REPORT

ON

LIFE-SAVING ORDNANCE

AND

APPURTENANCES.

BY

LIEUT. D. A. LYLE,
ORDNANCE DEPARTMENT U. S. ARMY.

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ORDNANCE OFFICE, WAR DEPARTMENT,
Washington, November 8, 1878.

SIR: I have the honor to inclose herewith a copy of the report on life-saving apparatus made by First Lieut. D. A. Lyle, Ordnance Department U. S. A., and embodied in my annual report to the Secretary of War for the present year.

Respectfully, your obedient servant,

S. V. BENÉT,
Brigadier-General, Chief of Ordnance.

S. I. KIMBALL, Esq.,
General Superintendent Life-Saving Service,
Washington, D. C.

REPORT

ON

LIFE-SAVING APPARATUS: GUNS, PROJECTILES, ETC.

BY LIEUT. D. A. LYLE, ORDNANCE DEPARTMENT U. S. A.

[Fifty-four plates.]

NATIONAL ARMORY, SPRINGFIELD, MASS.,
August 16, 1878.

SIR: I have the honor to submit herewith my report upon life-saving apparatus.

Fifty-four plates accompany the report.

Very respectfully, your most obedient servant,

D. A. LYLE,
First Lieut. Ord. Dept. U. S. Army.

The CHIEF OF ORDNANCE, U. S. A.
(Through the commanding officer, National Armory.)

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NOTE.—The greater part of these drawings were made by Mr. Emery, National Armory.

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D. A. LYLE,
Lieutenant of Ordnance.

NATIONAL ARMORY, *August* 15, 1878.

INTRODUCTION.

In the early part of the year 1875 the honorable Secretary of the Treasury applied to the Secretary of War for assistance in the prosecution of experiments for the purpose of improving the life-saving apparatus used by the Treasury Department, which at that time were under the special charge of Capt. J. H. Merryman, United States Revenue Marine, and requested that an officer or officers of the Ordnance Department be designated to assist Captain Merryman "in these important matters."

On the recommendation of the Chief of Ordnance, the Secretary of War directed that the "Board on Experimental Guns," convened by Special Order No. 221, Adjutant-General's Office, October 10, 1874, of which Major Crispin, Ordnance Department, was president, be charged with the prosecution of these experiments, in connection with Capt. J. H. Merryman, United States Revenue Marine. This action was taken April 12–16, 1875, and Sandy Hook, N. J., was selected as the most favorable locality for these experiments.

The important and multifarious duties with which the Ordnance Board—formerly "Board of Experimental Guns"—was specially charged were so great as not to admit of any one of its members devoting the time necessary for a thorough investigation and discussion of the subject. In view of this fact Captain Merryman recommended, on May 21, 1877, "that an application be made to the Chief of Ordnance for the detail of an officer for this special service." Colonel Crispin, president of the "Ordnance Board," concurred in this recommendation in his indorsement of June 1, 1877, upon Captain Merryman's letter, and further recommended that said officer should place himself in communication with Captain Merryman and the Ordnance Board, "for such suggestions and instructions as may be deemed proper to give him." These recommendations were approved by the Chief of Ordnance June 6, 1877, and Lieut. D. A. Lyle, Ordnance Department, was "specially assigned to this duty in addition to his regular duties" at the National Armory, Springfield, Mass. This officer entered upon the duty at once, and the results of his labors are embodied in this report.

No claims of great originality are made, as this apparatus, like the Parrott patent, is a direct evolution from the system of Captain Manby, which dates back to the beginning of the present century. The advances which have been made during the past year are the result of careful study and conscientious experiment. The data recorded are of value for future reference. The writer appreciates the fact that many improvements are yet to be made in life-saving apparatus, and entertains the hope that his humble efforts may serve as a basis upon which to found future experiments.

PART I

REPORT.

CHAPTER I.

I. RIFLE PROJECTILES.

The first experiments were made with rifle projectiles fired from a 3-inch muzzle-loading rifled mortar. This method did not prove satisfactory for the following reasons:

I. On account of the lack of simplicity in loading. The detailed operations of loading are given below.

1. Inserting cartridge and ramming home.
2. Inserting junk-wad or sabot.
3. Unscrewing cap on front end of projectile.
4. Removing cap.
5. Inserting line in axial cavity and drawing it through shot.
6. Putting on rubber washer or washers.
7. Putting on metal washer.
8. Tying knot in end of line.
9. Inserting washers and knot in the cavity in the front end of shot and drawing the line taut.
10. Returning the cap to its position.
11. Putting in the retaining screw to hold the cap.
12. Adjusting line in radial slot in base and in longitudinal groove.
13. Twisting the fine wire which passes around the head of the cap about the line to hold it in the prolongation of the axis of the bore and prevent its being cut off by abrasion in passing out of the piece.
14. Inserting projectile in the bore and ramming it home.

II. The liability of the heated gas from the charge to enter the axial cavity and either burn off the line or blow off the cap. The loss of the cap permits the knot and washers to escape, and when the strain comes upon the line it is very likely to be cut by the edges of the axial cavity in front, as is exemplified in Fig. 13, Plate XXIX.

III. The failure of wire ropes (either copper or iron) to sustain the shock of discharge. These ropes or cords are interposed between the shot and line for the purpose of avoiding the action of the flame upon the line. These rigid materials generally broke before the line.

IV. The necessity for the employment of wads and sabots.

V. The diminution of range due to resistance of the air to the passage of the line. This increased resistance of the air was developed by the spiro-conical form assumed by the line in the trajectory, due to the rotation of the rifle projectile.

VI. The twisting of the line due to the rotation of the projectile.

It was judged, from the indications left upon the wooden sabots which were recovered (see Figs. 11, 12, Plate XXIX) after firing, that if a soft-metal sabot had been used the force of discharge would have wedged it in the radial slot of the base and have caused it to cut the line as it was suddenly swung to the rear by the strain, unless a very thick sabot were used. Paper wads were found to be better than wooden sabots.

VII. The greater expense and difficulty attending the manufacture of both guns and projectiles.

After losing the caps belonging to the rifled projectiles, they were fired a few times by inserting them point first into the rifled mortar. The shot reversed after leaving the gun, and retained their axial rotation, though their flight was unsteady.

Solid, smooth-bore projectiles were next tried in the rifled mortar and gave better results. The escape of gas through the grooves was very great, in some instances burning off the line. One shank was broken off in firing, which was due, not to the form of the shank, but to the material, it having been made of high steel instead of wrought iron. No particular difficulty seemed to be experienced in firing smooth-bore projectiles from rifled guns, provided the shanks were long enough to protect the line from the gases which escape through the grooves.

Enough was learned from these experiments to warrant the conclusion that smooth-bore guns and projectiles were better adapted for this purpose than the rifled ones as here applied; and that spiral springs, wire cords, and rubber washers were either useless or annoying, and always more or less impracticable.

II. SMOOTH-BORE GUNS AND PROJECTILES.

After the difficulties first experienced it was determined to cut loose from rifled mortars, rifle projectiles, wire ropes, spiral springs, rubber straps, rubber washers and plugs, brass washers, caps and retaining screws, and seek for a solution of the problem in some system which would combine great simplicity with efficiency, and which would lessen the cost of manufacture and furnish a method whose details would not be so complicated as to be beyond the comprehension of those required to put it in practice.

1. SMOOTH-BORE GUNS.

The second attempt was made with smooth-bore guns. Bronze was selected as the material from which to make the experimental guns, for the following reasons: On account of its great ultimate tenacity, its ductility, its combination of great strength with light weight, its freedom from destructive corrosion when exposed to the moisture of sea-coast stations, its non-liability to sudden rupture, its availability for recasting, and its value as old bronze after condemnation. Guns made from this material are easily kept in order, as the bores do not rust, a fact of considerable importance with small calibers, on account of the difficulty of cleaning the bore. They are not liable to burst explosively, by reason of their ductility, and when worn out they may be sold for a fair price as old bronze. The only external injury to which they are liable is the bending of the trunnions.

The internal injuries resulting from the powder, such as enlargement at the seat of the charge, and cavities produced by the melting away of the metal by the heat developed by the explosion of the charge, are not serious. The erosive action of the gases is not great, because of the almost entire absence of windage. The wear of the vent is obviated by the use of copper vent pieces. Lodgments and enlargements are not produced in these guns, since projectiles nearly the length of the bore are used and therefore there is no balloting. The bore may be scratched by projectiles and sand, but that is not a serious injury. The softness of the metal, and its proneness to deterioration under rapid firing which causes heating, though grave objections to the use of bronze for field-pieces, do not affect its use for this service, where rapid firing is never resorted to, consequently there is little danger of heating or of melting the metal of the bore. Small charges of powder are generally used, therefore little is to be apprehended from excessive erosion.

2. PROJECTILES.

Full descriptions of these are given in a subsequent part of this report. These projectiles are modifications of Captain Manby's shot. The caliber and weight have been reduced. The lengthening of the bore, the suppression of a greater part of the windage, and the employment of improved lines, have increased the *effective* force of the powder, diminished the resistance which the projectile and line experience from the air, and have extended the range. It will be seen that the weights were increased as the experiments proceeded; this resulted in decreasing the initial velocity and the consequent violence of the vibrations of the line when the charge of powder remained constant. These projectiles are carefully turned and finished to fit the bore of the gun accurately. The careful method of finishing renders them more expensive, but even then they are cheap. Few of them are required, and the resulting efficiency counterbalances the extra cost. As in the Parrott gun, the bore of the gun must be kept clean and the projectiles free from rust.

The gun being of bronze, no difficulty is encountered in keeping the bore clean. The few projectiles at each station are easily kept free from rust by the men. Experimental projectiles Nos. 15, 16, and 17 are the ones recommended for use with 2″, 2″.5, and 3″ guns respectively. The 2″ projectile will be the most expensive, as it has to be bored out and filled with lead to increase its weight. But even its cost is trifling as compared with rockets and some patented projectiles. Lead projectiles similar to experimental projectile No. 13 are found to upset more or less, to lead the bore, and to strain the gun greatly. Wrought-iron projectiles scratch the surface of the bore badly.

3. SHANKS.

These were found to be of great importance. By prolonging them near to or beyond the muzzle of the gun when it is loaded, they keep the line from being cut off by the passage of the projectile, and do away with the necessity for a line-supporter. Several kinds of shanks were used. It was found that with very short shanks, the line would be burned off where tied in the eye. It was suspected that this arose partly from the shortness of the shank and partly from the shape of the base. The gases which pass over and around the shot at the first instant of expansion would follow the incline of the frustum and converge at and near the apex of the cone produced. The apex was near the eye-hole of the short shanks. Then a longer shank was tried, and that portion of its length between the base of the shot and eye-hole polished brightly, in order to ascertain, if possible, whether the gas converged at any point upon the shank; and, if so, where. The result confirmed the hypothesis, and a very dark stain showed the maximum convergence of the gas to be about the apex of the cone, whose frustum formed the base, or, perhaps, a little in front of it. Long shanks were afterwards used, and with great success. The earlier shanks were made of whatever scrap could be obtained for the sake of economy. At first the thread extended an inch and a half into the shot, but the junction of the thread and body was found to be a point of weakness, which should have been anticipated, especially as it came directly at the base of the shot, where the greatest strain was thrown on the shank when the projectile reversed. They were found to bend and crack at this point. The next step was to shorten the length of the screw-thread and let the body of the shank extend a short distance into the shot. This was an improvement, but continued practice upon hard earth showed that the shank could be bent and was still weak. A shank forged from wrought iron, with the dimensions increased, was then made and adopted. It may be seen in experimental projectiles Nos. 15, 16, and 17. A few very long shanks were tried and behaved very well. The shanks should always be of the best wrought iron, and should be carefully forged and finished. A steel shank, that was made by mistake, broke off in firing, showing that material to be too brittle for this purpose.

III. GUN-CARRIAGES.

The gun-carriages are made with wooden cheeks, bound with iron. They combine elasticity with strength, and act well upon sandy beaches. The wrought-iron handles increase the ease with which they may be carried. If necessary the gun may be dismounted, and carried by one man upon his shoulder, while another takes the carriage. Two projectiles may be placed upon the rear transom and the whole carried easily by four men. The small gun and carriage are intended to be carried by two men; here, as before, the projectiles may be placed upon the rear transom. The load may be balanced by sliding the hands along the handles. The addition of iron cheek-straps increases greatly the durability of the carriages. The carriages for guns C and B are the ones recommended for adoption. The vent pieces of the guns project high enough to avoid difficulty in the use of friction primers at ordinary angles of elevation. Gun B and carriage are too light to be used with ordinary friction primers without some danger of disturbing the pointing of the piece, as the primers pull off too hard.

IV. SPONGE AND RAMMER.

A single staff, with a rammer head on one end and a sponge on the other, constitutes this implement.

V. WIPING-RODS.

These were made from old condemned musket ramrods of obsolete pattern. One end is curved to form an eye, and a cork-screw wiper is screwed on the other end. This is useful for withdrawing cartridges when necessary, and, with flannel or cotton waste wrapped around the wiper, is valuable for cleaning the bore of the gun. It also may be used as a rammer for pressing home the cartridge, by reversing it and inserting the eye-end in the bore.

VI. PRIMING-WIRES.

Two of these are issued with each gun, as one may be lost. They are made of steel or brass wire, preferably of the former.

VII. GUNNER'S HAVERSACK.

One of these should be issued with each piece, to be carried by the keeper of the station. The cartridges, friction primers, priming-wires, lanyard, combination-level, and a piece of flannel for use with the wipers are carried in this pouch.

VIII. POWDER.

No particular kind of powder has ever been adopted for use at the life-saving stations. "Pebble" powder was deemed too large grained, and "rifle" powder too fine grained for this service. Four different specimens of powder were procured from the Hazard Powder Company.

The tests for initial velocity, which will be given upon subsequent pages, show that Navy cannon powder gives a good initial velocity for a not excessive strain or pressure. That test, however, was not a fair one for this powder, which, on account of its large grain, was more or less broken and compressed in loading the metallic shells. It is probable that both the velocity and pressure are too great as given. The uniform action of this powder during the experiments was such as to commend it to very favorable notice. Musket, rifle, and duck-shooting powders are all more or less quick and violent in their action. The musket (Hazard) is very uniform, but quite too rapid in its inflammation. A direct comparison of these powders was made, with the results given below.

Comparisons of different kinds of powder.

[Maker: Hazard Powder Company. Gun: 2".5 bronze gun C. Charge of powder: 3 ounces in every case; carefully weighed. Projectile: Experimental No. 16, marked "L. 12." Weight of projectile: 18.75 pounds. Shot-line: Linen No. 7 (Silver Lake); same line as used in first series of experiments. Faking-box: Box A. Place: Sandy Hook, N. J. Date: May 6, 7, and 8, 1878. The same projectile, line, and faking-box were used throughout the comparison.]

