindle, with four tubular feeders at its head, which deposit the percussion composition in the cups; second, the magazine on the right; and, third, the circular plate on the left, on which the unprimed cups are fed to the machine.

The four tubular composition feeders at the head of the spindle consist each of a small depending stem, down which a closely-fitting tube is made to slide, the lower edge projecting a little below the end of the stem. By the revolving motion of the spindle these tubular feeders are brought successively over the magazine and over the cups to be primed.

At the moment a feeder is presented over the magazine, which is a shallow dish containing the percussion composition, the magazine rises until its metal bottom is in contact with the tube, a slight shaking motion of the magazine during its progress serving to deposit compactly into the open projecting end of the tube a sufficient quantity of composition for the priming of a single cup. The magazine then recedes, while the revolving spindle carries the charged feeder to the circular plate on the left, which presents the cups for priming. The motion of this plate is from left to right, while that of the spindle is from right to left, whereby the feeders and cups are made to meet and leave each other in opposite directions.

The plate is provided with eight upright movable stems, on the ends of which the unprimed cups are fed.

As the cups and feeders are brought, by the revolutions of the plate and spindle, in a vertical line with each other, the cups are raised by their stems so as to receive the percussion composition exactly in their circular recesses from the tubes of the feeders. The tube, at the moment of contact with the cup, slides up its depending stem and frees the composition from its end, which is pressed by the upward motion of the cup snugly into the circular recess. The feeders and cups in parting leave each other horizontally in opposite directions, so that the percussion composition is sheared off evenly and smoothly with the bottom surface of the cup. A specific quantity of composition is thus deposited in the recess of each cup at each operation.

The principal difficulty heretofore encountered in perfecting a machine of this kind is entirely overcome by the use of this peculiar feeder.

This machine primes at the rate of 38 per minute.

TAPERING MACHINE.

The tapering is performed in two operations: first, by forcing the shell through dies made in three cylindrical sections of graduated dimensions; second, while the composition is still moist in the circular recesses of the cups, the latter are put into the headed cases and crimped into position, the cases being tapered and reduced at the same time. The first operation prevents the case from wrinkling or folding; the second completes the tapering.

The tapering machine consists of four vertical tapered dies, with stems projecting from their centers, on which the cases and cups are fed, the crimpers which work from the sides of the dies, and the descending punch which forces the cases into the dies.

The primed cups are placed on the ends of the stems projecting from the dies, and the cases are placed over them. By the revolution of the horizontal plate on which the dies are placed, each die is in succession brought under the descending punch, which forces the cases into the dies and presses their heads hard against the primed cups, while the crimpers move forward from the side and bite the cups snugly and firmly into place. The central stem rises out of the die as the latter leaves the punch, and the case is removed by a spring extractor.

The section of the case which is to envelop the bullet is not tapered by the machine, but reduced to the form of a right cylinder whose inner diameter is the same as that of the bullet. This gives the bullet a securer hold in the case and helps to make the cartridge water-proof.

THE BULLET.

THE LEAD.

The United States elongated service-bullets are made by compression by means of machinery adapted to this purpose. They are uniform in size and weight, smoother and more homogeneous, more accurate, and give better results than cast and swaged bullets. The alloy for bullets should be pure soft lead of commerce, of specific gravity about 11.35, which is increased by pressure to about 11.45, and which melts at 600° Fahrenheit and volatilizes at red heat, and in proportion of 16 parts of lead to 1 of tin.

The lead is first melted and skimmed of dross—amounting to 5 per centum in good lead—and cast in iron molds into cylindrical bars, .50 of an inch in diameter and 20 inches long. These bars are passed through rolls which reduce them to .38 of an inch in diameter and increase their length to 36 inches. The surplus lead, if any, is trimmed off in rolling.

A man will cast in a day of 10 hours 1,500 bars of lead.

A man and boy will roll and trim in a day of 10 hours 3,000 bars of lead.

BULLET MACHINE.

The bars are fed to the bullet machine through a vertical tube above a horizontal cutter, which cuts at each stroke a length sufficient to form a single bullet and transfers it to the die,* in which, by means of a vertical punch, the bullet is formed with its grooves. The surplus lead is forced out at the junction of the dies in the direction of the longer axis of the bullet, and at the junction of the punch and dies at its head.

* The dies and punches for the bullet machines are made with great care of the best cast steel. The dies are cut out with cherries to the form and dimensions of the bullet and have as hard and smooth a surface as it is possible to give them. They are hardened in pure cold water and the temper drawn to a light straw color. They are made in such a manner that only small portions of their faces, just surrounding the base of the bullet, may be in contact while the bullet is being formed.

A bullet machine will make in a day of 10 hours about 25,000 to 27,000 bullets.

Best lard oil is used on the lead bars to lubricate the dies.

BULLET-TRIMMING MACHINE.

The operation of trimming the bullet is performed by the bullet-trimming machine. The bullets are fed by hand into a revolving perforated circular plate whence they are forced by a punch through trimmers which open from the point to the base of the bullet, and which conform to its shape, a cutter at the same time passing over the base. After this they are forced by the punch through the gauge under the trimmer. The best lard oil is used with these machines.

The bullet must not vary more than two grains above or below their prescribed weight.

A boy will trim and gauge in a day of 10 hours 15,000 bullets.

THE LUBRICANT.

The lubricant for bullets is made of—

Bayberry tallow, by weight .... 8 parts.
Graphite, by weight .... 1 part.

The latter must be of the best quality and free from grit. The bullets should be lubricated by machinery whenever possible, as the grooves are more surely and completely filled and more closely packed by mechanical pressure.

Experiment has shown that one of the best lubricants for use with the gun, and in the lubricating machine, is Japan wax. It gives a very small per centum of fouling and works freely in the machine. It is generally cheaper than the above lubricant and has been in use several years.

LUBRICATING MACHINE.

The lubrication of the bullet is done by the lubricating machine. The lubricant is molded into cylinders of about 10 inches in length. These cylinders are fed to the machine through a vertical tube, pressure being applied to keep the supply constant. The bullets are placed by hand in a perforated revolving vertical plate and forced by a punch through a sizing-die fixed in the bottom of the tube, which is pierced with small holes. The lubricant is forced through these holes into the grooves of the bullet, filling them completely.

In cold weather an arrangement for slightly warming the lubricant should be provided.

A boy will lubricate in a day of 10 hours 15,000 bullets.

LOADING.

LOADING MACHINE.

The cases are now loaded with powder and bullet by means of the loading machine, which consists of ~~a~~ revolving circular plates with holes or receivers, and a hopper and powder measure. The cases and bullets are fed on revolving plates, 35 a minute; the former are lifted into the receivers, passed under the hopper and measure for a charge of powder, and then under the bullet-feeder for a lubricated bullet. In order to insure a full charge in each cartridge, the machine is provided with a bell which gives notice to the operative of any failure in this particular. The edge of the case is then crimped on the bullet in a very simple manner. The receivers are smaller at the top where the bullet enters, than at the bottom where the case is received, the diameter of the former being only equal to that of the interior of the open end of the latter. After the bullet has been pressed into the case, the cartridge is lifted so that the edge of the case is forced into the conical surface of the receiver between its larger and smaller diameters.

The powder is placed in a pasteboard hopper, about two feet above the machine, and is fed to the cases through a paper tube one inch in diameter; the hopper and tube stand inside of a large conical shield of boiler-iron.

During the process of manufacture, accidents are only possible with the loading machine; and, consequently, every precaution has been taken to provide against their occurrence. As the machine is now made and arranged, the explosion of one cartridge may communicate fire to the few charged cases near it without danger. The entire charge of powder in the hopper may be thus exploded without the possibility of injury, either to the operative or to the machine, as the hopper and tube offer but a slight resistance to the action of the gases that expend their forces in every direction without affecting the stability of the protecting shield.* This has been proved by experimentally exploding full charges of two and a half pounds in the hopper itself. But the explosion of a cartridge in the operation of loading is of very rare occurrence. Out of the many millions loaded at Frankford arsenal in the past ten years, a trifling number only have exploded prematurely, resulting in no damage whatever.

After loading, the cartridges are wiped clean and put up in paper packages and packed in wooden boxes for storage or issue.

BLANK CARTRIDGES.

The blank cartridge consists of a copper case, 80 grains of muske powder, a cup anvil, and ½ grain percussion powder. The copper for blank cartridges is rolled in strips 35 inches long, 3.2 inches wide, and .028 of an inch thick; each strip will cut 42 disks. The process of manufacture of the cases, &c., is the same as for the ball-cartridges; † the cartridges are then wiped clean, and the open end touched with shellac varnish. They are afterward put up in suitable paper boxes, which are packed in wooden boxes for transportation.

PACKING.

The cartridges are put up in paper boxes holding 20 rounds. Each box is arranged for two rows of 10, the rear row being higher than the front, each alternate cartridge having its rim below that of the other, for facility in loading and close packing. The frames and skeleton divisions of the boxes are made of straw-boards, the shapes of each part being cut with punches and dies, and such as require it being creased for folding. The frame of the box is covered with stout paper bearing a printed description of the contents, and projecting far enough over to paste down the lid

*A magazine outside of the loading room, above the roof, constructed like the loading-machine hopper, is now used to draw the supply of powder for use of loaders, holding 100 pounds of powder.

†They are filled by the loading machine, receiving sufficient pressure to hold the charge firmly as they are delivered from the machine, the open end of case partially closed on the charge.

securely. For convenience in opening the box, a piece of strong twine is fastened at one end of the box and pasted along the inside of the seam of the lid, the loose end projecting a few inches.

Three girls will make in a day of 10 hours 700 paper boxes.

The cartridges are packed, for storage or transportation, in wooden boxes, containing fifty packages each. These ammunition-boxes are painted, and the description of contents is stencil-marked on the ends, the date of fabrication branded on the sides, and the place of fabrication on the interior of the lid.

CARTRIDGES FOR GATLING GUNS.

The cartridges used for the Gatling guns, caliber .50″ and .45,″ are the service rifle-musket cartridges of these calibers.

The cartridges used for the 1-inch Gatling gun are of two kinds: an elongated bullet-cartridge, and a cartridge of fifteen buck-shot in groups of three, with a hemispherical bullet. This ammunition is made by machinery similar (but suited to heavier work) to that used in making the caliber .45″ and .50″ cartridges, except that the long cases require six drawers and three annealings, and the short cases five drawers and three annealings. The copper is in strips 36 inches long, 6¾ inches wide, and .04 inch thick. One pound will make eight long cases, or eleven short cases, ⅓ scrap; the copper for which latter is 5½ inches wide.

Anvils are made of sheet-copper strips 24 inches long, 12½ inches wide, and .055 inch thick, unannealed. Thirty pounds of metal will make 2,000 anvils.

Machines required to make 100,000 *bullet-cartridges a day.*

Number.	Machines.	Working capacity of each in ten hours.
	FOR CASES.	
4	Double-action presses	28,000
16	Single-action presses	26,000
6	Trimming machines	18,000
4	Heading	26,000
7	Tapering	16,000
7	Loading	16,000
2	Annealing furnaces	....
	Wash-tubs, barrels, trays, &c	....
	FOR CUPS.	
5	Double-action presses	20,000
4	Vent-punching machines	28,000
6	Trimming machines	18,000
4	Impression machines	28,000
7	Priming machines	16,000
	FOR BULLETS.	
*5	Bullet-machines	25,000
7	Bullet-trimmers	16,000
7	Bullet-lubricating machines	16,000
2	Sets of rolls	....
	Lead-pots, molds, &c	....
	FOR PAPER BOXES.	
1	Paper-cutter	....
2	Creasing machines	....
6	Single presses	....
1	Printing-press	....
	Type, &c., wooden formers, paste-kettles, brushes, knives, &c	....
6	Weighing machines	....
6	Inspecting machines	....

* One as a reserve.

Materials required for 100,000 *blank cartridges.*

*2,390	pounds sheet-copper; scrap one-third, .03 inch thick.	1,028	pounds tarred boards; scrap, 10 per cent.
†575	pounds sheet-copper; scrap one-third, .045 inch thick.	1	quart varnish.
1,145	pounds musket-powder (80 grains to each cartridge).	800	feet lumber.
7¼	pounds percussion-powder.	4½	gross screws.
32	pounds nails, 8d.	25	pounds paste.
4	pounds nails, wrought.	1¼	pounds putty.
15	pounds paint.	45	pounds paper covers.
1	pound twine.	3	pounds glue.

* 42 cases to one pound. † 126 cases to one pound.

Dimensions of the Springfield-rifle cartridge, caliber .45″.

Names of parts.	Standard dimensions.	Variations allowed. Max.	Variations allowed. Min.
CASE.	*Inches.*	*Inches.*	*Inches.*
Total length	2.105	2.105	2.103
Length of cylinder at front	.660	.670	.650
Diameter of cylinder inside	.458	.458	.458
Thickness of head	.070	.070	.068
Diameter of head	.610	.610	.600
Diameter of body at head	.505	.505	.504
Diameter of body at front	.480	.480	.480
BULLET.			
Total length	1.110	1.110	1.110
Diameter of cylindrical part	.458	.458	.458
Diameter of conical part (maximum)	.445	.445	.445
Depth of grooves	.030	.030	.030
Width of grooves	.125	.125	.125
Width of lands	.083	.083	.083
Length inserted in case	.645	.655	.645
Length outside of case	.465	.465	.455
Weight, grains	.405	.407	.403
Alloy (16 lead, 1 tin)			
Lubricant (Japan wax in grooves)			
CARTRIDGE.			
Total length	2.570	2.570	2.560
Weight of powder ... grains	70	72	69
Initial velocity ... feet	1,350	1,350	1,310

The carbine cartridge is the same as the rifle, except—
The weight of powder charge is 55 grains.
The initial velocity is 1,100 feet.

Materials for 10,000 *cartridges for Gatling gun,* 1-*inch caliber.*

1,255 pounds sheet-copper, long cartridge; scrap one-third.
912 pounds sheet-copper, short cartridge; scrap one-third.
305 pounds sheet-copper, scrap one-third.
5,000 pounds of lead for each.
470 pounds musket-powder.
11½ ounces percussion-powder.
45 pounds paper covers.
¼ pound twine.
4 pounds nails, wrought, 2¼.
15 pounds paint.
3 pounds glue.
14½ pounds lubricant.
437 pounds tar-boards.
30 pounds nails, 8d.
800 feet lumber.
4 gross screws.
1¼ pounds putty.

Dimensions and weights of musket-cartridge, caliber .50″.

Parts of—	True.	Max.	Min.	Grains.
CASE.	*Inches.*	*Inches.*	*Inches.*	
Extreme length of case	1.75			
Diameter before tapering		.563	.561	
Diameter under head, after tapering		.563	.561	
Diameter at open end, after tapering		.543	.541	
Diameter at head		.665	.660	
Thickness of head	.05			
CUP.				
Height of cup	.20			
Diameter of cup		.527	.526	
Diameter of recess	.15			
Depth of recess	.025			
Diameter of vents	.07			
BULLET.				
Length of bullet	1.00			
Diameter of bullet	.515			
Length of finished cartridge	2.285			
Weight of case				130
Weight of cup				30
Weight of powder				70
Weight of percussion composition				.5
Weight of bullet				450
Weight of finished cartridge				680.5
BLANK CARTRIDGE.				
Length of case	1.5			
Weight of case				135
Weight of finished cartridge				215

Dimensions and weights of Gatling 1-inch cartridge.

Parts of—	True.	Grains.
CASE.	*Inches.*	
Extreme length	4	
Diameter before tapering	1.02	
Diameter of head	1.16	
Thickness of head	.10	
CUP.		
Height of cup	.30	
Diameter of cup	.98	
Diameter of recess	.18	
Depth of recess	.02	
Diameter of vents	.07	
BULLET.		
Length of elongated	1.90	
Diameter of elongated	1.25	
Length of hemispherical bullet	.70	
Diameter of hemispherical bullet	.96	
Diameter of buck-shot	.45	
Length of long cartridge	4.60	
Length of short cartridge	3.90	
Weight of long case		687
Weight of short case		450
Weight of cup		90
Weight of powder		325
Weight of percussion powder		.5
Weight of elongated bullet		3,500
Weight of hemispherical bullet		1,074
Weight of buck-shot		138
Weight of finished cartridge, long		9 ozs. 290 grs.
Weight of finished cartridge, short		9 ozs. 35 grs.

Weights of caliber .50″ cartridges, for transportation.

	Lbs.	oz.
Of one paper package containing 20 musket-cartridges	2	2
Of one box packed with 50 paper packages, containing 1,000 musket-cartridges	118	4
Of one paper package containing 20 blank musket-cartridges		12
Of one box packed with 50 paper packages, containing 1,000 blank musket-cartridges		47
Of one paper package containing 5 cartridges for 1-inch Gatling gun, elongated bullet	3	1
Of one box packed with 20 paper packages, containing 100 1-inch Gatling-gun cartridges	70	
Of one paper package containing 5 cartridges for 1-inch Gatling gun, buck and bullet	3	2
Of one box packed with 20 paper packages, containing 100 1-inch Gatling-gun cartridges	72	

Dimensions of revolver cartridge, ball, caliber .45″.

Total length of case	1.11	inch.
Total length of cartridge	1.42	inch.
Diameter of case at head	.481	inch.
Diameter of case at front	.480	inch.
Diameter of head	.52	inch.
Thickness of head	.06	inch.
Diameter of bullet	.458	inch.
Length of bullet	.69	inch.
Weight of bullet	230	grains.
Charge of powder (musket)	28	grains.
Total weight of cartridge	343	grains.

Material for service metallic ammunition.

Designation.	Sheet-copper.					Bullet, canister and ball.					Lubricant for 1,000.	Musket powder for 1,000 cartridges.	Priming for 1,000 anvils.	Remarks.
						Lead 16; tin 1.		Lead.						
	Length.	Width.	Thickness.	Required for 1,000 cartridges.	Scrap from 1,000 cartridges.	One pound of alloy.	Required for 1,000 bullets.	Required for 1,000 bullets.	Round balls required for 1,000 canisters.	End pieces for 1,000 canisters.				
	In.	*In.*	*In.*	*Lbs.*	*Lbs.*	*No.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lubricant.*
Rifle ball-cartridges, cal. .45	36	3.3	.03	25	8	16	62	...	...	..	.75	10	...	
Carbine ball-cartridges, cal. .45	36	3.3	.03	25	8	16	62	...	...	...	.75	7.85	...	Japan wax in grooves.
Rifle and carbine blank cartridges, cal .45.	35	3.2	.028	22.8	7.5	...	...	...	...	...	...	11.4	...	——
														Priming composition.
Revolver ball-cartridges, cal. .45	35	2.6	.025	15	5	29	36	...	...	...	.5	4	..	Fulminate of mercury, 35 parts.
Revolver blank cartridges, cal. .45.	35	2.6	.02	14.3	4.7	..	..	...	...	...	...	4.8	...	Chlorate of potassa, 16 parts. Plate-glass dust, 45 parts.
Gatling gun, ball, cal. 1″	36	5.25	.04	91	30	...	...	500	...	...	1.5	4.7	...	Gum arabic, 2 parts.
Gatling gun, canister, cal. 1″	36	6.5	.04	125	40	..	..	....	300	150	1.5	4.7	...	Gum tragacanth, 2 parts. Water to form a paste.
Cup-anvil for rifle and carbine	25	2.5	.045	5.6	1.86	..	...	....	..	...	..	....	.6	——
Cup-anvil for revolver	25	2.5	.035	4.9	1.6	..	...	....	...	...	..	...	.5	Copper for cases is annealed
Cup-anvil for Gatling, cal. 1″	24	2.5	.055	30	10	...	...	...	...	..	...	....	.1	Copper for anvil is unannealed.

NOTE.—The cartridges are packed in paper boxes made from No. 40 straw-board, 24 by 30 inches, and manila paper wrapper having printed label. Pasteboard partitions inside the box separate the cartridges from one another, as shown in annexed drawings.

Dimensions, material, &c., of wooden packing-boxes, for service metallic ammunition.

Designation.	Dimensions inside.			Width of boards.		Square feet per box.	Screws 2″, No. 13.		Cut-nails, 7d.		$2\frac{1}{4}$″ wrought clinch-nails in each handle.	Color painted.		Number of packages of 20 each in box.	Number of packages of 12 each in box.	Number of packages of 5 each in box.	Number packed in box.	Weight of box packed.
	Length.	Width.	Depth.	Top and bottom.	Sides and ends.		In tops.	In bottom.	In bottom.	In corners.		On box.	On handle.					
	In.	*In.*	*In.*	*In.*	*In.*		*No.*	*No.*	*No.*	*No.*								*Lbs.*
Rifle ball-cartridges, cal. .45	$14\frac{1}{8}$	12	$6\frac{9}{16}$	15	15	9	8	4	12	20	3	Olive	Olive	50	...	..	1,000	107
Carbine ball-cartridges, cal. .45	$14\frac{1}{8}$	12	$6\frac{9}{16}$	15	15	9	8	4	12	20	3	..do.	Blue.	50	..	...	1,000	105
Rifle and carbine blank cartridges, cal. .45	$13\frac{5}{16}$	$9\frac{5}{16}$	6	15	12	6.75	8	4	8	20	3	..do.	..do.	50	...	...	1,000	41
Revolver, ball, cal. .45	$13\frac{5}{16}$	8	$5\frac{7}{8}$	12	12	6.5	6	4	8	20	3	..do.	Olive	...	100	..	1,200	71
Revolver, blank, cal. .45	12	$6\frac{3}{4}$	$5\frac{7}{8}$	15	15	6	6	2	8	12	3	..do	..do.	...	...	...	1,200	31
Gatling gun, ball, cal. 1″	$16\frac{5}{8}$	$12\frac{5}{8}$	$5\frac{1}{2}$	15	15	9.5	8	6	16	20	4	..do.	..do.	...	...	40	200	140
Gatling gun, canister, cal. 1″	$14\frac{3}{4}$	$12\frac{3}{4}$	$5\frac{1}{2}$	15	12	9	8	6	12	20	4	..do.	Red.	....	...	30	150	107

Boxes are made from red-knot white-pine boards, planed both sides, $\frac{13}{16}$ inch thick, corners halved together and secured with glue.

Handles $1\frac{3}{4}$ inch wide across ends of box, beveled at ends, and under-cut for gripping.

Two screw-holes, each in top and bottom, countersunk $\frac{3}{16}$ inch deep, 1 inch diameter, for sealing.

AMMUNITION FOR FIELD AND MOUNTAIN SERVICE.

The ammunition for field and mountain service consists of—

Shot for the 12-pounder gun.

Shells for the 12-pounder gun, 12-pounder mountain-howitzer, and 3 and $3\frac{1}{2}$-inch rifle-guns.

Case-shot for the 12-pounder gun, 12-pounder mountain-howitzer, and 3 and $3\frac{1}{2}$-inch rifle-guns.

Canisters for the 12-pounder gun, 12-pounder mountain-howitzer, and 3 and $3\frac{1}{2}$-inch rifle-guns.

The projectiles are attached by straps of tin to a wooden sabot, to which is also fastened the *cartridge-bag* containing the charge for the 12-pounder and the mountain-howitzer, making together, a round of fixed ammunition. In rifle-guns, the cartridge is not attached to the projectile.

CARTRIDGE-BAGS.

The cartridge-bag is a cylindrical bag with a circular bottom, made of merino or serge. The material should be composed entirely of wool, free from any mixture of thread or cotton, and of sufficiently close texture to prevent the powder from sifting through; that which is twilled is preferred. Flannel is used when the other materials cannot be conveniently obtained.

TO CUT THE CLOTH.

IMPLEMENTS.—*Two tables; patterns,* of hard, well-seasoned wood, or of sheet-iron or tin, for the rectangles and bottoms; *shears, chalk, or colored crayons.*

A marker and assistant spread out the cloth on the table in two thicknesses, and make it fast at each end of the table on three or four hooks driven in the ends of the tables, or by means of weights, drawing it sufficiently to take out the folds, and no more.

They mark out the rectangles and bottoms with the patterns and ruler, so disposing and combining them as to cut the cloth to the best advantage.

The length of the rectangle (development of the cylinder) should be taken in the direction of the length of the stuff, as it does not stretch in that direction. The selvage, if there be any, ought to be at the mouth of the bag. The cutter takes a piece thus marked to another table, and cuts out the rectangles and bottoms with a pair of shears. The bottoms may be cut out with a hollow punch of the proper size.

SEWING.—Marks for the seam are traced on the rectangles and bottoms by means of patterns of the proper size. The seam should be at least a half-inch from the edge. The bag is sewed with woolen yarn, with a back-stitch, 12 to the inch. The edges are turned down on the same side of the seam and basted, to prevent the powder from sifting through; the edges of the bottom are basted down upon the sides. Bags may be sewed advantageously by the sewing-machine. Bags for fixed ammunition are sewed to within 3 inches of the mouth for 12-pounders; all others up to the mouth. A bag is given as a model to sew by.

Cartridge-bags, when filled, should pass through the small shot-gauge of their caliber; those used for patterns should be thus verified. The empty bags should be measured by laying the bag, flattened out, between two marks on a table, showing the width of the pattern-bag; a variation of 0.1 inch, greater or less, is allowed. Reject those sewed with too large stitches.

Bags for practice or blank cartridges may be formed by sewing together two rectangular pieces with semicircular ends; the cloth is marked for cutting and sewing, with stamps made of 1-inch boards of the dimensions of the cutting-stamp, with a strip of tin or copper fastened to the edge of the board, and projecting about $\frac{3}{4}$ inch perpendicular to the side; another strip, parallel to the first, is inserted in a groove $\frac{1}{2}$ inch from it; the edges of these strips are made rough to retain chalk or paint used in marking. A handle is placed in the middle of the face opposite to the marking-strips. Width of cutting-stamp for 12-pounder, 7.6 inches; length, including semicircular ends, for 12-pounder, 10.5 inches.

PACKING.—Cartridge-bags are preserved from moths by being packed with pounded camphor and black pepper, or dipped in water with arsenic dissolved in it, or a solution of sulphate of copper, 1 pound of sulphate to 25 pounds of water; or they may be sealed up in bundles of fifty in cases made of cartridge-paper, carefully closed with strips of thin paper pasted over the seams. Each bundle is marked with the number and kind of bags They may be preserved from moisture by being enveloped in water-proof paper.

SABOTS AND CARTRIDGE-BLOCKS.

Sabots and cartridge-blocks are made of poplar, bass-wood, or other light, close-grained wood; it must be well seasoned and should be clear of knots and splits.

The assistant saws the scantling to the proper length for a sabot, roughs it out, and marks its center. The turner puts it in a lathe and turns, first, the exterior and grooves, and then the cavity for the projectile.

The holes for the handles are bored with a bit, and countersunk on the inside to receive the knot on the end of the cord. Distance between them, for shells is 1.5 inch; for canisters, 2.3 inches. Length of cord for handles, for shells 12 inches; for canisters, 20 inches; diameter of cord, .15 inch.

The cartridge-blocks and sabots for shot and spherical case-shot for guns have one groove. Sabots for gun-canisters and mountain-howitzer shells, spherical case-shot, and canisters have two grooves. All the grooves are .3 inch wide and .15 inch deep. They are .8 inch apart, from center to center, for guns, and .5 for the howitzer. The corners and bottom of the grooves are slightly rounded.

The dimensions of finished sabots and blocks are verified with appropriate gauges.

A day's work.—One man can make 350 sabots for 12-pounder gun, or 300 sabots for howitzer, or 600 cartridge-blocks, small charge, or 700 cartridge-blocks, large charge.

STRAPS.

Straps are made of sheet-tin. For shot there are two straps crossing at right-angles, one passing through a slit in the middle of the other; for shells there are four straps fastened to a ring of sheet-tin pierced with four slits, through which the ends of the straps are passed and folded down on the under side.

The sheet of tin is first cut to a length equal to that of the straps, and, if the straps are for shot, a line is drawn, dividing it into two equal parts, to mark the place for the slit. The straps are cut with circular shears. If such be not at hand, the width of the strap is marked on the sheet, cut with tinner's shears, and straightened on a bench with a mallet.

The slits are made with a cold-chisel on a block of lead, and a strap not slit is passed through and set flat by a blow of the hammer.

RINGS.

Rings are cut from sheet-tin by means of two punches, the first having the diameter of the exterior, and the other that of the interior of the ring. The slits are made with a cold-chisel, and the required concavity to fit the ball is given by hammering on a block of lead having a concave surface. The ends of the straps are passed through the slits, folded down, and set flat. Dimensions of rings: exterior diameter, 3.25″; interior diameter, 1.75″.

STRAPPING SHOT AND SHELLS.

IMPLEMENTS.—One *bench;* 2 *pans*, containing *nails* .55 inch long, with strong, flat heads .2 inch diameter; *boxes* and *barrels*, for straps and sabots; 4 *hammers*, for strapping; 1 *common hammer;* 4 *punches; shot-gauges*, of each caliber; 1 *gauge* for each caliber, .04 inch greater than the largest shot-gauge, through which the shot should pass after it is strapped; *tow* or *rags*, for wiping balls; 1 *wheel-barrow;* 1 *paulin*, if the shops have not a plank floor.

A helper knocks off the scales from the balls with a hammer, cleans and dries the interior of the shells, if requisite, wipes the balls, and gauges them, both before and after they are strapped.

The workman sitting astride the bench, places the shot or shell in the cavity of the sabot, the roughest part of the shot down, the fuse-hole of the shell on top, in the axis of the sabot. The ball should rest on the bottom of the cavity (it can be told from the sound, by striking on the bottom of the sabot with a hammer); if it do not, the sabot is rejected. The workman places the junction of the straps in the axis of the sabot, or the ring concentric with the fuse-hole of the shell; beginning with the strap which is not slit, he forces the end of it into the groove of the sabot with the back of the hammer, punches it, and nails it; he then draws the other end tight, punches it, and nails it, in the same manner. He disposes the other strap perpendicular to the first, nails it to the sabot as he did the first, cuts off the superfluous length, and with the hammer and side of the cold-chisel sets the straps in close to the ball at the top of the sabot.

A day's work.—Two men can strap in 10 hours 130 shot, or 75 shells, cutting the tin from the sheet.

THE BOXER MODE.—Bore a hole, .2 inch in diameter, .15 inch deep, in the shot; enlarge the hole at bottom. Take a copper rivet, .2 inch in diameter, hollow out the end, leaving the length of the rivet .25 inch greater than the least thickness of the sabot; bore a hole in the centre of the sabot for the rivet, with a countersink for the head; place the shot in the sabot, the hole down; insert the rivet in the sabot, making it enter the hole in the shot; strike the head of the rivet a blow with a hammer, to upset the end of the rivet and fasten the sabot.

ANOTHER MODE.—If tin or sheet iron cannot be procured, straps may be made of strong canvas, 1 inch wide, sewed at the point of crossing. The part of the ball which is to be inserted in the sabot is dipped in glue; the straps are also glued to the ball; the ends are doubled into the groove and secured by 2 nails in each end. Another method is to wrap round the ball a band of canvas 1 inch wide, one-half of which is glued to the ball, the other to the sabot; or the shot may be kept in place by merely tying the cartridge-bag over the top of it.

CHARGING SHELLS.

MATERIALS.—*Rifle or musket powder; plugs; fuses; chalk.*

IMPLEMENTS.—One *funnel; powder-measures* to hold the required charges; 1 *wooden straight-edge; large bowl; fuse-wrench.*

The shells having been properly cleaned, dried, tapped to receive the plug and the fuse, and attached to the sabot, are placed in two rows. The workman fills the measure with powder, strikes it level with the straight-edge, and pours it in the shell; the assistant holds the funnel, and marks the shell with chalk when filled, to prevent mistakes. The assistant screws in the plug. The workman puts a little white lead on the threads of the fuse, punches 4 or 5 small holes in the tin disk; and screws the fuse firmly into the shell, the assistant holding the shell to prevent it from turning.

CASE-SHOT.

The shot having been cleaned and inspected, the upper part of the fuse-hole is tapped to receive the fuse; the small hole is tapped to receive the plug.

TO FILL THE SHELLS.

MATERIALS.—*Spherical leaden balls*, caliber .69 inch; *sulphur* or *rosin; linseed oil.*

UTENSILS.—One *kettle;* 1 *ladle;* 1 *iron funnel,* the neck chased with the threads of a screw, to fit the small part of the fuse-hole.

FILLING THE SHELL.—Cover the lead balls with linseed oil, and fill the shell with them, pushing the upper balls aside with a stick, to get in as many as possible. Warm the shell gently, and screw the neck of the funnel into the fuse-hole; pour in the melted sulphur, filling the shell.

TO MAKE THE CHAMBER FOR THE CHARGE.—Chuck the shot in a lathe; screw the funnel into the fuse-hole to protect the threads from being injured by the auger, and with a common screw-auger bore a hole in the axis of the shell to the bottom. Diameter of the auger, .75 inch.

Lacker the shot and strap it; paint it red.

TO CHARGE THE SHOT.—Fill the chamber with musket-powder, ramming it slightly with a wooden drift and light mallet; screw in the iron plug, leaving its top flush with the bottom of the large portion of the fuse-hole, and lay over it a thin leather washer with a hole in the center; fill the hole in the plug and washer with rifle-powder; punch four or five small holes in the tin disk in the bottom of the fuse; put a little white-lead on the threads of the fuse, and screw the fuse firmly into the shell.