No. of round.		Kinds of powder.			
		Navy cannon.	Mortar.	United States musket.	Sea-shooting duck.
		Yards.	*Yards.*	*Yards*	*Yards.*
1	Ranges in yards	281⅝	284	292⅝	308⅓
2	......do	280	267⅝	284	293⅓
3	......do	266⅝	263⅜	289	300
4	......do	281⅝	269	280⅜	272
5	......do	280⅝	261	263	286⅓
	Total	1,390⅝	1,345	1,409	1,460
	Arithmetical mean	278.13	269	281.8	292
	Greatest variation from mean	11.47	15	18.8	20
	Least variation from mean	1.87	....	1.47	1.33
	Mean variation	4.58	6	8.1	10.2

From the above table it will be seen that the Navy cannon powder acted very uniformly, four of the five shots being almost identical. The "sea-shooting duck" is represented as giving the best mean range; this is explained by the difference in the velocities of the wind. The wind was light when the "duck" powder was used.

The Navy cannon is much coarser grained than the musket or rifle powder, but is not so coarse but that most, if not all, of it is consumed before the projectile leaves the piece. Army cannon is too coarse grained; a portion of the charge is lost by being blown from the gun before completely consumed. Selecting from the samples tested, the preference should be given to the Hazard Navy cannon. The effect of a powder depends more upon the manner of loading than has been supposed by those who are not accustomed to dealing with it. A charge of Navy cannon can, by two or three forcible jams of the projectile when inserted in the bore, be so compressed and the grains so broken, as to exhibit all the violence of a fine-grained powder. Powder stored along the coast is exposed more or less to the moisture of the sea-air and deteriorates very rapidly. Since only small quantities are kept at the life-saving stations, the powder should be renewed annually and the stock on hand used for drilling and exercising with the apparatus.

IX. SHOT-LINES.

On a comparison of the tables of the breaking weights of the different shot-lines, it will be seen that in every instance except two, the linen lines are stronger than the hemp. It will also be noted that the linen lines have more stretch per linear foot than the hemp lines. The tables, &c., may be found upon subsequent pages. The braided linen lines have proved superior in usefulness to the hemp. The preference should be given to unbleached linen thread for the manufacture of shot-lines. Great care should be taken that none but the best thread be put in such lines, and that in braiding a continuous line, when the spools are changed, they should not all be changed at the same moment, else a weak spot is the result. Bleaching of any kind is harmful. Hemp is too brittle and becomes very harsh after a few shots. The water-proof lines pass through the air with less friction than those having the ordinary finish and generally attain a better range. The vibrations of the line due to faking is the greatest danger to which it is subjected. These vibrations reach their maximum amplitude in the first part of the trajectory, when the velocity of the shot is greatest. A place varying from 20 to 40 yards from the shot seems to be the critical point. In that vicinity the line generally breaks. It is a case quite similar to that of snapping a whip and breaking off the farther portion of the lash. There is little doubt but that long storage of lines will destroy their good qualities. Lines after being stored for a year or two should be used for pratice drills. New lines when first received are stiff and refractory; this makes them difficult to fake. They should be wound from the original coil upon a reel, to avoid twisting, and should be fired once or twice with light charges of three or four ounces of powder. This usage will make them a little more flexible, so that they can be faked with less trouble. New lines, if possible, should be used when firing over wrecks. There should always be more than one good line at the station, for a line once wet becomes difficult to handle. New lines have not had the stretch taken out of them by firing, and consequently are not apt to be broken should it be necessary to fire with heavy charges.

X. FAKING-BOXES.

These are boxes, peculiarly constructed, to contain the shot-lines and preserve them in readiness for firing at a moment's notice. Their size varies with the diameter and length of line to be stored for service. It has been found that the less the boxes in length and width, the better they were adapted to prevent the rupture of the shot-line, in consequence of the necessary shortening of the fakes in the line. Experiment showed that short fakes or loops of line diminished very markedly the length or amplitude of the vibrations in the line when running out of the box. In the case of long fakes, the line would break at the bend, or change of direction of the line, before its inertia was overcome. The effect was the same as if the line had been nailed fast at the ends of the fakes. This was especially noticeable in the case of hemp lines, whose fibers are very brittle, though very strong. In the effort to diminish the lengths of the fakes, experiments were made with boxes of lesser length and width than those used in service at present. This required the faking-pins to be longer. This alteration demanded a much deeper faking-box and one that had to have some method devised to hold it at the proper inclination when about to fire. This form of box failed for the following reasons, namely: the faking-pins were so long that they bent toward each other unduly in the process of faking, rendering it somewhat difficult to disengage the line from them at the critical moment, and bringing such a strain upon the frame that it was liable to split. To remedy these defects, the frames and faking-pins would have to be made heavier and longer, which would add to the weight of the box; a result not desired. Increasing the depth of the box weakened it and made it more liable to be broken by the successive impacts of the vibrating fakes, which are always severe. It was found advisable to keep the height of the pins the same as at present and to make the boxes of a size just capable of holding the shot-lines, provided that in no instance should the boxes be longer than three feet. Four sizes of boxes were used, marked, respectively, A, B, C, and D. Boxes A and B are the sizes now used in the service; C and D were designed and used with lines No. 5 and No. 3½, respectively. It was found that the life of a wooden faking-box, when heavy charges of powder are used, is short. The vibrations of the line, especially the lateral ones, which originate in the change of the line from tier to tier of fakes, are powerful enough to split the ends of the box and to start the dovetailing after a few shots. In fact, the ends of the box are sometimes split at the first fire. The split usually occurs about four inches from top of the box. The natural vibrations of the line, due to its position in the tiers of fakes, would be in diagonal planes nearly at right angles to each other; this gives rise to a resultant vibration, whose plane is variable, depending on several changing circumstances. When this resultant plane happens to assume a position perpendicular to the bottom and longer axis of the faking-box, either the bottom or the uppermost side of the box, and sometimes both, are liable to be split. The plane of resultant vibration is so unstable in position, that this does not often occur; the ends are much more apt to be split. It was found that the interior edges of the box acted as knife edges, cutting the rapidly paying-out lines, and this, too, when the boxes are made of soft pine and the edges are angles of 90°. The velocity of the passage of the line, together with the striking due to the vibrations, compensated for the unfavorable nature and material of the knife edge. The edges were rounded, and no further difficulty was experienced from that cause. Sometimes the entire line was carried out, the end being taken in some instances more than 100 feet in front of the box. Should this occur in service, the shore end might be carried out into the water and be beyond the reach of the surfmen, though perfectly sucessful in all other particulars. To prevent this, a small notch, about the size of the diameter of the shot-line, is cut in the side of the box, and all its edges and corners carefully rounded and smoothed. Similar notches (which need not be rounded) are cut in each side of the "false" bottom. Then, after faking the line, the operator leads the end in his hand down one side of the tiers of fakes to either of the notches in the "false" bottom, and the assistant puts the faking-box over the rope and pins, with the notch in the box on the side where the line is led out; this allows the box and frame to be fastened together without trouble, and leaves the shore-end of the line hanging from the box. In firing, the *notched* side of the faking-box is placed *uppermost* and the protruding end made fast to another line on shore, to obviate the danger of its loss by being hauled out to sea. In the service boxes, the frames and boxes are held together by two staples and a hook. The latter was always coming out, exposing the frame and line to the chances of falling and becoming entangled in transportation. Hasps and turn-buttons were tried on the experimental boxes; these, though safe, sometimes gave trouble in getting ready for firing when in great haste, and, the button being on the box, it was thought to give an opportunity for the line, when vibrating or whipping, to catch and be cut off. Hasps, staples, and lever snap-hooks are now recommended for trial. The boxes now made have the corners strengthened for about five inches with yellow-metal (an alloy of tin and copper) angle-pieces at each corner, near the bottom—*top* when in position for firing.

XI. EXTENT OF RANGE OF SHOT-LINE.

In most all of the accounts of trials and experiments with line-carrying apparatus, the subject of *range* seems to be the only one considered.

If the attention of inventors is called to the fact that *accuracy* also is in some degree required, they immediately wander from the point, and bring up the fact of the slight deviation of their projectiles from the plane of fire as conclusive evidence that their method is perfect.

The minimum lateral deviation or *accuracy* with which a line can be extended a given distance is a matter of vastly more importance than apparently has ever been accorded by experimenters. The deviation of the projectile is seldom excessive, while the bowing or *drift* of the line may be out of all proportion.

What advantage accrues if a range of a mile be obtained when at every shot the line falls clear of the vessel by perhaps many yards, due to the lateral drift of the line from the effect of the wind? The *drift* or lateral deviation of the shot-line from the plane of fire increases with the lightness of the line, the increase in the angle of elevation of the gun, and the diminution of axial tension upon the line; and, lastly, it depends greatly upon the horizontal angle that the directions of transverse winds make with the plane of fire. The effect of the wind is greatest when this angle is 90° or blowing directly across the plane of fire. With light lines, longer ranges but less accuracy are obtained. The greatest range on record for a mortar and line-carrying projectile was obtained with gun A and a Silver Lake braided linen line No. 3½. This range was 694⅔ yards, measured distance.

The greatest range heretofore obtained with a mortar was 631 yards, reported by Captain Ottinger. How accurately this range was measured, or whether the distance was only estimated, or what size of line was used is unknown to the writer; but that the mortar was very much heavier than the one used in the case above cited is beyond doubt.

A range of 400 yards is understood to be about the maximum range necessary for the requirements of the service along our coasts, and it is not probable that a hawser and life-car can be used with success over even so great a distance.

XII. VELOCITY OF THE WIND.

The velocity of the wind given in the tables of fire is not the actual velocity at the instant of firing. The results are the mean velocities of the wind during the intervals between the shots. This interval varies generally from 10 minutes to 40 minutes. The method of obtaining the velocities is as follows: A reading of the anemometer was taken a few minutes before the first shot upon any given day, together with the time of observation; the second reading was taken directly after the first shot; the third reading was taken directly after the second shot, and similarly for the subsequent shots. From these times and readings the mean velocity of the wind during the intervals was computed.

It was found by observation that the velocity of the wind was constantly changing and came in variable puffs; that it would freshen up for a moment or two and then die away more or less. The intervals between the observations would often comprise several of these alternate maximum and minimum periods. In order that the mean velocity (the one recorded) should always fall *below* the *actual* velocity at the instant of firing, the piece was not fired until the wind freshened and was blowing with its greatest force.

The surface velocity of the wind appeared generally to be less than that above the ground at the summit of the trajectory. This was seen in the effect upon the line, especially when the wind was blowing directly across the plane of fire. The anemometer for surface velocities was always placed opposite the 200-yard stake, except during the last few days of the experiments, when it was situated 50 yards in front and to the right of the firing-point. It would have been placed near the 300-yard stake, but for the fact that the labor, already great, of walking down and back after every shot would have been increased. The writer took all readings himself, and either loaded the piece or was present every time it was loaded and fired during the experiments. This necessitated a great deal of toil through the sand.

During many gales and storms for the past year observations were made as to the frequency in duration of the temporary lulls of the wind.

These were found in the generality of cases to occur often and to last for a varying interval of time, ranging from 7 to 20 seconds. Now, experiments show that line-carrying projectiles rarely occupy more than 8½ seconds in their flight, and that it takes from 5 to 15 seconds more for the line to settle to the ground, depending upon the angle of elevation at which the gun is fired and the weight of the line. Here, then, for extreme cases it may be seen that an interval of about 25 seconds, and in ordinary cases about half that period, is required to fire the piece and to allow the shot to describe its trajectory and the line to settle upon the ground or water. Therefore the piece, in case of wreck, should be prepared for firing, and, with lanyard taut, the gunner should await the favorable lull or moment of least violence in the gale, and then fire the piece without loss of time.

CHAPTER II.

LIFE-SAVING APPARATUS.

RECOMMENDATIONS.

The following guns and projectiles are recommended for the Life-Saving Service:

The caliber of the gun will depend upon the size of line used and the range required.

For ranges of 300 yards and less, with heavy lines (larger than No. 7), a 3-inch gun should be used.

For ranges of 400 yards and less, with service braided lines between Nos. 4 and 7, a 2.5-inch bronze gun should be used.

For ranges of 250 yards and less, with service lines between Nos. 4 and 7, a 2-inch bronze gun will be sufficient.

It will be seen by comparing the above recommendations with the records of firing that the writer has allowed a wide margin or factor of safety, as far as range is concerned, for even the 2-inch bronze gun (B) has no recorded range of less than 278 yards, and that, too, with a heavy No. 7 line.

I. BRONZE LIFE-SAVING GUNS.

These guns are intended to be used in connection with projectiles having lines attached to them for the purpose of effecting communication between the shore and stranded vessels; or, under favorable circumstances, they may be used on shipboard for throwing lines to the shore. These guns are chill-cast, having smooth bores of 2″, 2″.5, and 3″ in diameter, respectively.

1. 2.5-INCH LIFE-SAVING GUN.

[Model: Bronze gun C. Caliber: 2.5 inches=6.35 centimeters.]

(Plate V.)

The exterior of this gun is divided into four principal parts, viz, the *breech*, the *first reinforce*, the *second reinforce*, and the *chase*.

The breech is a hemisphere, whose radius is equal to the semi-diameter of the first reinforce.

The first reinforce is cylindrical, and extends from the base of the breech to a point in front of the axis of the trunnions.

The second reinforce is a short frustum of a cone, joining the first reinforce to the chase. The latter is cylindrical, and is of a lesser diameter than the first reinforce.

The chase is terminated in front by the *face* of the piece, without any swell of the muzzle or muzzle-band. The cascabel and trunnions are short cylinders.

The rimbases unite with the exterior surface of the gun by tangent-curved surfaces.

The vent-piece is of copper. The vent is perpendicular to the axis of the bore, and is 1.25 inches (=3.175 centimeters) from the bottom of the bore.

The bore is cylindrical, and is terminated at its lower extremity by a hemispherical chamber, by which term it is proposed to designate the bottom of the bore.

Nomenclature.

A—Breech.
B—First reinforce.
C—Second reinforce.
D—Chase.
E—Chamber
F—Bore.
G—Trunnions.
H—Rimbases.
I—Cascabel.
V—Vent.

Dimensions, &c.

	Inches.		Centim'rs.
Diameter of first reinforce	5.5	=	13.97
Diamer of chase	4.5	=	11.43
Diameter of bore	2.5	=	6.35
Diameter of trunnions	2.0	=	5.08
Diameter of rimbases	2.8	=	7.112
Diameter of cascabel	1.5	=	3.81
Diameter of vent	.2	=	.508
Radius of breech	2.75	=	6.985
Radius of chamber	1.25	=	3.175
Radius of chase	2.25	=	5.715
Length of first reinforce	8.50	=	21.59
Length of second reinforce	2.00	=	5.08
Length of chase	9.5	=	24.13
Length of bore, exclusive of chamber	18.75	=	47.624
Total length of bore	20.00	=	50.799
Length of trunnions	2.0	=	5.08
Length of rimbases	.1	=	.254
Length of cascabel	1.5	=	3.81
Distance of vent from bottom of bore	1.25	=	3.175
Distance between the rimbases	5.7	=	14.478
Total length of piece	24.25	=	61.594

Weights.