Fix the case-shot the same as round shot.

CANISTER.

A canister for field service consists of a tin cylinder attached to a sabot, and filled with lead balls, eleven to the pound.

Canister for the mountain-howitzer are filled with lead balls.

MATERIALS.—*Sheets of tin,* .02 inch to .025 inch thick (double tin); *soft solder; rosin; culots* of rolled iron, .25 inch thick; covers of sheet-iron, .07

inch thick for the guns and 12-pounder howitzers, and .1 inch thick for the 24 and 32 pounder howitzers; *sabots; tacks.*

Canister for rifle-guns have metal sabots, and are filled with lead balls.

UTENSILS.—*Patterns; tracing-point; shears; cylinder* of hard wood; *mallet; gauges; furnace; soldering-iron; hammer; punch.*

TO MAKE THE CYLINDER.—The workman marks out the rectangle on the sheet with the pattern, cuts it, and traces the line for the lap. He draws a line parallel to the long side of the rectangle, .4 to .5 inch from it, for the length of the slits. It is then bent round the former, the edge brought to the line of the lap, clamped and soldered.

If lumps of solder be left, they are filed down. The cylinder is made round and gauged on the exterior with the large shot-gauge of the caliber, and the interior with a cylinder of a diameter .02 inch less than that given in the table, which should enter the canister. If it be not of the right size, it is unsoldered and soldered over again.

The slits are made and the sabot inserted and nailed with 6 to 8 nails.

Before filling the canister, dip the tin cylinder into a lacker of beeswax dissolved in spirits of turpentine, to prevent it from rusting. Coat the plates with paint or coal-tar.

FILLING CANISTERS.—The workman, sitting astride the bench, places the canister upright in front of him; inserts the iron bottom and places it flat on the sabot; puts in a tier of balls; fills the interstices with dry, sifted sawdust; packs it with a pointed stick, so that the balls will hold by themselves, and throws out the loose sawdust. He places another tier of balls, each ball lying in the interval between two balls of the lower tier, and proceeds in the same manner until the canister is filled; covers the upper tier with sawdust; puts on the cover, places on it one of the iron bottoms furnished with a handle, and strikes it with a small mallet in order to compress the sawdust; then removes this bottom, and turns down the slit pieces of the canister over the cover with a hammer. In the canister for the 12-pounder gun the center ball of the last tier is omitted. When the canister is finished verify its diameter with the large shot-gauge of the same caliber.

SAWYER CANISTER.

(Figures 1, 2, ~~and~~ ~~3~~. Plate ~~I~~ XXI)

The Sawyer canister-shot for all guns and howitzers consists of a casing, A, of malleable iron, in one piece, in the form of a hollow cylinder, having one end closed by a head cast therewith, through which head is formed one or more small holes, *a*, through which a portion of the gas occasioned by the explosion of the charge of powder enters, driving forward the small iron balls, and disengaging the metal cover *b*, placed in the forward end of the casing to hold the contents in position till fired. The casing has, cut through its walls, one or more series of oblique slits, *c c*, the end of each slit slightly overlapping the end of the next slit in the same series, thus nearly severing the casing into two or more sections, said sections being held together only by the narrow bars of metal *d d*, between the contiguous ends of two slits, *c c*, as shown in Fig. 1, which bars are sufficiently strong to withstand the ordinary shocks of handling and transportation, but not strong enough to resist the shock of the explosion of the charge of powder in the gun, so that when the shot is discharged from a gun the cover *b* is stripped from the mouth of the casing, and the casing is broken into two or more sections, from which the small shot *e* are more readily and completely discharged than they would be if the casing remained intact.

CYLINDERS AND CAPS.

For the greater security of field ammunition, the cartridges are covered with paper cylinders and caps. The cap is drawn off at the moment of loading the piece, and in using solid shot it may be placed over the shot to diminish the windage. A cylinder and a cap are formed together by folding the paper over a former, which allows a lap of about .75 inch for pasting. The requisite length for the cylinder is cut off from the smaller end. The rest forms the cap, which is choked at the end from which the cylinder is cut on a cylindrical former, which has a groove around it, marking the length from the rounded end for cutting the cap. The former should be bored through the axis with a .5 inch hole, to facilitate drawing off the cap.

The caps for shells are black; for spherical case-shot, red; for shot, not colored.

FIXING AMMUNITION.

IMPLEMENTS.—*Barrels for powder;* 1 *funnel;* 1 *set of powder-measures;* 1 *straight-edge*, to strike the measures with; *barrels; tubs*, formed of barrels sawed in two, *or boxes*, for the cartridge-bags; 2 *paulins;* 2 *benches;* 12 *choking-sticks*, 6 with holes in them and 6 slit; 6 *knives;* 6 *hand-barrows* with 4 legs and a box, and *paulins* to cover them; caliber-gauges for the cartridge-bags and for fixed ammunition (they may be made of wood); 6 *stools;* 1 *wheel-barrow;* 1 *mallet;* 1 *copper chisel;* 1 *copper drift*, or a *wrench*, to open powder-barrels.

FIXING SHOT OR CASE FOR SMOOTHBORE FIELD GUNS.

The bags should be filled in the small magazine or filling room. The assistant holds the pipe of the funnel in the mouth of the bag with both hands, the bag pressed close against the pipe. The gauger heaps up the measure with powder, strikes it level with the straight-edge, and pours it into the funnel When about 25 bags are filled the gauger takes a filled bag with one hand, squeezing the bag upon the powder; he gives it a blow with the other hand on the top and bottom of the bag, twisting the mouth of the bag down upon the powder at the same time; he then tries it with the small gauge through which it should pass with not more than .25 inch play; should it not do this, the bag is emptied and rejected. These bags, filled and gauged, are placed upright in a tub or box and carried by the gaugers into the finishing room, where the men are placed in pairs, sitting astride on a bench facing each other. One of them opens a bag and levels the powder, the other inserts the sabot of a strapped shot square upon the powder and draws up the end of the bag over the shot; the first man passes about 4 feet of twine through the pierced stick and makes two turns and a double hitch with the end at the top of the sabot; he makes a knot in the end of the twine, inserts it into the slit in the other choking stick, and tightens the double hitch by rolling the twine on the sticks and bearing upon the sabot; he then takes out the end of the twine from the slit, ties it in a hard knot, which he tightens with the assistance of the choking stick, and cuts the twine off near the knot. The second man turns down the mouth of the bag over the sabot and the first makes a similar tie in the groove; he makes another tie below the sabot, the twine being lodged between it and the powder to prevent the latter from sifting in between the bag and the sabot; he then runs the paper cylinder over the cartridge and sabot, leaving about two inches of the end of the cartridge uncovered, and he makes a tie similar to the others in the groove of the sabot. He now holds the shot in the left hand and examines it, striking the sabot with the right hand, if necessary, to bring it straight; if the shot be properly fixed, the sabot and the bag will have the same axis; the seams should be between two straps, and the knots should be neither on the seams nor on the straps.

The assistants pass the cartridges through the large gauge which is .04 inch larger than the large gauge for the shot. If the size be correct they put on the paper cap, lay the cartridges on their sides in the box of the hand-barrow, and carry them to the magazine. Those which will not pass through the gauge are handed back to the fixers, who cut the strings and put them up anew.

Canisters for smooth-bore field-guns are fixed in the same manner as shot, except that the first tie is made in the upper groove of the sabot; the cylinder is tied in the lower groove. The caps must be cut somewhat shorter than those for shot-cartridges.

For the mountain howitzer.—The sabots having but one groove the first tie is omitted and the cartridge is covered with a cap only.

When the shot is attached to the sabot by a single band of canvas, or when it is placed in the sabot without any strap, the cartridge-bag is drawn over it and tied on top; for this purpose the bag should have an additional length of from 2½ to 3 inches.

When sabots cannot be obtained, place upon the powder a layer of tow about .2 inch thick, forming a bed for the shot; tie the bag over the shot and around the tow; the bag requires to be 1 inch longer than for strapped shot.

PACKING FIELD AMMUNITION.

Packing-boxes for field ammunition are made of well-seasoned stuff (generally white-pine), 1.25 inch thick, dovetailed, with the tenon on the ends. The top of the box is fastened with six 2-inch screws; the box has two handles of $1\frac{3}{4}$ inch rope attached to brackets at the ends.

The boxes are painted on the outside different colors to indicate the contents of the box. Those containing shot are painted *olive;* shells, *black;* spherical case-shot, *red,* and canisters, a *light drab.* The kind of ammunition is marked on each end in large white letters. The place and date of fabrication are marked on the inside of the cover.

MANNER OF PACKING AMMUNITION-BOXES.

FOR SMOOTH-BORE GUNS.—*Shot, spherical case* and *canisters, fixed.*—Laid in two tiers across the box, the shot or canisters, alternating with the cartridges at each side. The shot or canisters of the upper tier rest on those of the lower and not on the cartridges.

Canisters are packed in the same manner, omitting the strips of wood in the bottom of the box.

FOR 12-POUNDER MOUNTAIN-HOWITZER.—*Shells* and *case-shot, fixed.*—Placed upright, the balls down, resting on strips of wood as for the other howitzer.

Canisters are packed in the same manner, resting on the bottom of the box.

FOR RIFLED GUNS.—*Shells* and *case-shot.*—Placed upright, the balls down, resting on strips of wood as for the howitzer. The iron part of the balls rests against strips of wood 4 inches wide and .25 inch thick, nailed to the side and ends of the box at the bottom, and similar strips placed between the rows of the balls to prevent the soft metal cups from bearing against the box or against each other and being bruised; the cartridges are placed on top of the projectiles.

Canisters are packed in the same manner as the case shot, omitting the strips of wood on the bottom of the box.

In all the boxes the small stores are placed in the vacant spaces on top of the ammunition.

A layer of tow is placed in the bottom of each box, and the whole contents are well packed in tow, filling the box so as to be pressed down by the cover. About 3 pounds of tow are required for a box.

AMMUNITION FOR SIEGE AND GARRISON SERVICE.

Ammunition for siege and garrison service consists of cartridges of sizes varying according to circumstances, and the following projectiles, viz:

Shot for 15, 10, and 8-inch ~~columbiads~~ smooth bore guns (model 1861) & 12", 10", 8" & 4½" rifle guns

Shells for 15, 10, and 8-inch ~~columbiads~~ smooth bore guns, and 13, 10, and 8-inch, and Coehorn mortars, and 8-inch siege-howitzer. & 12", 10", 8" & 4½" rifle guns.

Spherical case-shot and *canister* for 10 and 8-inch ~~columbiads~~ smooth bore guns, and 8-inch siege-howitzer.

The shells and spherical case shot (except for the 8-inch siege-howitzer) are attached to sabots; the other projectiles are not strapped.

CARTRIDGES.

The charge of powder for siege and garrison guns is inclosed in a cartridge-bag made of merino, raw silk, serge, cotton or paper, or of paper with woolen bottoms. Bags made of woolen or silk materials are preferable, as they are not so liable to leave fire in the guns, and are more durable; but they are much more costly.

Merino or cotton bags are cut in two pieces, in the form of a rectangle, with semi-circular ends, and sewed together to form the bag, as described in making bags for field-service. (See page 45 for manner of making and preserving them.)

Paper bags.—The paper is cut into rectangles to form the cylindrical part of the bag, the length of the rectangle being the development of the cylinder, allowing .5 inch on each side for the lap, and into circles for the bottoms. The sides of the rectangle are lapped and sewed with woolen yarn; one end of the bag is slit with longitudinal cuts, 1 inch long, .75 inch apart, and these strips are pasted on the paper bottom over a cylindrical form; or a circular piece of merino is sewed in the end of the paper bag forming the bottom.

To close a paper bag after being filled, the open end is folded down about .75 inch wide, and this fold is rolled on itself down to the powder, and the part which projects beyond the cylinder is turned in on the top of it. Two turns are taken with strong twine around the cartridge in the direction of its length, 90° apart, and then tied.

For mortars, cartridge-bags may be made in the same manner as for guns, their dimensions corresponding to those of the chamber of the mortar. But as the charge is generally poured loose into the chamber, the bag being used only for carrying it to the mortar, a gun cartridge-bag of any convenient size may be used for mortar-service.

For ricochet firing, or other occasions when very small charges are required, a cartridge-bag for a piece of an inferior caliber may be used. Or else, after the charge is poured into the bag, place on it another bag filled with hay, pressing it with the hands to reduce the diameter; after having shaken this bag down and rolled and flattened the empty part of the two bags, tie them with woolen yarn, like a bundle of musket cartridges, placing the knot on top.

For proving ordnance, cartridge-bags may be made of cotton cloth. They should be of the full diameter of the bore or chamber.

SABOTS.

Sabots are required for ~~the 8-inch canisters, for siege-howitzer, and~~ all shells and spherical case-shot for smooth-bore guns.

For canisters and the smaller guns, the sabots are turned in a lathe; for the larger calibers they are sawed from thick pine or poplar planks, and the cavity cut in a lathe, or the cavity is first cut by a tool of the proper curvature and the sabot afterward sawed out with a circular saw.

A day's work.—One man can make 350 sabots for a 10-inch ~~columbiad~~ gun in 10 hours; or 400 sabots for an 8-inch ~~columbiad~~. gun.

STRAPPING SHELLS.

The straps are cut and made as prescribed for shot for field-service, changing their dimensions. Two rings or loops of tin, .38 inch diameter, are attached securely to the slit strap of the howitzer and columbiad shells, for the purpose of attaching a handle made of cord .15 to .25 inch thick. A slit is made in the strap through which the ends of the tin loop are passed and soldered on the under side of the strap. For the handle, pass a piece of marline through both loops and tie the two ends together, leaving such length that the hand can embrace both branches.

The shells are placed in the sabot, and the straps put on in such a manner that the fuse-hole may fall in one of the angles, between two straps, and that the axis of the fuse-hole may stand at an angle of about 45° with that of the sabot. The eyes of the shell should not be covered by the straps. The straps are fastened at each end with 2 nails in the side and 2 in the bottom of the sabot.

In loading the piece care must be taken to place the fuse-hole in the upper part of the bore.

CANISTERS.

They are made and filled like canisters for field-service, except their dimensions, and, instead of being attached to a sabot, the lower end of the cylinder is slit with longitudinal cuts, .5 inch long and from .25 to .38 inch apart, according to the caliber. The strips thus formed are turned down over a cast-iron bottom plate .5 inch thick.

The cover for these canisters is of sheet-iron, .1 inch thick; it has a handle 3.75 inches long by 1.75 inch wide, made of iron wire No. 9, fastened to the cover by a strap of sheet-iron 2 inches long, 1.75 inch wide, secured by two rivets .15 inch thick.

Canisters for 8-inch siege-howitzer are attached to sabots made to conform to the bore.

GRAPE.

A stand of grape consists of 9 shot, put together by means of 2 cast-iron plates, 2 rings, and 1 bolt and nut.

The square of the nut is 2 diameters of the bolt; its thickness 1 diameter. The head of the bolt is countersunk flush with the bottom of the lower plate, which has a slot to prevent the bolt from turning when the nut is screwed on. Each plate has on the inside 3 beds for the shot, of a depth equal to half the thickness of the plate. They are made in the form of a spherical segment, the curvature of which is the same as that of the shot; their centers are on equidistant radii, midway between the edge of the bolt-hole and that of the plate. In the upper plate are 2 holes .25 inch diameter placed opposite to each other at .5 inch from the edge of the plate to receive a rope handle.

For the 8-inch siege-howitzer the stand of grape must be attached to a sabot as for canisters. The sabot may be fastened to the lower plate with screws, or the bolt may be made long enough to pass through it, or else the sabot may be inserted into the piece separately from the stand of grape.

FILLING SHELLS.

WORKMEN.—1 *man to fill*; 1 *helper.*

MATERIALS.—*Powder; cylinders* of rock-fire; *loaded fuses*; *fuse-plugs*: *tow.*

IMPLEMENTS.—1 *pair of shell-hooks*; 1 *handspike*; 2 *hand-hammers*; 2 *scrapers* (pieces of sword-blade); 2 *tow-hooks*; 2 *pairs of pincers*; *rags*; 1 *chisel* and 1 *mallet*, to clean the shells and break up any hard substances that may be found in the interior; 2 *searchers*, for sounding cavities; *shell-gauges*; 1 *grate*, to dry the shells on; 1 *fuse-saw*; 1 *gimlet*; a *ring of rope*, or a *hollow block*; 1 *funnel*; *powder-measures*; 1 *tub* or *vessel* for powder; 2 *baskets*, for the composition and fuses; 1 *rasp*; 1 *fuse-setter*; 1 *mallet*; 1 *fuse-reamer.*

The shells are cleaned inside and out, gauged, and examined that they have no defects that would cause their rejection; that the fuse-hole is not defaced; if there be water in the cavity, the shell is dried by gentle heat and cooled slowly.

TO FILL SHELLS FOR GUNS OR HOWITZER.—The helper places the shell on the block or ring of rope, the fuse-hole uppermost; inserts the fuse-plug and drives it in till the top is flush with the surface of the shell. The principal reams out the hole to its proper size, the helper holding the shell to prevent it from turning. The helper inserts the pipe of the funnel in the fuse-plug, and the principal pours in the powder and closes the hole with a wad of dry tow rammed in securely, leaving a portion of it projecting out.

When cylinders of rock-fire or other combustibles are used, they are inserted before the fuse-plug is driven.

TO FILL MORTAR-SHELLS.—Shells are generally filled and the fuses driven in the battery-magazines as they are required.

The helper places the shell on a ring of rope and inserts the pipe of the funnel in the fuse-hole; the principal pours in the bursting-charge, introduces the cylinders of rock-fire, and pushes them aside with a small stick, that they may not be in the way of the fuse when driven in. He then inserts the fuse, which should enter to within half an inch of the top, and with a mallet and fuse-setter drives it so that the end of the fuse shall project not more than .2 inch.

TO CUT THE FUSE.—The fuse is cut to the proper length, according to the range, before it is driven into the shell, by resting it in a groove made in a block to receive it and hold it steady, the saw running in a cut made for it; or the fuse may be bored through to the composition with a gimlet, at the proper length.

TO FIRE 12-POUNDER SHELLS FROM MORTARS OF LARGE CALIBER.—This kind of fire is intended only for short distances, as in the defense of a breach, and supersedes the use of the stone mortar.

Take a strong tub or half-barrel, provided with two strong rope handles, and add a second bottom on the outside, bringing it flush with the ends of the staves to which it is nailed.

To this bottom nail another, made of a single piece of wide 2-inch plank of sufficient length to support the ends of the staves. A block of light, dry wood, of the diameter and length of the bore, is attached to the bottom of the barrel or tub by nails, and the lower end of the block which goes next to the charge is covered with sheet-iron.

The fuses of the shells are cut, driven, uncapped, and the shells placed in the barrel, the fuses turned down. When the bottom tier is finished a second one is laid, and so on to the last, which is covered over with hay, which is rammed in to keep the projectiles in place.

The charge of powder is put in the mortar, the proper elevation and direction are given, and the barrel or tub, loaded, is raised by the handles, the block wiped clean and introduced into the bore and set home.

WADS.

Wads are used to prevent the ball from rolling out in firing at a depression.

MATERIALS.—*Junk* or *hay; marline.*

IMPLEMENTS.—One *wad-mold*, with two holes for each caliber, made of cast-iron cylinders set in oak, or of two strong pieces of oak strapped with iron and joined by a hinge; 1 *drift* for ditto; 1 *mall.*

TO MAKE WADS.—The hay or junk, after having been picked, is compressed by being beaten in the smaller mold, until it assumes the requisite dimensions; it is then taken out, by raising the upper part of the mold, and wrapped closely with rope-yarn passed over it in the direction of the axis of the cylinder, and fastened by a few turns round the middle of the wad; after which it is placed in the large mold and again beaten with the mall and drift; the diameter of the wad when finished is verified by a wooden gauge corresponding to the large gauge of the shot.

Ring-wads or grommets are to be preferred where the object of a wad is merely to retain the ball in its place. They consist of a ring of rope-yarn, about .7 inch thick, with two pieces of strong twine tied across it at right angles with each other. The size of the ring is the full diameter of the bore, in order that it may fit tight. These wads may be attached with twine to the straps or to the balls, or they may be inserted, like other wads, after the ball. These wads may be made of straw formed into rings of the proper size and wrapped with twine and tied to the ball.

SABOTS OF SHAVINGS.

In positions where the pieces of sabots might prove dangerous to our own troops, as in firing over their heads when making an attack, sabots made of thick shavings of soft wood or pasteboard are used. For this purpose select black-walnut, pine, or fir, not too dry, and as free as possible from knots.

Pieces of the proper length and width are dressed out, and by means of a coarse plane, shavings are cut .06 inch in thickness. Each shaving is rolled in a circle on a cylinder of iron, in which a longitudinal groove is cut. One end is thinned down, moistened and inserted in the groove, and the shaving is rolled on the cylinder, the smooth side turned outward; one man turns the cylinder by a crank, making three revolutions, the other holds the shaving so as to roll it evenly on itself, pulling it tight.

The different turns are then tacked together, the tacks being riveted on the inside against the iron cylinder; the end is thinned down with a rasp, and the sabot taken from the cylinder is immersed in a warm bath of thin glue. Pasteboard may be used instead of shavings of wood. The sabot is attached to the shell by means of four pieces of tape 1 inch wide. Each piece is folded around the sabot, and the ends sewed together; the seam is turned on the inside of the sabot, and is made fast to it by tacks, the four pieces of tape being attached to the sabot at the extremities of two diameters perpendicular to each other. The sabot is laid down on the table and the shell placed in it, the fuse-hole down; the ends of the tape are then drawn together and tied on top of the shell with a piece of strong twine.

FUSES.

FUSE-PLUGS.

Fuse-plugs are made of brass or of close-grained wood, well seasoned. They are turned to a size a little larger than the fuse-hole, but of the same taper, 2.5 inches long; a hole is bored through the axis and reamed out to receive the paper fuse, and the large end is counterbored and tapped to receive the water-cap.

If wooden plugs be used, a short, hollow cylinder of brass, .5 inch long, .15 inch thick, is inserted in the recess before the plug is driven, and afterward tapped to receive the water-cap.

The water-cap is a brass plug, .5 inch long, .6 inch in diameter, chased with 12 threads to the inch. One end has a shallow recess cut in it, .1 inch deep, larger at bottom than at top; a hole .1 inch in diameter is bored through the middle of the cap, and a hole is bored from either end into this transverse hole, but meeting it at points .25 inch or more apart; these and the recess in the end are filled with mealed-powder paste.

Dimensions.—Diameter of hole at bottom of recess, .53 inch; at small end, .4 inch.

Fuses for projectiles may be divided into three kinds—

Time-fuses.

Percussion-fuses.

Combination-fuses.

The time-fuse serves to explode a projectile during flight, or at the end of a given period of time after its discharge from the gun.

The percussion-fuse, rifled guns, serves to explode projectiles at the instant of striking a resisting object.

The combination-fuse serves to explode a projectile either during flight or on impact.

TIME-FUSES.

The time-fuse is composed of a column or ring of fuse-composition, driven or pressed into a suitable metal, wood, or paper case. The proportions of the composition vary according to the time it is intended to burn.

The service time-fuses comprise three varieties, viz:

Wooden-case mortar-fuses.

Metal-case (Bormann) fuses.

Paper-case fuses.

FUSES FOR MORTAR-SHELLS.

The hard, close-grained woods are best adapted for making fuses; beech or ash is generally used. It should be dry, sound, free from sap, knots, worm-holes, or shakes.

TO TURN THE FUSE-PLUG.—The helper saws the plank into lengths equal to that of the fuse, and then into prisms, taking off the edges, and centering it on each end. The turner puts the fuse-plug thus roughed out in the lathe, turns its exterior, and graduates it, by means of a steel gauge, into inches and tenths of an inch, commencing at the bottom of the cup. When a number have been turned, the turner puts each fuse-plug into a chuck, bores it, and makes the cup with a tool for that purpose.

The fuse-plugs should be carefully inspected, and verified with gauges, and those rejected which have splits, knots, or worm-holes, or which have not the proper dimensions.

A day's work.—One turner can turn 500 fuse-plugs, or turn and bore 250, in ten hours.

TO DRIVE FUSES.

MATERIALS.—*Empty fuse-plugs, fuse-composition,* dry; *mealed powder,* dry; *paste; paper.*

UTENSILS.—*Driving-blocks,* with holes of the size of the fuse-plug; *benches; mallets,* for the 13-inch, 10-inch, and 8-inch fuses, weighing 1 pound, for smaller fuses, weighing ½ to ¾ pound; *steel drifts,* shod with copper, the shortest with a mark .2 inch from the end; *copper ladles,* to contain sufficient composition to make a height, when driven, equal to 1 diameter of the bore; *copper-pans; brushes.*

Preparation of the composition.—The composition for 8 and 10-inch light mortar-fuses, is 2 parts of niter, 1 of sulphur, and 3 of mealed powder; for 10 and 13-inch heavy mortars, 2 of niter, 1 of sulphur, and $2\frac{1}{4}$ of mealed powder. The composition must be thoroughly ground and mixed with a muller, or in a leathern barrel, with brass balls. The time of burning will vary according to the quality of the materials used (especially of the mealed powder) and the degree of their admixture. Trials should be made with each composition by driving several fuses and getting their time of burning. There should not be any great variation in the times of burning of the different fuses of the same composition. Fuse-composition should be prepared only a short time before being used, and should be preserved in close vessels in a dry place.

Driving.—The workman is seated, his driving-block in front of him, and a bench to hold a pan of composition at his right hand. He takes a fuse, cleans it of all foreign matter, inserting the drift to the bottom of the bore. He then drops the fuse-plug into the driving-hole, takes a ladleful of composition, passing the drift along the edges of the ladle to strike off the surplus; pours the composition into the fuse-plug, strikes it two gentle blows with the mallet, inserts the drift, pressing it down on the composition, giving the fuse two slight blows to settle the composition. The workman strikes the drift 21 blows in volleys of three, raising the mallet about one foot each blow, and moving the drift after each volley. He puts in another ladleful, and continues as for the first. Care should be taken to put in equal charges of composition each time, and to give to each ladleful the same number of blows and with the same force.

Fuses may be driven by pressure in a screw-press.

Priming.—Fuses are all driven to the same height by means of a mark on the short drift, or the composition is bored out with a gouge to the same depth. They are primed with mealed powder for about .2 inch, driven with the same force as a ladleful of composition. The cup is filled with a paste of mealed powder and spirits of wine or strong whisky, and laid aside to dry; it is then covered with a small piece of paper, over which is pasted a cap of strong, water-proof paper, marked with the number of seconds the fuse burns to the inch.

TIME FUSES FOR GUNS.

The fuse consists of a *paper case* charged with fuse composition; it is inserted, at the time of loading the gun, into a brass or wooden plug previously driven into the fuse-hole of the shell.

TO MAKE THE CASES.

MATERIALS.—*Log-paper*, or thin drawing-paper; *isinglass.*

UTENSILS.—*Pattern* of wood, in the form of a rectangle joined to a trapezoid; *iron former*, .35 inch diameter; *knife; glue-pot; brushes.*

MAKING THE CASE.—The paper is cut to the proper size by means of the pattern. The whole length of the strip must be determined, by trial, for each kind of paper, to give the case the proper diameter. The strip is rolled hard on the former, beginning with the large end, and is glued after the first turn. When the case is dry, it is smoothed with a fine file or sandpaper.

PREPARATION OF THE COMPOSITION.—There are different compositions used, one inch burning 2.5, 5, 10, 15, and 20 seconds respectively. Their time of burning is subject to considerable variation, according to the quality of the ingredients, and the manipulation in mixing them; the exact proportions must be determined by experiment.

The composition is carefully mixed as described on page 65, and several fuses are first driven and their times of burning determined, and the proportions varied, if necessary, to produce the required result.

TO DRIVE THE FUSE.

MATERIALS.—*Empty cases; fuse composition.* Two pounds of composition are required for 100 fuses.

UTENSILS.—*Brass molds* in two parts, which are held together by a wedge or cam; the molds have holes for 4 or 5 fuses; steel drifts, .35 inch diameter; *knife; mallet,* weighing ½ pound.

DRIVING.—The mold is put together and secured; the empty cases are inserted and driven gently in; their upper ends, projecting above the mold, are slit with a knife into four parts. The composition is put in and driven as described on page 65, giving 15 blows to each ladleful, which will make .25 inch in length of the fuse.

They are next primed by covering the larger ends with shellac varnish and dipping them into rifle powder; when the priming has set, the entire fuse, except the priming, receives a coat of shellac varnish.

The fuse is stained the proper color, according to the composition used, and the number of seconds that one inch will burn is marked on each fuse.

CUTTING.—The fuse is inserted in an iron gauge, the bore of which is the same size and taper as the fuse, and its width is the true length of the fuse—2 inches. The projecting ends of the fuse are first sawed off with a fine saw and then trimmed with a knife.

They are packed in wooden blocks (poplar), bored to receive 5 fuses each, and these blocks are wrapped in various-colored paper, to distinguish the different times of burning, having a printed label setting forth the kind of fuse, and place and date of manufacture, &c.

The fuses are applied to projectiles, by inserting them in wood or metal plugs, which are driven or screwed into the fuse-hole of the projectile.

For sea-coast service, the paper-case time-fuse is inserted in a metallic plug fitting the projectile. The metallic plug is fitted with a screw-cap, called a water-cap, having a crooked passage, through which, by suitable priming, flame is communicated to the fuse, and the escaping gases are intended to exert sufficient pressure to prevent the entrance of water to extinguish the fuse, especially with spherical projectiles.

The insertion of the fuse in the rear end of the rifle projectile has been proposed to dispense with the use of the water-cap, but the enormous force exerted on the projectile, while in the gun, has been a serious obstacle to the practical use of a rear fuse.

FUSES FOR SMOOTH-BORE FIELD-GUNS AND MOUNTAIN-HOWITZERS. (Plate.)

A fuse for shells and spherical case-shot for field and mountain service is that known as the "Bormann fuse." It consists of a circular disk of soft metal, containing an annular space charged with mealed powder. The outer circumference of the disk is chased with the threads of a screw to secure it in the shell. The annular space for the composition is concentric with the outer circumference, and connects at one end by a hole with a small magazine in the center of the disk, filled with rifle-powder, and closed on the under surface by a thin disk of tin. The fuse is charged from the under side, by pressure, and a ring of the same metal is pressed firmly on the composition.

The composition is thus securely protected from accidents, and the fuse is screwed into the shell in the laboratory. The metal covering the composition on top, being left thin, is easily cut with a knife or cutter at the moment of loading, and the composition exposed at the required point to the action of the flame. The graduations into seconds and quarter-seconds are marked on the upper surface of the disk.

The time of burning of the whole length of fuse is 5 seconds.

TO CAST THE FUSE.

MATERIALS.—*Tin* and *lead* in equal parts; *rosin; tallow.*

UTENSILS.—*Molds* for the fuse; *molds* for the ring; *hacksaw; nippers; mallet; kettle; ladle.*

CASTING.—Melt the lead and tin together; heat the molds so as not to chill the metal in casting. Fill the mold with the melted metal, and tap it gently with the mallet to make the metal fill the small parts. Cut off the gate with the saw, and the ends of the ring with the nippers.

It has been found convenient in opening and closing the molds to attach the two parts of the mold for the fuse and also for the ring to the jaws of a bench-vise, so that both molds are opened and closed by the same movement of the screw. The fuse-mold is kept hot by means of iron disks, which are heated and hung on the arbor which supports the molds.

A mold of more approved pattern has been devised, by which the casting is expedited.

TO CHARGE THE FUSE.

MATERIALS.—*Mealed powder; musket-powder; rifle-powder; disks of tin*

UTENSILS.—A strong *screw-press; annular charger* the size of the ring; *annular drift; flat drift; round drift.*

Take the mold in which the fuse was cast, place the fuse in the parts of the mold containing the screw and the upper or graduated side, and secure the mold by a ring driven on it.

Draw up the piston, and fill the charger by pressing it into the mealed powder contained in a shallow pan; place the charger over the groove and force down the piston, transferring the powder into the fuse; insert the button in the magazine and the pin in the priming hole to preserve their shapes; place the ring on the powder, and, with the annular drift, force it down by means of a strong screw-press, bringing the ring flush with the surface of the fuse; rivet the ring in its place with another drift; withdraw the button and the pin, charge the priming hole with rifle-powder, and fill the magazine with musket-powder; cover the magazine with a disk of tin, and rivet it in place by means of, first, a flat drift, and then a round one, which turns down a part of the metal of the fuse over the disk.

Remove the fuse from the mold, place it in a screw-chuck made to fit it, and turn off in a lathe the lower surface smooth and to the proper thickness.

The powder of the fuse is now perfectly sealed up from the air. The fuse should be varnished.

Fuses.

Dimensions and weights.					Wooden fuses.			Paper fuses.
					13-inch.	10-inch.	8-inch.	
Fuse	Whole length			inches	10.8	9.4	6.3	2
	Diameter	At top		do	1.85	1.7	1.25	.53
		At bottom		do	1.25	1.0	.9	.4
		Of bore		do	.4	.3	.3	.35
First cone	Length			do	2.8	2.25	1.25	....
	Diameter at lower end			do	1.65	1.55	1.15	....
Cup	Depth			do	.6	.5	.4	....
	Diameter	At top		do	1.25	1.0	.75	....
		At bottom		do	.9	.8	.6	....
Thickness of wood at bottom of fuse				do	1.2	.9	.9	....
Length of composition				do	9.0	8.0	5.0	2.0
Drifts	Diameter			do	.36	.27	.27	.3
	Length, exclusive of handle	First		do	9.0	8	8	....
		Second		do	4.5	4	4	....
Weight	Of composition for 100 fuses			pounds	8	4	2.5	2
	Of 100 fuses complete			do	54	33	16	....
Paper for the case	Whole length			inches	....	....	....	19
	Length of rectangle			do	....	....	....	6
	Width of rectangle			do	....	....	....	2.25
	Width of small end			do	....	....	....	.4

Bormann fuse.

Diameter of fuse, including threads	1.65 inch.
Thickness	.45 inch.
Number of threads to the inch	12
Diameter of plug, including threads	1.07 inch.
Thickness for field-guns	.3 inch.
Number of threads to the inch	12

PERCUSSION-FUSES.

Many varieties of fuses have been used in service, under the names of percussion and concussion fuses.

Among the simpler ones, the *Absterdam*, *Hotchkiss*, *Parrott*, and *Schenkl* may be named. They are much alike in their general features.

They consist of hollow metallic screw-plugs to fit the fuse-hole of the projectiles. A loosely fitting plunger is inserted in the bore of the plug, the front end of which is closed by a screw-plug or cap. On the forward end of the plunger, a percussion cap, or rather detonating device is arranged, to be exploded, and communicate fire to the bursting charge, through an opening at the rear, by the plunger striking the plug or cap when the motion of the projectile is arrested.

Various safety devices are used, having sufficient strength to prevent the plunger being thrown forward by shocks in transportation, &c., but weak enough to be broken by the shock of discharge, or impact of the projectile, as the case may be.

HOTCHKISS PERCUSSION-FUSE,

Consists of a metal body, A, closed at the front end with a screw-cap, B; it has a conical hole at the rear, which is closed with a lead plug, C (the safety plug), pressed in very tightly, so that the plug projects a little through the base of the body-case, toward the inside.

The plunger D is composed of lead, cast into a brass casing, to strengthen it and to prevent the lead being upset by the shock of discharge. Two brass wires, F, cast into the lead, on opposite sides of the plunger, hold it suspended in the case, the wires going through the hole in the bottom of the case, and being held securely in position by the safety-plug. The plunger has a nipple cast into the lead, and is primed with an ordinary percussion cap; in its axis, it has a powder-chamber, G, containing the igniting charge.

The operation of the fuse is thus: The safety-plug is dislodged backward into the interior of the projectile by the shock of discharge; the wires then being not held tight in the hole, the plunger is disengaged and rests on the bottom of the fuse-case, and is free to move in the line of axis.

When the flight of the projectile is suddenly retarded by its striking any object, the plunger, in consequence of its inertia, is driven forward, and the primer strikes against the screw-cap, thus igniting the powder in the channel, and so firing the bursting-charge of the projectile.

Recent trials have been made with this fuse, of which several thousand have been fired, with less than one-tenth per cent. of failures.

COMBINATION FUSES.

Many varieties of combination fuses have been proposed and tested, but without satisfactory results.

This kind of fuse would be best adapted to general service if perfected.

If a perfect combination fuse can be made, none other would be required, as it would have the properties of the other two, capable of use separately or combined.

Granting certainty of ignition of the time element, only one kind of fuse would be required for all kinds of service.

A good one should possess, in one structure, the properties of the most perfect time and impact fuses. It should be simple in construction, safe to handle and transport, and easily applied to the projectile.

It is the opinion of many who have given the subject much study, that no fulminate or friction composition should enter into its construction, except perhaps to insure the ignition of the time element of the combination. Certainty of ignition by the gases in the gun, is not always attainable, especially with rifle projectiles and breech-loading cannon which have but slight windage; therefore some form of inertia igniter is necessary.

Such igniters are simple and easily made, and may be arranged for attachment to the fuse at the last moment before loading the gun, thereby avoiding all risk of accident in transportation, &c.

The above conditions exclude all but a few of the devices subjected to trial, and the subject is still unsettled and under test. No one variety of the many offered for test has given sufficiently satisfactory results to warrant its adoption.

STORAGE AND PRESERVATION OF AMMUNITION AND FIREWORKS.

Storehouses and magazines should be kept in the neatest possible order, the stores arranged, as much as possible, by classes, kinds, and calibers, and labelled. They should be ventilated from time to time, in the middle of the day, in fine weather, particularly those which contain ammunition and fireworks, which are injured by moisture.

Provide cloth blinds for all windows exposed to the sun.

Leaden balls are generally kept in cellars, on account of their weight; the boxes should be kept as dry as possible, and so piled as to admit the circulation of air about them.

Cartridges for small-arms are kept in magazines, the barrels or boxes being piled 3 or 4 tiers high at most.

Fixed ammunition for cannon.—If not in boxes, it should be placed in piles formed of two parallel rows of cartridges, with the sabots together, in 4 tiers for 12-pounder; chock the lower tier with strips of wood fastened with small nails; put a layer of tow 2 inches thick between the shot; let the piles rest on planks, if there be no floor, and cover them with paulins; have the place swept, and the cartridge-bags brushed off. Leave a passage of 18 inches between the double rows, and keep them 2 feet from the walls.

Fixed ammunition should not be put into powder-magazines if it can be avoided; it should be kept in a dry place, above the ground-floor if practicable. The store-rooms should be always aired in fine weather; the piles should be taken down and made up again every six months at most, the bags examined and repaired, and the damaged cartridges broken up. A ticket on each pile should show the number and kind of cartridges, the additions to the pile, and the issues.

Canisters.—Piled up like fixed ammunition, in 4 or 5 tiers. Empty canisters in 10 or 12 tiers, the bottoms and covers separately.

Cartridge-bags, filled.—Like fixed ammunition, or packed in boxes or barrels.

Cartridge-bags, empty.—In bundles of 50, sealed up in paper cases, carefully closed with strips of thin paper pasted over the seams.

Paper cartridge-bags.—In bundles, or packed in boxes or on shelves, in a dry place, with pounded camphor and black pepper or tobacco, the flannel bottom dipped in a solution of the sulphate of copper.

Loaded shells should never be put into magazines, except from absolute necessity; powder is not well preserved in them. They should be piled on the ground-floor of a secure building, on planks, if the floor be not boarded, in 6 tiers at most; the fuses of the lower tier, in the vacant spaces between the shells; those of the other tiers, turned downward, like the fuse-holes of empty shells. The pile should be covered with a paulin.

Use the same precautions against moisture and accidents as in a powder-magazine.

Canister-shot.—Keep them, the different kinds, together, in bins or boxes.

Slow-match.—In a dry place, such as a garret, in boxes or barrels, or piled on the floor.

BREAKING UP SMALL-ARM AMMUNITION.

PAPER CARTRIDGES.

In breaking up small-arm ammunition, the tables should be arranged against the sides of the room, and in front of them, on the floor, boards one foot wide are secured on edge, so as to leave a space of three feet between them and the tables, inside of which the workmen stand and the scrap paper is thrown. By these means the center of the floor remains clear, and should be kept wet.

Each workman should be provided with small wooden boxes or copper pans, one for powder, one for caps, and one for bullets.

The tables should be kept as clean as possible, counter-brushes being provided for that purpose.

A square copper box, with screw top and a capacity of about 100 pounds of powder, is placed at one side of the room; into this the men empty the powder obtained; a large copper funnel, 18 inches wide at the top, is used to prevent the powder from spilling on the floor. When the box is full, it is carried to the magazine on a hand-barrow, the contents packed in barrels and piled up.

One man is detailed to collect, count, and pack the caps, sweep the floor, and keep it wet, &c.

Powder should be removed from the tables and emptied in the box very frequently.

About 200 box s of cartridges are brought from the storehouse at one time and piled in a shed for that purpose adjacent to the workshop. The boxes should be opened in the shed.

No more cartridges than are actually needed to work on, one box for each man, should be allowed in the shop at a time.

A space on the table three feet wide is allotted to each man, a partition one foot high being the dividing line.

The box containing cartridges is placed on the table to the left; about 20 packages are opened at a time, the cartridges emptied into one end of the bullet-pan, which should set directly in front of the workman.

Take a cartridge with the thumb and forefinger of the right hand, remove the bullet and drop it in its pan, and empty the powder in the receptable intended for it.

Burnside's, metallic; Maynard's, metallic; Smith's, foil and rubber; Gallagher's paper and wrapped metal, and all other metallic cartridges are broken up by the hand-breaker, unless it be a cartridge otherwise provided for.

Brass shells, before being packed, should be taken to an open place on the ground, some distance from the buildings, spread out two or three inches deep in a space about 10 feet square, and sprinkled with a little powder; a match is then applied, and any powder which may chance to be in the shells is thus burnt out.

Brass shells should never be soaked in water, especially those lined with paper, for they are never afterward thoroughly dried until melted in the crucible.

The hand-breaker is composed of brass and wood, and is 7 inches long. The blade is of brass, $\frac{1}{8}$ inch thick, 1 inch wide and 4 inches long; oak handle 1 inch square, edges rounded, and 5 inches long. A slot 2 inches long is sawed into one end of the handle; into this slot 2 inches of the blade is inserted; two holes are bored through for rivets that firmly secure the blade in its place. A hole of the size to suit the ball of the cartridge to be broken up is drilled through the projecting end of the blade about $\frac{1}{2}$ inch from the end.

In using this instrument hold it firmly in the left hand over the bullet-pan; insert the bullet end of the cartridge in the hole and pry upward; the bullet drops out and the powder is disposed of as previously directed.

When breaking up shell-cartridges with a wad between the bullet and powder, the bullet should be removed from two or three hundred before working at the powder. A small brass pick and scraper combined is used, with the edges and point sharpened, with which the wad is removed and the interior of the shell scraped.

DESCRIPTION OF MACHINE FOR BREAKING UP METALLIC CARTRIDGES.

The machine consists of a *box*, *drawer-frame*, *drawer*, *magazine*, *firing bolt*, and *firing-bolt bar*.

The *box*, 2 feet wide, 4 feet long, and 3 feet deep, is lined with $\frac{1}{8}$-inch boiler-iron. The lining should taper inward toward the bottom from both ends and sides, forming an oblong shaped funnel, the bottom opening being about 1 foot wide by 3 feet long. At each end of the box inside, screwed on about the center, is an upright cleat, oak, $2\frac{1}{2}$ inches wide by 2 inches thick; it extends from the bottom edge of the box to within 1 inch of the top. A rabbet 1 inch deep and $1\frac{1}{2}$ inch long is cut out of the front of the cleat at the top; the shoulder thus formed serves as a rest for the magazine, and the top of the cleat answers the same purpose for the firing-bolt bar. The cleats are covered with the same kind of iron as the box is lined with. The iron should be cut in strips and screwed on. The front is covered first, the covering extending from the bottom of the rabbet to the lower end of the cleat. Cover the sides the same way, except that the strips extend to the top edge of the box; this will form a receptacle at the top end of the cleat, and serve as a slide for the magazine and bolt-bar that will prevent them from shifting out of place. The cover of the box is made of the same kind of iron as the lining, and in two parts, forming front and back covers; they rest on cleats screwed on the ends of the box inside, and extend from the top edge of the perpendicular cleat to the front and back of the box, the lower end being about 10 inches below the top edge of the box; the covers thus rest on an angle of about 45°. The top edges of the cover should fit snugly against the sides of the firing-bolt bar, but not so as to prevent its being taken out and replaced freely. The back cover may be made fast, as it is not necessary to remove it; the front one, however, has to be removed at every discharge of the magazine, and for this reason has to be a little loose. Oak strips 1 x 2 inches are screwed on the tops of the covers at the lower and upper edges to prevent the iron from warping; the upper one on the front cover also serves for a handle.

The magazine is made of iron, has two plates riveted together, the large or upper plate to be ½ inch thick, 2½ inches wide, and long enough to fit in the box lengthwise, its end resting on the rabbet cut in the cleat, the small or lower plate to be ¼ inch thick and 1½ inch wide. Twenty holes, ¾ inch in diameter, are drilled through the large plate on a center line from end to end. They should be one inch apart and commence about 6 inches from the ends of the plate. The small plate is then riveted to the large one, the rivet-holes coming between the large ones. The holes for the cartridges are then drilled through the small plate, and should be a little larger in diameter than the cartridge, but not so large as to destroy the shoulder or bearing for the flange of the shell.

The firing-bolt bar is made of wood, white oak, 2½ inches wide, 2 inches thick, and about 2 inches longer than the magazine. Holes for the bolts should be bored so that they will come directly opposite the holes in the magazine. Care must be taken to have this correct. Iron washers are screwed on the under and upper sides of the bar over each hole, to prevent their wearing by the action of the bolts. (No. 2 washers for bolts are just the size. See page 71, Ordnance Manual 1861.)

Firing-bolts are made of ½-inch round bar steel. They are 7 inches long; about 6 inches are turned off in the lathe to fit the holes in the bar; the other inch forms a head, which is the firing end of the bolt. About 2 inches from the other end a hole is drilled through to receive a pin. The bolts are then put through the holes in the bar and pinned. This gives them a play of 4 inches. The firing end of the bolt-head end should be hard, and the striking end soft.

The frame upon which the box rests is made of 2-inch pine, and is 1 foot high (the box is designed to set inside this). Two sides and one end are closed. Cleats are nailed inside, about 1 inch from the top edge. Upon these the box rests. The other end of the frame is left open for the drawer.

The drawer should be made of $\frac{3}{16}$-inch boiler-iron and water-tight, and so constructed that when it is in its place under the box the top edges, both ends and sides, will extend as far as possible inside the lower edges of the lining of the box, thus preventing the bullets and pieces of copper from dropping behind the drawer.

Three men are required to operate the machine: one to load, one to fire, and one to eject the fired shells from the magazine. An open box 5 feet long (an ordinary musket-box answers the purpose) is set at the end of the machine, to the right, across the opening, and about 9 inches from each end. Toward the center a flat strip of ½-inch bar-iron is attached, the ends projecting about 10 inches over each side of the box. These are to rest the magazine on when being charged, and also when the shells are being ejected. They should be far enough apart to catch the magazine about 2 inches from the ends, so as not to interfere with the holes.

Three or four magazines are required; also, 2 small hammers, punch, &c.

The packages of cartridges should be opened and contents emptied into a small box, which should set alongside of the loader.

Everything is now ready to commence operations. The loader (operator No. 1) seats himself at the front of the shell-box, takes a handful of cartridges in his right hand and charges the magazine; passes it to the firing operator (No. 2), who places it on its rest in the firing box; takes the firing-bolt bar (which may be placed on the back cover when not in use), sets it on the magazine so that the heads of the bolts drop into the holes; throws down the front cover, that has in the mean time been lifted, takes the hammer from a convenient place and strikes each bolt one smart blow in quick succession. He then lifts the cover and rests it against the front of the box inside, takes out the firing-bolt bar, and lays it on the back cover; takes out the magazine and passes it to operator No. 3, who sits directly opposite the loader. No. 3 then examines it, to ascertain if any of the cartridges have missed fire; if so, he takes them out and places them in a small box for that purpose, turns the magazine, small holes up, punches the remaining shells out into the open box, and then slides it across to No. 1; the other operations in the mean time continuing.

The drawer may contain water or not. There is less smoke, however, when water is used, as the ignited powder is sooner extinguished.

When about 5,000 cartridges have been exploded, the bullets are removed from the drawer and washed, and whatever pieces of copper are among them picked out. Three men can break 10,000 in 8 hours.

All primed cartridges, rim and center fire, can be broken up by the above process. The firing ends of the bolts should be pointed for the latter. Of course the larger the cartridge the more necessary it would be to have the box larger and stronger.

NOTE.—An improvement is contemplated for the purpose of preventing the pieces of copper from dropping among the bullets. This improvement would necessitate the enlargement of the box, and instead of one drawer three would be required.

The box would be partitioned off lengthwise into three compartments, the top edges of the two center partitions to be about 2 inches below the points of the bullets as they hang in the magazine. The pieces of copper always strike the cover and fly toward the front and back of the box, and would consequently drop down the side compartments, the bullets dropping down the center one.

BREAKING UP SERVICE SMALL-ARM METALLIC AMMUNITION.

UTENSILS.—1 *bullet-extractor;* 1 *wire screen;* 1 *bench;* 2 *large buckets; cylindrical wire screen; tubs* or *troughs; iron pans.*

The wire screen is fastened to one end of the bench; one of the buckets is placed under the screen, the other at one side, each two-thirds full of water.

The operator, sitting astride the bench, withdraws the bullet with the extractor, over the wire-screen, which allows the loose powder to fall through into the bucket. The powder is washed from the cases in the cylinder, which revolves over the tub or trough, a constant stream of water passing through the cylinder into the trough. The water being drained from the cases, they are placed in the iron pans, which are put one above the other in a furnace, where the percussion composition is burned out.

The caps of outside primed cartridges are extracted with a hand instrument devised for the purpose.

PRECAUTIONS.—Allow no accumulation of scattered powder on benches or floor. Watch the buckets to see that dry powder does not accumulate on the surface of the water. The powder of each cartridge should be destroyed as soon as the bullet is withdrawn. Experience has shown that there is no economy in attempting to save it.

To prevent carelessness, the work should be done by the day and not by the piece.

Five men can break up 10,000 cartridges in 10 hours.

For safety and economy it is proposed to break up small-arm ammunition by machinery, arranged to fire the cartridges and save the bullets and cases.

BREAKING UP UNSERVICEABLE STORES.

FIXED AMMUNITION FOR CANNON.—1 *paulin;* 1 *box;* 2 *barrels;* 1 *knife;* 2 *brushes;* 1 *punch;* 1 *hammer;* 1 *scraper; tow;* a *tub* half full of water, to clean the balls; *stools.*

One man holds the cartridge over the box, while another cuts the twine near the knot, takes off the strapped shot, brushes it, and stands it on the paulin on its sabot; the first man pours the good powder into a barrel, the caked powder into another, turns the bag wrong side out and cleans it. The strapped shot are taken to the door of the laboratory, where the shot which still require cleaning are separated from their sabots and immersed in the tub of water; after standing some time they are washed and cleaned; the others remain strapped. The serviceable, reparable, and unserviceable cartridge-bags are separated from each other; the last are immersed in water and used for rags; the pieces of twine are tied up in bundles; the shells are put aside to be unloaded and cleaned in a like manner.

The breaking up of fixed ammunition requires many precautions, and should never be done in the magazine, but as much as possible in the open air. Never have but little powder and a few cartridges in the shop at one time.

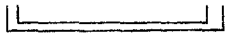
CANISTERS.—Turn up the slit ends of the canisters by means of a small chisel; take off the cover and pull out the balls and sawdust into a box by means of a hook; take out the bottom plate and straighten the cylinder with a mallet on an anvil.

PORT-FIRES.—Split the paper; take out the composition, and pulverize it by rolling for two hours. It may be made to burn more or less quickly by adding mealed powder or sulphur.

UNLOADING SPHERICAL CASE AND SHELLS—BORMANN FUSE.

FIXTURES consist of *tables, protector, water-boxes, drill-presses, drill-braces, drills, &c.*

The table on which the protector is placed is about 3 feet high, and is necessarily heavy, the top being 6 feet long, $2\frac{1}{2}$ feet wide, and 3 or 4 inches thick.

The protector is composed of iron; the bottom and top plates have bent ends, thus, ; they are $4\frac{1}{4}$ feet long and 12 inches wide. Near each end, leaving space enough between them and the bent ends for the admission of the end plates, two 1-inch bolt-holes are drilled; and eighteen inches from each of these, toward the center, corresponding sized holes are drilled, making eight bolt holes in each plate These holes are extended through the table.

The bottom plate is laid on the table, bent ends up, and its front edge flush with the front edge of the table; the end plates (18 inches long, 12 inches high) are set edgewise on the bottom plate against the bent ends; the top plate is laid on, bent ends downward. The bolts are passed through from beneath the table, thread end upward, the nuts are adjusted and screwed down to keep the plates together, and the middle or partition plates are fixed in position. Two partition plates are necessary in consequence of the front plate having a hole in the center (being an O. P. 15-inch pintle-plate), a partition being placed each side of the hole.

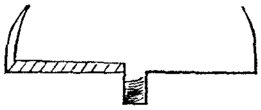
Three compartments are thus formed in the protector, but the middle one being useless is filled in with a block of wood. A hole $1\frac{1}{4}$ inch in diameter is drilled through the top plate over the center of each of the working compartments for the entrance of the drills.

The lower edge of the front plate rests on wooden supports; the upper edge projects about one inch above the surface of the top plate; it is held in position by four braces, one lower and one upper, at each end, shaped thus 

The outer ends of the braces are bolted to the corners of the plate, and the inner ends are clamped together by means of a screw-bolt and nut; the bolt passing through the table and bolt-braces.

The water-boxes are made strong, about 7 inches deep. They are 16 inches long and 10 inches wide, outside measurement. The ends are 4 or 5 inches thick. Having the box in the same position in its compartment every time it is replaced is essential; and for this purpose strips are made fast to the bottom plate to serve as guides for the box to slide between.

The drill-presses are fixed to the table at each end of the protector and have sliding arms. The thread-end of the perpendicular bar passes through the table, and by means of a nut is firmly fastened. The sliding arms have set-screws, one to make it fast to the perpendicular bar, and one at the other end to press on the drill-brace. The press is so attached to the table that the points of the set-screws are in a direct line above the drill-holes in the top plate. The drill-braces are iron; one end having a socket for the drill, and the other end is countersunk for the point of the set screw.

The drills are steel and are about 10 inches long; the small ones are ¼ inch wide at the drill-end and pointed; the large ones are 1¼ inches wide and ⅛ inch thick at the drill-end. The blade has a round blunt point projecting from its center, and is straight each side of the point, with slightly beveled opposite edges, thus 

A smaller table is used in the operation of removing the iron plugs, the water-box for this purpose being screwed fast to the surface of the table; a small iron wrench with two teeth to fit the holes in the plug, is used. A bench-vise should be attached to this table. A small hand-punch, monkey-wrench, heavy riveting-hammer, and a small ½-inch cold-chisel, are necessary tools.

A tub or iron pot, to hold water, in which to place the shells after having the plugs removed, is used.

When *case-shot* are being unloaded a heavy hand-hammer is needed to strike the shell on the outside so as to crack the casing inside.

All *spherical projectiles* can be unloaded by the above plan; and if the following directions are carefully followed explosions cannot possibly occur.

First.—Fix the shell firmly by means of a wooden wedge in the water-box. Be sure that the quantity of water in the box is sufficient to cover the fuse; then slide the box in its compartment in the protector so that the location of the fuse is in a direct line beneath the drill-hole.

Second.—Place the point of the small drill on the center of the fuse, and set the other end into the socket of the brace, lower the brace on the drill to avoid displacing the point; bore the hole through the fuse and iron plug, if a Bormann fuse; remove the drill and work the water into the powder with a brass wire; set the large drill in the same manner as the small one, and remove enough of the fuse to uncover the entire surface of the iron plug; remove the shell from the box and put in the water-tub.

Third.—The shell is taken from the tub by another operator, who secures it in the fixed water-box, and with the cold-chisel cuts through one side of the fuse; he then strikes one end of the ring at the cut and drives it in toward the center of the iron plug; this will detach it from the thread of the shell. With the toothed wrench extract the iron plug. The shell is replaced in the tub from whence it is subsequently taken and the powder removed.

Three men can unload from 100 to 115 shells, Bormann fuse, in 8 hours; and four men can unload the same number of case in the same time.

COMPOSITIONS.

The term composition is applied to all mechanical mixtures which, by combustion, produce the effects sought to be attained in pyrotechny. They are principally derived from gunpowder by an admixture of sulphur and niter in proper proportions.

Compositions are prepared in a dry or liquid form. The ingredients should be pure and thoroughly mixed.

For dry compositions the ingredients are pulverized separately on a mealing table with a wooden muller; leather sacks, or mortars and pestles, may be used. They are then weighed and mixed with the hands and then passed through the sieves. For certain purposes, as for signal-rockets, the charcoal should not be an impalpable powder. It is pulverized in a leather sack.

The sack is filled and closed up; one man holds it by the mouth, lays it on an even block, and turns it frequently, while another strikes it with a billet of wood. After five minutes the charcoal is taken out and passed over a silk screen to get rid of the dust; what remains is then separated into three numbers:

No. 1. That which passes through the screen No. 1.

No. 2. That which passes through the screen No. 2.

No. 3. That which passes through the screen No. 3.

For the liquid form.—When it becomes necessary to use fire to melt the ingredients, the greatest caution is necessary to prevent accidents, particularly when gunpowder enters. The dry part of the composition may be generally mixed together first and put by degrees into the kettle, when the other ingredients are fluid, stirring well all the time. When the dry ingredients are very inflammable the kettle must not only be taken from the fire, but the bottom must be dipped in water to prevent the possibility of accidents.

To give portable form to compositions they are inclosed in cases, cast in molds, or attached to cotton yarn, rope, &c.

MATCHES, PORT-FIRES AND PRIMERS.

MATCHES.

SLOW-MATCH.

SLOW-MATCH is prepared rope which is used to keep and carry fire; it burns slowly with a firm, hard coal and is not easily extinguished.

MATERIALS.—*Hemp* or *flax rope* of three strands, slightly twisted, about 25 yards long, and of a uniform diameter of 0.6 inch; acetate of lead (sugar of lead), water.

UTENSILS.—One *kettle*; 1 *tub*; 2 *wooden spatulas*; *levers*; *twisting-winch*; *mats* or *hair cloth*.

METHOD WITH ACETATE OF LEAD.—Boil the rope for 10 minutes in water holding in solution one-twentieth of its weight of acetate of lead; remove it with spatulas into the tub, or let it remain in the cold solution until it is thoroughly saturated. First twist it over the kettle, and then, by attaching one end to the hook of a twisting winch, twist it hard, keeping it stretched by means of a stick passed through a loop at the other end, at the same time rubbing it smartly, always in the same direction from the hook, with coarse mats, hair cloth, or cuttings of buff leather, until the diameter of the match is reduced 0.1 inch, and it has an uniform twist and hardness. Stretch it on poles or on a fence to dry, and put it up in neat coils, well secured.

Match thus prepared burns 4 inches in an hour.

METHOD BY LEACHING.—If sugar of lead cannot be procured, the rope may be simply leached. For this purpose it is put into a leach-tub and steeped in pure water for 12 hours; this water is then drawn off and replaced by lye prepared in a boiler, with a quantity of ashes equal to half the weight of the rope, to which 5 per cent. of quicklime is added. This lye, with the ashes, is put, after being warmed, into the hopper of the tub, and when it has run through and remained some time in the tub it is drawn off, heated again, and poured back on the ashes. This operation is repeated several times in the course of 24 hours, which is the time required for the rope to be well leached. After being taken out and twisted with sticks, it is steeped for 5 minutes in hot water, being stirred at the same time, and the operation is finished as before. Match prepared in this manner burns 5 inches in an hour.

Cotton rope, well twisted, forms a good match without any preparation.

A slow-match may be made of strong paper by immersing it in a warm solution of niter, of about 1 pound to 2 gallons of water. When dry, roll each sheet separately, pressing it firmly, and pasting the last turn.

A half-sheet thus prepared will keep fire for three hours.

Slow-match weighs from 3 to 5 ounces to the yard.

PACKING.—Slow-match is packed in tight casks or boxes. A cask 40 inches high, 24 inches diameter (weighing 60 pounds), contains 150 pounds of match. The casks and boxes should be marked with the kind and quantity of match, place and date of fabrication.

Dimensions of a box to hold 200 pounds of hemp or 220 pounds cotton match: 44 inches long, 28 inches wide, 18 inches deep; weight, 87 pounds. It is made of boards 1 inch thick, ends 1¼ inch, and has corner-pieces of hard wood. 2.25 inches square.

QUICK-MATCH.

Quick-match is cotton yarn, of several strands, saturated and covered over with an inflammable composition. It is used for communicating fire from point to point in fireworks, &c.

MATERIALS.—*Mealed powder; cotton yarn,* wound in loose balls of convenient size (say 1 pound, which will measure about 1,000 yards), such as is used for candle-wick. When doubled and slightly twisted in the fingers it should be about .07 inch in diameter. *Gummed brandy* or *whisky,* in the proportion of 1 ounce of gum to ½ gallon of spirits. The gum is first dissolved in the smallest quantity of hot water or vinegar, and afterward mixed with the whisky. *Strips of paper; thread.*

One thousand yards of quick-match require 1 pound of cotton yarn, 8 pounds of mealed powder, 1¼ gallons of spirits, and 2½ ounces of gum arabic. Weight when dried, 9 pounds.

UTENSILS.—*Wooden* or *copper bowls;* 1 *quart measure; funnel* or *frame; reel.*

PREPARATION.—Steep the balls of yarn in the gummed whisky until they are thoroughly saturated. Make a paste of mealed powder, by mixing 1 quart of gummed whisky to 2 pounds of powder, and put a layer of it about ½ inch deep in the bowl; on this spread a coil of the cotton by unrolling the ball and distributing it equally on the surface of the paste until there are 5 or 6 yarns over one another; put another layer of the paste, and proceed in this manner until the bowl is full, taking care not to entangle the strands; the last layer of paste should be a little deeper than the others. After the cotton has been 3 or 4 hours in the bowl, wind it on a reel, or stretch it on nails 40 or 50 feet apart, making it pass through a funnel, or the hand, filled with the paste, and taking care that the several turns of yarn do not touch each other. Before it is dry dredge it with mealed powder; let it dry slowly, then cut it off from the reel or nails and put it in bundles.

During the winter quick-match should be made in a warm room.

Match thus prepared should be hard and stiff, and the composition should hold firmly on. One yard burns, in the open air, 13 seconds.

By using *vinegar*, a match is made which burns less rapidly, in the proportion of 4 to 5; and with pure water, in the ratio of 4 to 6. *Alcohol* makes a quicker match, but it cannot be gummed, and the composition does not stick.

A slow kind of match is made by adding sulphur to the mealed powder. With $\frac{1}{6}$ of sulphur, one yard of match burns 22 seconds; with $\frac{1}{5}$, 33 seconds; with $\frac{1}{4}$, 53 seconds; with $\frac{1}{2}$, 162 seconds.

Quick-match inclosed in tubes, burns more rapidly than in the open air, and more so in proportion as the tubes are smaller. To communicate fire very rapidly, it is inclosed in paper tubes, called leaders.

PORT-FIRES.

The port-fire consists of a cylindrical paper case filled with a composition that burns slowly. It is used for firing rockets, &c., and, in cases of necessity, for discharging cannon.

TO MAKE THE CASES.

MATERIALS.—*No.* 4 *paper; paste.*

Required for 100 cases, 50 sheets, 13 pounds of paper.

UTENSILS.—*Formers,* steel, turned smooth, 22 inches long, 0.5 inch diameter; a hole .2 inch diameter is made through one end to withdraw it from the case; *hand-rolling board; rulers; knives.*

TO MAKE THE CASE.—Cut the paper into rectangles 18 inches long, and from 10 to 14 inches wide, according to the thickness of the paper, to make the exterior diameter of the finished case .65 inch. Roll the rectangle on the former, pasting it after the first turn; press the case firmly by rolling it on a table with a hand-rolling board; withdraw the former, and place the cases in a box to dry.

TO DRIVE PORT-FIRES.

MATERIALS.—*Cases; composition for* 100 *cases* (13 pounds niter, 4.5 pounds sulphur, and 2 5 pounds mealed powder); *scrap paper.*

UTENSILS.—*Port-fire molds,* made of brass in two parts, which are held together by a socket at bottom, and by four strong bands. The molds are 18 inches long, 1 inch exterior diameter at top, $1\frac{1}{4}$ inch at bottom, with a bore of .65 inch diameter. Three *drifts,* steel, .4 inch diameter, 22, 15, and 10 inches long, with brass tips, .5 inch long, upon the lower end; 4 *spiral grooves,* making one-half of a turn in 22 inches, are cut upon the surface of the drifts; the handles of the drifts are 6 inches long, and .75 inch diameter, with a head 1.25 inch diameter. *Mallets,* turned of hard wood, weighing 1 pound; *funnels; ladles.*

DRIVING.—Put the case in the mold, and drive on the rings; insert a piece of paper, and push it to the bottom of the case with the long drift; insert in a small funnel in the top of the case; pass the long drift through the funnel to the bottom of the mold; fill the funnel with composition, and strike the drift about three blows every second, raising the drift about half an inch, with the fingers of the left hand, between the blows. In this way the composition finds its way around the sides and through the grooves of the drift to the bottom, and is uniformly and compactly driven. The shorter drifts are used as the case is filled.

Port-fires should not be primed with mealed powder; after they are driven, the top of the case should be turned in and beaten down; thus both ends of the composition are secured.

Port-fires made as above described burn 10 minutes each, or 1¾ inch per minute.

A day's work.—A man can drive 120 port-fires in 10 hours.