	Lbs.		Kilos.
Weight of piece	108.25	=	49.096+
Preponderance	1.5	=	0.680+

2. 2-INCH LIFE-SAVING GUN.

[Model: Bronze gun B. Caliber: 2 inches=5.08 centimeters.]

(Plate IV.)

This gun is of the same general form as gun "C" (2".5), but is much smaller and lighter.

Nomenclature.

A—Breech.
B—First reinforce.
C—Second reinforce.
D—Chase.
E—Chamber.
F—Bore.
G—Trunnions.
H—Cascabel.
V—Vent.

Dimensions, &c.

	Inches.		Centim'rs.
Diameter of first reinforce	4.0	=	10.16
Diameter of chase	3.5	=	8.89
Diameter of bore	2.0	=	5.08
Diameter of trunnions	1.75	=	4.445
Diameter of cascabel	1.5	=	3.81
Diameter of vent	.2	=	.508
Radius of breech	2.0	=	5.08
Radius of chamber	1.0	=	2.54
Radius of chase	1.75	=	4.445
Length of first reinforce	8.0	=	20.32
Length of second reinforce	1.0	=	2.54
Length of chase	9.0	=	22.86

Length of bore, exclusive of chamber	17.0	=	43.179
Total length of bore	18.0	=	45.719
Length of trunnions	1.5	=	3.81
Length of cascabel	1.5	=	3.81
Distance of vent from bottom of bore	1.25	=	3.175
Distance between the rimbases	4.0	=	10.16
Total length of gun	21.5	=	54.609

Weights.

	Lbs.		Kilos.
Weight of piece	54.25	=	24.607+
Preponderance	1.0	=	.453+

[NOTE.—A 3-inch (=7.62 centimeters) gun may be made differing but slightly in weight and dimensions from the 2½-inch above given. The model is essentially the same in both.]

II. PROJECTILES.

1. 2.5-INCH PROJECTILE.

Diameter, 2.5 inches=6.35 centimeters.

(Plate XXII.)

This is a solid cast-iron shot. The form is cylindro-ogival. A frustum of a cone forms the base.

The radius of the ogival head is equal to one diameter of the shot. A wrought-iron shank is screwed into the base, having an eye at its posterior extremity for attaching the shot-line.

Dimensions.

	Inches.		Centm'rs.
Total length	15.7	=	39.877
Length of ogival head	2.17	=	5.5118
Radius of head	2.5	=	6.350
Length of cylindrical part	12.43	=	31.5712
Diameter of cylindrical part	2.5	=	6.350
Length of frustum	1.1	=	2.794
Diameter of smaller base of frustum	1.35	=	3.429
Shank—Total length	6.5	=	16.510
Length of screw	1.5	=	3.810
Diameter of screw	1.0	=	2.540
Length from plane of base	5.0	=	12.700
Distance from base to center of eye-hole	4.5	=	11.430
Diameter of eye-hole	.4	=	1.016
Width at eye	1.0	=	2.540
Thickness at eye	.4	=	1.016
Diameter of neck	.625	=	1.5875
Distance of center of gravity from plane of base	7.45	=	18.923

Weight.

	Lbs.		Kilos.
Weight, about	19	=	8.61+

2. 2-INCH PROJECTILE.

Diameter, 2 inches=5.08 centimeters.

(Plate XVIII.)

This projectile is similar to the larger calibers, being cylindro-ogival in form, with a conical frustum for its base. The radius of the ogival head is equal to one diameter of the shot. The body is of cast iron.

An axial cavity, bored from the base, runs nearly the whole length of the projectile. Into this cavity melted lead is poured and allowed to cool, after which the shank is screwed in. The lead increases the weight of the shot without increasing its volume.

Dimensions.

	Inches.		Centim'rs.
Total length	15.0	=	38.090
Length of ogival head	1.73	=	4.3942
Radius of head	2.0	=	5.080
Length of cylindrical part	12.27	=	31.1148
Diameter of cylindrical part	2.0	=	5.080
Length of frustum	1.0	=	2.540
Diameter of smaller base of frustum	1.375	=	3.4925
Axial cavity—Total length	13.5	=	34.289
Length filled with lead	12.0	=	30.479
Diameter	1.0	=	2.540
Shank—Total length	6.5	=	16.510
Length of screw-thread	1.5	=	3.810
Diameter (exterior) of screw-thread	1.1	=	2.794
Length from plane of base	5.0	=	12.700
Distance from base to center of eye-hole	4.5	=	11.430
Diameter of eye-hole	.4	=	1.016
Width at eye	1.0	=	2.54
Thickness at eye	.4	=	1.016
Diameter of neck	.5625	=	1.42875
Distance of center of gravity from base	7.0	=	17.78

Weight.

	Lbs.		Kilos.
Weight, a little more than	13	=	5.896

3. 3-INCH PROJECTILE.

Diameter, 3 inches = 7.62 centimeters.

(Plate XI.)

This is an elongated, solid, cast-iron smooth-bore projectile. In form it is cylindro-ogival, with a frustum of a cone for its base.

The radius of the ogival head is equal to the diameter of the shot.

The edges or angles about the base are slightly rounded.

A *shank*, or eye-bolt, of wrought-iron is screwed into the base of the projectile to serve as a point of attachment for the shot-line.

Dimensions.

	Inches.		Centim'rs.
Total length	13.8	=	35.051
Length of ogival head	2.6	=	6.604
Radius of head	3.0	=	7.620
Length of cylindrical part	9.9	=	25.146
Diameter of cylindrical part	3.0	=	7.620
Length of frustum	1.3	=	3.302
Diameter of smaller base of frustum	1.7	=	4.318
Shank—Total length	6.5	=	16.510
Length of screw	1.5	=	3.810
Diameter of screw	1.0	=	2.540
Length from plane of base	5.0	=	12.700
Distance from base to center of eye-hole	4.5	=	11.430
Diameter of eye-hole	.4	=	1.016
Width at eye	1.0	=	2.540
Thickness at eye	.4	=	1.016
Diameter of neck	.625	=	1.5875

Weight.

	Lbs.		Kilos.
Weight about	23	=	10.432

III. GUN-CARRIAGES.

The carriages or beds for these guns are shown in the accompanying drawings, which are sufficiently explanatory. The cheeks and front transom are of wood, and all other parts are made of metal; wrought iron in the two already made.

WEIGHTS.

1. *Carriage for 2.5 and 3 inch guns.*

(Plate XXVII.)

	Lbs.	Kilos.
For gun C, carriage and quoin	54.25	=24.607+
For gun C, carriage alone (49.41 lbs.) say	50.0	=22.68

2. *Carriage for 2-inch gun—(Gun B.)*

(Plate XXVI.)

	Lbs.	Kilos.
Weight of carriage and quoin	35.0	=15.876
Weight of carriage alone	33.5	=15.196

IV. FAKING-BOXES.

Faking-box A should be used for lines Nos. 6 and 7.
Faking-box B, for braided lines Nos. 4 and 4½.
Faking-box C, for braided line No. 5.
Faking-box D, for braided line No. 3½.

V. SHOT-LINES.

The Silver Lake Company's braided linen lines Nos. 3½, 4, 4½, 5, 6, and 7, should be preferred. No. 3½ is advisable where extreme range is required. The others may be used in ordinary cases. The "water-proof finish" should be required.

VI. IMPLEMENTS, &C.

The following list of minor implements and articles should go with each gun:

LIST.

Sponge and rammer.
Wiping-rod and wiper.
2 priming-wires.
Lanyard.
Combination level.
Gunner's haversack.
Cartridge-bags, two sizes.
Friction primers.
Quick-match for 2″ gun.

VII. SERVICE CHARGES OF POWDER (ORDINARY).

1. For 2″.5 gun.		2. For 2″ gun.	
Number of line.	Weight of powder.	Number of line.	Weight of powder.
	Ounces.		*Ounces.*
3½	4 to 6	3½	3 to 4
4 and 4½	4 to 6	4 and 4½	3 to 4
6 and 7	4 to 8	5, 6, and 7	3 to 6

3. For drills, 3 ounces should be used.

CHAPTER III.

I. INSTRUCTIONS.

Keep the bore of the gun clean at all times. There is often a deposit left after firing, near the seat of the charge, which prevents the projectile from going entirely down to the cartridge. This deposit should always be removed.*

The projectiles should be kept free from rust. The use of emery-cloth and the application of a little oil will protect the shot from rust.

In loading, always measure the distance from the charge to the muzzle with the ramrod or wiper and apply it to the shot. In this manner the gunner can always tell whether the projectile is fully down or is obstructed by dirt or sand.

If the piece be fired when the projectile is not "home," it strains the gun unnecessarily.

II. DIRECTIONS FOR FIRING.

Having the gun and apparatus on the ground, to prepare for firing:

1. Select a place where the gun and carriage may recoil without striking rocks or other obstructions.
2. Note the position of the vessel to be relieved; her distance from the shore, the direction and approximate force of the wind.
3. Place the gun in position, making allowance for the force of the wind and for the drift of the line.
4. Place the faking-box and line on the windward side of the gun, and two or three feet from it—not more. The box should be on a line with the muzzle of the gun. Loosen the hasps, invert the box, and incline it to the front at an angle of about 45°.
5. See that the vent is clear by inserting the priming-wire.
6. Wipe off the shot with care, freeing it from dirt and sand.
7. Remove the frame and faking-pins, pressing at the same time gently upon the "false" bottom to keep the fakes in place. Then remove the "false" bottom by lifting it slowly until clear of the box.
8. Seize the end of the line, drawing out just enough to reach to the gun without disturbing the fakes in the box, pass the end through the eye-hole in the shank and tie two or three half-hitches in it, drawing the knot down close to the eye; then wet about three or four feet of the line.

[The wetting is a precaution that was not taken in the experimental firing, it not being found necessary. It is better, however, to err on the safe side.]

9. Remove the tompion or muzzle cover from the piece.
10. Insert the cartridge.
11. Insert the projectile slowly until it rests upon the cartridge.
12. Prick the cartridge with the priming-wire to avoid disturbing the elevation after being given.
13. Set the "combination level" to the desired angle.
14. Place the lower arm of the level lengthwise upon the chase.
15. Elevate the muzzle until the bubble of the level stands at the middle of the tube.
16. Adjust the quoin.
17. Unroll the lanyard and insert the hook in the wire loop of the friction primer.

* Generally removed by using wet sponge. In very cold weather, alcohol should be used instead of water, to prevent freezing.

18. Insert the primer gently in the vent.
19. Stand clear of the line.
20. Fire the piece.

NOTE.—If any of the fakes should slide from the box to the ground, place the loose line in small fakes not more than 18 inches long in front of the box. The necessity for this operation should be avoided if possible.

III. MANNER OF FAKING.

Faking is an operation which requires some care. Any person may learn to do it in a kind of way, but it requires a man who can exercise a little common sense to do it well. Carelessness and ignorance are the most fruitful causes of want of success in laying up lines by this method. Practice alone can make a successful "faker." One man *may* fake a line, but, having to attend to three operations at the same time, does none of them properly. Two men may put up a line, but, as before, there being more operations than men, they often fail. Three men *can* fake a line well. For convenience of reference, I will number these men Nos. 1, 2, and 3. Their duties will be given here consecutively, but it must be understood that they are performed simultaneously.

Duties of No. 1.

No. 1 is the "faker," and is responsible for the condition in which the line is stowed away. He takes the faking-box, places it on the ground with the side or top uppermost, puts the frame with the pins on top of it, seizes the "false" bottom and lowers it into position over the pins, and stands at the side facing the box. He is now ready to begin faking. The cord or line is supposed to be on the same side of the box as the "faker," and at some distance in rear of him, in coils or upon an improvised reel.

No. 2 stands on the opposite side of the box from No. 1 and facing him.

No. 3 is about two yards behind No. 1, and stands ready to pay out the line from the reel or coil.

No. 1 seizes the end of the line, with his right hand draws it forward, letting it pass close to his right side, lays the end along the "false" bottom with the end to his right. [It was formerly the custom to coil several yards of line loosely upon the "false" bottom before beginning to fake; this should not be done; no more line should be put on the bottom than just sufficient to reach the length of the box, as that length will generally be sufficient to reach from the box to the gun in loading, thus avoiding long fakes on the ground and the disturbance of the fakes in the box.] He then leads the line between the corner and second pins at the left-hand corner of the frame, on the side of No. 2, brings it around the corner pin and between the second and third pins in the end row, thence diagonally across the corner and around the second pin of the side row from left to right (No. 2 holds down this loop), thence back and around third pin of the end row (holding down this loop with the thumb and finger of his left hand); this forms the first fake in the first tier. Repeating this operation, he forms a tier of diagonal fakes and brings up at the right-hand corner on his own side of the box, and passing the line around the second and corner pins of the end row (on the right) between the corner and second pins on the side row next to him, he carries the line along the length of the box, and out between the corner and second pins in the left-hand end row, and around the corner and second pin in the row on the side towards him, thence across the corner and around the second pin in the end row, then back around the third pin in the side row, forming the first fake of the second tier.

The second tier will end at the right-hand corner on the side opposite the faker, when the line is carried in a similar manner along the frame on the side of No. 2 to the left-hand corner on that side, where the third tier begins.

Thus, it will be seen that the odd numbers of tiers begin at the left-hand corner on the side opposite to the faker, while the second, fourth, sixth, &c., or even numbers of tiers begin always at the left-hand corner on the side upon which the faker stands.

No. 1 continues this operation of faking with his right hand and holding down the loops nearest to him with his left until the pins are filled, then if any line be left unfaked he coils it loosely on top of the tiers and passes the end down on one side to the notch in the "false" bottom.

Nos. 1 and 2 take hold of the frame, one at each end, lift it off the box and place it on the ground.

No. 3 seizes the box and inverts it over the faking-pins and line, with the notched side over the loose end of line, which is allowed to extend out for about a foot. No. 1 holds this end in the notch of the "false" bottom until the box is adjusted in position, when Nos. 2 and 3 close and fasten the hasps. The box and line are now ready for transportation.

Duties of No. 2.

No. 2 takes his place opposite to No. 1, the box with the faking-pins being between them. His duty is to press down and hold the loops in place on his side of the frame as fast as No 1 passes them over the pins; when the faking is completed he assists No. 1 in moving the frame and line from the box to the ground, and fastens the hasp at one end of the box.

Duties of No. 3.

The position of No. 3 is about 6 feet or less in rear of No. 1. He pulls the line from the reel (which may be mounted upon a temporary stand or frame) or coil, disentangles it, removes all knots or kinks, and pays it out to No. 1, who fakes it up. The ease and rapidity with which No. 1 fakes will depend greatly upon the manner in which No. 3 pays out the line. If he does not give enough slack, No. 1 will draw the fakes too tightly around the pins, bending and drawing them together at the top, bringing unnecessary strain upon the frame, and in exceptional cases bending the frame so much that the hasps cannot be fastened. The same effect will be produced if No. 3 permits too much slack, as then the extra weight and effort causes No. 1 to wind too tightly. No. 3 must obey the directions of No. 1 in paying out line, and accommodate himself to the rapidity of action of the faker. Strict attention and frequent practice are necessary to acquire any degree of skill in this manipulation. No. 1 has the tedious and tiresome part to perform in this operation. He must be especially careful not to draw the loops too tightly around the pins; this he unconsciously will be sure to do without the exercise of great caution. He should instruct No. 3 in regard to the rapidity of passing the line. When faking, he should always leave the fakes as loose upon the pins as he thinks is necessary, and then leave them a little looser.