Packing.—Port-fires are packed in boxes containing 100 or 200 port-fires. The contents of the box should be marked in white letters on each end, and the place and date of fabrication on the inside of the cover.

Packing-boxes for port-fires.

	Length.	Width.	Depth.	Weight.
For 100 port-fires	18	9.1	5.1	38
For 200 port-fires	18	9.1	10.1	70

FRICTION-PRIMERS FOR CANNON.

The friction-primer for cannon is a small brass tube filled with gunpowder, which is ignited by drawing a flat wire, with serrated edges, briskly through friction composition, contained in a smaller tube inserted into the first near the top and soldered at right angles to it. A lanyard, with a hook attached, is used to ignite the primer.

Two kinds are in use in the service: the long primer for heavy and the short for light cannon.

The friction-primer is composed of one long tube; 1 short tube; 1 wire igniter; friction composition; musket-powder; wax, and shellac varnish.

The long tube is made from a circular disk of sheet brass, by means of a series of punches and dies, gradually diminishing to the last, which is of the required size of the tube. The brass must be annealed before each drawing or reducing. This is done in open pans, or in a revolving cylinder in a special furnace. The brass should not be heated above a dark-red color. It is then allowed to cool in the air, and afterwards pickled in a bath of 40 parts of water and one of sulphuric acid to remove the scale, and then thoroughly washed to remove all trace of acid.

Thickness of sheet-brass disk, .036″; diameter, .62″ for short, and .98″ for long primers.

The tube is cut to the prescribed length, measuring from the closed end, by means of a circular saw, and the holes for the short tube and wire igniter are drilled, and the burs removed.

Length of long tube for short primer, 1.75 inch; for long primer, 2.35 inches; exterior diameter, maximum, .195 inch; minimum, .187 inch; interior diameter for short primer, .175 inch; for long primer, .155 inch; diameter of holes, .15 inch and .06 inch.

The short tube is formed from the long one by using two additional punches and dies, reducing the size each time. It is cut to the proper length by circular saws placed at the required distance apart, and the bur removed by rolling in a barrel. Length of the short tube, .44 inch; exterior diameter, .15 inch; interior diameter, .133 inch.

One end of the short tube is dipped in a solution of zinc chloride, inserted in the hole drilled in the long tube, heated in the flame of a spirit-lamp, until solder melts, and soldered with soft solder; it is then washed and dried.

The wire igniter is made of brass wire .05 inch diameter, annealed, cut to the proper length, and pressed flat at one end by a machine for that purpose. The flat end is serrated by a punch and die with dentated edges, and the tip is annealed in the flame of a spirit-lamp. Length of wire, 3.4 inches; length of flattened end, .65 inch.

The friction composition is made of 55 parts antimony trisulphide, 37 parts potassium chlorate, 5 parts flowers of sulphur, and 3 parts gum arabic.

The materials must be finely pulverized, and mixed thoroughly in a bowl of stone ware, by stirring with equal quantities of alcohol and water until the mixture attains the consistency of paste.

CHARGING AND VARNISHING.—The small tube is charged by pressing the open end in the friction composition spread on a flat piece of zinc, and brought to the consistency of soft putty, the long tube being closed its whole length with a wooden or metal plug.

A conical hole is made in the composition while yet moist, with a conical drift, and the surplus composition removed; the wire igniter is passed through the short tube and through the small hole in the long tube, the round end first, leaving the annealed tip projecting out of the open end, which is then closed by pressing the top and bottom together firmly with pincers, and bending the tip against the bottom.

The end of the wire igniter is doubled on itself and twisted, leaving a loop .2 inch diameter.

The head of the long tube, including the short tube and the joint, is dipped into shellac varnish colored with lampblack.

When dry, the long tube is filled with musket-powder (7 or 10 grains, according to length), and closed with beeswax mixed with tar and rosin.

Both ends are touched with varnish, and the tube thoroughly dried.

The material for closing the ends of the primer is made of 15 parts of beeswax, 5 rosin, and 8 pine tar, boiled 2½ hours on a slow fire, constantly stirred to prevent burning, and then allowed to cool.

PACKING.—To pack the primers, rectangular wooden blocks are made, having holes .38 inch, and .57 inch in diameter, bored in two opposite ends. The primers are placed in the holes, 5 or 10 to each block. The block is covered with a paper wrapper, which is then varnished. A printed label states contents, place and year of manufacture. The blocks are packed in wooden boxes containing 1,000 of five primers each, or 100 of ten each.

For better preservation in sea-coast fortifications, the primers are also packed in rectangular tin cases, containing 5 paper packages of 20 primers each. The tin cases are hermetically sealed, japanned, and stenciled with contents, place and year of manufacture. Fifty tin cases are packed in a wooden box.

Dimensions and weights.

	Length.	Width.	Depth.	Weight
	Inches.	*Inches.*	*Inches.*	*Pounds.*
Cases for short primers	7.35	2.2	2.1	1
Cases for long primers	7.6	2.65	2.2	1.56
Box for 1,000 blocks	22	12	12.5	83
Box for 100 blocks.. { Long primers	16	9	6.125	26
Box for 100 blocks.. { Short primers	12	9	6.125	22
Box for 50 tin cases, short primers	22	11.5	7.5	70
Box for 50 tin cases, long primers	27.5	11.25	7.75	90

Materials required for 10,000 *friction primers.*

136 pounds sheet-brass, .036″ thick, 6.75″ wide for long primers; 60 pounds sheet brass, .036″ thick, 6.75″ wide for short primers; about ½ returned as scrap.
20 pounds brass wire, .05 inch.
1.25 pounds solder.
1.5 pounds antimony trisulphide.
1 pound potassium chlorate.
0.125 pound flowers of sulphur.
0.094 pound gum arabic.
7.5 pounds beeswax.
2.5 pounds rosin.
11 pounds musket-powder.
2 quarts pine tar.
1.25 quarts varnish (.75 pound shellac, 1 quart alcohol, .25 ounce lampblack).
.5 pint alcohol for friction composition.

ELECTRIC-PRIMERS FOR CANNON.

This primer consists of the long tube of the service friction-primer, split at one end to receive a large piece of brass tube, to which it is soldered. The larger tube incloses a cylindrical piece of hard wood, slotted midway of its length, and perforated at each end to receive short pieces of copper wire, which are connected across the slot by a coiled piece of fine platinum wire. The outer ends of the copper wires project a few inches to connect the wires of the primer with the terminal wires of the battery. When thus connected, the battery current, by reason of the resistance met with in passing through the platinum wire, heats this wire sufficiently to ignite a small piece of loose gun-cotton which, together with the platinum wire, occupies the slotted portion of the wooden cylinder. The ignited gun-cotton communicates its flame to the powder in the long tube.

The open ends of the large tube are turned down on the wooden plug to prevent blowing out. These and the open ends of the small tube are closed and dipped in varnish, as described for the friction-primers.

The platinum wire is coiled to increase its length between the copper ends. By this means the absorption of heat by the latter is overcome. The coil is also less liable to be broken by any slight displacement of the copper wires.

With the standard length of one inch, and thickness .003 inch for the platinum wire, the resistance of this primer is about 7 ohm cold and 1.2 ohm at explosion.

Fulminate of mercury may be used instead of gun-cotton. The latter is preferred, however, as being equally serviceable and less dangerous.

FIREWORKS.

FIREWORKS FOR SIGNALS.

SIGNAL-ROCKETS.

Rockets for signals are composed of a paper case charged with composition, a pot filled with ornaments, and a light stick to give direction.

Rockets are denominated by the interior diameter of the case. The most common sizes are the .75-inch, 1-inch, and 1.5-inch.

TO MAKE THE CASE.

MATERIALS.—*No.* 4 *paper ; paste ; strong twine.*

IMPLEMENTS.—*Awl ; ruler ; knife ; sandstone ; rolling-bench ; press* and *crank; choking machine; gauge for the case ; paste-brush.*

TO CUT THE PAPER.—Lay off the paper into rectangles, their width equal to the length of the case, pricking with the awl the four corners on several sheets at once ; cut them with the knife.

A sheet of No. 4 paper makes two rectangles for a .75-inch or for an inch rocket, by cutting it parallel to the short or long side, respectively.

TO ROLL THE CASE.—Roll the rectangle smoothly on the former, pasting the paper after the first turn; put the case and former in one of the grooves of the press, and, by means of the crank slipped on the square end of the former, turn it, the top of the press bearing on it slightly at first. Paste the second rectangle, introduce one end under the last rectangle, and roll it as at first. Gauge the case to see that it is the size of the mold.

If there be no rocket-press at hand, a long hand-rolling board may be used instead.

TO CHOKE THE CASE.—Wrap a piece of strong paper around the end of the case to be choked to prevent the cord from chafing it, take a turn around it with the choking cord, and press on the treadle, turning the case at the same time and drawing out the small part of the former as the paper contracts; make the choke fast by wrapping it several times with strong twine, drawing it firmly, and tie it in a hard knot; place the case away to dry in the shade.

TO DRIVE THE ROCKET

MATERIALS.—*Empty cases; composition, clay,* or *plaster of Paris.*

The composition is composed of 26 parts of niter, 5½ of sulphur, and 19 of charcoal, which are mixed by rubbing them in the hand, and passing them three times through the sieve No. 2; the charcoal is added and mixed with the hands. If antimony or steel filings be used, they should be added after the charcoal.

When beginning with a new composition or new materials, it is necessary to try the composition by firing two or three rockets made of it, and regulate the height of the solid If the rockets do not ascend sufficiently high, increase the quantity of niter, and diminish it if the rockets burst or blow out the head.

When rockets are well made, they ascend rapidly to a great height, and throw out their ornaments at the highest point of the curve, after all the composition has burned out.

UTENSILS.—*One mold* and *spindle;* 1 *block of wood,* settled in the ground; 3 *hollow drifts,* bored to admit the spindle; 1 *solid drift; mallets; knives; sandstones;* 1 *charging-ladle,* of such size that its contents, when driven in the case, shall be a diameter in height.

TO PUT THE CASE IN THE MOLD.—In the first place, cut off the choked end of the square end, and to such a length that when the case is settled down on the spindle, the choke should fit closely over the nipple, and the end of the case rest on the base of the spindle.

Place the case on the spindle, the choked end down; settle it with two or three blows of the mallet; set the mold over the case, and key it down.

DRIVING THE ROCKET.—Take a ladleful of composition, strike off the surplus and pour it into the case. Use first the longest hollow drift, and give each ladleful 25 or 30 blows with the mallet, keeping the drift down on the composition. As the case fills, use the shorter drifts until the composition reaches the top of the spindle; then drive one diameter in height with the solid drift, cover this with a patch of stiff paper, cut to fit the case, and over this patch drive a wad $\frac{1}{3}$ diameter high, of clay, or of plaster of Paris, slightly moistened with water.

Rockets are sometimes driven solid throughout, and afterward bored and reamed out with a reamer of the form of the spindle.

The *molds* for driving are not indispensable. Rockets are often driven without them. For this purpose, screw the spindle vertically into the top of a block of wood firmly imbedded in the ground. To the opposite sides of this block attach two upright strips of plank, and fasten to them a cross-piece, which has near its center a hole to fit the rocket-case and keep it steady on the spindle in driving.

To guard against accidents drive rockets in an empty room; particularly, let no powder be in the room, or composition, except that used at the time, and let no filled rocket-cases be lying about. In fair weather use a tent for a driving room.

To PRIME THE ROCKET.—Insert in the bore of the rocket one end of a piece of quick-match, 2 feet long, a small piece of paper attached, and push it in securely; coil the rest of the match in the bore and bottom of the case. To secure it from dampness, paste over the end of the case a circular cap of strong paper.

TO MAKE THE POTS.

MATERIALS.—*No.* 4 *paper; paste.*

UTENSILS.—*Knife; former; rolling-board; bowl* for paste; *brushes.*

MAKING THE POT.—Cut the rectangle and roll it on the former as described for port-fire cases.

To ATTACH THE POT.—Paste the pot on the inside the distance of one-half of a diameter, and also the outside of the case, at the end containing the clay, for the same length; slip the pot on the pasted end, leaving the length of the pot above the top of the case one and a half diameter.

To secure the pot in place and give a neat finish, cover the rocket-case and pot, when dry, with thin paper pasted on.

TO MAKE THE CONES.

MATERIALS.—*No.* 4 *paper; paste; thin paper.*

UTENSILS.—*Compasses; knife; scissors; conical former; bowl* for paste; *brushes.*

MAKING CONES.—Mark out the No. 4 paper by describing with the compasses circles with a radius equal to the length of the cone required. Cut them out with the scissors, and cut each circle into semi-circles. Paste each semi-circle and roll it separately on the former; press it firmly, and put it away to dry. Cut the cones to such length that their bases shall be of the same diameter as the pot. Make, in the same way, a similar cone of thin paper one inch longer, and paste it on the first; cut the part of the cone formed of one thickness of paper into longitudinal slips ¼ inch wide.

TO LOAD THE POT AND FIX THE CONE.—Put the bursting charge of 150 to 300 grains of powder in the bottom of the pot, and fill it with the decorations, placing the serpents and streamers on end, the primed ends down. Fill the cone with tow, and paste the strips of the cone; place the cone on the pot, and press the strips on the side of the pot; paste a narrow band of paper around the rocket close to the base of the cone.

The axes of the rocket-case of the pot and the cone should be in the same line.

TO ATTACH THE STICK.—Tie the stick to the rocket with strong twine or annealed iron wire from .04 to .08 inch in diameter, at two places: first, at the choke of the case and the second notch in the stick, crossing the ends of the twine under the stick to prevent its moving to the right or left; the second, in the notch in the end of the stick and near the pot; tie the twine in a hard knot, and cut the ends close.

If wire be used, twist the ends together with pliers, and flatten the ends into the notch.

After the stick is attached, the center of gravity of the rocket should be from .8 inch to 2 inches from the end of the case, according to the kind of decorations used. For this purpose, if necessary, reduce the size of the stick at the end.

DECORATIONS FOR ROCKETS.

STARS.

MATERIALS.—See table.

UTENSILS.—The necessary utensils for weighing and grinding the materials, *a cylindrical mold* with a pin in the axis, and a piston for pushing out the stars.

TO PREPARE THE COMPOSITION.—Reduce the materials to the finest powder; mix them with the hands; pass them three times through the sieve, mixing them each time with the hand.

Moisten the composition with whisky in which gum has been dissolved,* so that the composition shall retain its form when pressed in the hand.

TO MOLD THE STARS.—Fill the mold by pressing it in the composition spread out in a wooden bowl; push out the star with the piston, letting it fall lightly on a sheet of paper dusted over with mealed powder.

Colored stars are made in the same manner as white ones, using the compositions indicated in the table.

SERPENTS.

Serpents are very small rocket-cases charged with composition.

MATERIALS.—*No.* 4 *paper; thread; paste; clay.*

UTENSILS.—*Knife; former*, .4 inch in diameter; *bowl* for paste; *brushes; wooden mold; nipple; drift; mallet; charger; hand-rolling board.*

TO MAKE THE CASE.—The case is made by rolling a rectangle of paper No. 4 with a hand-rolling board, and choking it at one end.

The cases are driven ⅜ their length, giving each ladleful of composition three blows with the mallet.

The case is choked over the composition, and the remainder of it is nearly filled with mealed powder, upon which a small paper wad is placed. A clay head is then driven on it, and the end of the case turned down to secure it. The other end is primed with priming paste, or a small strand of quick-match.

*The use of the gum is to give consistency to the stars, so that the explosion of the pot may not break them to pieces and thereby destroy the effect.

STREAMERS.

Streamers are small paper cases from .2 to .4 inch diameter, and from 2 to 4 inches long, made of 4 turns of No. 7 paper. One end is closed, and the case is charged and primed like that of a lance.

A number of streamers produce the effect known as rain of fire.

GOLD RAIN.

Gold rain is made of small stars, all of the same size. The stars are cubes, the length of the side being .5 inch.

MARRONS.

Marrons are small cubic boxes, made of pasteboard, filled with powder, and wrapped with strong twine. They are used to give a loud report, or the effect of cannonading.

MATERIALS.—*Pasteboard; cartridge-paper; strong twine* or *marline; paste; quick-match; powder.*

UTENSILS.—*Knife; ruler; pencil; punch.*

TO MAKE THE MARRONS.—Cut the pasteboard into rectangles, whose sides shall be 3 and 5 times, respectively, the length of the side of the marron required. Divide the rectangle into 15 equal squares; cut out the squares forming the four corners of the rectangle, and divide the three remaining squares on the long side from each other by a cut the length of their side and perpendicular to the long side of the rectangle.

Form a small cubic box with the pasteboard thus cut out; paste the squares together which cover each other, and paste a band of paper around the box, leaving the cover open. When dry, fill the box with powder, paste down the cover, and envelop it with two or three layers of strong twine. Cover the marron with glue or kit, and prime it with quick-match inserted in a hole punched into the powder at the middle of one of the faces.

Dimensions and weights of rockets and their ornaments.

		Interior diameter of rockets.		
		.75-inch.	1-inch.	1.5-inch.
Height of rectangle for cases	inches..	10	11	13
Length of the finished case*	do....	9. 25	10. 60	12. 50
Interior diameter of the choke	do....	0. 25	0. 42	0. 65
Exterior diameter of the case	do....	1. 35	1. 60	2
Spindle — Height	do....	6. 25	6. 75	8. 0
Spindle — Diameter at ' ase	do....	0. 25	0. 42	0. 65
Spindle — Diameter at top	do....	0. 13	0. 21	0. 33
Nipple — Diameter	do....	0. 75	1. 0	1. 48
Nipple — Height	do....	0. 65	0. 7	1. 0
Diameter of cylinder and part of nipple	do....	0. 75	1. 0	1. 48
Drifts — Length of cylindrical part — Diameter	do....	0. 72	0. 97	1. 47
Drifts — Length of cylindrical part — 1st drift	do....	9. 65	10	12. 75
Drifts — Length of cylindrical part — 2d drift	do....	7. 25	9	10
Drifts — Length of cylindrical part — 3d drift	do....	4. 5	5. 25	7. 60
Drifts — Length of cylindrical part — 4th drift	do....	2. 5	3. 0	4. 0
Drifts — Conical cavity — Diameter at bottom or base — 1st drift	do....	0. 27	0. 44	0. 67
Drifts — Conical cavity — Diameter at bottom or base — 2d drift	do....	0. 24	0. 36	0. 64
Drifts — Conical cavity — Diameter at bottom or base — 3d drift	do....	0. 21	0. 33	0. 60
Drifts — Conical cavity — Common diameter at top	do....	0. 14	0. 23	0. 33
Drifts — Conical cavity — Length of — 1st drift	do....	6. 75	7. 5	8. 50
Drifts — Conical cavity — Length of — 2d drift	do....	4. 25	5. 0	6. 0
Drifts — Conical cavity — Length of — 3d drift	do....	3	3	4
Driving mallet — Weight	pounds..	1. 25	1. 5	2. 0
Driving mallet — Length of handle	inches..	8	8	8
Charger — Diameter†	do....	2. 25	2. 75	3. 5
Charger — Length of cylinder	do....	2. 5	2. 20	2. 85
Charger — Whole length	do....	7	7. 75	8. 30
Height of the solid	do....	1. 5	2. 0	3. 0
Composition for 100 rockets	pounds..	30	50	125
Clay in head	ounces..	0. 75	1	1. 25
Pot — Rectangle — Length	inches..	12. 5	7. 25	15
Pot — Rectangle — Height	do....	3. 10	3. 25	5
Pot — Former diameter	do....	1. 35	1. 60	2. 25
Pot — Weight of pot — Stars	ounces..	1	1. 5	2
Pot — Weight of pot — Serpents	do....	1	1. 5	3
Pot — Weight of pot — Gold rain	do....	1	1. 75	2. 5
Pot — Bursting-charge	do....	0. 5	1	1. 25
Cone — Conical former — Height	inches..	3. 25	3. 75	4
Cone — Conical former — Diameter at base	do....	1. 5	2. 0	2. 30
Cone — Length of finished cone	do....	1. 75	4	4. 35
Stick — Length	do....	80	84	96
Stick — Thickness of large end	do....	0. 6	0. 66	0. 8
Stick — Thickness of small end	do....	0. 35	4	0. 5

	.75-inch rocket.		1-inch rocket.		1.5-inch rocket.	
	Number.	Weight.	Number.	Weight.	Number.	Weight.
		Grains.		*Grains.*		*Grains.*
Stars	10	490	15	700	20	890
Gold rain	10	490	15	700	20	870
Streamers	8	685	12	1, 025	18	1, 575
Serpents	3	525	4	850	8	1, 350

* Without the pot. † Its contents, when driven, should be half a diameter in height.

BLUE LIGHTS.

MATERIALS.—For 100 lights: *niter*, 9 pounds, 10 ounces; *sulphur*, 2 pounds, 6½ ounces; *red orpiment*, 11 ounces; *mealed powder*, 11 ounces. The materials should be pure, well pulverized, and thoroughly incorporated, rubbing them in the hands, and passing them several times through a fine hair sieve. *Hemispherical cups*, of well-seasoned wood (beech, linden, &c.), with a handle 10 inches long, 1¾ inch diameter; *quick-match; paper; paste.*

UTENSILS.—The necessary utensils for pulverizing and mixing the composition.

PREPARATION.—Fill the cup with composition, and press it firmly in; prime the cup with quick-match, and cover the whole with cartridge-paper pasted to the bottom of the cup.

The brilliancy of the light depends on the purity and thorough incor poration of the ingredients.

The composition may also be driven in a paper case, and afterward cut off to suit the required time of burning. Both ends of the case are closed with paper caps and primed with quick-match, in order that one or both ends may be lighted at pleasure. A light in which the composition is 1.5 inch in diameter can be easily distinguished at a distance of 15 miles

HALE'S WAR-ROCKETS.

The general construction of the 12 and 24 pounders are the same, differing only in general dimensions and the number of vents and curved shields or walls, the 12-pounder having 3 and the 24-pounder 5.

The rocket consists of four pieces. A head, conoidal in shape, of cast iron, hollow for bursting, having a cylindrical hole in the base about $\frac{15}{16}$ inch diameter, with screw-thread for fuse; there is also a small hole in front, used for filling shell with combustible material, closed by a screw, but into which can, if desirable, be fitted a nipple and cap for ignition by percussion; the head is turned down at the rear about $\frac{1}{8}$ inch so as to enter the body of the case about $\frac{13}{16}$ inch, and to which it is secured by 6 pins or screws. A *cylindrical body* of sheet-iron about $\frac{1}{8}$ inch thick, with edges lapped, riveted, and brazed at the longitudinal joints. A *thick iron disk* or annular ring fitted in and fixed by screws or pins closes the base. A *tail-piece* of cast iron containing the vents and shields or walls is screwed into the disk which closes the base. The vents themselves are conical, the apex of the cone being toward the rear; the gas escaping through the vents and pressing against the curved shields, each placed in the same relative position to one of the vents, keeps the rocket point foremost in its flight, and gives the rotary motion on the turbine principle. The composition which is separated from contact with the iron by pasteboard to prevent oxidation, consists of saltpeter, sulphur, and charcoal, in the proportions of 70, 16, and 23, and is introduced into the case in successive pellets and pressed by hydraulic power; it is afterward bored out in a cone for about two-thirds of its length.

The war-rockets are fired from a trough mounted on a stand, either singly or in groups of seven, by means of an ordinary friction tube and lanyard.

THE LIFE-SAVING ROCKET.

Differs from the above only in that the head, instead of being cast iron, is of wood, and in the addition of a piece of chain about 3 feet long, which is connected to the center of the bottom of the tail-piece by a double swivel; to the chain is attached the life-line.

This rocket is fired from an ordinary **V**-shaped trough, which may be given any desired elevation. As the chain is hardly long enough to prevent the burning off of the rope by the gas escaping from the vents, it is safest to wet about two fathoms of rope next to the chain.

MACDONALD'S IMPROVED HALE'S WAR-ROCKET.

The case of the improved rocket is of steel of great strength, at the end of which is soldered a collar, *b*, to the center of which is screwed a wrought-iron tube, *c*; this tube unites the head to the body of the rocket and allows the gas to escape through the upper vents.

The head has a cavity, *d*, communicating with the exterior by five openings directed toward the rear. These vents or openings, as in the Hale rocket, have semi-cylindrical flanges; the gas escaping acts against the concave face of the flanges and imparts a motion of rotation to the rocket.

The lower end of the case is closed by a disc, also pierced with five vents corresponding to those in the head, and furnished with similar flanges. This construction applies the motion of rotation to the head as well as the rear part of the rocket, and remedies the considerable deviation of the Hale rocket due to the motion of rotation being applied to the base only;

as its center of gravity is considerably in front, the head describes large and irregular spirals.

The rocket composition consists of 70 parts of niter, 16 parts of sulphur, and 23 parts of charcoal. It is pressed into the tube *a* with a pressure of 90 tons. As it is bored throughout its whole length by the channel *c*, the surface of inflammation is much more considerable than in the Hale rocket, and its velocity much greater.

The head has at its front part, in front of the cavity *d*, a shell with a bursting charge, which is ignited by means of a fuse, either percussion or time.

The rocket thus perfected has given results very superior to those obtained by war-rockets of other systems.

Five 12-pounder rockets thrown under an angle of 8° 15′ had a mean range of 1,870 meters, with a lateral deviation of 2.74 meters only, while Hale rockets of the same caliber, under the same angle of elevation, had a range of only 1,200 meters with a lateral deviation of 34 meters.

INCENDIARY FIREWORKS.

ROCK-FIRE.

Rock-fire is a composition which burns slowly, is difficult to extinguish, and is used to set fire to buildings, ships, &c. That which is put into shells is cast in cylindrical cases of paper having a priming in their axes.

MATERIALS.—*Rosin*, 3 parts; *sulphur*, 4; *niter*, 10; *regulus of antimony*, 1; *mutton-tallow*, 1; *turpentine*, 1.

UTENSILS.—1 *furnace* of second kind, or *large kettle* in the open air; *spatulas; ladle* with long handle; *balance and weights; sieves.*

PREPARATION OF THE COMPOSITION.—Pulverize the sulphur, niter, and antimony separately; mix them with the hands, and pass them through sieve No. 2; melt the tallow first, then the rosin, stirring the mixture with spatulas; add the turpentine, and next the other materials in small quantities at a time, stirring the whole constantly with large spatulas.

Let one portion of the composition be melted before more is added, and work with great precaution to prevent it from taking fire. When the composition becomes of a brown color, and white vapors are disengaged, the fire is permitted to go down; and when the composition is sufficiently fluid the cases are filled with the ladle not more than three-fourths full.

Paper cases and priming tubes.—The cases are made of rocket-paper in the manner described for port-fire cases. The priming tubes are made of cartridge-paper, pasted after the first turn, and rolled hard.

Filling the cases.—The cases are arranged in a frame, the lower end of each inserted in a socket, in the center of which is a spindle to support the priming tube.

The upper ends of the cases are held in place by short cylindrical spouts attached to the lower side of a reservoir which rests on the top of the frame. The composition is poured into the reservoir, and the frame is gently shaken to settle the composition in the cases until they are filled.

When the composition has become solid, the cylinders are taken out of the frame and trimmed; the priming tubes are charged with composition No. 1 for mortar-fuses, driven the same as mortar-fuses; the ends of the cylinders are last dipped in mealed powder.

When rock-fire cannot be had to put into shells, the paper cases may be filled with port-fire composition, driven as usual; or pieces of port-fire may be inserted in the shells.

CARCASS.

A carcass is a hollow cast-iron projectile, filled with burning composition, the flame of which issues through four fuse-holes to set fire to combustible objects.

Materials.—*A cast-iron shell* with four fuse-holes; *port-fire composition; tow; white turpentine; spirits of turpentine* and *quick-match.*

Utensils.—*One drift; 5 sticks of wood,* .5 inches in diameter.

Composition.—The composition is the same as for port-fires, mixed with a small quantity of finely-chopped tow, and as much white turpentine and spirits of turpentine as will give it a compressible consistency.

Preparation.—The composition is compactly pressed into the shell with the drift, so as to fill it entirely; one of the sticks is then inserted into each fuse-hole with the points touching at the center so that when withdrawn corresponding holes shall remain in the composition. In each hole thus formed three strands of quick-match are inserted and held in place by dry port-fire composition, which is pressed around them. About three inches of the quick-match hangs out when the carcass is inserted in the piece; previously to that it is coiled up in the fuse-hole, and closed with a patch of cloth dipped in melted kit.

A common shell may be loaded as a carcass by placing the bursting charge on the bottom of the cavity, and covering it with carcass composition driven in until the shell is nearly full, and then inserting four or five strands of quick-match, secured by driving more composition. This projectile, after burning as a carcass, explodes as a shell.

INCENDIARY-MATCH.

Incendiary-match is made by boiling slow-match in a saturated solution of niter, drying it, cutting it into pieces, and plunging it into melted fire-stone. It is principally used in loaded shells.

FIREWORKS FOR LIGHT.

TORCHES.

Torches are made of a number of strands of twine slightly twisted, or old rope, covered with a composition to give light.

MATERIALS.—*Hemp twine*, slightly twisted, about 0.08 inch diameter; *cartridge-thread; mutton-tallow; yellow wax; rosin; glue; quicklime.*

UTENSILS.—*One pot*; 2 *spatulas*; 1 *ladle*; *glue-pot* and *bath*; *knife*; 1 *mold*.

PREPARATION.—Melt in the pot, 1 part of tallow, 2 of yellow wax, and 8 of rosin, stirring it with spatulas. The twine is formed in hanks of about 40 threads, 3 feet long, cut at one end, and tied with twine, forming a handle at the other.

The hanks are immersed for 10 minutes in the composition, and then drawn through a mold of the proper size. They are suspended by the handle in a shady place to harden; 24 hours after, they are painted over with a warm solution of a half pound of quicklime and $\frac{7}{8}$ of an ounce of glue to a quart of water.

WITH OLD ROPE.—Boil the rope, well beaten and untwisted, in a solution of equal parts of niter and water; when dry, cut it in pieces 4 feet long; tie three or four of these pieces around a piece of pine wood, 2 inches in diameter and 4 feet long; cover the whole with a mixture of equal parts of sulphur and mealed powder, moistened with brandy; fill the intervals between the cords with a paste of 3 parts of sulphur and 1 of quicklime. When it is dry, cover the whole torch with the following composition: *Pitch*, 3 parts; *Venice turpentine*, 3 parts; *turpentine*, ½ part.

PITCHED FASCINES.

Pitched fascines are fagots of dry twigs, covered over with an incendiary composition, and used to set fire to buildings or to light up a work.

TO MAKE PITCHED FASCINES.

MATERIALS.—*Dry branches*, about .5 inch diameter, or other light, combustible wood; *iron wire*, about .05 inch diameter.

UTENSILS.—*Four pickets*, about 40 inches long and 1¼ inch diameter; *cylindrical sticks*, 20 inches long, 1¼ inch diameter; 2 *trace-ropes;* 1 *rope* for a capstan; 2 *levers;* 1 *small cord;* 1 *flat punch;* 1 *saw*, or *bill-hook;* 1 *block*.

TO MAKE THE FASCINES.—Form two crotches, 1 foot apart, with the 40-inch pickets; cut the branches 20 inches long, and tie them in the middle of their length, and about 2 inches from their ends, with annealed wire, and place in the axis a cylindrical stick, intended to preserve a vacant space; draw the branches tightly together, that they may hold the composition better and cut off the ends square.

TO PITCH THE FASCINES.

MATERIALS.—*Pitch; tar; mutton-tallow; linseed-oil*, in a bowl; *saw-dust*, in a barrel; *rock-fire* for priming.

UTENSILS.—*Two pots*, in a furnace of the first kind; 2 *spatulas;* 1 *ladle*, with a long handle; 1 *small iron fork*, with a long wooden handle; 2 *tubs; planks*.

The fascines receive two coats of composition.

First coat.—Melt 20 parts of pitch and 1 of tallow in the pots, filling them not more than half full. Having first well oiled the cylindrical stick, plunge the fascine into the liquid with the fork, first one end then the other, each time pouring on the upper end two ladlefuls of the composition. Let the composition harden, holding the fascine over the pot, turning it slowly and then immerse it in the tub of water. The assistant, with his hands covered with oil, fashions the fascine, rolling it on the bottom of the tub, and places it on the planks.

Second coat is put on 24 hours after the first; it is composed of equal parts of pitch and rosin melted and mixed together in the pot. The cylindrical stick is taken out, and the fascine immersed in the composition, as with the first coat; it is permitted to drip, and is then laid in saw-dust and powdered all over with it. A fascine requires about 1.1 pound of each composition Fascines should be primed only a short time before being used. For this purpose, dip each end, for a distance of half an inch, into a kettle holding melted rock-fire.

When used for incendiary purposes, fascines are placed in piles, and pieces of quick-match and port-fire scattered over them, to make the whole mass take fire at once.

TARRED LINKS.

Tarred links are made of old rope, covered over with a composition to give light.

MATERIALS.—*Old slow-match* or *rope; cartridge-thread; ends of rope.* One link requires ½ pound of *tow*, and 1 to 1¼ pound of *composition.*

UTENSILS.—*Mallet; knife.*

TO MAKE THE LINKS.—The old rope is well beaten with mallets; the short ends are tied together with cartridge-thread. The links are formed by coiling the soft rope around the hand, in coils of 3 inches interior and 6 inches exterior diameter, loosely tied with thread.