It is almost impossible for one man to fake a line without drawing it too tight; besides which, it is a long and toilsome process. Two men can do it but little better, since No. 2 can render No. 1 no assistance in drawing the line from the reel or coil. Three men should always be employed when possible. Practice, and a great deal of it, alone can make an expert faker.

Intelligent instruction by illustration should be given to new men until they thoroughly understand the method, for faulty customs and habits when formed are not easily corrected.

Frequent drills in faking should be maintained by the keepers of stations, during which all the surfmen should be taught, not only how to fake, but how to do it well and rapidly.

An ordinary faker with two *good* assistants can put up 600 yards of No. 7 line in from 25 to 28 minutes. A clumsy man will generally be from 40 to 50 minutes putting up the same line.

It must be remarked, however, that the more rapid the faking the greater the danger of getting it too tight upon the pins.

IV. CONCLUSION.

In the use of this, as of all other apparatus, a certain degree of care and common sense must be constantly exercised by those who have it in charge. The best and most perfect apparatus in the world will prove a miserable failure in the hands of ignorance and carelessness. The necessity for thorough instruction and frequent practice is nowhere so urgently called for as in the fitting of men to handle efficiently the appliances for saving human life.

PART II.

CHAPTER I.

BRONZE LIFE-SAVING GUNS.

The term "life-saving guns" is here used to designate such ordnance as may be employed to effect communication between stranded vessels and the shore, by throwing a projectile carrying a line from the shore over a vessel, or from a vessel to the shore.

The guns and mortar treated of in this chapter are given in the chronological order of their preparation for experimental firing.

SECTION I. RIFLED MORTARS.

3-INCH MUZZLE-LOADING RIFLED MORTAR.

(Plate I.)

DESCRIPTION.

This piece is made from an old bronze gun which was found among a lot of captured ordnance. The gun is of an obsolete pattern and its history is unknown. It was prepared under the direction of "The Ordnance Board," United States Army, for making experiments in connection with the United States Life-Saving Service.

The muzzle was cut off 5''.4 from the trunnions, and a muzzle-band or cylindrical (exterior) ring 5'' in length screwed on as shown in the plate (Plate I, Fig. 1).

The rifling consists of 3 grooves, 0''.75 wide and 0''.1 deep. The grooves begin 1''.25 in front of the chamber and reach their full depth at 2'' from the same plane.

The ramp, joining the surfaces of the bore and the bottom of the grooves, is 0''.75 in length.

The grooves are rectangular in section with the corners slightly rounded. The exterior tapers slightly from the base ring to the trunnions. The old vent had been filled up and a new one with a copper bouche inserted.

The axis of the trunnions is below that of the piece. The chamber is cylindro-spherical.

Dimensions.

Total length	26.25 inches.
Total length of bore, including chamber	20.25 inches.
Diameter of base ring	6.2 inches.
Diameter in rear of trunnions	5.1 inches.
Diameter at vent	5.7 inches.
Diameter in front of chamber	5.65 inches.
Diameter at muzzle	5.35 inches.
Diameter of bore	3.0 inches.
Diameter of chamber	2.5 inches.
Total length of chamber	2.75 inches.
Length of cylindrical part of chamber	1.50 inches.

Radius of bottom of chamber	1.25 inches.
Length of trunnions	1.9 inches.
Diameter of trunnions	2.0 inches.
Thickness of metal at vent	1.6 inches.
Thickness of metal in front of chamber	1.32 inches.
Thickness of metal at muzzle	1.1 inches.
Distance of vent from bottom of chamber	1.5 inches.
Number of grooves	3
Depth of grooves	0.1 inch.
Width of grooves	0.75 inch.
Twist, one turn in 10 feet.	
Vent piece, diameter of screw	0.75 inch.
Vent piece, diameter of head	0.85 inch.
Vent, diameter of	0.2 inch.

Weights, &c.

Weight of rifled mortar (converted)	133 pounds.
Preponderance	43.25 pounds.

SECTION II. SMOOTH-BORE GUNS.

Bronze was selected as the metal from which to cast the experimental guns.

The necessary calculations and drawings were made, and copies of the latter, upon tracing-linen, were placed in the hands of the South Boston Iron Company, who had undertaken the fabrication of the guns.

I. BRONZE GUN A.

Caliber, 3 inches=7.62 centimeters (converted).

(Plate II.)

In the plate this gun is represented with the diameter of the bore 2.5 inches. Later, the bore was enlarged to a diameter of 3 inches, as will be seen hereafter, though the total length of the bore remained unaltered.

The exterior of this gun is divided into four principal parts, viz, the *breech*, the *first reinforce*, the *second reinforce*, and the *chase*.

The breech is a hemisphere whose radius is equal to the semi-diameter of the first reinforce.

The first reinforce is cylindrical, and extends from the base of the breech to a point in front of the axis of the trunnions.

The second reinforce is a short frustum of a cone, joining the first reinforce to the chase. The latter is cylindrical, and is of a lesser diameter than the first reinforce.

The chase is terminated in front by the *face* of the piece without any swell of the muzzle or muzzle-band. The cascabel and trunnions are short cylinders.

The rimbases unite with the exterior surface of the gun by tangent-curved surfaces.

The vent-piece is of copper. The vent is perpendicular to the axis of the piece, and is 1.5 inches (3.81 centimeters) from the bottom of the bore.

The bore is cylindrical and is terminated at its lower extremity by a hemispherical chamber, by which term it is proposed to designate the bottom of the bore. The gun was designed for a caliber of 2.5 inches (6.35 centimeters).

When first completed, however, it was bored out to a caliber of only

2 inches (5.08 centimeters), in order to make some preliminary experiments with projectiles of that diameter. It was afterwards bored up to caliber of 2.5 inches, and a series of experiments made. Still later the size of the bore was increased to 3 inches, and half an inch was taken from the length of each trunnion.

The following table gives the respective weights of this gun after the successive operations:

Weights of bronze gun A.

	Actual weight.	Calculated. weight.
	Pounds.	*Pounds.*
With bore 2″ in diameter	137	132.410+
With bore 2″.5 in diameter	127.5	122.467+
With bore 3″ in diameter	114	....

The theoretical weight was calculated upon the assumption that the specific gravity of the alloy was 8.7.

PREPONDERANCE.

With 2″ caliber, about .... 6 ozs. ("muzzle preponderance.")
With 2″.5 caliber .... 2.5 lbs.
With 3″.0 caliber .... 6.5 lbs.

1. Character of the bronze.

The alloy, as shown by the fracture, appeared to be very homogeneous. The action of the metal in the turning-lathe indicated great toughness. The surfaces of the specimens tested presented after fracture that peculiar blistered appearance and change of form which is usually exhibited by good bronze when subjected to great tensile strain.

This gun was cast muzzle downward, and consequently the "riser," or sinking-head, was in rear of the cascabel. The specimens for testing were taken from that portion of the "riser" which was nearest to the breech of the gun. They were four in number.

Three of the specimens were cut from the exterior of the "riser" equidistant from each other, measured circumferentially; the fourth was an axial specimen from the same mass of metal. (See Plate III, Fig. 1.)

The axes of all the specimens were parallel to the axis of the gun.

Screw-threads were cut upon the heads to fit them to the holders of the testing-machine.

Upon both ends of the pieces were marked the letter A, to designate the gun, the letter H to indicate the sinking-head, from whence they were taken, and the numbers of the specimens.

Dimensions of specimens.

Total length	6.4	inches.
Length of shoulders	0.2	inch.
Length between shoulders	4.0	inches.
Length of heads	1.0	inch.
Diameter	0.798	inch.
Area of cross-section	0.5	inch.
Diameter of heads before cutting thread	1.4	inches.
Diameter of heads after cutting thread	1.25	inches

(See Plate III, Figs. 1, 2, and 3.)

These carefully turned and finished samples of bronze were placed in the hands of Mr. C. B. Richards, engineer of the Colt's Patent Fire-Arms

Manufacturing Company of Hartford, Conn., to be tested upon the testing-machine constructed by that company. This machine owes its present accuracy and general excellence to the scientific ability of Mr. Richards, under whose supervision it was constructed. In this place a mere abstract of the results of the tests will be given; for further detailed information in regard to the tests and the machine reference must be made to the report of Mr. Richards, which will be found upon subsequent pages.

Tests of metal in bronze gun A.

		912.	913.	914.	915.
Original mark on the end of the specimen		A. H. 1.	A. H. 2.	A. H. 3.	A. H. 4.
Original minimum diameter of the specimen		0.789	0.797	0.797	0.798
Minimum area of cross-section	Original	0.489	0.499	0.499	0.5
	After fracture	0.283	0.292	0.283	0.418
Distance between gauge-marks	Original	3.49	3.49	3.49	3.49
	After fracture	5.38	5.30	5.38	3.95
Greatest observed stress sustained without set		5500.	6000.	6000.	3500.
Breaking stress		23280.	23340.	23740.	14220.
Elastic resistance, in pounds, per square inch of original cross-section		11000.	12000.	12000.	7000.
Ultimate resistance, in pounds, per square inch of original cross-section		47600.	46780.	47580.	28440.
Greatest reduction of cross-section ... per cent		42.1	41.5	43.3	16.4
Ultimate elongation between gauge-marks per cent		54.1	51.6	53.9	13.3

(First header cell: Test-number of the specimen.)

NOTE.—Dimensions and areas are given in inches and stresses in pounds. No. 915 was the axial specimen.

"The stresses were applied gradually in all cases."

"Observations to ascertain when a permanent set was produced were made after the addition of each 500 pounds stress up to the elastic limit."

"The extensions produced by increasing the stress from 1,000 pounds to 3,000 pounds were as follows:

Test-number of specimen	912.	913.	914.	915.
Extensions ... ten-thousandths of an inch	11.	10.	8.5	10.
Moduli of elasticity ... millions of pounds	12.7	14.	16.5	14."

2. MARKS.

The only external mark upon the gun is the letter A on top of the gun between the trunnions.

3. NOMENCLATURE.

A—Breech.
B—First reinforce.
C—Second reinforce.
D—Chase.
E—Chamber.
F—Bore.
G—Trunnions.
H—Cascabel.
I—Rimbases.
V—Vent.

4. NOTATION AND DIMENSIONS.

D = diameter of first reinforce = 6.0 inches.
d_1 = diameter of chase = 4.5 inches.
d_2 = diameter of bore = 2.5 inches.
d_3 = diameter of trunnions = 2.5 inches.
d_4 = diameter of cascabel = 2.0 inches.
d_5 = diameter of rimbases, assumed to be cylinders = 3.5 inches.
R = radius of breech = 3.0 inches.
r = radius of chamber = 1.25 inches.
r^1 = radius of chase = 2.25 inches.
l_1 = length of first reinforce = 7.25 inches.
l_2 = length of second reinforce = 2.0 inches.

l_3=length of chase .... = 8.75 inches.
l_4=length of bore exclusive of chamber .... =16.75 inches.
l_5=length of trunnions .... = 2.5 inches.
l_6=length of cascabel .... = 1.5 inches.
l_7=length of rimbases .... = 0.1 inch.

v_1, v_2, v_3, &c., =volumes of breech, first reinforce, second reinforce, &c., in cubic inches.
x_1, x_2, x_3, &c., =distances of centers of gravity of breech, first reinforce, second reinforce, &c., from plane of reference.

5. Calculations.

a. Volumes.

A. Breech—hemispherical:

Volume $= \frac{1}{2}$ $D^3 \times .5236 = \frac{1}{2} \times 216. \times .5236 = v_1 = 56.5485 \times$ cubic inches.

B. First reinforce—cylindrical:

Volume $= D^2 \times .7854 \times l_1 = 36 \times .7854 \times 7.25 = v_2 = 204.9886$ cubic inches.

C. Second reinforce—frustum of a cone:

Volume $= \frac{1}{3}\, l_2 \times .7854 \left(\frac{D^3 - d_1^3}{D - d_1}\right) = \frac{1}{3} . 2 \times .7854 \left(\frac{216 - 91.125}{6 - 4.5}\right) = v_3 =$ 43.59 cubic inches.

D. Chase—cylindrical:

Volume $= d_1^2 \times .7854 \times l_3 = 20.25 \times .7854 \times 8''.75 = v_4 = 139.1627$ cubic inches.

E. Chamber—hemispherical:

Volume $= \frac{1}{2}\, d_2^3 \times .5236 = \frac{1}{2} . 15.625 \times .5236 = - v_5 = 4.0906$ cubic inches.

F. Bore—cylindrical:

Volume $= d_2^2 \times .7854 \times l_4 = 6.25 \times .7854 \times 1675 = - v_6 = 82.2213$ cubic inches.

G. Trunnions (2)—cylindrical:

Volume $= 2\, d_3^2 \times .7854 \times l_5 = 2 \times 6.25 \times .7854 \times 2''.5 = v_7 = 24.5436$ cubic inches.

H. Cascabel—cylindrical:

Volume $= d_4^2 \times .7854 \times l_6 = 4 \times .7854 \times 1.5 = v_8 = 4.71$ cubic inches.

I. Rimbases (2)—cylindrical (assumed to be):

Volume $= 2d_5^2 \times .7854 \times l_7 = 2 \times 12.25 \times .7854 \times 0''.1 = v_9 = 1.9242$ cubic inches.

Weight.

	Cubic inches.		Cubic inches.
$v_1 =$	56.5486	$- v_5 =$	$-$ 4.0906
$v_2 =$	204.9886	$- v_6 =$	$-$ 82.2213
$v_3 =$	43.5900		(−) 86.3119
$v_4 =$	139.1627		

× 444.2899 = volume of gun less trunnions, rimbases, and cascabel.
(−) 86.3119 = volume of chamber and bore.

× 357.9780 = volume of metal less trunnions, rimbases, and cascabel.
$v_7 =$ 24.5436 = volume of metal in trunnions.
$v_8 =$ 4.7100 = volume of metal in cascabel.
$v_9 =$ 1.9242 = volume of metal in rimbases.

$V = \Sigma(v) =$ 389.1558 = total volume of metal in gun.

$w = 0.3147$ pounds avoirdupois = weight of one cubic inch of bronze whose specific gravity is 8.7.

Hence $W = V \times w = 389.1558 \times .3147$ pound $= 122.467 +$ pounds = weight of gun.

b. Center of gravity.

Assuming the plane YZ, the plane of reference, to coincide with the base of the breech, and the axis of X to coincide with the axis of the bore, then, since the volume is symmetrically disposed in regard to this axis, the center of gravity of the gun will be given by the formula—

$$x = \frac{v_1 x_1 + v_2 x_2 + v_3 x_3 + \&c.}{v_1 + v_2 + v_3 + \&c.}$$

in which

x = the distance of the center of gravity of the gun from the plane of reference, and

v_1, v_2, &c. = the elementary volumes;

x_1, x_2, &c. = the distances of their respective centers of gravity from the plane of reference.