TO TAR THE LINKS.—The links are covered with composition, as described for fascines.

Tarred links burn one hour in calm weather, half an hour in a high wind, and are not extinguished in the rain. Two of them are put in a rampart-grate on a bed of shavings. The grates are placed about 250 feet apart.

FIRE-BALLS.

Fire-balls are projectiles of an oval shape, formed of sacks of canvas filled with combustible composition. They are used to light up the enemy's works, and are loaded with shells to prevent them from being approached.

MATERIALS.—*Strong, close canvas (sail-cloth); rope; cartridge-thread; red chalk; slow-match; loaded shells; pitch. A composition of* 8 *parts of saltpeter,* as it comes from the refinery; 2 *of pulverized sulphur,* and 1 *of antimony* passed through sieve No. 2. These materials are mixed in the hands, passed through sieve No. 4, moistened with $\frac{1}{30}$ their weight of water, and passed again through the same sieve.

UTENSILS.—The necessary utensils for grinding and preparing the composition: *Wooden pattern; red chalk;* 1 *pair shears; collar-needles; mallet; small gauge,* of the caliber of the fire-balls; *scoop; tarred links;* 1 *wooden mold;* 2 *wooden drifts* 20 inches long, one of them $1\frac{1}{4}$ inch and the other $2\frac{1}{2}$ to 4 inches in diameter; 2 *wooden pins* $4\frac{1}{2}$ inches long, the small end the size of a paper fuse.

TO MAKE THE SACK.—Mark out the pieces by means of the pattern, and cut them with the shears; baste two or three thicknesses together, according to the strength of the canvas; sew three or more together, enough to make the sack; leave one end open, forming a mouth for charging; turn the bag to bring the seams on the inside. The mouth may be made fast to an iron hoop, large enough to admit the shell, with which the fire-ball is loaded.

TO PREPARE THE SHELL.—Charge the shell with powder and put in a slow fuse. Dip the tarred link into the melted rosin, pitch, and tallow, and fasten it with twine to the shell around the fuse-hole.

TO CHARGE THE SACK.—Place the sack in the mold and secure the mouth to it. Put the shell with the tarred link in the bottom of the sack, the fuse-hole downward, and fasten the shell down with twine passed through the sides of the sack, or with a piece of canvas secured to the sides; put in the composition with a scoop and ram it, first with the small drift, and when it is half the height of the projectile, with the large drift, driving it with the mallet. Continue in this way till the sack is filled to the top. Close the mouth of the sack, sewing the pieces together.

THE IRON BOTTOM.—The ball is furnished with an iron bottom to prevent it from being broken by the force of the charge in the mortar. To make the bottom, the iron, .2 inch thick, is cut in a circular form, heated and partly shaped with a set-hammer in a concave wooden former; it is again heated and finished in an iron former. It is then put into a lathe where the outer edge is trimmed and chamfered to the thickness of one-eighth inch.

The iron bottom is attached to the ball with cement; the bottom is filled about one-third full with the cement, and the loaded end of the fire-ball is inserted in it and left to cool.

The ball is next covered and strengthened with a net work made of spun yarn or cord from .25 to .5 inch thick according to the size of the ball. This net work is commenced at the bottom of the sack and terminates at the top in a strong loop which forms a handle for carrying the ball. Fire-balls are dipped in a composition of equal parts of pitch and rosin made warm. The ball when finished should pass through the large shell-gauge.

TO PRIME THE BALLS.—Make 4 holes about 3 inches below the top by driving in the greased wooden pins 2 inches deep. When the ball is to be primed take out these pins and fill the holes with fuses and with two strands of quick-match, held fast by the composition; leave room in the priming-hole for coiling the quick-match and cover it with a piece of canvas fastened with 4 nails.

The balls are not primed until they are to be fired.

LIGHT-BALLS.

Light-balls are made in the same manner as fire-balls, except that there is no shell in them, as they are used for lighting up our own works.

LIGHT-BARRELS.

A light-barrel is a common powder-barrel pierced with numerous holes, and filled with shavings that have been soaked in a composition of pitch and rosin; it serves to light up a breach, or a bottom of a ditch.

ORNAMENTAL FIREWORKS.

LANCES.

Lances are small paper cases, .2 to .4 inch diameter, filled with one or more compositions, each burning with a flame of a particular color. They are used to mark the outlines of figures, and are attached to light frames of wood or sticks of bamboo.

To MAKE THE CASES.—Cut the paper into rectangles of a length equal to the required length of the case and of such widths as to make the case three thicknesses of No. 7 paper. The length of the case is generally about ten times its exterior diameter, depending on the composition with which it is be filled and the time it is required to burn.

Paste the rectangle and roll it on an iron former with the hand. When the cases are dry cut them to their proper length.

To DRIVE THE LANCE.—Place the cases in holes bored in a block of hard wood, the holes .02 inch larger than the case, and their depth .25 inch less than the length of the case.

Drive in the bottom of each case a ladleful of clay. Insert in the top of the case a small funnel; pass the drift through the funnel into the case; fill the funnel with composition; raise the drift one inch above the top of the case; press it to the bottom and give it three light blows with a rocket-drift; continue in the same way, raising the drift above the top of the case between each volley until the case is filled to .25 inch of the top.

Prime the lance with mealed powder, moistened with gummed water, and dip the end while moist in rifle-powder.

When the case is to be filled with two different compositions, drive the case with the first composition till it is about .2 inch above the required height; remove the surplus to the exact height with a gauge, and proceed with the second composition as with the first.

To FASTEN THE LANCES TO THE FRAME.—Bore holes .02 inch larger than the lances, and .5 inch deep, from 2 to 4 inches apart, according to the size of lance. The holes should be bored so that the lance shall be horizontal when the frame is in position. Dip the end of the lance in glue, and press it firmly in the hole, arranging the lances parallel to each other. Or they may be fastened to the frame by means of sharp nails or tacks, driven into the frame and projecting about .4 inch. The end of the lance is pierced with an awl, dipped in glue and thrust on the point of the nail, arranging them perpendicularly to the frame.

SUN-CASES.

Sun-cases are strong cases made like those for rockets, and filled with a composition which burns more slowly than rocket composition. They are attached to wooden frames, to give long rays of sparkling light. The choke is sometimes made by driving clay in the end of the case, and boring a hole through it for the escape of the flame; or the clay is driven on a short nipple, forming the choke.

Sun-cases are generally made from .75 inch to 1.5 inch interior diameter; their exterior diameter about double that of the interior. The length of the case may vary according to the time they are required to burn.

The diameter of the choke is about $\frac{1}{4}$ the interior diameter.

To MAKE THE CASES.—The cases are made like rocket-cases.

To DRIVE THE CASE.—Set the case on the nipple, and place it in a wooden mold; pour in a ladleful of composition and give it ten blows with the mallet; continue in the same way till the case is filled to the required height; put in a charge of rifle-powder, and over it drive a ladleful of clay.

When the cases are filled prime them by inserting in the choke a strand of quick-match doubled in the middle and secured by driving a little composition on it with a lance-drift.

Paste on each end of the case a strip of paper 5 inches wide, projecting 3 inches over the end of the case and forming an envelope to inclose the leaders.

Sun cases are fastened to the frames in the plane of the frame by means of iron wire, or with strong twine.

LIGHTS.

Lights are made by pressing lance or similar composition in shallow vessels, or in cases of large diameter. The burning surface being large, the light attains a great intensity.

Shallow earthen, wooden, or metal vases or paper cases are used. The vase or case is filled with dry composition, slightly pressed in; or composition moistened with gummed water may be used and pressed in the case more compactly. It is primed by powdering the surface first with a mixture of equal parts of the composition and mealed powder, and then with powder alone. Cover the top over with paper, pasted on the sides of the case. Through the center of the cover pass several strands of quick-match, spreading them over the surface and uniting them on the exterior in a single strand.

When the light is made with dry composition, the case must be placed in a vertical position. It may be placed horizontally if moistened composition be used and firmly packed.

TORCH-LIGHTS for funeral ceremonies are made by impregnating large strands of cotton with a thin alcoholic pap, the whole arranged in vases like an oil-lamp, the pap replacing the oil.

PETARDS.

Petards are small paper cases filled with powder. One end is entirely closed and the other has only a small hole left for a piece of quick-match, to communicate fire to the powder Petards are placed at the bottom of lances; they are also used to imitate the fire of musketry.

ROCKETS.

Rockets are made and driven as described for signal-rockets, except that different compositions are used, giving a more brilliant train of fire.

Rockets may be made of all sizes; their general dimensions may be deduced from those given.

Generally, in proportion as the size of the rocket is increased the thickness of the case must be increased and the bore of the rocket diminished, or the quickness of the composition, or both of them.

The stick should be 8 to 9 times the length of the case, and of such thickness as to throw the center of gravity about 1.25 inch from the end of the case.

TOURBILLON.

The tourbillon is a paper case filled with composition, with the holes for the escape of the gas so disposed as to cause the case to rise vertically in the air at the same time that it revolves horizontally around its middle point. It has light wings attached to it to direct its motion.

SHELLS.

Shells are made of light wood or paper, and filled with ornaments of different kinds. They are thrown nearly vertically from a mortar, and when at their highest point explode and throw out their ornaments, set on fire by the bursting charge.

To MAKE THE SHELL.—Turn in a lathe, from well-seasoned poplar or pine, two hemispheres of the size and thickness required, leaving a rabbet to unite the two. Cover the shell thus formed with lens-shaped pieces of No. 2 paper, pasted on smoothly, two or three thicknesses; or form the shell on a ball, the size of the cavity of the shell, by pasting on it strips of paper of lens-shape until it is .2 inch thick. Cut the shell into two equal parts, and take out the core; place the two halves together, and continue to paste on pieces of paper, permitting them to dry perfectly, until the shell is of the required thickness. This mode requires much time, as the shells dry slowly, and each successive layer must be thoroughly dry before other pieces are pasted on.

To CHARGE THE SHELL.—Introduce the stars, serpents, &c., through the fuse-hole, and then the bursting charge; cover the fuse where it comes in contact with the shell with glue, and drive it in place.

To insure the fuse taking fire, tie around the shell two pieces of quick-match, crossing over the fuse.

Cover the fuse with several strips of paper, pasted to the shell at their ends. These are removed before the shell is fired.

STARS.

Stars for shells are made as described. Those made of composition which burn with difficulty must have a hole in their axes, like those used for Roman candles.

WHEEL-CASES.

Wheel-cases are made and driven like sun-cases. They are used to give a rotary motion to pieces mounted on an axis, and to produce at the same time a brilliant fire. They are attached to the end of the spoke of the wheel which they are to turn by means of iron wire or strong twine, and they are inclined to the spoke from 20° to 30° to give a larger circle of fire.

ROMAN CANDLES.

The Roman candle is a long and strong tube charged with stars, which are thrown out successively by a charge of powder placed under each star.

The ends of gunbarrels, 20 inches long, are used for cases. When paper cases are used, make them about .65 to .7 inch interior diameter, and 1-inch exterior diameter; roll them like port-fire cases.

Three drifts of different lengths are used; they are made of hickory or other hard wood, with brass tips on the lower ends.

To CHARGE THE CASE.—Put in the case a ladleful of clay, and drive it with ten blows of the mallet; then a ladleful of composition, which is driven in the same way; next a charger of powder and a star, which is gently pressed down, then another ladleful of composition, a second charger of powder, and another star, driving the composition and pressing down the star gently; continue until the ten stars are in, and add a half ladleful of composition.

Prime the candle with a strand of quick-match 6 inches long, held in place against the side of the case by a little composition driven in on its ends. Cover the end of the candle with a strip of paper pasted on.

Roman candles are inserted in holes bored in frames, or tied with wire or twine in the direction in which they are to throw their stars. The stars used for Roman candles have a hole through their axes communicating the fire to the charge below, which throws it out.

LEADERS.

Leaders are long paper tubes of small diameters inclosing a strand of quick-match. They are used to communicate fire rapidly from one point to another.

The velocity of combustion is from 1 to 2 yards per second, depending upon the size of the tube, being more rapid as the tube is smaller.

Leaders are made by rolling a strip of thin paper, 2.5 inches wide, as obliquely as possible, on a ramrod, or cut the paper into trapezoids 4 inches wide at one base and 2¼ at the other; paste the edges of the strips 0.25 inch, and roll them on a ramrod so that one end shall be enlarged, funnel-shape. When dry, pass a strand of quick-match through, and let it project about an inch at each end.

To unite them into a long line, insert the end of one into another a distance of .75 inch, and tie them with a thread.

If the line be long, first stretch a piece of twine, and attach the leader to it every few feet.

PREPARATION OF COLORED FIRES.

The materials for colored fires should be as pure as can be obtained; those which crystallize should be procured in the crystalline state. They should be generally first dried, ground fine, weighed out and mixed. The composition is then moistened and pressed into shape. Some of the materials, such as the flowers of sulphur and lampblack ought to be first well washed in warm water. Antimony, glass, copper filings ought, as well as other materials, to be passed through sieve No. 1.

Drying.—All materials should be perfectly dry. Those which contain water of crystallization, as the barium nitrate, strontium nitrate, and copper sulphate, should have it driven off. For this purpose, place the salt in a broad, shallow vessel in a water-bath, or on a moderate fire, and stir it till it be perfectly dry, taking it off the fire some minutes before.

As the copper sulphate is easily decomposed in this operation, and as the sulphuric acid set free might occasion a spontaneous explosion when the copper sulphate was brought in contact with the chlorates, two parts of liquid ammonia are poured by degrees on the copper sulphate powdered and yet hot. (The ammonia neutralizes the acid, and, instead of injuring the color, it heightens it. The same process should be adopted with other decomposable salts.) A thick liquid of an indigo-blue color is obtained; place it on the fire, and warm it gently until it becomes a thick paste; then, leaving only a few coals under it, stir it with a spatula and crush it into a powder.

Grinding.—The materials are ground in a mortar with a pestle, or on a sieve with copper balls 0.4 inch diameter, of equal weight with the composition to be ground. All the utensils should be kept perfectly clean.

To pulverize antimony melt it and pour it into a cast-iron mortar previously warmed; when the metal is on the point of congealing stir it briskly with the pestle; it is thus reduced to fine grains, which are then pulverized with a pestle. Zinc and other similar metals are treated in the same way.

To obtain shellac in the state of a fine powder, it is first broken into pieces and melted with its weight of niter. The mass is then ground as usual, and the powder thus obtained is washed in pure water till all the niter is removed.

The resins and other substances insoluble in water and difficult to pulverize in their pure state are treated in the same manner.

All materials when pulverized should be passed through hair sieve No 1. They ought, if possible, to be. sifted when warm, and placed away immediately in well-stoppered bottles to preserve them from moisture

The chlorates should be pulverized in a marble mortar with a hard-wood pestle. The mortar, pestle, and sieve, should be used only for a single chlorate, and the whole operation be performed in a place apart to avoid accidents. The chlorate can be ground and manipulated by itself without danger; but when it is mixed with sulphur, charcoal, &c., it explodes very readily.

WEIGHING.—Each material should be weighed accurately by itself, according to the proportions laid down in the table.

MIXING.—The materials, after being weighed out, are poured on a sheet of pasteboard, and mixed as well as possible with the hand; they are then passed three times through sieve No. 2, keeping the sieve stationary, and stirring the materials with the hand.

If a chlorate enters into the composition, begin by mixing all the materials on a pasteboard, except the sulphur, charcoal, lampblack, sugar, tallow, and shellac. When they are well mixed, add the combustible materials separately, mix them thoroughly, and then add the chlorate.

Pass the composition three times through sieve No. 2, using a feather for the purpose.

All these manipulations with compositions into which a chlorate enters should be performed in a place aside, and with a small quantity at a time.

Compositions thus prepared should be preserved in well-stoppered bottles, carefully labeled. Those containing chlorates should be placed away from the rest, and apart from each other.

Dampening.—Compositions are dampened by pouring the pure or gummed liquid on them, a little at a time, and mixing it well with the hand or a wooden knife. Compositions should not be dampened until just before they are to be molded.

Molding.—All compositions may be firmly compressed, provided care be taken to avoid friction and blows with those containing chlorates.

However great the care taken in the choice of materials, their proportions and manipulations, it is difficult always to get uniform results. It is necessary, therefore, to try the mixtures and modify the proportions as may be required.

In every composition there are certain substances which are used to furnish oxygen for the consumption of the rest; the nitrates and chlorates are such. There are other substances, as sulphur, charcoal, and vegetable matters, which are burned; and others which are only used to give color to the flame, as antimony, lead, copper, strontia, &c.

The same substances may furnish oxygen and color the flame at the same time. Certain materials are used only to heighten the color, as the mercuric chloride and the ammonium chloride; the action of the latter is weaker than that of the former.

When a composition burns too slowly, there is an excess of coloring-matter, or of that which is to be burned, or some other substance (as water, for example), very rarely of that which furnishes oxygen. When the composition burns too fast, it is necessary to add coloring matter, or such substances as sugar, rosin, or tallow, which operate by separating the substances, supplying the oxygen from those which are burned, and at the same time keeping up the combustion.

Generally, the quicker the combustion the more will the flame approach to whiteness, whatever may be the coloring principle; and the slower the combustion the more certainty there will be of obtaining the desired color

Dimensions and weights of paper or poplar shells.

Caliber.	Thickness of— Sides.	Thickness of— Bottom.	Weight of— Empty. Lbs.	Weight of— Empty. ozs.	Weight of— Loaded. Lbs.	Weight of— Loaded. ozs.	Weight of charge. In mortar.	Weight of charge. In shell.	Drain of fuse-hole.	Time of fuse.	Ornaments. Weight of— Stars.	Ornaments. Weight of— Gold rain.	Ornaments. Weight of— Rain of fire.	Ornaments. Weight of— Serpents.	Ornaments. Number of— Stars.	Ornaments. Number of— Gold rain.	Ornaments. Number of— Streamers.	Ornaments. Number of— Serpents.
In.	*In.*	*In.*	*Lbs.*	*ozs.*	*Lbs.*	*ozs.*	*Oz.*	*Oz.*	*In.*	*Sec.*	*Oz.*	*Gr.*		*Gr.*				
5.8	0.5	0.62	~~10~~	~~1~~0.5	2	10	3.5	0.5	1.4	3	0.5	40	....	210	60	170	32	14
8	0.5	0.62	1	10	7	8	5	0.5	1.4	3	0.5	40	....	210	40	600	40	60
10	0.75	0.1	3	25	11	14	5	1	1.4	3	0.5	40	....	210	270	950	230	130
15	1.25	1.5	14 ~~11~~	14	35		12	1	1.4	3	0.5	40	....	210	900	3,400	760	460

Dimensions for sun and wheel cases.

		Sun-cases.			Wheel-cases.		
Interior diameter	inches	0.75	1.0	1.5	0.75	1.0	1.5
Case: Exterior diameter	do	1.2	1.6	2.0	1.20	1.6	2.0
Case: Length	do	11	10.60	12.5	8.75	8.75	8.75
Spindle: Diameter at bottom	do	0.28	0.55	0.65	0.28	0.55	0.65
Spindle: Diameter at top	do	0.18	0.38	0.40	0.18	0.38	0.40
Spindle: Length	do	0.35	0.75	0.80	0.35	0.75	0.80

Rate of burning of compositions.

Dimensions.		Wheel-fires. Common.	Wheel-fires. White.	Wheel-fires. Chinese.	Standing fires. Sun.	Standing fires. Star.	Standing fires. Roman candles.
Length of case	inches	8.75	8.75	8.75	11	8	19
Interior diameter	do	0.75	0.75	0.75	0.75	0.75	0.75
Weight of composition	ounces	3.5	3.5	4	5	4	5
Time of burning, per inch	seconds	17	17	21	22	20	45

Dimensions.		Lances. Red.	Lances. White.	Lances. Blue.	Lances. Yellow.	Lances. Green.	Port-fires. Red.	Port-fires. White.	Port-fires. Blue.	Port-fires. Yellow.	Port-fires. Green.	Port-fires. Lilac.	Changeable wheels.
Length of case	inches	4	4	5	4	4	3	3	3	3	3	3	3
Interior diameter	do	0.32	0.32	0.32	0.32	0.32	1	1	1	1	1	1	0.75
Weight of composition	grains	141	140	150	150	160	547	560	546	545	560	550	250
Time of burning	seconds	90	90	90	90	90	60	65	45	65	65	45	60

COMPOSITIONS FOR FIREWORKS.

(*The parts are by weight.*)

STARS.—*White.*—16 niter; 8 sulphur; 4 mealed powder.

Blue.—69 potassium chlorate; 24 sulphur; 7 copper sulphate.

Red.—32 strontium nitrate; 9 sulphur; 8 potassium chlorate; 2 lampblack.

Green.—18 barium nitrate; 6 sulphur; 4 potassium chlorate; 1 lampblack.

Purple.—24 potassium chlorate; 4 sulphur; 3 copper sulphate.

Yellow.—1 charcoal; 1 sulphur; 6 sodium nitrate.

Five pointed.—7 sulphur; 10 mealed powder.

LANCES.—*White.*—26 niter; 9 sulphur; 5 mealed powder.

Yellow.—16 nitrate of soda; 4 sulphur; 4 mealed powder; 2 lampblack.

Red.—30 strontium nitrate; 16 niter; 10 sulphur; 7½ mealed powder.

Blue.—8 niter; 2 sulphur; 4 copper sulphate.

Green—96 niter; 64 sulphur; 8 lampblack; 192 barium nitrate.

LIGHTS.—*White.*—16 niter; 8 sulphur; 4 mealed powder.

Yellow.—2 niter; 4 sulphur; 20 sodium nitrate; 1 lampblack.

Red.—5 niter; 6 sulphur; 20 strontium nitrate; 1 lampblack.

Blue.—8 niter; 2 sulphur; 4 copper sulphate.

Green.—24 niter; 16 sulphur; 48 barium nitrate; 1 lampblack.

Bengal.—2 antimony; 4 sulphur; 4 mealed powder; 16 sodium nitrate.

WHEEL-FIRES.—*Common.*—6 nitre; 1 sulphur; 16 mealed powder; 6 charcoal.

Brilliant—1 niter; 1 sulphur; 16 mealed powder; 7 steel filings.

Chinese.—1 niter; 1 sulphur; 16 mealed powder; 7 cast-iron filings.

White.—6 niter; 7 sulphur; 16 mealed powder.

SUN-FIRES.—*Chinese.*—1 niter; 1 sulphur; 16 mealed powder; 7 cast-iron filings.

STREAMERS.—2 niter; 1 sulphur; 16 mealed powder; 4 charcoal.

SERPENTS.—2 charcoal; 16 mealed powder.

ROMAN CANDLES.—6 nitre; 2 sulphur; 16 mealed powder; 6 charcoal.

GOLD RAIN.—16 nitre; 10 sulphur; 4 mealed powder; 3 lampblack; 1 flowers of zinc; 1 gum arabic.

The sodium nitrate may be replaced by the bicarbonate of soda or the oxalate of soda. The copper sulphate is ammoniated.

STORAGE AND PRESERVATION OF FIREWORKS.

Storehouses and magazines should be kept in the neatest possible order, the stores arranged as much as possible by classes, kinds, and calibers, and labeled. They should be ventilated from time to time in the middle of the day in fine weather, particularly those which contain ammunition and fireworks which are injured by moisture.

Provide cloth blinds for all windows exposed to the sun.

Slow-match.—In a dry place, such as a garret, in boxes or barrels, or piled on the floor.

Quick-match—If not in boxes it may be hung up in bundles on ropes or pins and covered with paper.

Friction-primers.—In tin boxes.

Port-fires.—Bundles of ten are placed in boxes or in barrels on end in safe and dry situations.

Fuses.—Packed in boxes, fuses of the same kind, as much as possible, in the same box, in very dry and well-ventilated stores.

Cylinders of rock-fire.—In boxes or barrels like fuses.

Fire-balls.—In cool but dry and airy places, suspended by the handle, the bottom resting on a board or floor that they may not become deformed. Each ball should be labeled, stating its caliber, weight, and year of fabrication.

Signal-rockets.—Packed in boxes, the sticks tied together. Each box should contain rockets of but one caliber, and should be marked with the size and the kind of decoration. If the sticks be attached they are tied in bundles of 5 according to the kind of decoration.

War-rockets.—Preserved in dry places with the same precautions as loaded shells.

Tarred links.—Strung on a rope and hung up. For transportation they are packed in barrels with straw between the tiers.

Fascines and *torches.*—Packed like the preceding.

The parts of ornamental fireworks, owing to their liability to deteriorate in store, are generally made as required. They may be packed in the same manner as port-fires.

TOOLS AND IMPLEMENTS.

The following list of laboratory tools and implements shows the kinds and proportions which may be required for a large laboratory and for a park of artillery:

Kind.		Quantity. Laboratory.	Quantity. Park.
Awls, brad		3	1
Adze, copper, weighing 5 pounds		1	1
Bench, for drawing the loads of shells		1	....
Bench-stake		1	....
Bick-iron		1	....
Bill-hooks		....	2
Blocks...	For driving fuses of different calibers	20	....
	For driving signal-rockets and port-fires	4	....
	For punches	2	....
	For cutting on	1	....
Bottles, with ground-glass stoppers		4	....
Boxes, for 12 workmen making cartridges—3 to each		36	....
Bowls....	Wooden, various sizes	12	4
	Earthen, glazed, large	6	....
Braces and bits		2	1
Brushes of various kinds		18	4
Buckets		6	....
Callipers, various sizes		3	1
Chargers, copper...	For fuses	10	5
	For port-fires	2	1
	For signal-rockets	6	2
	For cartridges for small-arms (revolving)	4	1
Chisels...	Brass, for unloading shells	6	3
	Cold	3	2
	Joiners	3	2
Compasses ..	Common	3	1
	Spring	2	1
Coopers' drivers, copper and wood		2	2
Crow-bar		1	1
Cutting-boards		6	....
Cylinders for gauging balls		3	2
Dippers		6	....
Dredging-boxes		6	2
Drifts....	Of iron, pointed with copper or brass, for driving port-fires	2	....
	For driving fuses for 13-inch and 10-inch shells—long and short	24	8
	For driving fuses for 8-inch shells and howitzers—long and short	24	8
	For driving signal-rockets—sets for 1 inch	1	....
	For driving signal rockets—sets for 0.76-inch	2	1
	For driving serpents, iron	6	2
Drills, assorted		6	3
Files.....	Half-round	6	4
	Saw	4	2
	Rat-tail	3	2
	Large	4	2
Formers..	Of iron or wood, for port-fire cases	2	....
	For rocket-cases—sets for each caliber	2	1
	For serpents	6	2
	For leaders	2	....
	For small-arm cartridges, of each caliber, one to each workman	20	20
	For cylinders and caps, for each caliber	2	1
	For pot for rockets, for each caliber	1	1
	For cutting pots on, for each caliber	1	1
	For cones for rockets, for each caliber	1	1
	For wads	1	....
Fork, iron, for dipping pitched fascines		1	....
Funnels of copper and tin, various kinds		20	5
Fuse-cutters		......	2
Fuse-setters		......	5
Fuse-extractors		2	1
Gauges ..	Steel, for shot and shells, for each caliber	2	2
	Double, for grape and canister, for each caliber	1	1
	Double, for cartridge-formers for each caliber	1	1
	Of sheet-iron, for sabots, for each caliber	1	1
	Of sheet-iron for canister-bottoms, for each caliber	1	....
	Of sheet-iron for canisters, for each caliber	1	....
	Of copper or wood, for cannon-cartridges	1	1

Tools and implements—Continued.

Kind.	Quantity.	
	Laboratory.	Park.
Gimlets	2	2
Gimlets, for priming rockets	6	3
Glue-pot and brush	1	....
Gunners' callipers	....	1
Gunners' pincers	3	3
Hammers { Iron hand, for strapping shot, &c	13	4
Hammers { Copper	2	1
Hand-barrows, with rope bottoms, for powder-barrels	2	....
Hatchet	1	1
Hooks for unpacking ammunition-boxes	6	3
Implements for making paper fuses, sets	4	1
Kettles { Iron, for melting lead	2	1
Kettles { Iron, for rock-fire, &c	2	....
Kettles { Iron, for pitch	1	1
Kettles { Copper, for paste	2	1
Knives { For cutting paper, large and small	12	6
Knives { Block	1	....
Ladles { Iron, for lead, pitch, &c	5	1
Ladles { Copper, for saltpeter, &c	1	....
Lanterns	5	5
Letter-punches (stencils), set	1	1
Mallets { For driving fuses and port-fires	20	5
Mallets { For driving rockets	6	4
Mallets { Carpenters	2	....
Measures { For powder, from 8 pounds to 4 ounces	22	12
Measures { Gallon, quart, pint, half pint, and gill	5	5
Mortar and pestle, bronze	1	1
Mortar, marble, with pestle of hard wood	1	....
Molds { For balls and buckshot, sets	....	2
Molds { For incendiary-balls, different calibers	4	....
Molds { Brass, for port-fires	2	....
Molds { For rockets of each caliber	2	1
Mullers, wooden	4	2
Needles of various kinds	150	50
Nippers { For cutting wire	2	1
Nippers { For trimming balls	....	1
Palms for sewing canvas	4	2
Paste-brushes	12	12
Patterns { For cartridge-papers for small-arms	4	2
Patterns { Tin, for each kind and caliber, for paper cartridges	1	1
Patterns { Tin, for each kind and caliber for flannel cartridges	1	1
Patterns { Tin, for each kind and caliber for canisters	1	....
Pans, copper, various sizes	18	6
Pitchers, stone	6	....
Plane	1	....
Pliers, flat, for twisting wire	4	2
Plugs, pointed, for loading spherical case	2	....
Press for paper and pasteboard	1	....
Profiles of sheet-iron for sabots, for each caliber	1	....
Punches	6	....
Punches { For piercing shot-straps	12	2
Punches { Center	4	....
Punches { For fuse-caps, for 13, 10, and 8 inch, 2 each	8	....
Rasps for wood	6	6
Reels or frames for quick-match	2	....
Rocket-stand	1	....
Rolling-boards for port-fire-cases, &c	2	....
Rules { Carpenters'	2	1
Rules { Iron, for cutting by	8	2
Sandstones for sharpening knives	6	2
Saws	2	1
Scale, of one foot (diagonal), divided into inches and 100ths	1	1
Scales, copper, large, small, and medium	5	2
Scissors and shears, of different sizes	12	12
Scoops, copper, for taking up materials	6	4
Screw-drivers	4	2
Scribers	4	2
Shell-hooks	1	....
Shell-plug screws	4	2
Sieves { Hair, Nos. 1, 2, 3, and 4, with frames	4	4
Sieves { Bolting-cloth	2	2
Screens, for demolition of cartridges for small-arms	2	....
Shovels	2	....
Skimmer, copper, for saltpeter	1	....
Soldering-furnaces and irons	2	1

Tools and implements—Continued.

Kind.	Quantity: Laboratory.	Quantity: Park.
Socks, pairs	60	....
Spatulas. Steel, for saltpeter, &c	3	1
Spatulas. For rock-fire	6	....
Spatulas. For packing ammunition-boxes	24	2
Spoke-shave	1	....
Sponges	2	....
Spools for twine	40	....
Squares.. Wooden	6	2
Squares.. Iron	2	1
Stamps, for flannel cartridges, for each caliber	1	....
Paulins	4	2
Thimbles	6	6
Tinner's creaser	1	....
Tinner's shears	2	1
Trestles, pairs	2	....
Trivets, iron	2	....
Tubs .... For the demolition of cartridges for small-arms, common	1	....
Tubs .... For making slow-match, &c. (casks sawed in two)	6	....
Twisting-machine, for slow-match, &c	1	....
Watering-pots	2	1
Weights, set for each balance or pair of scales	1	1
Whetstones	......	1
Wrenches Screw	1	1
Wrenches Fuse	1	1
Yard-stick	1	1

Ammunition for siege, garrison, and sea-coast services.

	Smooth-bore guns.			Howitzers.	Mortars.					Rifled guns.								Rifled mortars.		Remarks.
	8-inch.	10-inch.	15-inch.	8-inch.	8-inch.	10-inch.	10-inch.	13-inch.	Coehorn.	30-pounder.	4.5-inch.	8-inch.	10-inch.	12-inch.	300-pounder.	200-pounder.	100-pounder.	8-inch.	10-inch.	
Charge of powder, maximum ... lbs	15	28	120	4	2.25	4	12	20	0.5	3.25	3.25	15	70	120	25	16	10			
Height of charge ... in	9	11	26	6						8.5	7.5	23	32	35	11	12.5	11.25			For canister use.
Diameter of cartridge ... do	7.25	9.2	14	4.2						3.75	4	7.25	9.125	11	9.37	7	5.5			Lead bullets, or slugs, 11 to the pound.
Cartridge-bag: Length ... do	18	21	37	14						12.75	14	15	40	57.15	23.5	22	19.5			
Cartridge-bag: Width ... do	7	9	12	7.6						12.75	12.75	24	30	35	16	12.5	10			
Cartridge-bag: Pieces ... No	4	4	4							2	2	2	2	2	2	2	2			
Cartridge-bag: Diameter, bottom ... in	8.25	10.2	15	5.2						4.75	5.5	4.25	10.2	13	10.37	8	7			
Sabot: Height ... do	1.9	2	2.37	*4																Parrott projectile for 300-pounder.
Sabot: Diameter ... do	7.5	9.6	14.62	7.7																Parrott projectile for 200-pounder.
Strap, 2 for each: Length ... do	23.5	29.2	52.5																	Parrott projectile for 100-pounder.
Strap, 2 for each: Width ... do	0.75	1	1.25																	Parrott projectile for 30-pounder.
Canister: Length ... do				25.1																Hotchkiss projectile for 4.5-inch.
Canister: Height ... do				8.6																Butler projectile for 4.5-inch.
Canister: Interior diameter ... do				7.8																Dyer projectile for 4.5-inch.
Canister: Number of shot ...				48																
Canister: Weight ... lbs				53.5																
Shell: To fill mortar-powder ... do	1.75	3	13.5	2.5	2.5	4.75	4.75	8.50	5	1.25	1				14	5	4.75			Long shell.
Shell: To blow mortar-powder ... oz	5	9	16	4	4	5	5	10	15								3.25			Short shell.
Shell: Rock-fire ...																				
Grape: Plate: Diameter ... in		7.85																		
Grape: Plate: Thickness ... do		6																		
Grape: Ring, diameter ... do		6.55																		
Grape: Bolt: Length ... do		14.7																		Grape should not be used in rifled cannon.
Grape: Bolt: Diameter ... do		6																		
Grape: Weight ... lbs		75.5																		
Wad, junk: Diameter ... in	7.8	9.75																		
Wad, junk: Height ... do	8.5	16.5																		
Wad, junk: Weight, finished ... lbs																				
Wad, junk: Junk ... do																				
Wad, junk: Strands of hemp ... No																				
Charge for 20-inch guns ... lbs																				200 pounds mammoth powder.
Height of charge for 20-inch guns ... in																				16.5 inches.

* Spherical segment.

Ammunition for field and mountain service.

	Smooth-bore gun.				Howitzer.			Rifle guns.						Hotchkiss.	
	12-pounder, bronze.				12-pounder mountain-howitzer.			3-inch iron.			3.5-inch iron.			Revolving gun.	
	Shell.	Case.	Shot.	Canister.	Shell.	Case.	Canister.	Shell.	Case.	Canister.	Shell.	Case.	Canister.	Shell.	Canister.
Charge of powder ... pounds	2	2.5	2.5	2	0.5	0.5	0.5	1	1	1	2.25	2.25	2.25	*Grains.* 1,850	*Grains.* 1,850
Height of charge ... inches	3.75	4.75	4.75	3.75	2.25	2.25	2.25	5.75	5.75	5.75	7	7	7	3.5	3.5
Cartridge-bag: Length ... do	14.2	14.2	14.2	14.2	10.42	10.42	10.42	9	9	9	11	11	11	4.724	4.724
Cartridge-bag: Width ... do	10	10	10	10	5	5	5	8.75	8.75	8.75	9.5	9.5	9.5	.....	.....
Cartridge-bag: Diameter of bottom ... do	5.25	5.25	5.25	5.25	4	4	4	3.75	3.75	3.75	4.5	4.5	4.5	1.641	1.641
Sabot: Whole height ... do	2.125	2.125	2.125	2.285	2.785	2.785	3.781	.....	.....	.....	.....	.....	.....	.....	.....
Sabot: Height of cylinder ... do	.....	.....	.....	0.575	2	2	2.55	.....	.....	.....	.....	.....	.....	.....	.....
Sabot: Diameter of cylinder ... do	4.45	4.45	4.45	4.45	4.4	4.4	4.4	.....	.....	.....	.....	.....	.....	.....	.....
Sabot: Diameter of top of cone ... do	.....	.....	.....	.....	4.17	4.17	4.45	.....	.....	.....	.....	.....	.....	.....	.....
Sabot: Diameter of bottom of cone ... do	.....	.....	.....	.....	3.17	3.175	3.23	.....	.....	.....	.....	.....	.....	.....	.....
Strap: Length ... do	7	7	13	.....	7	7	7	.....	.....	.....	.....	.....	.....	.....	.....
Strap: Width ... do	0.5	0.5	0.5	.....	0.5	0.5	0.5	.....	.....	.....	.....	.....	.....	.....	.....
Rings, diameter, exterior ... do	3.25	3.25	.....	.....	3.25	3.25	3.25	.....	.....	.....	.....	.....	.....	.....	.....
Weight of sabot ... ounces	4.5	4.5	4.5	7.5	5.5	5.5	9.5	.....	.....	.....	.....	.....	.....	.....	.....
Weight of projectiles, strapped ... pounds (Shell and case loaded.)	8.8	11.25	12.1	14.2	9.35	12.2	11.2	*8.12	*9.13	.....	.....	.....	.....	.....	.....
Canister: Length ... inches	.....	.....	.....	14.35	.....	.....	14.4	.....	.....	8.0	.....	.....	11	.....	.....
Canister: Height ... do	.....	.....	.....	6.66	.....	.....	4	.....	.....	7	.....	.....	8.5	.....	.....
Canister: Interior diameter ... do	.....	.....	.....	4.45	.....	.....	4.47	.....	.....	2.8	.....	.....	3.2	.....	.....
Canister: Diameter of plates ... do	.....	.....	.....	4.38	.....	.....	4.42	.....	.....	2.8	.....	.....	3.2	.....	.....
Canister: Thickness of top plate ... do	.....	.....	.....	0.116	.....	.....	0.1	.....	.....	0.125	.....	.....	0.125	.....	.....
Canister: Thickness of bottom plate ... do	.....	.....	.....	0.125	.....	.....	0.125	.....	.....	0.125	.....	.....	0.125	.....	.....
Canister: Number of shot	.....	.....	.....	27	.....	.....	148	.....	.....	154	.....	.....	0.140	.....	.....
Canister: Weight ... pounds	.....	.....	.....	14.2	.....	.....	11.2	.....	.....	10.75	.....	.....	17	.....	.....
Fixed ammunition: Whole length ... inches	9.5	10.3	10.7	12.12	8.17	8.17	9.4	.....	.....	.....	.....	.....	.....	8.15	8.15
Fixed ammunition: Weight ... pounds	11	13	15.3	16.44	9.9	12.6	11.8	.....	.....	.....	.....	.....	.....	*Lb. Ozs.* 1 10½	*Lb. Ozs.* 1 9.4
Packing box: Interior diameter: Length ... inches	17.5	17.5	17.5	18.37	27.5	27.5	27.5	16.5	16.5	16.5	11	11	11	.....	.....
Packing box: Interior diameter: Width ... do	9.75	9.62	10.5	12.5	9.25	9.25	9.25	12.5	12.5	12.5	11	11	11	.....	.....
Packing box: Interior diameter: Height ... do	9.25	9.25	9.5	9.5	8.5	8.5	9.5	8	8	7.5	9	9	8	.....	.....
Packing box: Weight, packed ... pounds	106	122	140	156.5	154	184	175	161	184	175	160	180	198	.....	.....
Packing box: Number of rounds	8	8	8	8	12	12	12	12	12	12	9	9	9	.....	.....
Packing box: Number of primers	10	10	10	10	18	18	18	13	18	18	14	14	14	.....	.....
Packing box: Color	Black	Red ..	Olive	Drab.	Black	Red ..	Drab	Black	Red ..	Drab.	Black	Red ..	Drab.	.....	.....

* Hotchkiss, Butler, and Dyer projectiles for 3-inch rifles.

REMARKS.

Shells are filled with the bursting-charge of mortar-powder to their capacity.

Case-shot are filled with lead balls which are set with melted sulphur or rosin, and bored out for the bursting-charge with as large a chamber as the fuse-hole will admit of, which is filled with powder or bursting-charge of other explosive, space being left for the fuse-plug or fuses. When sabots are used a spherical cavity is made for the seat of the projectile.

When port fires are used, one to each box of ammunition, and half a yard of slow-match is packed, and sufficient tow to make the whole packing secure.

Large charge for 3-inch rifle-gun, 1.5 pound; one-half of an inch is allowed for each seam in a cartridge bag.

Rifle ammunition has no wooden sabots, nor is the cartridge attached to the projectile; these are packed on top of the projectiles, or better, in a part of the box separated from the projectiles by a partition, in which case the small stores are packed on top of the cartridges.

Hotchkiss ammunition is metallic; wrapped metal; center-primed case.

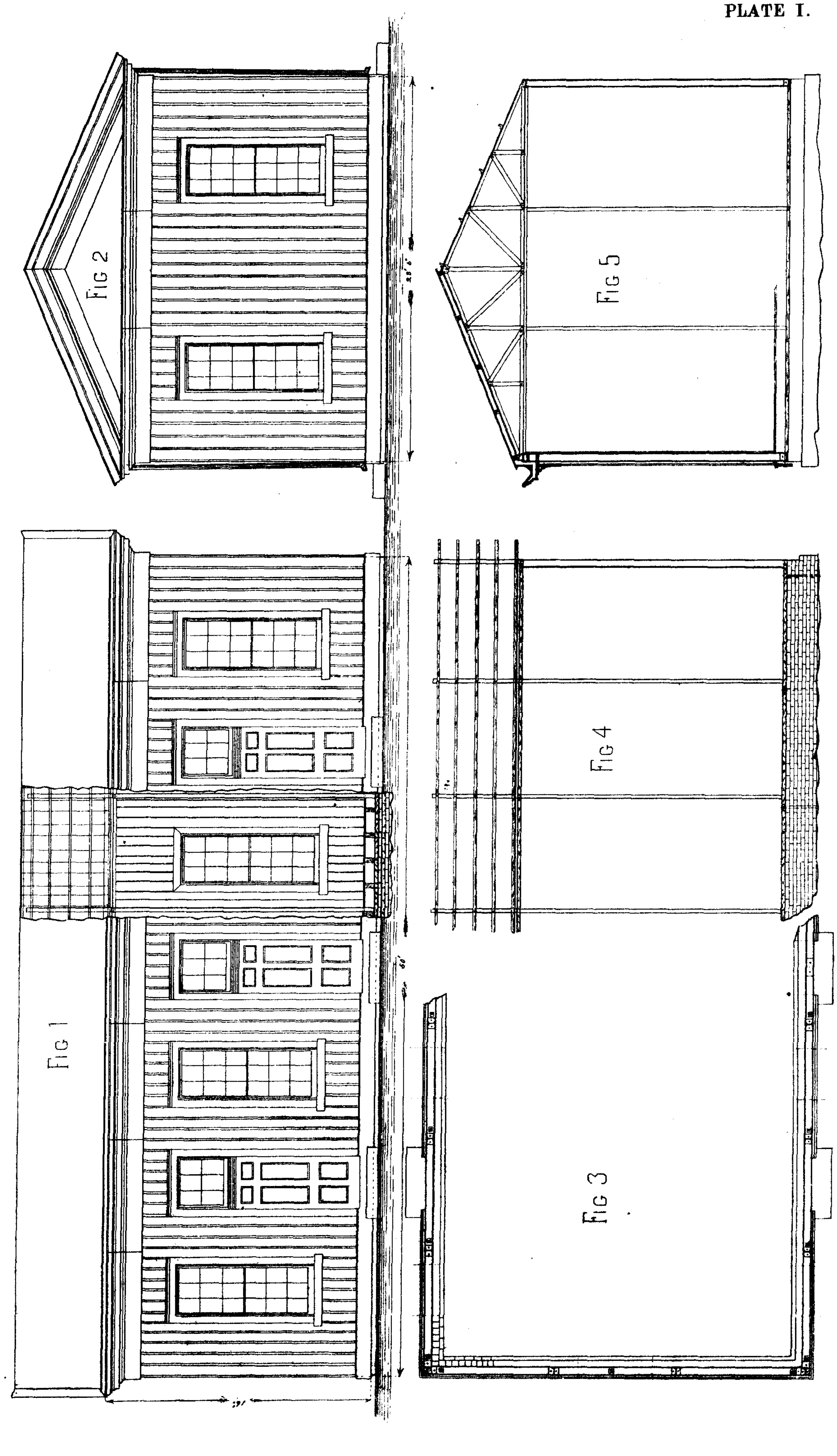
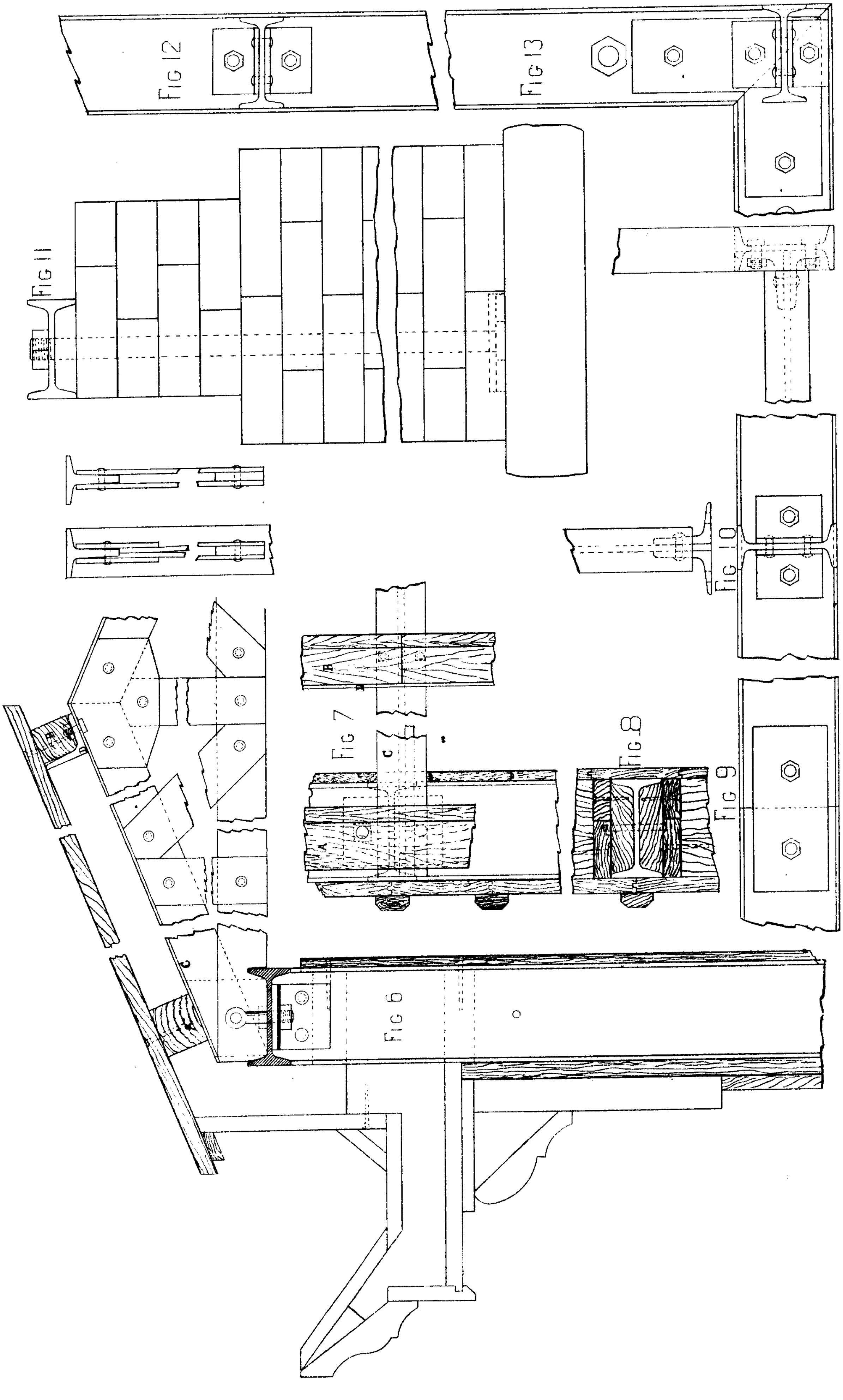
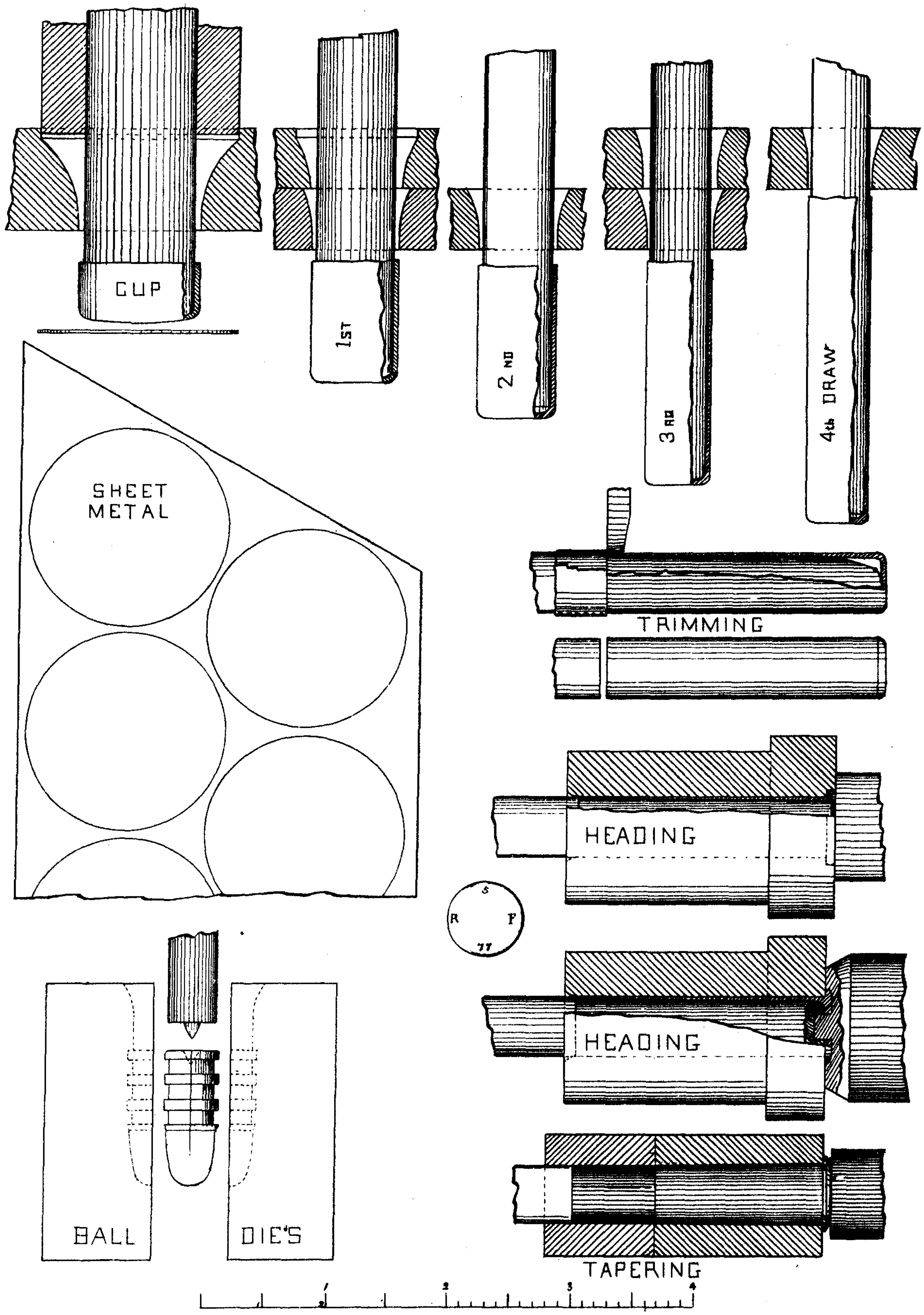


Fig 1
Fig 2
Fig 3
Fig 4
Fig 5

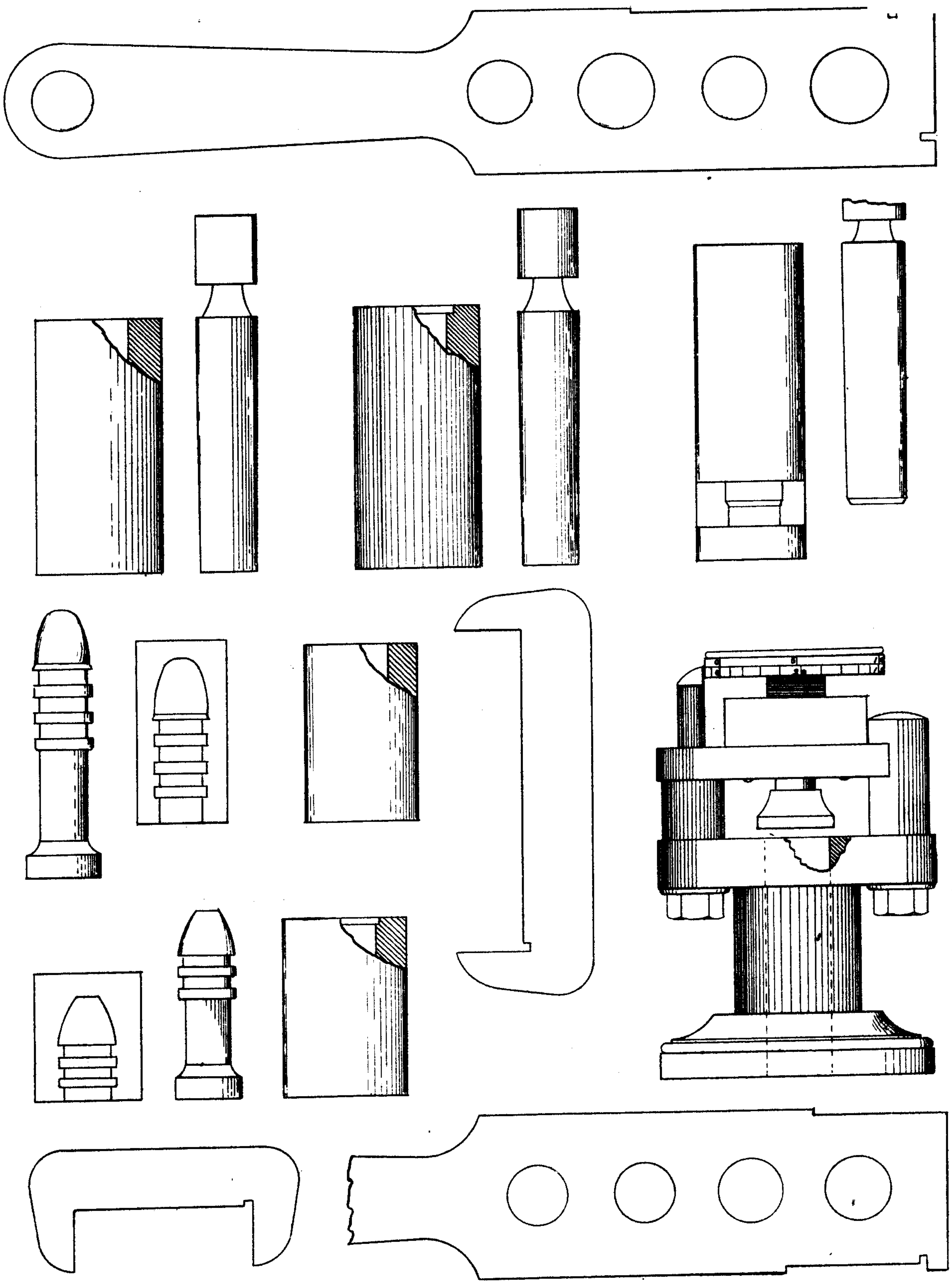
PLATE II.



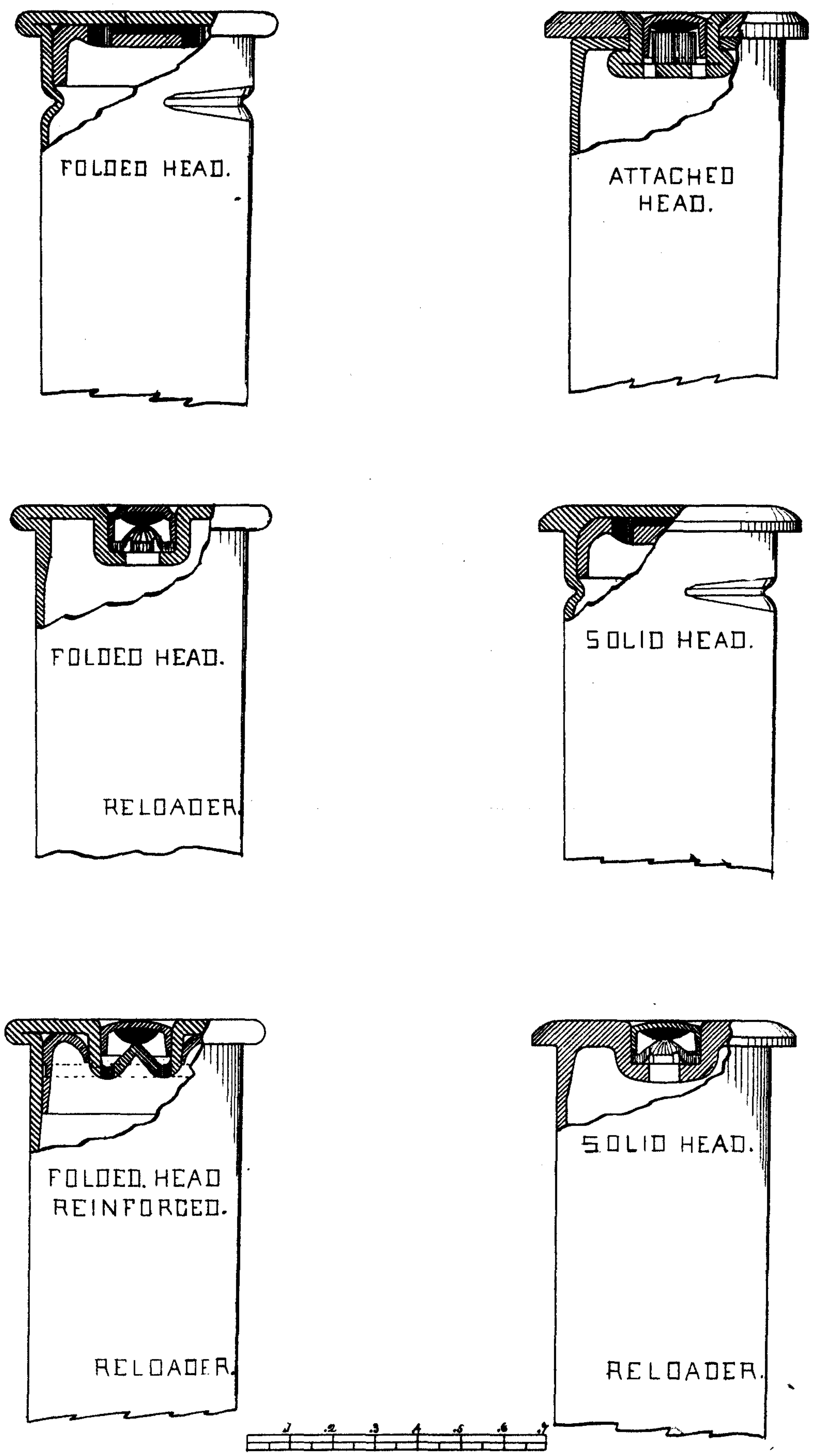
OPERATIONS OF CARTRIDGE MANUFACTURE.



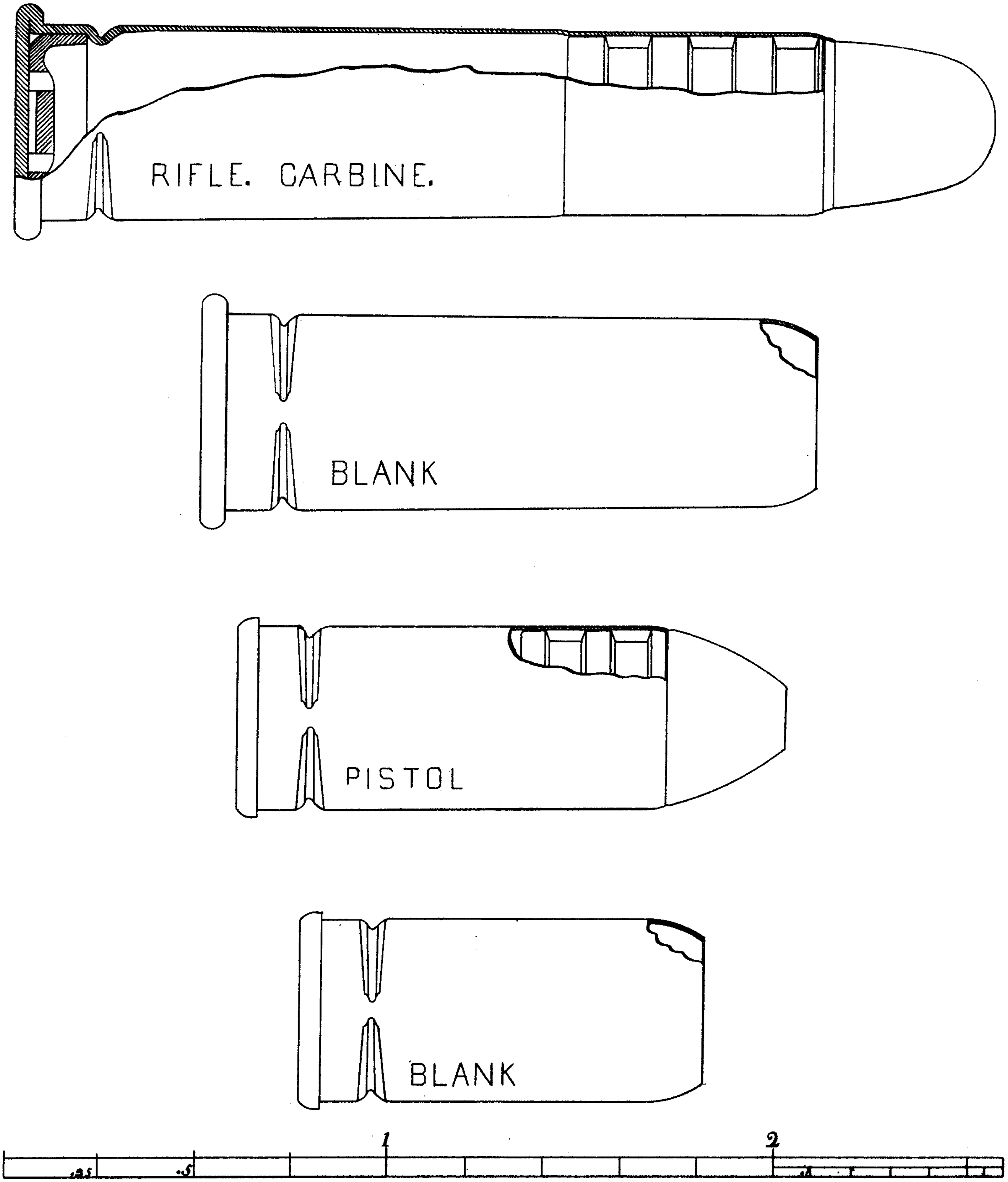
GAUGES FOR INSPECTION OF CARTRIDGES.