All distances estimated toward the right from the plane YZ are regarded as positive; all estimated toward the left from this plane are regarded as negative.

The volumes of all cavities (such as bore, chamber, &c.) are considered as negative.

The volumes of the trunnions and rimbases are omitted in this computation, since they are symmetrically disposed about a line passing through the center of gravity of the gun, and perpendicular to the axis of the gun.

The cascable is also omitted on account of its small size and weight.

COMPUTATION.

Values of x_1, x_2, x_3, &c.

For—

A. Breech—hemisphere:

$$(-)\, x_1 = \tfrac{3}{8} R = \tfrac{3}{8} . 3'' = -1''.125.$$

B. First reinforce—cylinder:

$$x_2 = \tfrac{1}{2} l_1 = \tfrac{1}{2} . 7''.25 = 3''.625.$$

C. Second reinforce—frustum of cone:

$$x_3 = 7''.25 + \tfrac{1}{4} . l_2 \left(\frac{3 r'^2 + 2 R r' + R^2}{R^2 + R r' + r'^2} \right)$$

$$= 7''.25 + \tfrac{1}{4} . 2'' \left(\frac{15.1875 + 13.50 + 9}{9 + 6.75 + 5.0625} \right)$$

$$= 7''.25 + 0''.9054$$

$$\therefore x_3 = 8''.1554$$

D. Chase—cylinder:

$$x_4 = 9''.25 + \tfrac{1}{2} l_3 = 9''.25 + 4''.375 = 13''.625.$$

E. Chamber—hemisphere:

$$x_5 = 1''.25 - \tfrac{3}{8} r = 1''.25 - .''46875 = 0''.78125.$$

F. Bore—cylinder:

$$x_6 = 1''.25 + \tfrac{1}{2} l_4 = 1''.25 + 8''.375 = 9''.625.$$

Substituting the values of v_1, v_2, &c., and x_1, x_2, &c., in eq., and multiplying, we have—

$$x = \frac{(-63.61735 + 743.0844 + 355.4901 + 1896.0870 - 3.19577 - 791.38)}{56.5485 + 204.9886 + 43.59 + 139.1627 - 4.0906 - 82.2213}$$

or

$x = 5''.968155$, say $x = 5''.97$ = distance of center of gravity of gun from the plane of reference.

6. Fabrication of experimental bronze gun A.

1. *Drawing.*—A full-size drawing of the gun was first made; the dimensions in inches and decimal parts of an inch were marked upon this drawing. An accurate copy of this drawing was made upon tracing-linen and sent to the South Boston Iron Company to guide the founder.

2. *Drawing for the chills.*—The manufacturers prepared a full-size drawing of a set of iron chills in which the gun was to be cast. The dimensions of the chills were such as to allow for the contraction of the metal in cooling, for finishing the gun, and for the sinking-head, or "riser." The chills are made in two parts, which are identical in form.

3. *Pattern.*—From the above drawing, a model or pattern of one-half of the chill was made of white pine, due allowance being made for the shrinkage of the cast-iron in cooling. The model was completed by smoothing it off with sand-paper and varnishing.

4. *Molding.*—From this half-model a mold of one of the half-chills was formed in wooden flasks. This was done by ramming molding-composition compactly around the mold. This composition is a kind of sandy loam, containing just enough clay to make it cohesive when slightly moistened and pressed together. The wooden half-flasks are kept from sticking together by being sprinkled with a dry white sand, called *parting-sand* by molders. The mold for the second half-chill was made in the same manner. The molding being completed, the half-flasks were bolted together, and placed in an oven to dry thoroughly.

5. *Casting the chills.*—When perfectly dry, the flasks containing the molds were removed from the oven, the cast iron was melted and run into them. After cooling, the flasks were removed and the chills were prepared to receive the bronze casting for the gun.

6. *The chills.*—(Fig. 1, plate 47.) These were of cast iron, 1″.75 thick. The total length was 13″ greater than the extreme length of the gun. Of this surplusage, one inch was on the muzzle end, and 12″ at the breech for a sinking-head or "riser." The cavity at the breech end was cylindrical, 6″.5 in diameter; that at the muzzle was a frustum of a cone whose lesser base had a diameter of 5″. The faces of the flanges where the half-chills came together were planed, in order to fit closely. The half-chills were bolted together, and the bottom closed by an iron plate, 1″.75 thick, bolted to the bottom flange.

7. *Heating the chills.*—The inside surfaces of the chills were coated with clay-wash and placed in an oven to dry and become heated before pouring the melted metal for the gun, in order that the exterior should not cool too rapidly. This clay-wash is made by mixing three parts of ground fire-brick with one part of German or English fire-clay, and adding a sufficient quantity of water. When nearly ready to cast the gun, the chill was removed from the oven and taken to a place near the furnaces where the crucibles were heating. A "clay-mold," 6″ in length, whose interior diameter was also 6″, was added to the height of the sinking-head, in order to avoid getting cinders in the metal near the breech of the gun. The chills were so made that the gun was cast muzzle downwards.

8. *The furnaces.*—(Fig. 2, plate 47.) These were iron cylinders, about 3′ high and 2′ in diameter, lined with fire-brick. They are technically called "pots." A high chimney furnished the draught. The gun being a small one, it was unnecessary to use a reverberatory furnace, since three crucibles (Fig. 3, plate 47) would hold the requisite amount of metal. The crucibles were placed in the "pots" and the metals for the alloy melted without difficulty. The fuel used was Lehigh coal, with

broken charcoal put over the metal in the crucibles. The condition of the furnaces or "pots" was such that only two of those in the new foundery could be used. The third crucible had to be heated in a "pot" about forty yards from the others. The isolated "pot" had a less efficient chimney.

9. *Charging the crucibles.*—The metals used were Lake Superior copper and German tin. Both of these metals were in the form of ingots. The copper ingots weighed from 12 to 13 pounds each. The metals were carefully weighed and placed in the crucibles, as stated in the table given below. The tin was removed when the crucibles were placed in the furnace and added subsequently. The proportions of the two metals used were as follows:

Copper	92 per cent.
Tin	8 per cent.

The calculated charge was:

Copper	333.96 lbs.
Tin	29.04 lbs.
Total	363.00 lbs

Actual charges.

Metal.	In crucible. No. 1.		In crucible. No. 2.		In crucible. No. 3.		Total.
	Lbs.	*ozs.*	*Lbs.*	*ozs.*	*Lbs.*	*ozs.*	*Pounds.*
Copper	120	00	120	00	94	00	334
Tin	10	7	10	7	8	2	29
Total charge							363

10. *Time of melting, &c.*—The fires were lighted under all the crucibles at 11 a. m. The copper in Nos. 1 and 2 was all melted at 3.15 p. m., while that in No. 3, though a less charge, was not melted on account of a defective draught or some other cause. This necessitated the holding back of Nos. 1 and 2. The charge of No. 3 was finally melted at 4 p. m. On examination, it was found that the metal in No. 2 was not quite hot enough. At 4.15 p. m. the tin was added to the melted copper in the crucibles. The ingots of tin were immersed in the melted copper and stirred up thoroughly as it melted to prevent oxidation.

11. *Casting.*—When ready for casting, crucible No. 3 was lifted from the "pot" and carried through the open air to the room where Nos. 1 and 2 were situated. The pouring ladles were (Fig. 4, plate 47) at hand, filled with burning charcoal, to keep them hot. When all was ready, crucible No. 3 was emptied into ladle No. 1, but not filling it, crucible No. 1 was hoisted out and the ladle filled from it. Ladle No. 2 was then filled with what remained in crucible No. 1 and the contents of No. 2. As soon as both ladles were ready, their contents were, in succession, poured directly into the chills, filling the cavity to the top. The gun was cast at 4.40 p. m. From unskillful manipulation a good many cinders and a good deal of scoria found a passage into the chills. The casting was taken from the chills at 7 to 7.30 a. m. the next morning, and weighed, in a rough state, 363 pounds with the riser. The above weight, 363 pounds, was given by Mr. Reed, the superintendent in charge of the foundery. This first casting was made on October 1, 1877. When the gun came to be turned, it was discovered that the

metal or alloy had not been hot enough when poured, and that charcoal cinders had entered with the molten metal and appeared all along the chase and breech. This casting was rejected. An attempt was now made to prepare a runner-box or receptacle for the metal which should be self-skimming. This was accomplished by placing on top of the sand flask a runner-box having near one side a 2″ hole pierced through the bottom to allow the liquid metal to pass, and on the other side a cup or bowl into which this metal was first poured. A partition a few inches in height separated the two compartments.

Second casting.

Mode of pouring.—The runner box being placed in position upon the flask, the melted metal, in ladles, was then poured, at first slowly, into the cup-shaped receptacle until it rose to the top of the partition and ran over it. The partition was intended to arrest the scoria in the first instants of the casting until enough metal ran over to fill the two-inch hole and rise above it a sufficient distance to preclude any chance of the scoria or cinders getting through the bottom orifice. When the operation had proceeded thus far, all that was necessary was to pour fast enough to keep the metal from falling so low as to permit the residuum to pass before the flask was filled.

Notwithstanding these precautions enough cinders passed into the chills and lodged in the trunnion holes on top (in rear of) of the trunnions to reject this casting also. It was then decided to cut away 0″.375 of the metal in the chills in rear of the trunnions where this lodgment had occurred. This would allow a small lodgment of cinders, &c., without injuring the soundness of the casting.

A third and successful trial was then made. Below are given the charges and dates of the recastings, and a *résumé* of the first trial.

First casting.

Date: October 1, 1877.

		Pounds.
Charge:	Copper	334
	Tin	29
	Total	363

Weight of rough casting, 363 pounds (Reed).

Second casting.

Date: October 4, 1877.

Charge: First casting, weight 363 pounds.
No metal used except the previous casting.

Third casting.

Date: October 8, 1877.

		Pounds.
Charge:	Metal from second casting	319
	Copper, ingot	17
	Tin, ingot	2.9
	Total charge	338.9
Weight of rough casting		329
Weight of finished gun bored out to 2 inches caliber		137

Of the 2.9 pounds of tin added to the charge for this casting, 1.4 pounds was the proportion to be added to the 17 pounds of new copper, and 1.5 pounds was about one-half of 1 per cent. of the weight of metal used from second casting. This was added to supply the amount of tin assumed to be lost by oxidation in the two previous castings.

In the third trial the fire was lighted at 10.30 a. m.; metal all melted at 2.30 p. m.; tin added at 2.30 p. m.; gun cast at 3 p. m.

The gun was turned, bored, and finished in the usual manner.

II. BRONZE GUN B.

Caliber: 2 inches = 5.08 centimeters.

(Plate IV.)

This gun is of the same general form as gun A, but is much smaller and lighter. It also was made by the South Boston Iron Company. This piece was cast in chills, muzzle downward, and finished in a similar manner to gun A. The cast-iron chill was 4 inches longer than the length of the gun including the cascabel. A clay mold 8 inches in length was added above the chill to increase the height of the "riser," or sinking-head.

Details of casting.

Date: January 11, 1878.

	Pounds.
Charge of metal	160
Lake Superior copper, 92 per cent	147.2
German tin, 8 per cent	12.8
Total	160.0

Fire lighted in furnace at	8.30 a. m.
Copper charged	9.30 a. m.
Copper melted	1.30 p. m.
Tin added	2.00 p. m.
Gun cast	2.45 p. m.

Weights.

	Pounds.
Weight of rough casting	156.00
Weight of "riser"	40.25
Weight of gun-casting	115.75

Weight of gun.

Specific gravity of alloy, assumed	8.7	pounds.
Theoretical weight of gun	53.279+	
Actual weight of gun	54.25	
Preponderance	1.0	

1. Specimens for testing.

(Plate III, Figs. 2, 3, and 4.)

These were four in number, as in the preceding case, and were taken from the "riser" or sinking-head, just in rear of the cascabel. They were of the same size and form, and occupied the same relative positions in the casting as did the specimens from gun A. The heads of each specimen were marked with the letters B and H, together with its serial number; No. 4, as in the previous instance, being the number of the axial specimen. The letter B was cut on the top of the gun, between the trunnions.

Below will be found a tabulated statement of the results obtained by the testing-machine. These tests were made by Mr. Richards, engineer of the Colt Company. For further details see his appended report.

Tests of metal from sinking-head of bronze-gun B.

Test-number of specimen		937.	938.	939.	940.
Original mark		B. H. 1.	B. H. 2.	B. H. 3.	B. H. 4.
Diameter of minimum cross-section	Original	0.798	0.798	0.798	0.798
	After fracture	0.66	0.67	0.665	0.73
Area of minimum cross-section	Original	0.500	0.500	0.500	0.500
	After fracture	0.342	0.352	0.347	0.418
Distance between gauge-marks	Original	3.50	3.50	3.50	3.50
	At instant of fract'e	4.69	5.02	4.95	4.07
Greatest observed stress sustained without set		6000.	5500.	6500.	4500.
Breaking stress		20820.	21900.	21920.	16860.
Limit of elastic resistance		12000.	11000.	13000.	9000.
Ultimate resistance (tenacity)		41640.	43800.	43840.	33720.
Greatest reduction of cross-section	per cent	31.6	29.6	30.6	16.4
Ultimate elongation between gauge-marks	per cent	34.0	43.4	41.4	16.3

Dimensions and areas are given in inches, stresses in pounds, and resistances in pounds per square inch of the original cross-section of the specimen.

2. Nomenclature.

A—Breech.
B—First reinforce.
C—Second reinforce.
D—Chase.
E—Chamber.
F—Bore.
G—Trunnions.
H—Cascabel.
V—Vent.

3. Notation and dimensions.

D = diameter of first reinforce = 4 inches.
d_1 = diameter of chase = 3.5 inches.
d_2 = diameter of bore = 2 inches.
d_3 = diameter of trunnions = 1.75 inches.
d_4 = diameter of cascabel = 1.5 inches.
Diameter of vent = 0.2 inch.
R = radius of breech = 2 inches.
r = radius of chamber = 1 inch.
r_1 = radius of chase = 1.75 inches.
l_1 = length of first reinforce = 8 inches.
l_2 = length of second reinforce = 1 inch.
l_3 = length of chase = 9 inches.
l_4 = length of bore, exclusive of the chamber = 17 inches.
l_5 = length of trunnions = 1.5 inches.
l_6 = length of cascabel = 1.5 inches.

v_1, v_2, v_3, &c., = volumes of breech, first reinforce, &c., in cubic inches.

x_1, x_2, x_3, &c., = distances of centers of gravity of breech, first reinforce, &c., from plane of reference.

4. Calculations.

a. *Volumes.*

A. Breech—hemispherical:

$$\text{Volume} = \tfrac{1}{2}\, D^3 \times .5236 = \tfrac{1}{2}\, .64 \times .5236 = v_1 = 16.7552 \text{ cubic inches.}$$

B. First reinforce—cylindrical:

Volume $= D^2 \times .7854 \times l_1 = 16 \times .7854 \times 8 = v_2 = 100.5312$ cubic inches.

C. Second reinforce—frustum of cone:

Volume $= \frac{1}{3} l_2 \times .7854 \times \left(\frac{D_3 - d_1^3}{D - d_1}\right) = .3333 \times .7854 \times \left(\frac{21.125}{0.5}\right) = v_3 =$ 11.0599 + cubic inches.

D. Chase—cylindrical:

Volume $= d_1^2 \times .7854 \times l_3 = 12.25 \times .7854 \times 9 = v_4 = 86.5903 +$ cubic inches.

E. Chamber—hemispherical:

Volume $= \frac{1}{2} d_2^3 \times .5236 = \frac{1}{2} .8 \times .5236 = -v_5 = 2.0944$ cubic inches.

F. Bore—cylindrical:

Volume $= d_2^2 \times .7854 \times l_4 = 4 \times .7854 \times 17 = -v_6 = 53.4072$ cubic inches.

G. Trunnions—cylindrical:

Volume $= 2 \times d_3^2 \times .7854 \times l_5 = 2 \times 3.0625 \times .7854 \times 1.5 = v_7 = 7.2158 +$ cubic inches.

H. Cascabel—cylindrical:

Volume $d_4^2 \times .7854 \times l_6 = 2.25 \times .7854 \times 1.5 = v_8 = 2.6507$ cubic inches

Weight.

	Cubic inches.			Cubic inches.
$v_1 =$	16.7552		$-v_5 =$	− 2.0944
$v_2 =$	100.5312		$-v_6 =$	− 53.4072
$v_3 =$	11.0599			− 55.5016
$v_4 =$	86.5903			
	214.9366	= volume of gun less trunnions and cascabel.		
	− 55.5016	= volume of chamber and bore.		
	159.4350	= volume of metal less trunnions and cascabel.		
$v_7 =$	7.2158	= volume of metal in trunnions.		
$v_8 =$	2.6507	= volume of metal in cascabel.		
$V = \Sigma(v) =$	169.3015	= whole volume of metal in gun.		

$w = 0.3147$ pounds avoirdupois = weight of one cubic inch of bronze, whose specific gravity is 8.7.

Hence $W = V \times w = 169.3015 \times .3147 = 53.279 +$ pounds = weight of gun.

b. Center of gravity.

Assuming the plane YZ, the plane of reference, to coincide with the base of the breech, and the axis of X to coincide with the axis of the bore, then, since the volume is symmetrically disposed in regard to this axis, the center of gravity of the gun will be given by the formula—

$$x = \frac{v_1 x_1 + v_2 x_2 + v_3 x_3 + \&c.}{v_1 + v_2 + v_3 + \&c.}$$

in which

$x =$ the distance of the center of gravity of the gun from the plane of reference, and

v_1, v_2, &c. = the elementary volumes;

x_1, x_2, &c. = the distances of their respective centers of gravity from the plane of reference.

All distances estimated toward the right from the plane YZ are regarded as positive; all estimated toward the left from this plane are regarded as negative.

The volumes of all cavities (such as the bore and chamber) are considered as negative.

The volumes of the trunnions are omitted in this calculation, since they are symmetrically disposed about a line passing through the center of gravity of the gun, and perpendicular to the axis of the bore.

The cascabel is omitted on account of its small size. Its weight is insignificant.

COMPUTATION.

Values of x_1, x_2, x_3, &c.

For—

A. Breech—hemisphere:

$$x_1 = \tfrac{3}{8}\,\mathrm{R} = \tfrac{3}{8}\,.\,2'' = -0''.75.$$

B. First reinforce—cylinder:

$$x_2 = \tfrac{1}{2}\,l_1 = \tfrac{1}{2}\,.\,8'' = 4''.$$

C. Second reinforce—frustum of cone:

$$x_3 = 8'' + \tfrac{1}{4}\,l_2\left(\frac{3r'^2 + 2\,\mathrm{R}\,r' + \mathrm{R}^2}{\mathrm{R}^2 + \mathrm{R}\,r' + r'^2}\right)$$

$$= 8'' + \tfrac{1}{4}\,.\,1''\left(\frac{9.1875 + 7. + 4}{4 + 3.5 + 3.0625}\right)$$

$$= 8'' + ''.25\left(\frac{20.1875}{10.5625}\right) = 8'' + 0''.4778 +$$

$$\therefore x_3 = 8''.4778 +$$

D. Chase—cylinder:

$$x_4 = 8'' + 1'' + \tfrac{1}{2}\,l_3 = 8'' + 1'' + \tfrac{1}{2}\,.\,9'' = 13''.5.$$

E. Chamber—hemisphere:

$$x_5 = 1'' - \tfrac{3}{8}\,r = 1'' - 0''.375 = 0''.625.$$

F. Bore—cylinder:

$$x_6 = 1'' + \tfrac{1}{2}\,l_4 = 1'' + \tfrac{1}{2}\,.\,17'' = 1'' + 8''.5 = 9''.5.$$

Substituting the values of v_1, v_2, &c., and x_1, x_2, &c., in equation, we have—

$$x = \frac{(16.7552 \times -0''.75) + (100.5312 \times 4'') + (11.0599 \times 8''.4778) + (86.5903 \times 13''.5) + (-2.0944 \times 0''.625) + (-53.4072 \times 9''.5)}{16.7552 + 100.5312 + 11.0599 + 86.5903 - 2.0944 - 53.4072}$$

or,

$$x = \frac{+\,1143.6136}{+\,\;159.435} = 7''.1729 + \text{ say } x = 7''.2 =$$

distance of center of gravity from the plane of reference.

III. BRONZE GUN C.

Caliber: 2.5 inches = 6.35 centimeters.

(Plate V.)

The exterior of this gun is divided into four principal parts, viz, the *breech*, the *first reinforce*, the *second reinforce*, and the *chase*.

The breech is a hemisphere whose radius is equal to the semi-diameter of the first reinforce.

The first reinforce is cylindrical, and extends from the base of the breech to a point in front of the axis of the trunnions.

The second reinforce is a short frustum of a cone, joining the first reinforce to the chase. The latter is cylindrical, and is of a lesser diameter than the first reinforce.

The chase is terminated in front by the *face* of the piece without any swell of the muzzle or muzzle-band. The cascabel and trunnions are short cylinders.

The rimbases unite with the exterior surface of the gun by tangent-curved surfaces.

The vent piece is of copper. The vent is perpendicular to the axis of the bore, and is 1.25 inches (= 3.175 centimeters) from the bottom of the bore.

The bore is cylindrical, and is terminated at its lower extremity by a hemispherical chamber, by which term it is proposed to designate the bottom of the bore.

1. Details of casting.

This gun was cast in the chill made for casting gun A.

Three castings were made before a satisfactory gun ingot was obtained.

First casting.

Date: March 23, 1878.

	Pounds.
Charge of metal	350
Lake Superior copper 90 per cent	315
German tin 10 per cent	35
Total	350
Fire lighted in furnace at	6.30 a. m.
Copper charged	7.00 a. m.
Copper melted	9.30 a. m.
Tin added	9.55 a. m.
Gun cast	10.40 a. m.
Amount of coal used	250 pounds.

Three crucibles were used in melting the charge: two "No. 60" crucibles, containing 99 pounds of copper and 11 pounds of tin, each; and one "No. 70," containing 117 pounds of copper and 13 pounds of tin.

Weights.

	Pounds.
Weight of rough ingot	347
Weight of "riser"	117
Weight of rough casting	230

This ingot was rejected on account of being porous at the breech.

Second casting.

Date: March 28, 1878.

	Pounds.
Charge of metal from former casting	345
Weight of rough ingot	338

Casting rejected, porous around trunnions.

Third casting.

Date: March 30, 1878.

	Pounds.
Charge of metal from preceding casting	338
Lake Superior ingot copper	13.5
German tin, ingot	1.5
Total charge	353.0
Fire lighted in furnace at	7 a. m.
Copper charged at	8 a. m.
Copper melted at	11 a. m.
Gun cast at	11.30 a. m.

Weights.

	Pounds.
Weight of rough casting	347
Weight of finished gun	108.25
Preponderance	1.5

A few spots of tin showed on the exterior surface of the gun just in front of the right trunnion.

This gun is marked with the letter C on its upper surface between the trunnions.

2. Specimens for testing.

(Plate III, Figs. 2, 3, and 5.)

The specimens for testing were similar to those for the preceding guns. The marks on the heads of the specimens are given in Fig. 5, Plate III.

For details of the tests in this case, see appended report of Mr. C. B. Richards.

3. Nomenclature.

A—Breech.
B—First reinforce.
C—Second reinforce.
D—Chase.
E—Chamber.
F—Bore.
G—Trunnions.
H—Rimbases.
I —Cascabel.
V—Vent.

4. Notation and dimensions.

D=diameter of first reinforce	= 5.5	inches.
d_1=diameter of chase	= 4.5	inches.
d_2=diameter of bore	= 2.5	inches.
d_3=diameter of trunnions	= 2	inches.
d_4=diameter of rimbases [true diameter=2″.8], assumed	3	inches.
d_5=diameter of cascabel	= 1.5	inches.
R=radius of breech	= 2.75	inches.
r=radius of chamber	= 1.25	inches.
r'=radius of chase	= 2.25	inches.
l_1=length of first reinforce	= 8.50	inches.
l_2=length of second reinforce	= 2	inches.
l_3=length of chase	= 9.5	inches.
l_4=length of bore exclusive of the chamber	=18.75	inches.
l_5=length of trunnions	= 2	inches.
l_6=length of rimbases	= 0.1	inches.
l_7=length of cascabel	= 1.5	inches.

v_1, v_2, v_3, &c.,=volumes of breech, first reinforce, second reinforce, &c., in cubic inches.

x_1, x_2, x_3, &c.,=distances of centers of gravity of breech, first reinforce, second reinforce, &c., from plane of reference.

5. Calculations.

a. Volumes.

A. Breech—hemispherical:

Volume $= \frac{1}{2}$ D^3 $\times$ .5236 $= \frac{1}{2}$ 166.375 $\times$ .5236 $= v_1 =$ 43.557 cubic inches.

B. First reinforce—cylindrical:

Volume $=$ D^2 $\times$ .7854 $\times$ $l_1 =$ 30.25 $\times$ .7854 $\times$ 8''.5 $= v_2 =$ 201.9458 cubic inches.

C. Second reinforce—frustum of cone:

Volume $= \frac{1}{3} l_2 \times .7854 . \left(\frac{D_3 - d_1{}^3}{D - d_1}\right) =$ .6666 $\times$ .7854 $\times$ 75.25 $= v_3 =$ 39.401 cubic inches.

D. Chase—cylindrical:

Volume $= d_1{}^2 \times .7854 \times l_3 =$ 20.25 $\times$ .7854 $\times$ 9''.5 $= v_4 =$ 151.0916 cubic inches.

E. Chamber—hemispherical:

Volume $= \frac{1}{2} . d_2{}^3 \times .5236 = \frac{1}{2}$. 15.625 $\times$ .5236 $= - v_5 =$ 4.0906 + cubic inches.

F. Bore—cylindrical:

Volume $= d_2{}^2 \times .7854 \times l_4 =$ 6.25 $\times$ .7854 $\times$ 18''.75 $= - v_6 =$ 92.0391 + cubic inches.

G. Trunnions (2)—cylindrical:

Volume $= 2 . d_3{}^2 \times .7854 \times l_5 = 2 \times 4 \times .7854 \times$ 2''. $= v_7 =$ 12.5664 cubic inches.

H. Rimbases (2)—assumed cylindrical:

Volume $= 2 d_4{}^2 \times .7854 \times l_6 = 2 \times 9 \times .7854 \times$ 0''.1 $= v_8 =$ 1.4137 + cubic inches.

I. Cascabel—cylindrical:

Volume $= d_5{}^2 \times .7854 \times$ 1''.5 $=$ 2.25 $\times$ .7854 $\times$ 1.5 $= v_9 =$ 2.6507 + cubic inches.

Weight.

Cubic inches.	Cubic inches.
$v_1 =$ 43.5570	$- v_5 =$ 4.0906
$v_2 =$ 201.9458	$- v_6 =$ 92.0391
$v_3 =$ 39.4010	
$v_4 =$ 151.0916	$-$ 96.1297
$v_7 =$ 12.5664	
$v_8 =$ 1.4137	
$v_9 =$ 2.6507	

+ 452.6262 = total volume of gun.
− 96.1297 = volume of bore and chamber.

V $= \Sigma (v) =$ 356.4965 = total volume of metal in gun.

$w =$ 0.3147 pound avoirdupois = weight of one cubic inch of bronze whose specific gravity is 8.7.

Hence V $\times$ w = 356.4965 cubic inches $\times$ 0.3147 = 112.1896 + pounds = weight of gun.

b. Center of gravity.

Making the same assumptions and using the same notation, and, in addition, omitting the volumes of the rimbases, the center of gravity is found in a similar manner to that of gun B.

COMPUTATION.

Values of x_1, x_2, x_3, &c.

For—

A. Breech—hemisphere:

$$x_1 = \tfrac{3}{8}\,R = \tfrac{3}{8}.\,2''.75 = -1''.03125.$$

B. First reinforce—cylinder:

$$x_2 = \tfrac{1}{2}.\,l_1 = \tfrac{1}{2}.\,8''.5 = 4''.25.$$

C. Second reinforce—frustum of cone:

$$x_3 = 8''.5 + \tfrac{1}{4}\,l_2\left(\frac{3\,r'^2 + 2\,R\,r' + R^2}{R^2 + R\,r' + r'^2}\right) =$$

$$= 8''.5 + \tfrac{1}{4}.\,2''.0\left(\frac{15.1875 + 12.375 + 7.5625}{7.5625 + 6.1875 + 5.0625}\right) =$$

$$= 8''.5 + 0''.5\left(\frac{35.1250}{18.8125}\right) = 8''.5 + 0''.9335 = 9''.4335 +$$

$$\therefore x_3 = 9''.4335 +$$

D. Chase—cylinder:

$$x_4 = 8''.5 + 2''.0 + \tfrac{1}{2}\,l_3 = 8''.5 + 2''.0 + \tfrac{1}{2}.\,9''.5 = 15''.25.$$

E. Chamber—hemisphere:

$$x_5 = 1''.25 - \tfrac{3}{8}\,r = 1''.25 - 0''.46875 = 0''.78125.$$

F. Bore—cylinder:

$$x_6 = 1''.25 + \tfrac{1}{2}.\,l_4 = 1''.25 + \tfrac{1}{2}.\,18''.75 = 10''.625.$$

Substituting the values of v_1, v_2, &c., and x_1, x^1, &c., in the general formula, we have—

$$x_1 = \frac{(43.577\times -1''.03125) + (201.9458\times 4''.25) + (39.401\times 9''.4335) + (151.0916\times 15''.25) + (-4.0906\times 0''.78125) + (-92.0391\times 10''.625)}{+43.557 + 201.9458 + 39.401 + 151.0916 - 4.0906 - 92.0391}$$

or,

$$x_1 = \frac{2497.6883}{339.8657} = +\,7''.349,$$

say $x_1 = +\,7''.35$ = distance of center of gravity from the plane of reference.