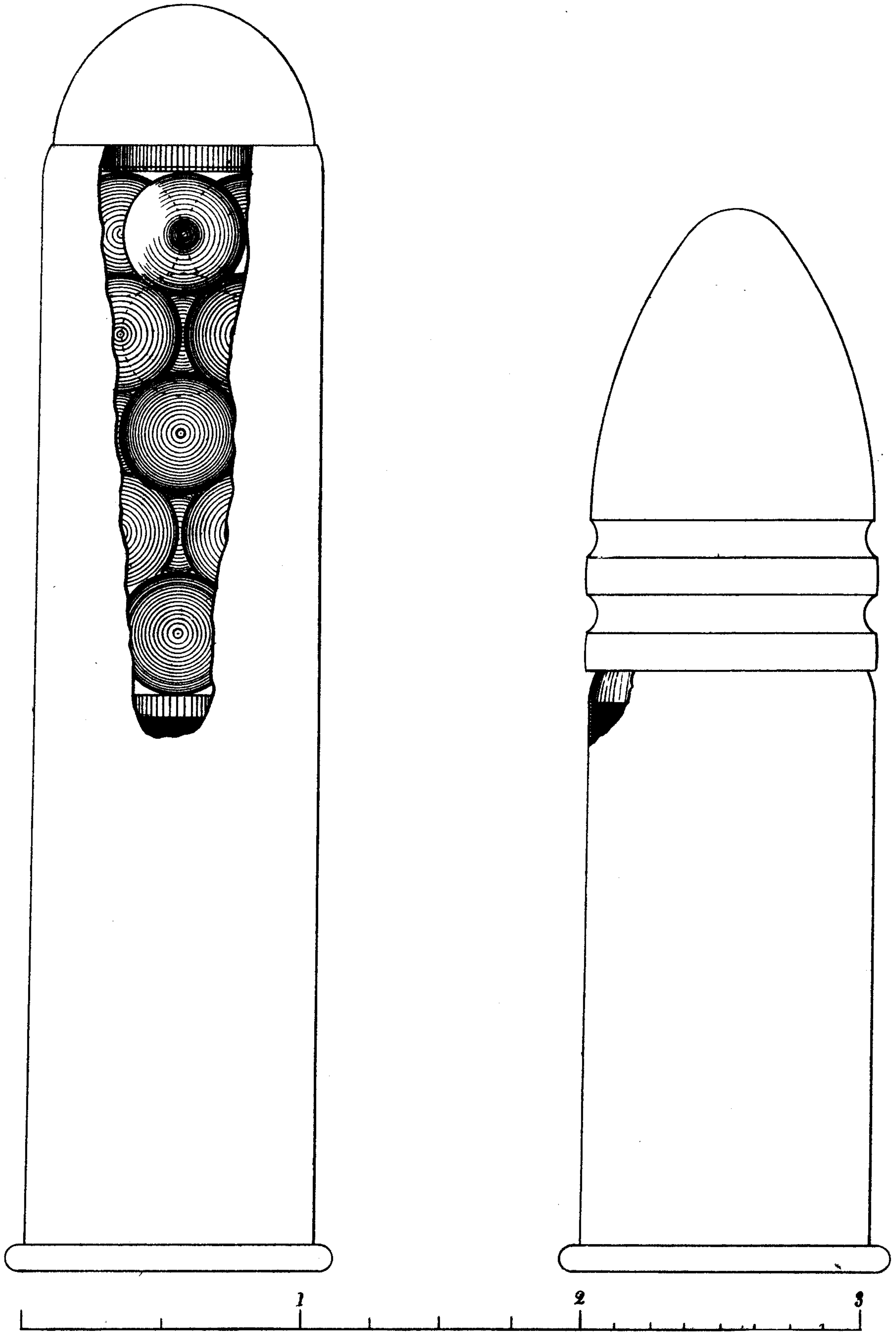
CLASSES OF CENTRE FIRE CARTRIDGES



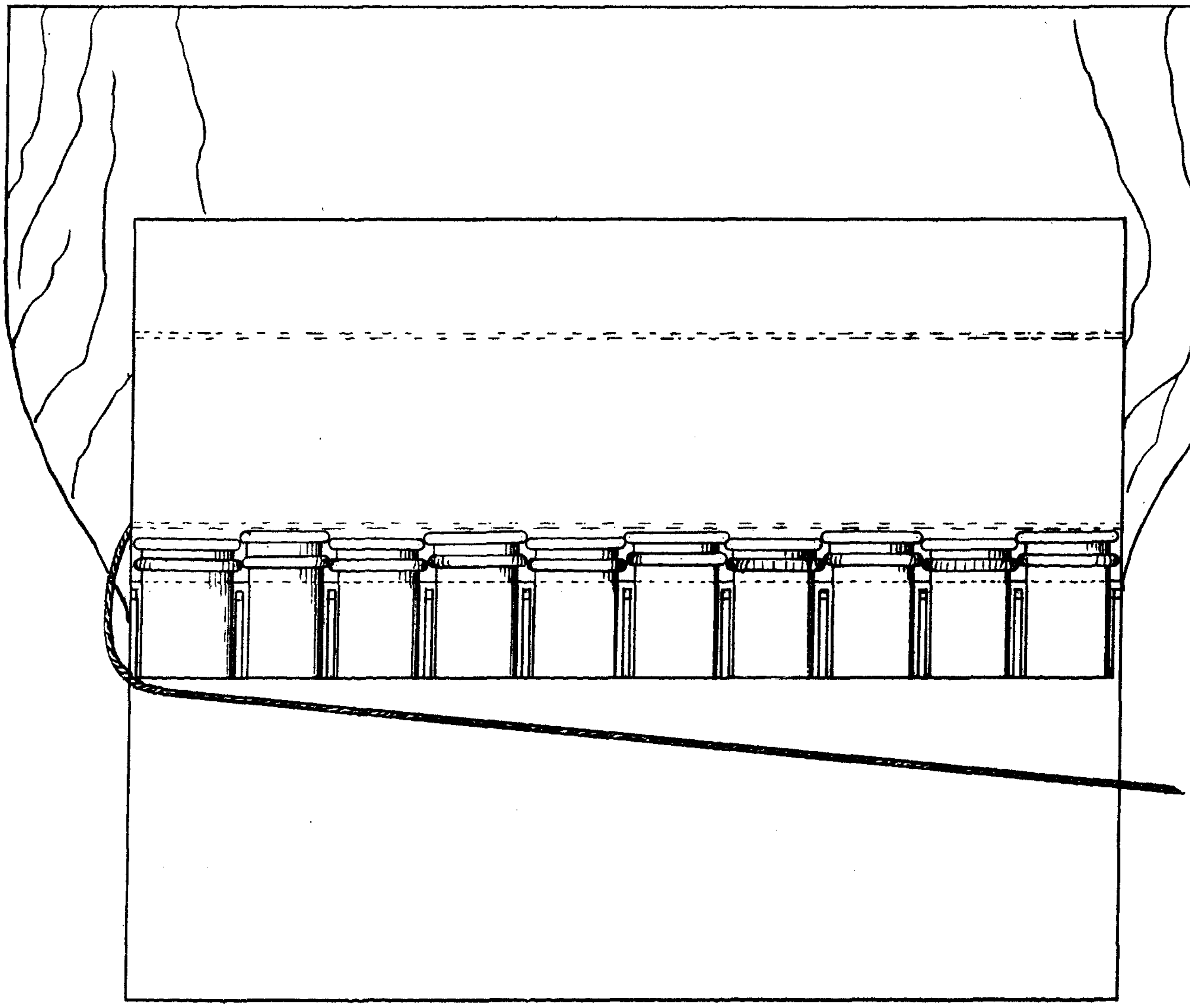
SERVICE CARTRIDGES.

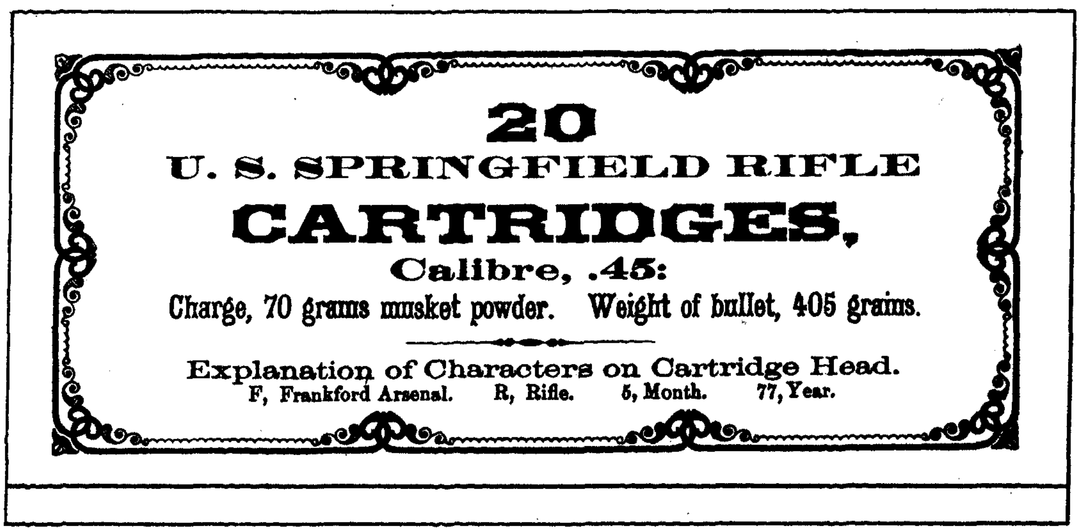


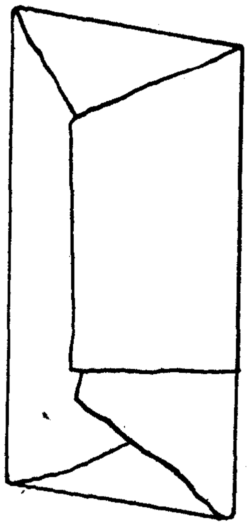
BALL & CANISTER FOR GATLING GUN CAL. 1.



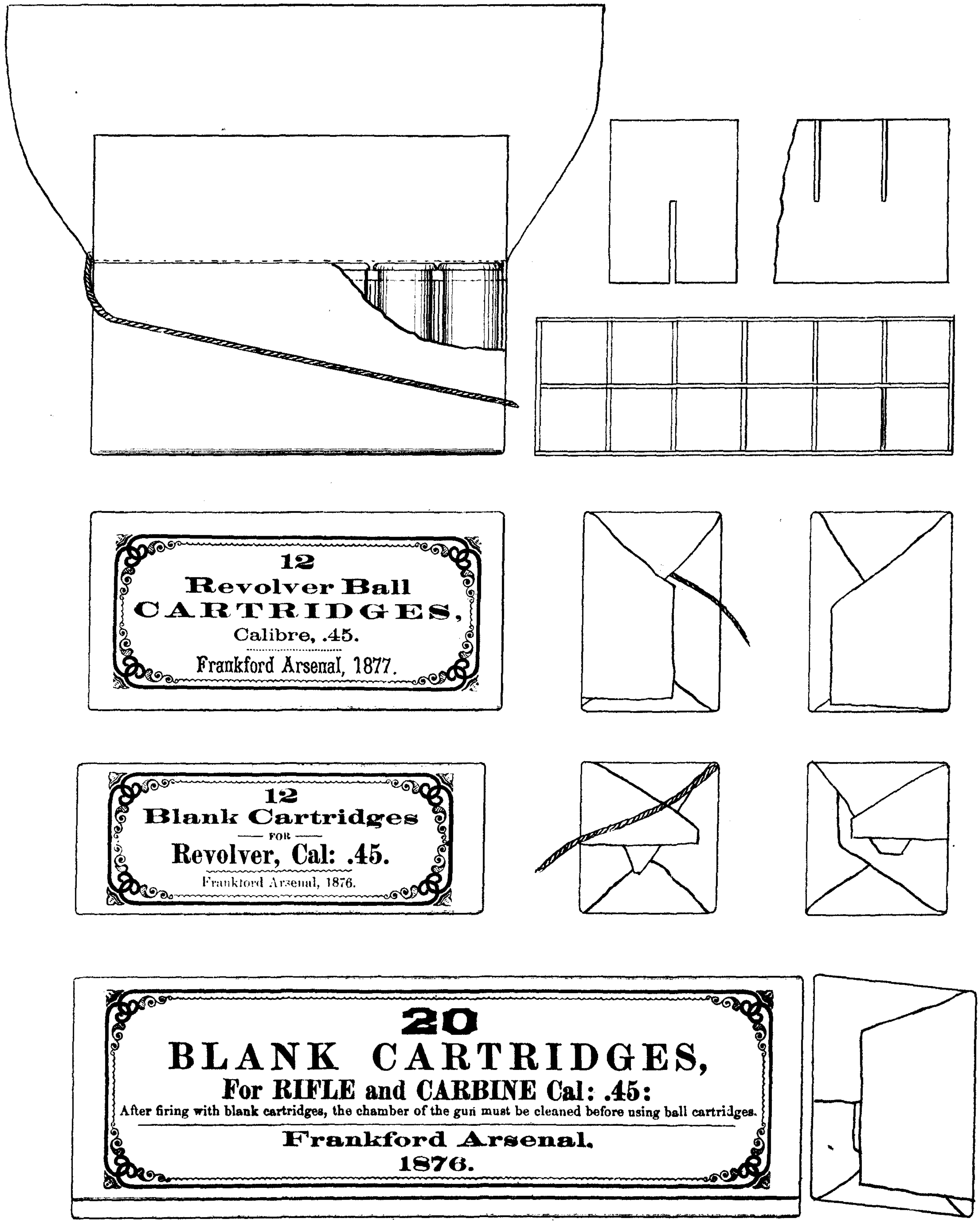
PAPER PACKING BOXES FOR CARTRIDGES.







PAPER PACKING BOXES FOR CARTRIDGES.



PAPER PACKING BOXES FOR CARTRIDGES.

5

CENTRE-PRIMED, METALLIC

BALL CARTRIDGES,

FOR GATLING GUN,

CALIBRE, 1 Inch.

CHARGE, .75 OUNCE MORTAR POWDER.

WEIGHT OF BULLET, 8 OUNCES.

FRANKFORD ARSENAL,

1868.

5

CENTRE-PRIMED, METALLIC

CANISTER CARTRIDGES,

FOR GATLING GUN,

CALIBRE, 1 Inch.

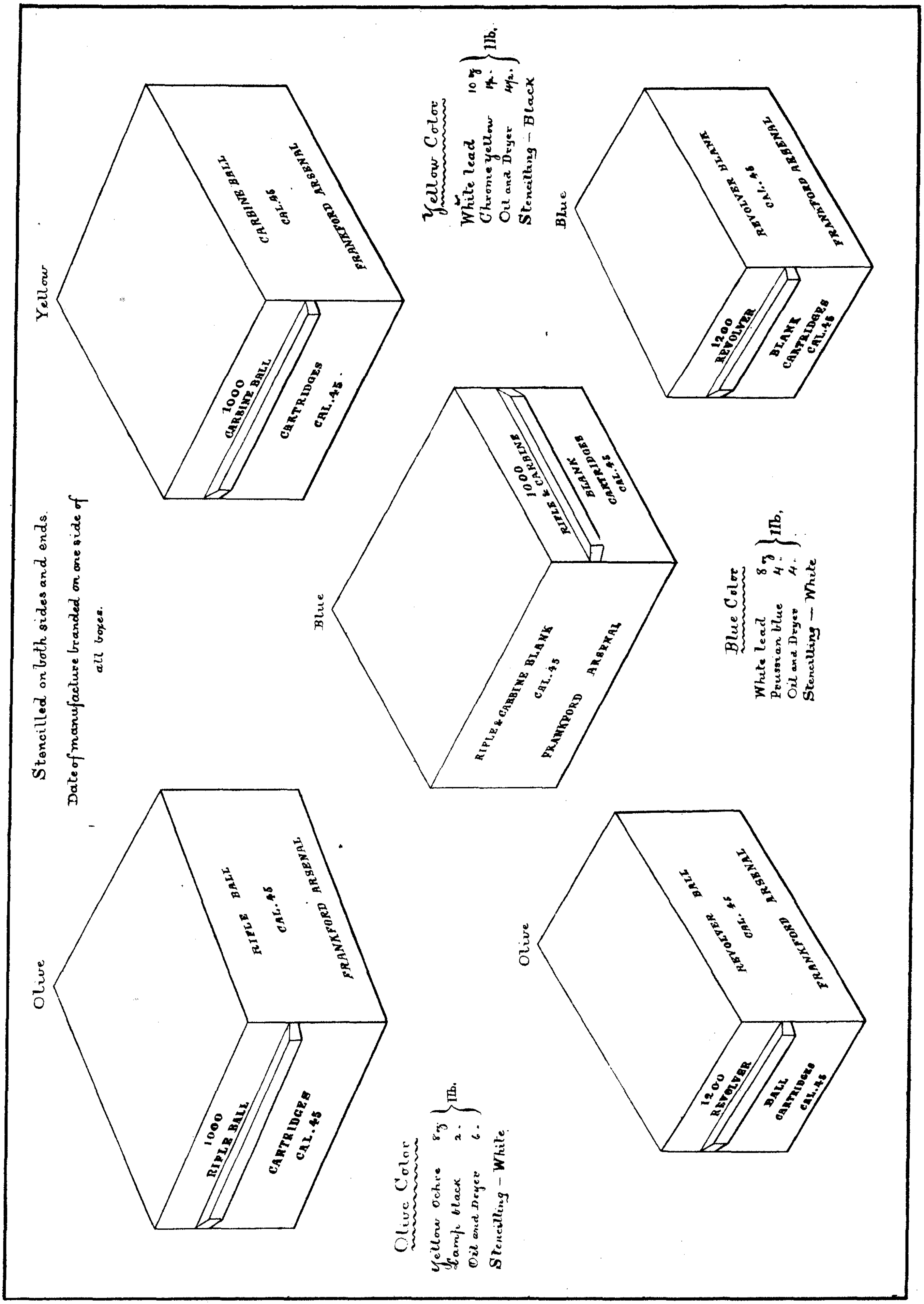
CHARGE, .75 OUNCE MORTAR POWDER.

15 .45 -INCH BULLETS..

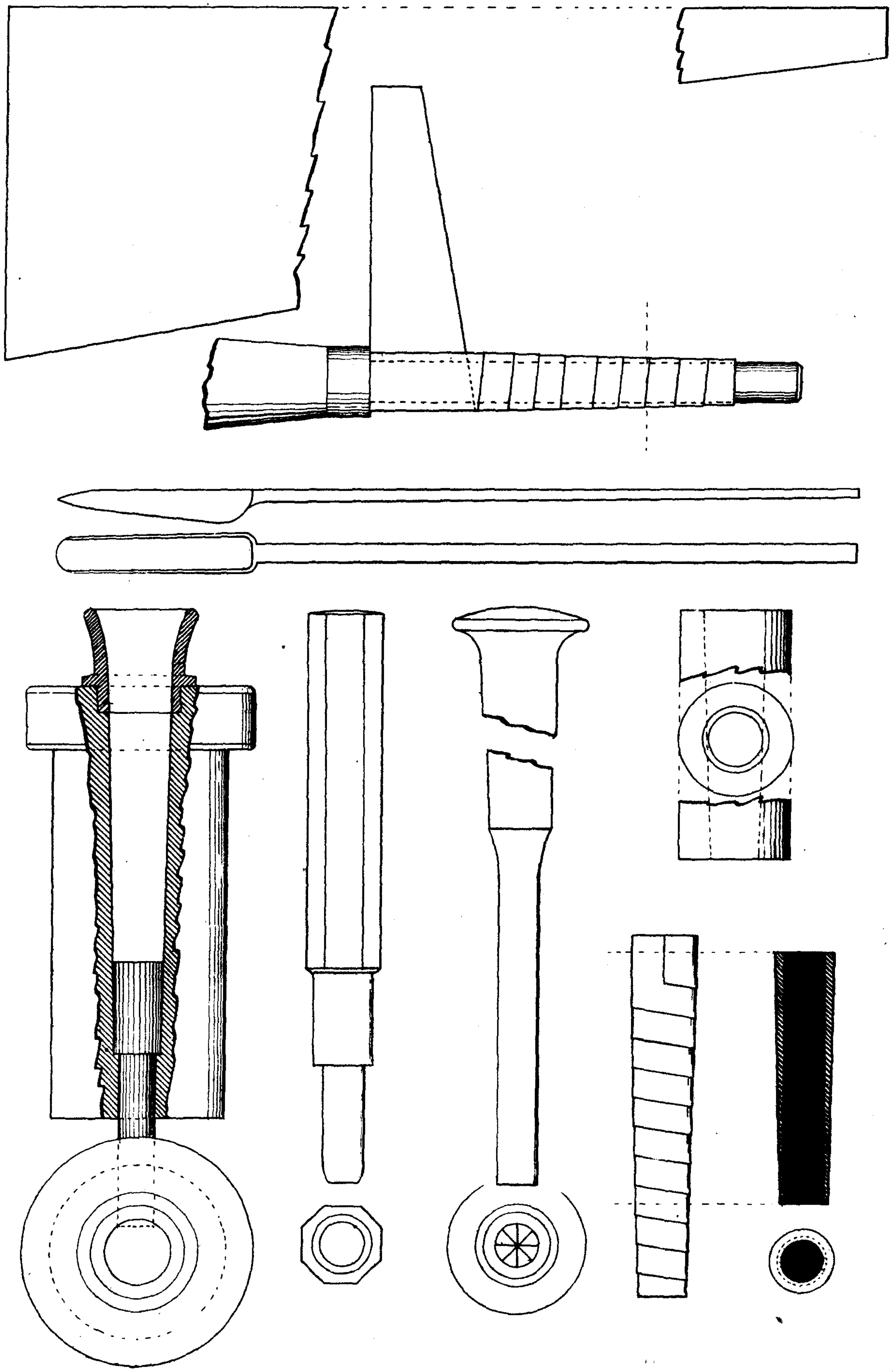
FRANKFORD ARSENAL,

1868.

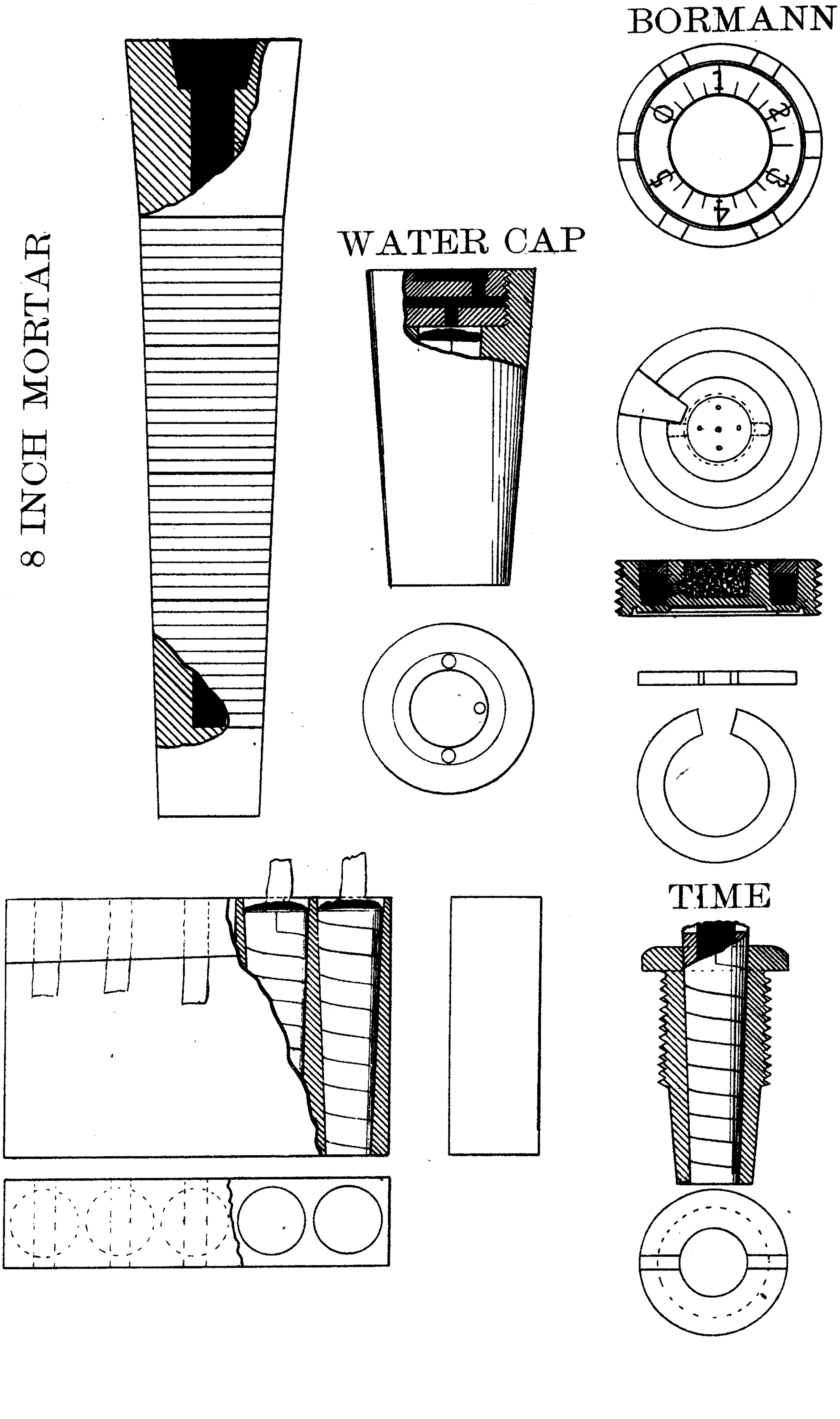
WOOD PACKING BOXES FOR CARTRIDGES.



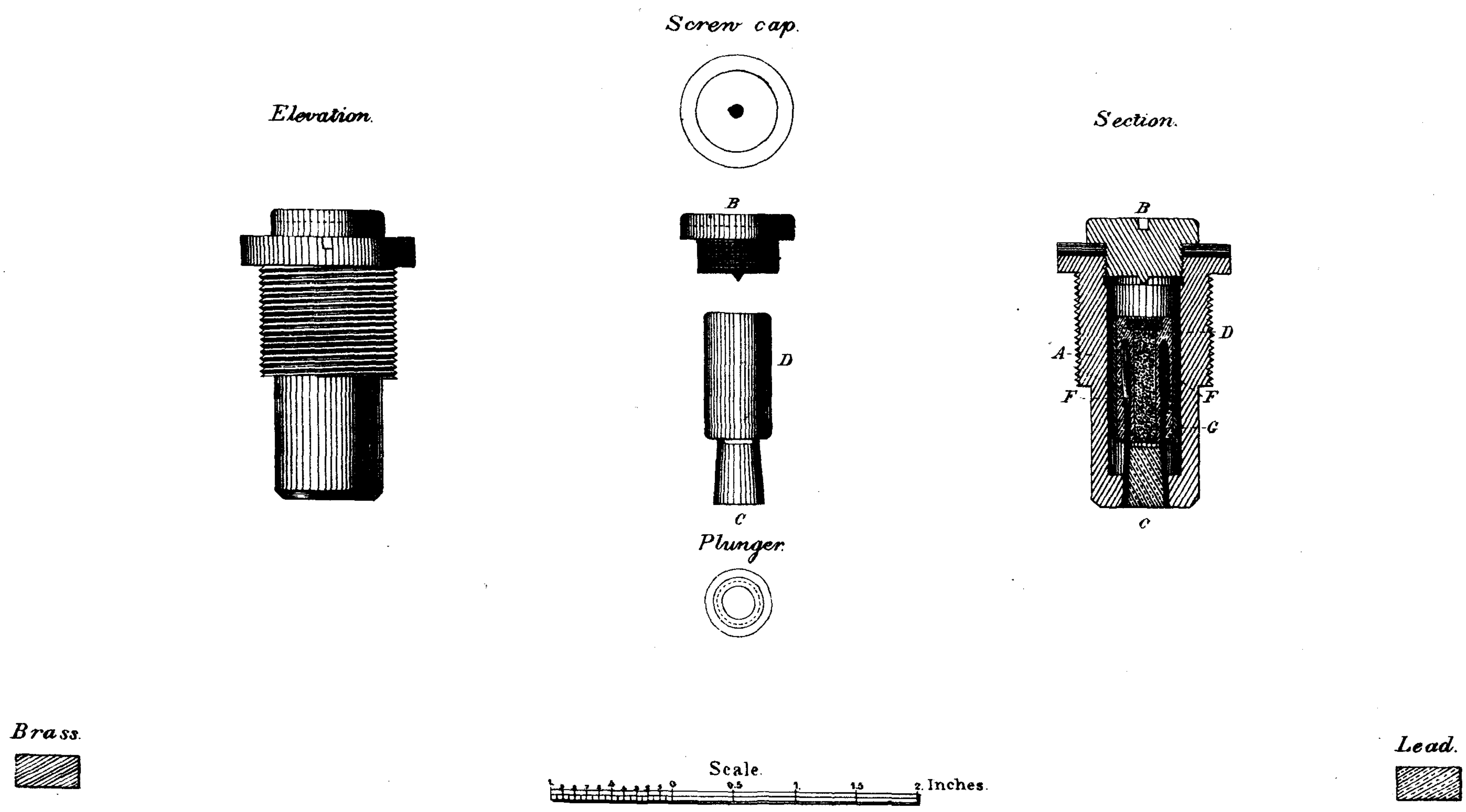
PAPER TIME FUZE & IMPLEMENTS.

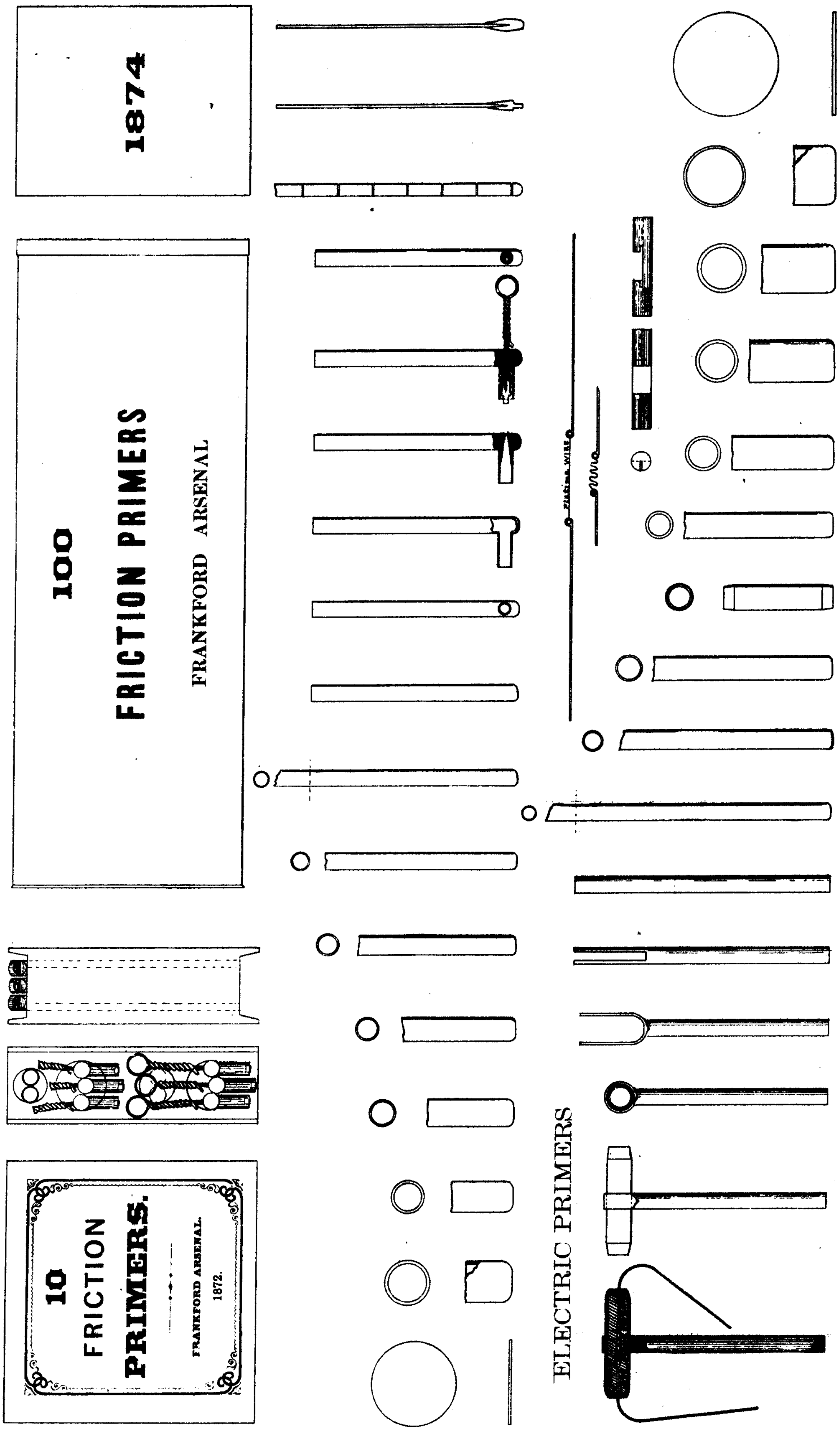


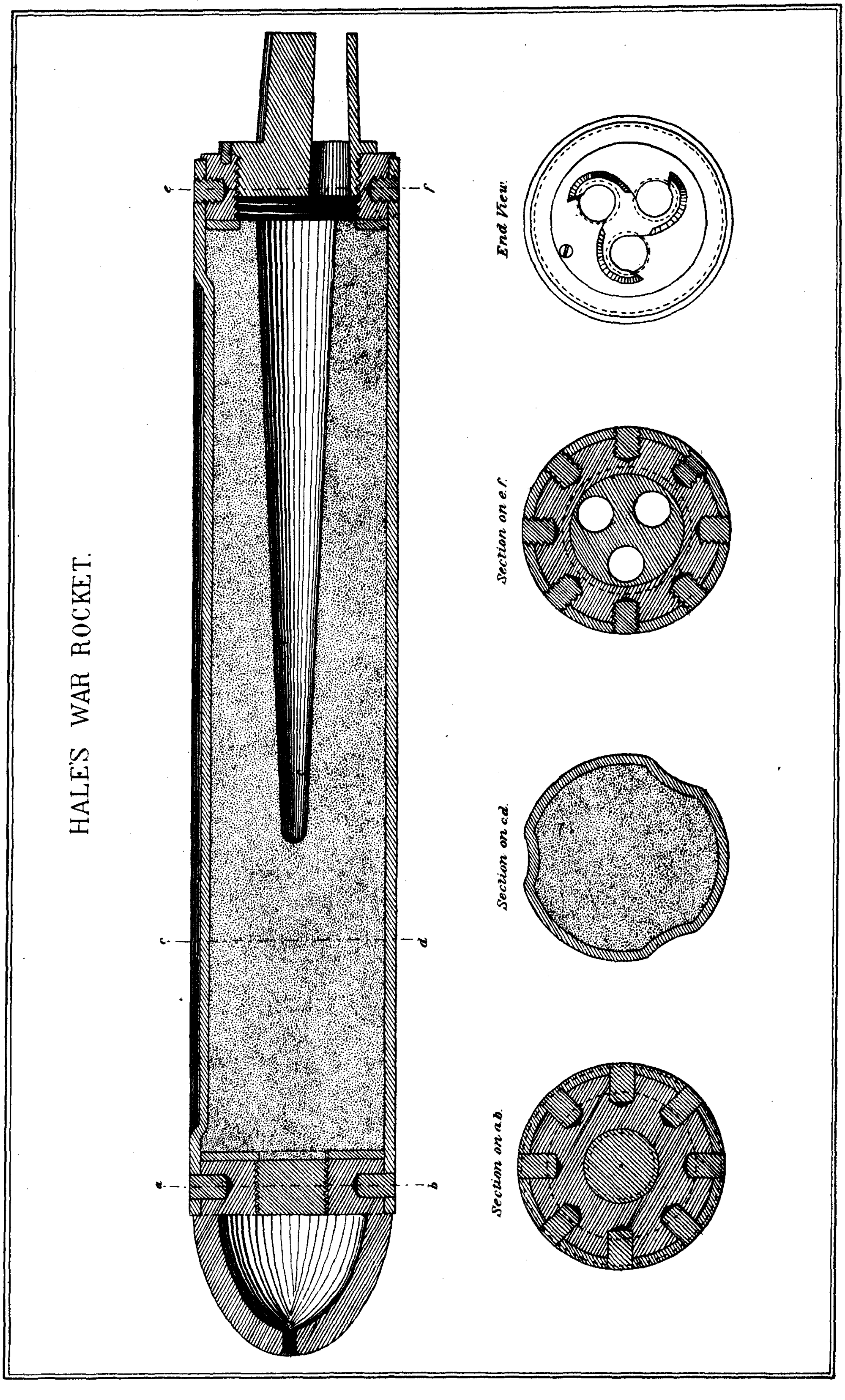
TIME FUZES.