CHAPTER II.

LIFE-SAVING PROJECTILES.

The experimental projectiles, both rifle and smooth bore, are numbered in one series, corresponding to the order in which they were made. This series comprises projectiles of all calibers made for the experiments.

SECTION I. RIFLE PROJECTILES.*

I. EXPERIMENTAL PROJECTILE No. 1.

(Plate VI.)

This is a cast-iron projectile and was finished when received. It was one of a lot of similar projectiles prepared under the direction of the Ordnance Board for like experiments.

* These projectiles were used with 3-inch M. L. rifled mortar.

It is cylindrical, with sphero-segmental head. This shot is cast with a core, which leaves a hole through the shot from end to end. This hole is cylindrical for 2″.5 from the base; at which distance there is an annular shoulder ″.25 wide, whose outer circle forms the smaller base of the frustum of a cone, in which the hole is continued to the head of the shot.

The cylindrical part of this axial cavity is 2″.5 long and ″.6 in diameter; the conical (a frustum) part is 10″.75 long, with diameters of 1″.1 and 1″.3 at the smaller and larger ends, respectively. The base of this frustum is at the head of the shot. A straight groove, ″.6 wide and ″.5 deep, runs the whole length of the shot and is parallel to the axis. The bottom of this groove is circular.

A radial slot 1″ deep and ″.6 wide connects the longitudinal groove with the axial cavity.

The rifled motion is given by two rings of copper or brass studs, three in each ring. The distance between the two rings of studs is 6″.25, and the rear ring is situated 3″.15 from the base of the shot. The studs are radial, and are screwed into the shot.

The bearing edges of the studs are filed parallel to the line joining their centers. Within the axial cavity are contained a rubber plug and a lead washer, through both of which the cord or line to be projected passes. The opening at the head of the shot is closed by a sheet-iron cap. This cap consists of a cylindrical body, on one end of which is brazed a circular head. The head, from its greater diameter, projects as a flange, which latter is curved downwards so as to embrace the point of the shot. The body has a hole pierced in one side to receive the screw which holds the cap in place when the shot is fired from the piece. This screw passes through the wall of the shot near the front end of the longitudinal groove, and its head is countersunk in the metal at the bottom of this groove.

1. Weights, dimensions, &c.

Projectile.

Total length	13.25 inches.
Diameter of body	2.94 inches.
Diameter of body over studs	3.12 inches.
Radius of head	1.47 inches.
Distance of center of gravity from base	6.30 inches.
Distance of first row of studs from base	3.15 inches.
Distance between first and second row of studs	6.25 inches.
Number of studs	6
Number of studs in each row	3
Height of studs	0.09 inch.
Width of studs	0.69 inch.
Front stud to right of rear stud (both for same groove)	0.5 inch.
Angle due to one turn in 10 feet	4° 30′
Weight, about	18 pounds.

2. Cap (sheet-iron).

Body—Diameter	1.28 inches.
Length	1.2 inches.
Head—Diameter	1.7 inches.

3. Washer (lead).

Diameter	1. inch.
Thickness	0.25 inch.
Diameter of hole	0.5 inch.

4. Rubber plugs.

Diameter—Greatest	1.2 inches.
Least	1.07 inches.
Length	from 2 inches to 6 inches.
Diameter of longitudinal hole	0.5 inch.

5. Marks.

Only two of these shot were made and finished. They are marked on one of the rear studs C. 1 and C. 2, respectively.

II. EXPERIMENTAL PROJECTILE No. 2.

(Plate VII.)

This projectile is of the same general form as the preceding one. It differs only in the weight, and in the details of its dimensions and construction. The metal is cast iron except the studs, which are of brass. The following table and the drawings are sufficiently explanatory.

1. Dimensions, weight, &c.

Total length	10.3 inches.
Diameter of body	2.94 inches.
Diameter of body over studs	3.14 inches.
Radius of head	1.47 inches.
Distance of center of gravity from base	5. inches.
Distance of first row of studs from base	2.50 inches.
Distance between first and second row of studs	5. inches.
Number of studs	6
Number of studs in each row	3
Height of studs	0.10 inch.
Width of studs	0.69 inch.
Front stud to right of rear stud (both for same groove)	0.40 inch.
Angle due to one turn in 10 feet	4° 30′.
Longitudinal groove for short line—Length	Length of shot.
Width*	0.40 inch.
Depth*	0.37 inch.
Axial cavity—Cylindrical portion, diameter of	0.60 inch.
Counterbore, front end, diameter of	1. inch.
Counterbore, front end, length of	2. inches.
Weight	16 pounds.

2. Cap. (sheet-iron.)

Body—External diameter	1. inch.
Length	1.1 inches.
Head, diameter of	1.3 inches.

3. Washer. (brass.)

Diameter	1. inch.
Thickness	0.15 inch.
Diameter of hole	0.3 inch.

4. Marks.

Two shot of this pattern and size were made. They are marked on the rear studs as follows, viz: one, C. L. 3; the other, C. L. 4.

* The radial slot in the base has the same width and depth.

SECTION II. SMOOTH-BORE PROJECTILES.

I. 3-INCH SMOOTH-BORE PROJECTILES.

1. EXPERIMENTAL PROJECTILE No. 3.*

(Plate VIII.)

This is an elongated solid, cast-iron smooth-bore projectile. In form, it is cylindro-ogival with a frustum of a cone for its base. The radius of the ogival head is equal to the diameter of the shot.

The edges or angles about the base are slightly rounded.

A *shank*, or eye-bolt, of wrought iron is screwed into the base of the projectile to serve as a point of attachment for the shot-line.

1. *Dimensions.*

Total length	13.8 inches.
Length of ogival head	2.6 inches.
Radius of head	3. inches.
Length of cylindrical part	9.9 inches.
Diameter of cylindrical part	3. inches.
Length of frustum	1.3 inches.
Diameter of smaller base of frustum	1.7 inches.
Shank: Total length	2.7 inches.
Length of screw	1.5 inches.
Diameter of screw	0.5 inch.
Length from plane of base	1.2 inches.
Distance from base to center of eye-hole	0.7 inch.
Diameter of eye-hole	0.4 inch.
Width at eye	1. inch.
Thickness at eye	0.4 inch.
Diameter of neck	0.625 inch.
Weight, about	22 pounds.

2. *Marks.*

Two of these shot were made and marked as follows: first, C. 5; second, C. 6.

2. EXPERIMENTAL PROJECTILE No. 4.

(Plate IX.)

The form and dimensions of the body of this shot are identical with those of "experimental projectile No. 3" (which see). The only difference is in the shank. The details of this projectile are fully shown in the drawing.

1. *Dimensions of shank, &c.*

Total length of shank, including screw	11.5	inches.
Length of screw-thread	1.5	inches.
Diameter of screw	0.5	inch.
Length of shank	10.	inches.
Diameter of shank	0.625	inch.
Diameter of eye-hole	0.4	inch.
Width at eye-hole	1.	inch.
Thickness at eye-hole	0.4	inch.
Distance from plane of base to center of eye	9.5	inches.
Distance of center of gravity from plane of base	5.97	inches.
Weight, about	22	pounds.

*This and the two succeeding projectiles were made for 3" M. L. rifled mortar.

2. *Marks.*

One shot, marked C. 7.

3. EXPERIMENTAL PROJECTILE No. 5.

(Plate X.)

This shot also differs from No. 3 only in the length and details of the shank.

1. *Dimensions of shank, &c.*

Total length of shank, including screw	7.5	inches.
Length of screw-thread	1.5	inches.
Diameter of screw	0.5	inch.
Length of shank	6.	inches.
Diameter of shank	0.625	inch.
Diameter of eye-hole	0.4	inch.
Width at eye-hole	1.	inch.
Thickness at eye-hole	0.4	inch.
Distance from plane of base to center of eye	5.5	inches.
Distance of center of gravity from plane of base	6.2	inches.
Weight, about	22	pounds.

2. *Marks.*

Two shot made, marked, respectively, C. 8 and C. 9.

4. EXPERIMENTAL PROJECTILE No. 17.*

(Plate XI.)

This is a cast-iron projectile whose body has the same form and dimensions as "experimental projectile No. 3." The shank, however, is different, being longer, and having the portion which screws into the shot much larger. For convenience all the dimensions are here given.

1. *Dimensions.*

Total length	13.8	inches.
Length of ogival head	2.6	inches.
Radius of head	3.	inches.
Length of cylindrical part	9.9	inches.
Diameter of cylindrical part	3.	inches.
Length of frustum	1.3	inches.
Diameter of smaller base of frustum	1.7	inches.
Shank: Total length	6.5	inches.
Length of screw	1.5	inches.
Diameter of screw	1.	inch.
Length from plane of base	5.	inches.
Distance from base to center of eye-hole	4.5	inches.
Diameter of eye-hole	0.4	inch.
Width at eye	1.	inch.
Thickness at eye	0.4	inch.
Diameter of neck	0.625	inch.
Weight, about	23	pounds.

2. *Marks.*

Five of these shot were made, and marked serially from C. 10 to C. 14, both inclusive.

* This form used with gun "A" bored to a caliber of 3 inches.

II. 2-INCH SMOOTH-BORE PROJECTILES.

These projectiles were fabricated for use in connection with experimental bronze gun "A," which was first bored out to a caliber of 2 inches.

1. EXPERIMENTAL PROJECTILE No. 6.

(Plate XII.)

This 2-inch shot is made of solid wrought iron. It is cylindro-ogival in form. The base is the frustum of a cone. The radius of the head is equal to one diameter of the shot. It has a wrought-iron shank like the 3-inch smooth-bore projectiles, to which it is similar in all respects except in material.

1. *Dimensions.*

Total length	13.	inches.
Length of ogival head	1.73	inches.
Radius of head	2.	inches.
Length of cylindrical part	10.27	inches.
Diameter of cylindrical part	2.	inches.
Length of frustum	1.	inch.
Diameter of smaller base of frustum	1.	inch.
Shank: Total length	6.5	inches.
Length of screw	1.5	inches.
Diameter of screw	0.5	inch.
Length from plane of base	5.	inches.
Distance from base to center of eye-hole	4.5	inches.
Diameter of eye-hole	0.4	inch.
Width at eye	1.	inch.
Thickness at eye	0.4	inch.
Diameter of neck	0.625	inch.
Distance of center of gravity from base	6.22	inches.
Weight, about	10	pounds.

2. *Marks.*

One shot made, marked LL. 1.

2. EXPERIMENTAL PROJECTILE No. 7.

(Plate XIII.)

The body of this one is the same as the preceding, but the shank differs somewhat. All the dimensions of the body are identical with those of No. 6.

1. *Dimensions of shank, &c.*

Total length	3.5	inches.
Length of screw	1.5	inches.
Diameter of screw	0.5	inch.
Length from plane of base	2.	inches.
Distance from base to center of eye-hole	1.5	inches.
Diameter of eye-hole	0.4	inch.
Width at eye	1.	inch.
Thickness at eye	0.4	inch.
Diameter of neck	0.625	inch.
Distance of center of gravity from base	6.25	inches.
Weight, about	10	pounds.

2. *Marks.*

Two shot, LL. 2, and LL. 3.

3. Experimental projectile No. 8.

(Plate XIV.)

This shot has the same exterior form and dimensions as No. 6. The body is made of cast iron. A cylindrical cavity, whose axis is coincident with that of the shot, is bored out and filled with lead. This cavity occupies about two-thirds of the length of the projectile, and is drilled from the head or front end. A plug of wrought-iron screws into the open end, closing the cavity and forming the point of the shot. The shank, or eye-bolt, is of wrought iron. The details of construction are given in the drawings.

1. *Dimensions.*

Total length	13.	inches.
Length of ogival head	1.73	inches.
Radius of head	2.	inches.
Length of cylindrical part	10.27	inches.
Diameter of cylindrical part	2.	inches.
Length of frustum	1.	inch.
Diameter of smaller base of frustum	1.	inch.
Point of projectile—Total length	1.53	inches.
Head (ogival): Length	0.53	inch.
Diameter of base	1.20	inches.
Body (cylindrical): Length	1.	inch.
Diameter	1.10	inches.
Axial cavity (cylindrical): Total length	9.	inches.
Length filled with lead	8.	inches.
Diameter	1.	inch.
Shank: Total length	6.5	inches.
Length of screw	1.5	inches.
Diameter of screw	6.5	inch.
Length from plane of base of shot	5.	inches.
Distance from base to center of eye-hole	4.5	inches.
Diameter of eye-hole	0.4	inch.
Width at eye	1.	inch.
Thickness at eye	0.4	inch.
Diameter of neck	0.625	inch.
Distance of center of gravity from base ("LL. 4")	6.25	inches.
Distance of center of gravity from base ("LL. 5")	6.38	inches.
Weight, about	10	pounds.

2. *Marks.*

Two shot made, marked LL. 4 and LL. 5.

4. Experimental projectile No. 9.

(Plate XV.)

This is a cast-iron projectile and is cast solid. The exterior is cylindro-ogival with a part of the point removed. A groove is planed along one side of the shot, parallel to the axis, for the accommodation of the shot-line. A transverse slot is cut in the rear end of the projectile to connect the axial cavity with the longitudinal groove.

The axial cavity is bored out and has the front end counterbored for the reception of the brass washer and the knot on the end of the line.

The cavity is closed in front by a cap held in position by a side screw.

1. *Weights, dimensions, &c.*

Total length	13.	inches.
Diameter of body	1.995	inches.
Radius of head	1.995	inches.
Distance of center of gravity from base	6.25	inches.
Longitudinal groove for shot-line: Length	Length	of shot.
Width	0.40	inch.
Depth	0.35	inch.
Groove in base for shot-line: Width	0.40	inch.
Depth	0.35	inch.
Axial cavity, cylindrical portion: Diameter	0.60	inch.
Counterbore, front end: Diameter	1.	inch.
Length	1.50	inches.
Weight	8.75	pounds.

2. *Cap.* (*Sheet-iron.*)

Body: External diameter	1.0	inch.
Length	1.1	inches.
Head: Diameter of	1.3	inches.

3. *Washer.* (*Brass.*)

Diameter	1.0	inch.
Thickness	0.15	inch.
Diameter of hole	0.30	inch.

4. *Marks.*

Two shot were made, marked respectively LL. 6 and LL. 7.

5. Experimental projectile No. 13.*

(Plate XVI.)

The exterior dimensions of this shot are the same as those of No. 8. The shank in this instance extends axially through the entire length of the projectile. The front end of the shank is so shaped as to form the point of the projectile. The entire body of the projectile is of lead. The body is kept from turning on the shank by flattening the latter and raising some barbs on the angles with a cold-chisel.

1. *Dimensions.*

Point of projectile: Length of head	0.8	inch.
Diameter of base	1.55	inches.
Shank: Total length	18.	inches.
Length from base	5.	inches.
Distance from base to center of eye-hole	4.5	inches.