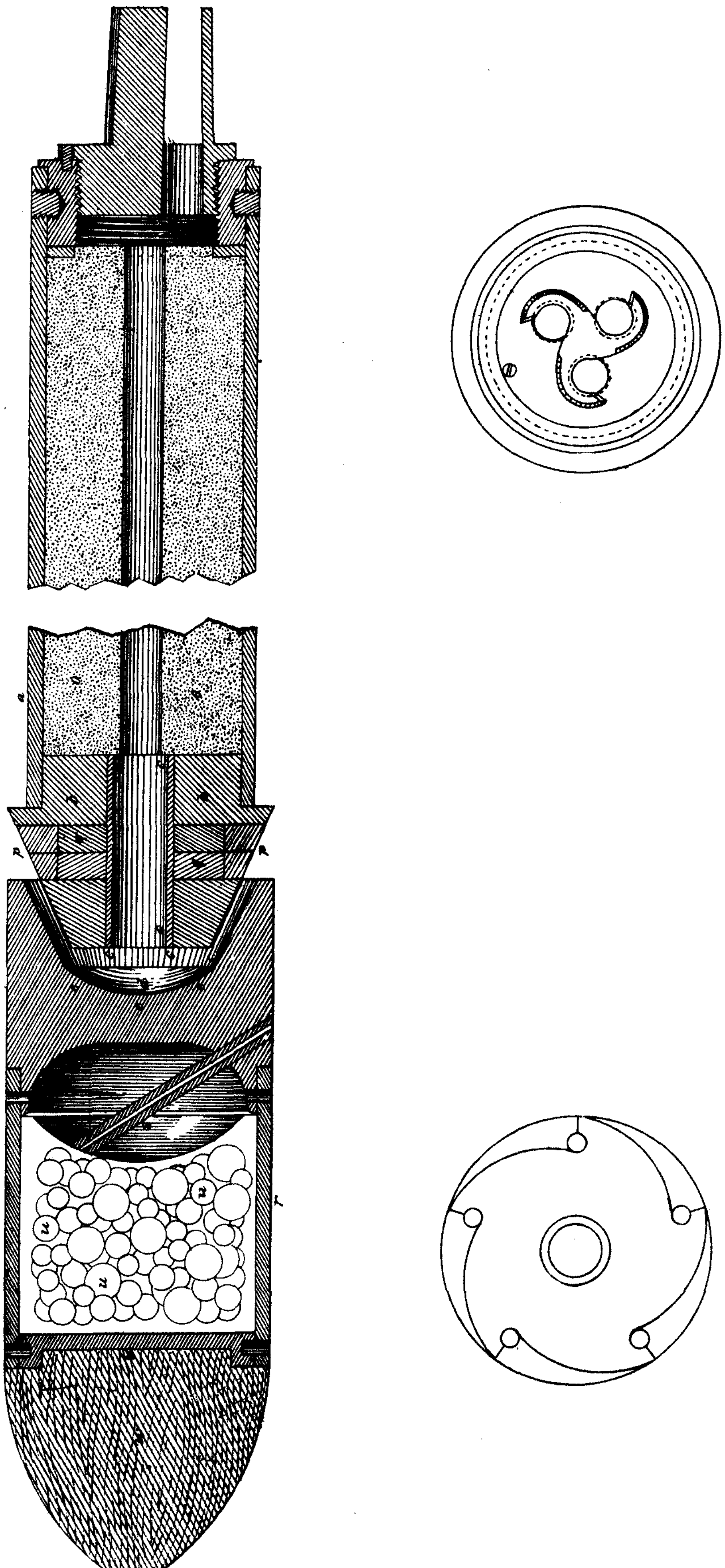
HOTCHKISS' PERCUSSION FUSE.



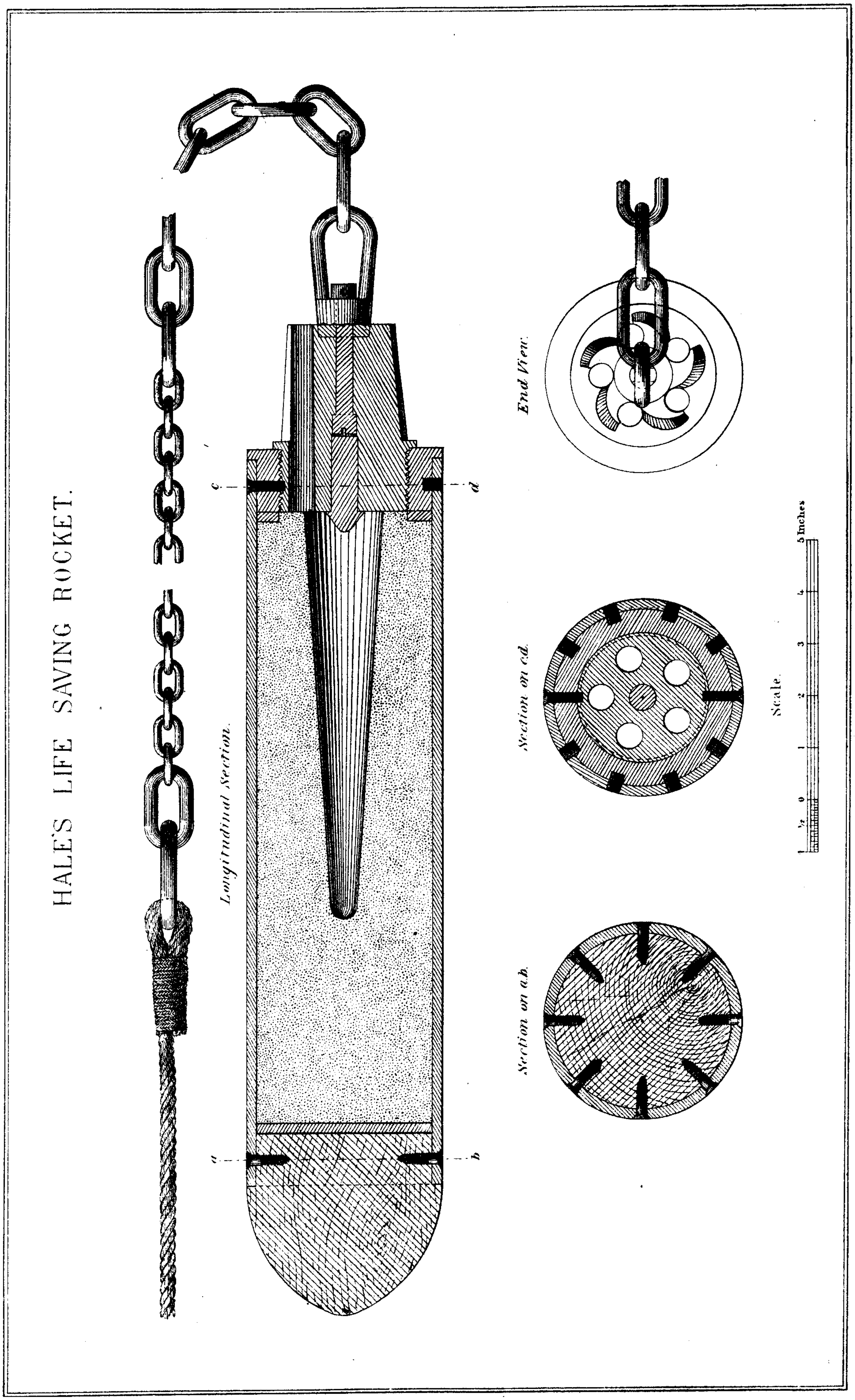

1874
100
FRICTION PRIMERS
FRANKFORD ARSENAL
10
FRICTION
PRIMERS.
FRANKFORD ARSENAL.
1872.
ELECTRIC PRIMERS



HALE'S WAR ROCKET.

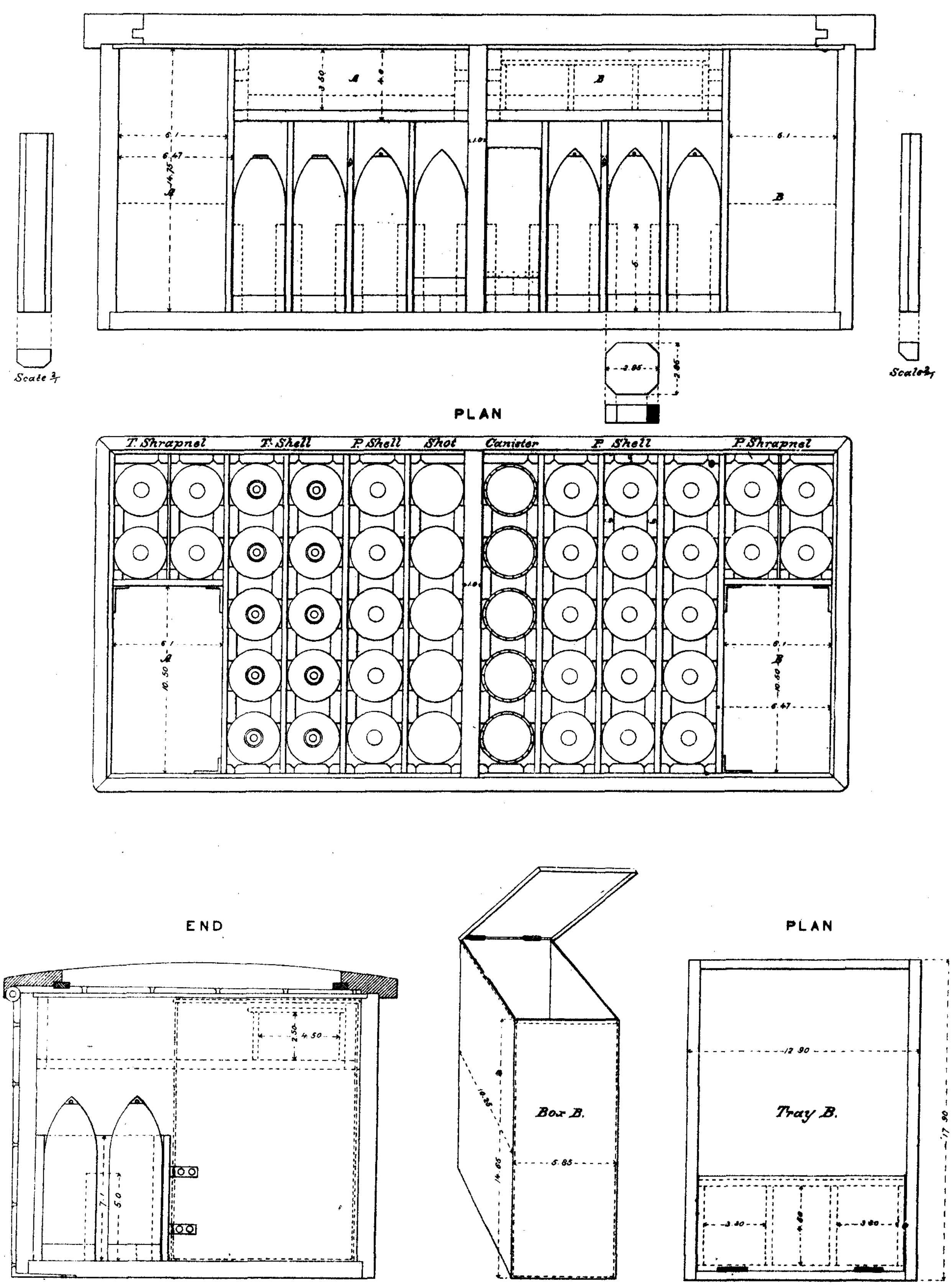


MACDONALD'S HALE WAR ROCKET.


HALE'S LIFE SAVING ROCKET.
Longitudinal Section.
c
d
a
b
End View.
Section on cd.
Section on a.b.
Scale.
5 Inches

INTERIOR ARRANGEMENT OF FIELD AMMUNITION CHEST

For 3in. Rifle Projectiles.

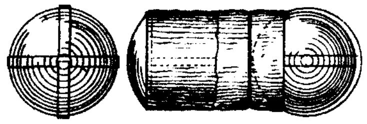


24 Cartridges (holding 1 lb. or 1¼ lbs. each) may be carried in each covered tin case
100 Friction primers
40 Time fuzes } may be carried in covered Tray Box.

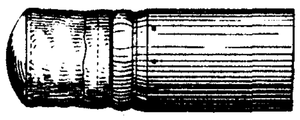
Scale:
0 5 10 15 20 Inches.

AMMUNITION FOR 12 P$^{dr.}$ FIELD GUN.

Round Shot Fixed.

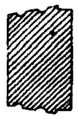


Canister Fixed.



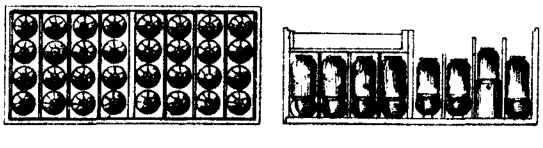
Shell Strapped.

For Canister.



For Shot.

Ammunition Chest.



SAWYER'S CANISTER SHOT.

Fig.1.

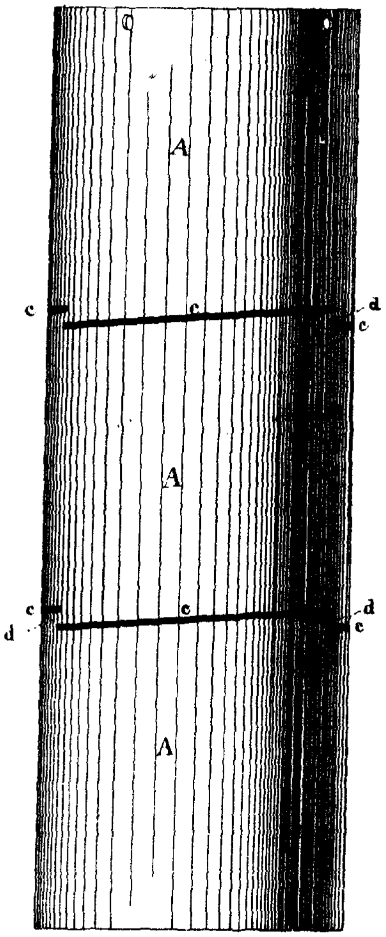
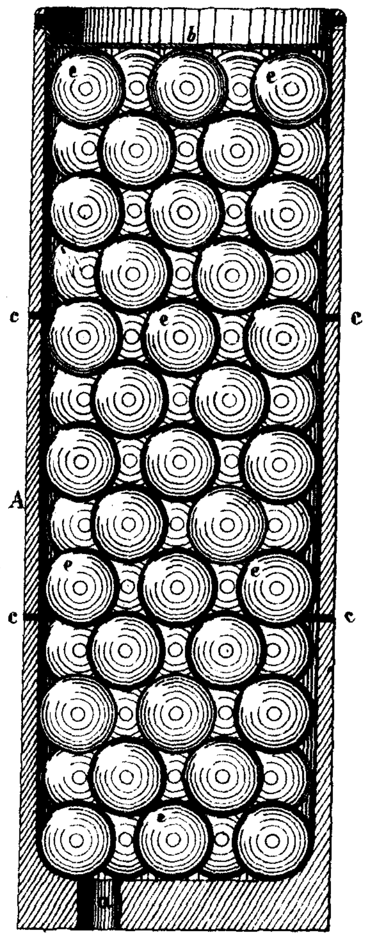
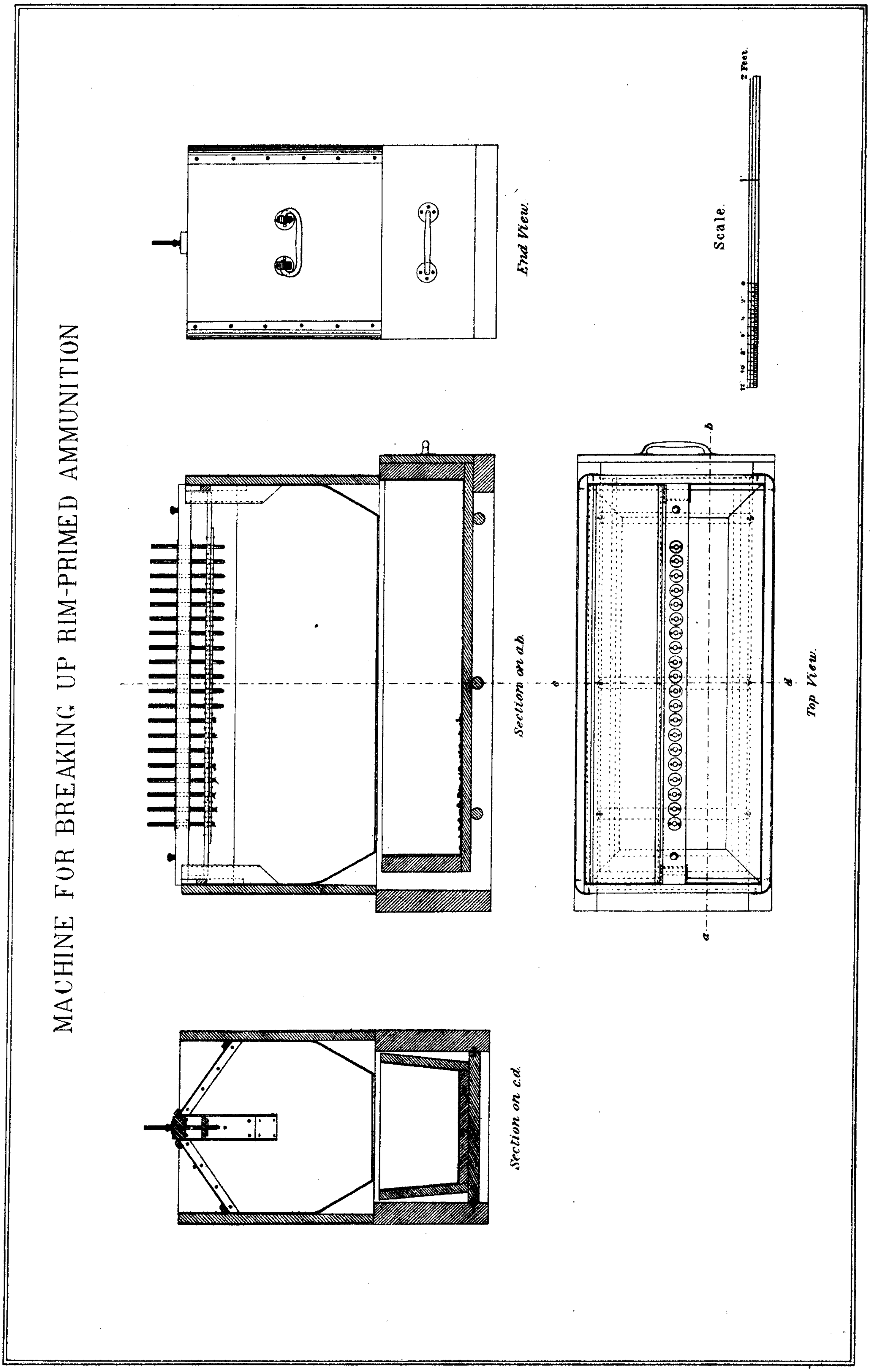
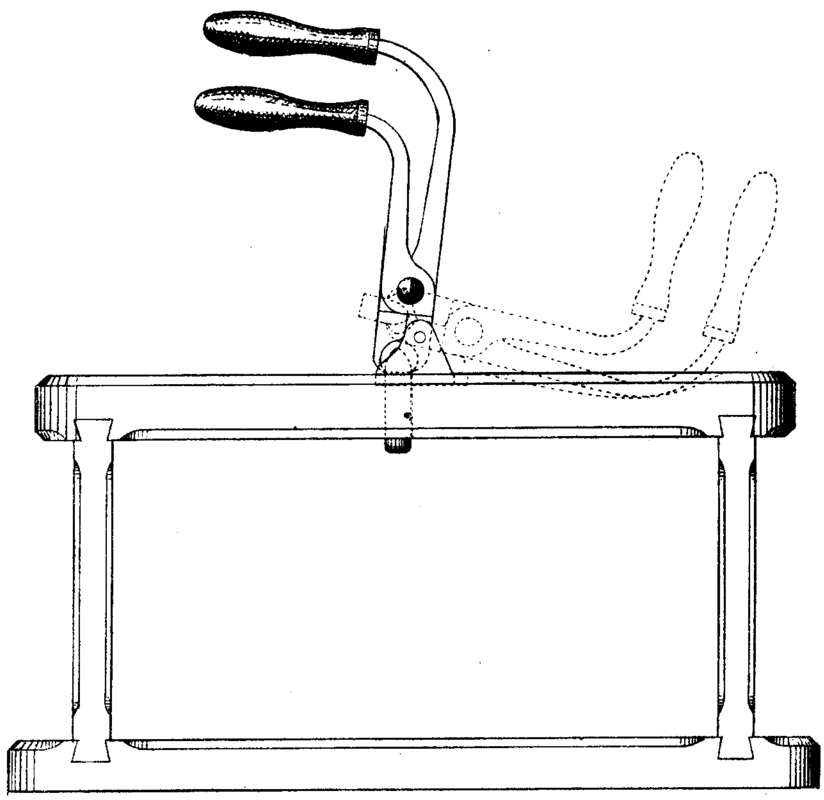


Fig.2.

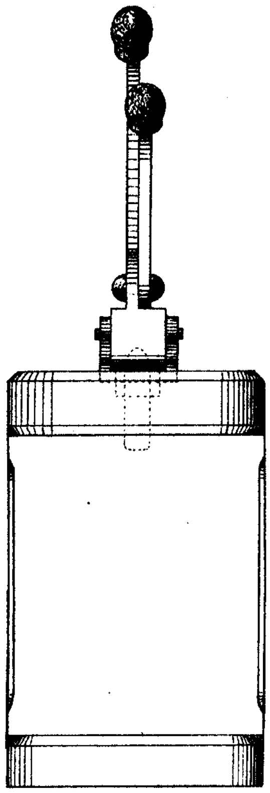



MACHINE FOR BREAKING UP RIM-PRIMED AMMUNITION
End View.
Scale.
2 Feet
Section on a.b.
Top View.
a
b
c
d
Section on c.d.

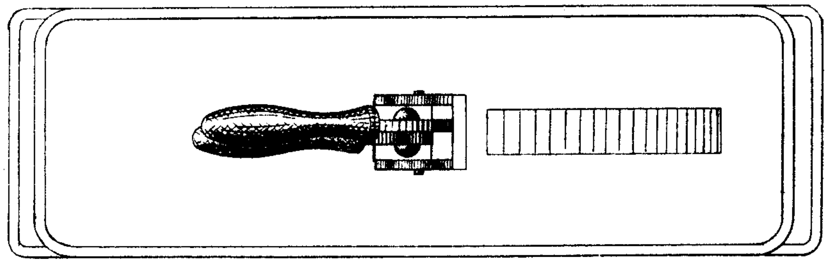
MACHINE FOR BREAKING UP GALLAGHER METALLIC AMMUNITION.



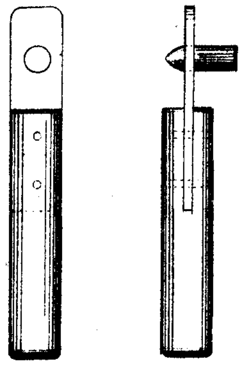
Side View



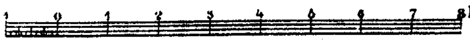
End View.

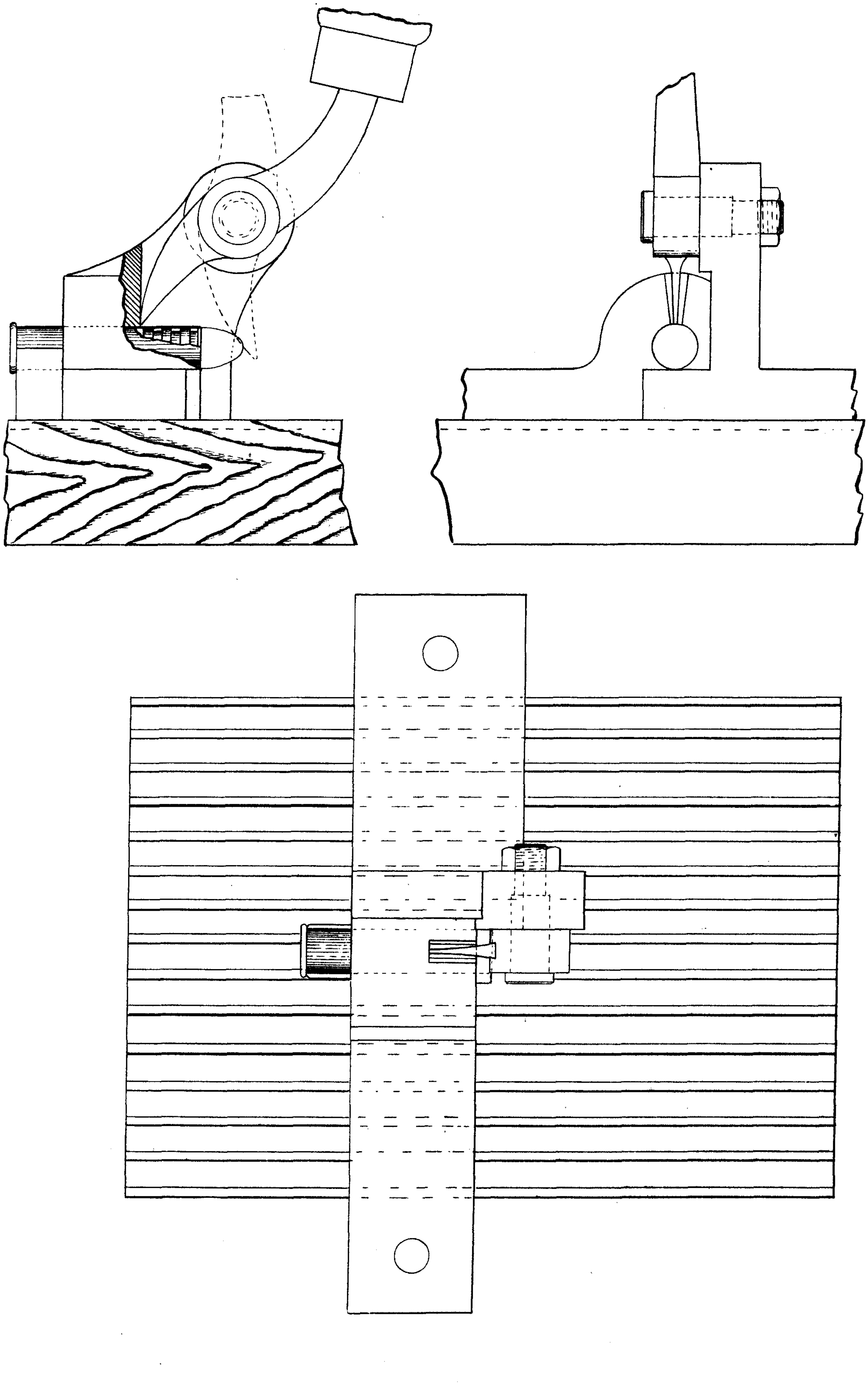


Top View

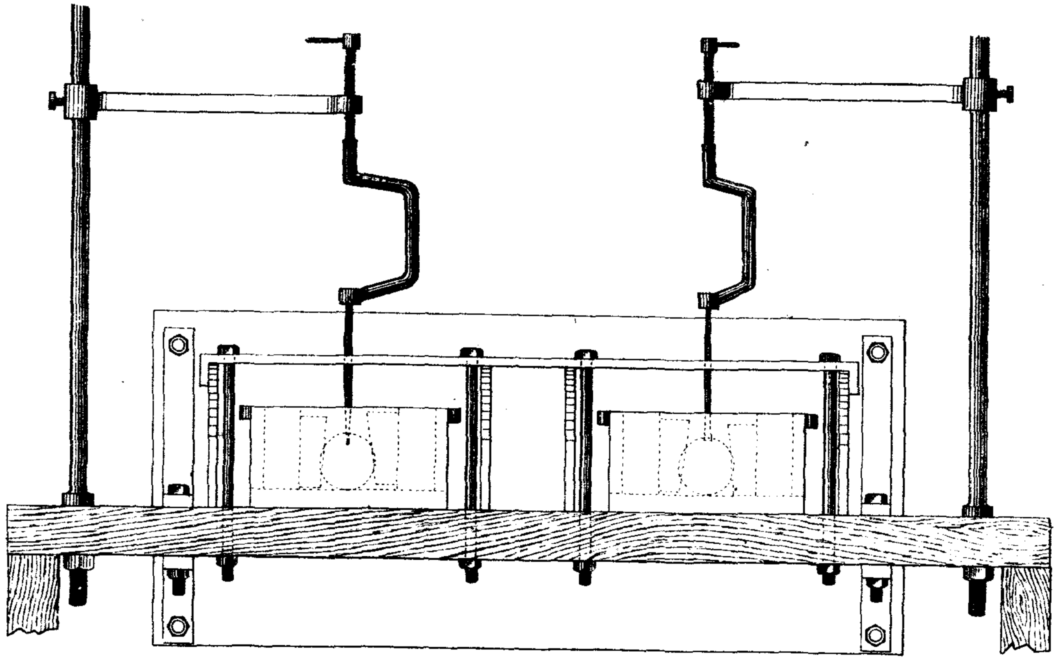


Scale.

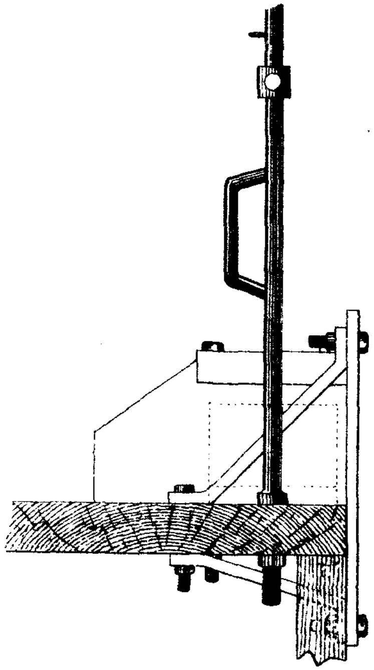




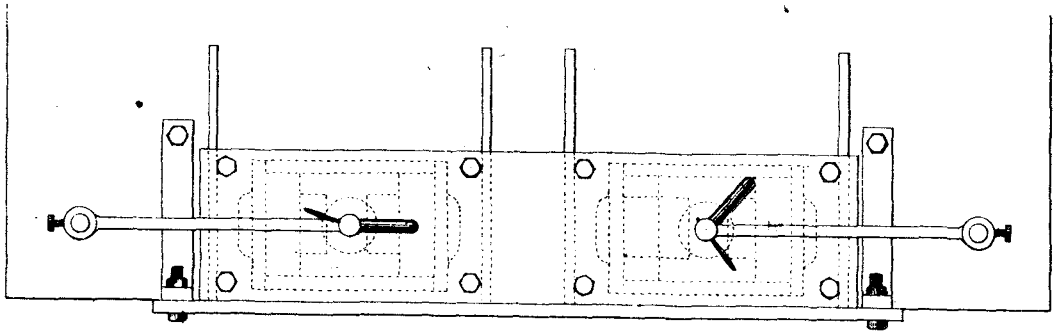
MACHINE FOR UNLOADING FIELD SHELL WITH BORMANN FUZES.



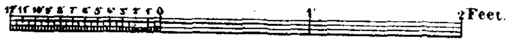
Rear View.



End View.



Top View.



Scale