For other dimensions see "experimental projectile No. 8," and plate above cited.

Weight	14.25	pounds.

2. *Marks.*

One shot, marked LL. O.

6. Experimental projectile No. 14.*

(Plate XVII.)

This is similar to projectile No. 8, from which it differs by having a heavier shank, and by having the axial cavity for the lead bored from

* Made for gun B.

the base of the shot. This leaves the head of the shot solid and diminishes the labor of manufacture. The dimensions wherein this projectile differs from No. 8 are given below. (See "Ex. proj. No. 8.")

1. *Dimensions.*

Diameter of small base of frustum	1.375	inches.
Axial cavity: Total length	11.5	inches.
Length filled with lead	10.	inches.
Diameter	1.	inch.
Shank: Diameter (exterior) of screw-thread	1.1	inches.
Diameter of neck	0.5625	inch.
Weight, about	11.	pounds.

2. *Marks.*

One shot made, marked LL. 8.

7. EXPERIMENTAL PROJECTILE No. 15.*

(Plate XVIII.)

This projectile is cylindro-ogival in form, with a frustum of a cone for its base. The body is of cast iron. An axial cavity is bored from the base nearly the whole length of the shot. Into this cavity melted lead is poured and allowed to cool, after which the shank is screwed in. The lead increases the weight of the shot without increasing its volume.

1. *Dimensions.*

Total length	15.	inches.
Length of ogival head	1.73	inches.
Radius of head	2.	inches.
Length of cylindrical part	12.27	inches.
Diameter of cylindrical part	2.	inches.
Length of frustum	1.	inch.
Diameter of smaller base of frustum	1.375	inches.
Axial cavity: Total length	13.5	inches.
Length filled with lead	12.	inches.
Diameter	1.	inch.
Shank: Total length	6.5	inches.
Length of screw-thread	1.5	inches.
Diameter (exterior) of screw-thread	1.1	inches.
Length from plane of base	5.	inches.
Distance from base to center of eye-hole	4.5	inches.
Diameter of eye-hole	0.4	inch.
Width at eye	1.	inch.
Thickness at eye	0.4	inch.
Diameter of neck	0.5625	inch.
Distance of center of gravity from base	7.	inches.
Weight, a little over	13	pounds.

2. *Marks.*

Six of these projectiles were made and marked, consecutively, from LL. 9 to LL. 14, both numbers inclusive.

III. 2.5-INCH SMOOTH-BORE PROJECTILES.

These projectiles were fabricated for use with experimental bronze gun A, after it was bored out to a caliber of 2.5 inches.

* Made for gun B.

1. Experimental projectile No. 10.

(Plate XIX.)

This is a 2.5-inch projectile made of solid cast iron. The form is cylindro-ogival. A frustum of a cone forms the base.

The radius of the ogival head is equal to one diameter of the shot. A wrought-iron shank is screwed into the base, having an eye at its posterior extremity for attaching the line. For details of construction, see plate.

1. *Dimensions.*

Total length	13.3	inches.
Length of ogival head	2.17	inches.
Radius of head	2.5	inches.
Length of cylindrical part	10.03	inches.
Diameter of cylindrical part	2.5	inches.
Length of frustum	1.1	inches.
Diameter of smaller base of frustum	1.35	inches.
Shank: Total length	6.5	inches.
Length of screw	1.5	inches.
Diameter of screw	0.5	inch.
Length from plane of base	5.	inches.
Distance from base to center of eye-hole	4.5	inches.
Diameter of eye-hole	0.4	inch.
Width at eye	1.	inch.
Thickness at eye	0.4	inch.
Diameter of neck	0.5625	inch.
Distance of center of gravity from base	6.3	inches.
Weight, about	15	pounds.

2. *Marks.*

Two shot made, marked L. 1 and L. 2.

2. Experimental projectile No. 11.

(Plate XX.)

This is, also, a 2.5-inch projectile, made of solid cast iron. The body of this shot has the same form as that of No. 10, and differs only in the length and weight.

The ogival head is identical with that of No. 10. The wrought-iron shank, or eye-bolt, differs slightly from the one attached to the preceding shot, in that the screw-thread is shorter and the neck extends into the base of the projectile for 0''.4 without diminution of diameter. The hole in the base is counterbored to accommodate the increased size. The details are given in the following table of dimensions and upon the drawing of the projectile.

1. *Dimensions.*

Total length	14.7	inches.
Length of ogival head	2.17	inches.
Radius of head	2.5	inches.
Length of cylindrical part	11.43	inches.
Diameter of cylindrical part	2.5	inches.
Length of frustum	1.1	inches.
Diameter of smaller base of frustum	1.35	inches.
Total length of hole for shank	1.5	inches.
Length of female screw	1.1	inches
Length of counterbore	0.4	inch.
Diameter of female screw-hole	0.5	inch.
Diameter of counterbore	0.5625	inch

Shank: Total length	6.5	inches
Length of screw	1.1	inches.
Diameter of screw	0.5	inch.
Length of neck inserted in base of shot	0.4	inch.
Length from plane of base	5.	inches.
Distance from base to center of eye-hole	4.5	inches.
Diameter of eye-hole	0.4	inch.
Width at eye	1.	inch.
Thickness at eye	0.4	inch.
Diameter of neck	0.5625	inch.
Distance of center of gravity from base	7.	inches.
Weight, about	17	pounds

2. *Marks.*

One shot made, marked L. 3.

3. Experimental projectile No. 12.

(Plate XXI.)

The length and weight of this projectile are greater than in the preceding one. In form and material it is the same. The shanks are also similar in every respect. The quantities given in the following table are the only ones in which this shot differs from projectile No. 11. (See plate.)

1. *Dimensions, &c.*

Total length	15.7	inches.
Length of cylindrical part	12.43	inches.
Distance of center of gravity from base	7.45	inches.
Weight, about	18	pounds.

2. *Marks.*

One shot made, marked L. 4.

4. Experimental projectile No. 16.*

(Plate XXII.)

This cast-iron shot is similar to No. 12, but it has a stronger shank. The details of form are fully shown in the plate.

1. *Dimensions.*

Total length	15.7	inches.
Length of ogival head	2.17	inches.
Radius of head	2.5	inches.
Length of cylindrical part	12.43	inches.
Diameter of cylindrical part	2.5	inches.
Length of frustum	1.1	inches.
Diameter of smaller base of frustum	1.35	inches.
Shank: Total length	6.5	inches.
Length of screw	1.5	inches.
Diameter of screw	1.	inch.
Length from plane of base	5.	inches.
Distance from base to center of eye-hole	4.5	inches.
Diameter of eye-hole	0.4	inch.
Width at eye	1.	inch.
Thickness at eye	0.4	inch.
Diameter of neck	0.625	inch.
Distance of center of gravity from plane of base	7.45	inches
Weight, about	19	pounds.

* Made for gun C.

2. *Marks.*

Nine shot made, numbered, serially, from L 5 to L 13, both inclusive.

Table of rifle projectiles.

Dimensions, &c.		Experimental projectiles. No. 1.	Experimental projectiles. No. 2.
Number of projectiles made		2	2
Caliber	inches	3	3
	centimeters	7.62	7.62
Marks, both inclusive		C. 1 and C. 2	C. L. 3 and C. L. 4
Total length	inches	13.25	10.3
	centimeters	33.654	26.162
Diameter of body	inches	2.94	2.94
	centimeters	7.468	7.468
Radius of head	inches	1.47	1.47
	centimeters	3.734	3.734
Distance of center of gravity from base	inches	6.3	5.
	centimeters	16.	12.70
Distance of first row of studs from base	inches	3.15	2.5
	centimeters	8.	6.35
Distance between two rows of studs	inches	6.25	5.
	centimeters	15.875	12.70
Number of studs		6.	6.
Number of studs in each row		3.	3.
Height of studs	inch	0.09	0.1
	centimeter	0.229	0.254
Width of studs	inch	0.69	0.69
	centimeters	1.753	1.753
Front stud to right of rear stud (both of same groove)	inch	0.5	0.4
	centimeters	1.27	1.016
Angle due to 1 turn in 10 feet (3.048 meters)		4° 30′	4° 30′
Longitudinal groove for shot-line:			
Width	inch	0.6	0.4
	centimeters	1.524	1.016
Depth	inch	0.5	0.37
	centimeters	1.27	0.94
Radial slot in base:			
Width	inch	0.6	0.4
	centimeters	1.524	1.016
Depth	inch	1.	0.3
	centimeters	2.54	0.762
Axial cavity:			
Cylindrical part, diameter	inch	0.6	0.6
	centimeters	1.524	1.524
Counterbore front end—			
Diameter	inch	....	1.
	centimeters	....	2.54
Length	inches	....	2.
	centimeters	....	5.08
Weight, about	pounds	18.	16.
	kilograms	8.16	7.26

Weights of rifle projectiles.

Number.	Marks.	Weight. Pounds.	Weight. Kilograms.
1	C. 1	18.	8.159
2	C. 2	17.75	8.051
3	C. L. 3	16.	7.258
4	C. L. 4	16.25	7.371

Table of 3-inch smooth-bore projectiles.

Dimensions, &c.		Experimental projectiles.			
		No. 3.	No. 4.	No. 5.	No. 17.
Number of projectiles made		2	1	2	5
Caliber	inches	3.	3.	3.	3.
	centimeters	7.62	7.62	7.62	7.62
Marks, both inclusive		C. 5 and C. 6	C. 7	C. 8, C. 9	C. 10 to C. 14
Total length	inches	13.8	13.8	13.8	13.8
	centimeters	35.051	35.051	35.051	35.051
Length of ogival head	inches	2.6	2.6	2.6	2.6
	centimeters	6.604	6,604	6.604	6.604
Radius of head	inches	3.	3.	3.	3.
	centimeters	7.62	7.62	7.62	7.62
Length of cylindrical part	inches	9.9	9.9	9.9	9.9
	centimeters	25.146	25.146	25.146	25.146
Diameter of cylindrical part	inches	3.	3.	3.	3.
	centimeters	7.62	7.62	7.62	7.62
Length of frustum	inches	1.3	1.3	1.3	1.3
	centimeters	3.302	3.302	3.302	3.302
Diameter of smaller base of frustum	inches	1.7	1.7	1.7	1.7
	centimeters	4.318	4.318	4.318	4.318
Shank:					
Total length	inches	2.7	11.5	7.5	6.5
	centimeters	6.858	29.209	19.05	16.51
Length of screw	inches	1.5	1.5	1.5	1.5
	centimeters	3.81	3.81	3.81	3.81
Diameter of screw	inch	0.5	0.5	0.5	1.
	centimeters	1.27	1.27	1.27	2.54
Length from plane of base	inches	1.2	10.	6.	5.
	centimeters	3.048	25.4	15.24	12.7
Distance from base to center of eye-hole	inches	0.7	9.5	5.5	4.5
	centimeters	1.778	24.13	13.97	11.43
Diameter of eye-hole	inch	0.4	0.4	0.4	0.4
	centimeters	1.016	1.016	1.016	1.016
Width at eye	inch	1.	1.	1.	1.
	centimeters	2.54	2.54	2.54	2.54
Thickness at eye	inch	0.4	0.4	0.4	0.4
	centimeters	1.016	1.016	1.016	1.016
Diameter of neck	inch	0.625	0.625	0.625	0.625
	centimeters	1.587	1.587	1.587	1.587
Distance of center of gravity from base	inches	....	5.97	6.2	....
	centimeters	....	15.164	15.748	....
Weight, about	pounds	22.	22.	22.	23.
	kilograms	9.979	9.979	9.979	10.433

Weights of 3-inch smooth-bore projectiles.

Number.	Marks.	Weight.	
		Pounds.	Kilograms.
1	C. 5	21.75	9.866
2	C. 6	21.75	9.866
3	C. 7	22.25	10.093
4	C. 8	21.875	9.922
5	C. 9	22.25	10.093
6	C. 10	22.59	10.248
7	C. 11	22.97	10.419
8	C. 12	23.062	10.46
9	C. 13	22.625	10.263
10	C. 14	22.906	10.39

Table of 2-inch smooth-bore projectiles.

Dimensions, &c.		Experimental projectile.						
		No. 6.	No. 7.	No. 8.	No. 9.	No. 13.	No. 14.	No. 15.
					Cordes.			
Number of projectiles made		1	2	2	2	1	1	6
Caliber	inches	2.	2.	2.	2.	2.	2.	2.
	centimeters	5.08	5.08	5.08	5.08	5.08	5.08	5.08
Marks, both inclusive		LL. 1	LL. 2 and LL. 3	LL. 4 and LL. 5	LL. 6 and LL. 7	LL. 0	LL. 8	LL. 9 to LL. 14
Total length	inches	13.	13.	13.	13.	13.	13.	15.
	centimeters	33.019	33.019	33.019	33.019	33.019	33.019	38.099
Length of ogival head	inches	1.73	1.73	1.73	....	1.73	1.73	1.73
	centimeters	4.394	4.394	4.394	....	4.394	4.394	4.394
Radius of head	inches	2.	2.	2.	1.995	2.	2.	2.
	centimeters	5.08	5.08	5.08	5.067	5.08	5.08	5.08
Length of cylindrical part	inches	10.27	10.27	10.27	....	10.27	10.27	12.27
	centimeters	26.086	26.086	26.086	....	26.086	26.086	26.086
Diameter of cylindrical part	inches	2.	2.	2.	1.995	2.	2.	2.
	centimeters	5.08	5.08	5.08	5.067	5.08	5.08	5.08
Length of frustum	inches	1.	1.	1.	....	1.	1.	1.
	centimeters	2.54	2.54	2.54	....	2.54	2.54	2.54
Diameter of smaller base of frustum.	inches	1.	1.	1.	....	1.	1.375	1.375
	centimers	2.54	2.54	2.54	....	2.54	3.493	3.493
Shank:								
Total length	inches	6.5	3.5	6.5	....	18.	6.5	6.5
	centimeters	16.51	8.89	16.51	....	45.719	16.51	16.51
Length of screw	inches	1.5	1.5	1.5	....	....	1.5	1.5
	centimeters	3.81	3.81	3.81	....	....	3.81	3.81
Diameter of screw	inches	0.5	0.5	0.5	....	....	1.1	1.1
	centimeters	1.27	1.27	1.27	....	....	2.794	2.794
Length from plane of base.	inches	5.	2.	5.	....	5.	5.	5.
	centimeters	12.7	5.08	12.7	....	12.7	12.7	12.7
Distance from base to center of eye-hole.	inches	4.5	1.5	4.5	....	4.5	4.5	4.5
	centimeters	11.43	3.81	11.43	....	11.43	11.43	11.43
Diameter of eye-hole	inch	0.4	0.4	0.4	....	0.4	0.4	0.4
	centimeters	1.016	1.016	1.016	....	1.016	1.016	1.016
Width at eye	inch	1.	1.	1.	....	1.	1.	1.
	centimeters	2.54	2.54	2.54	....	2.54	2.54	2.54
Thickness at eye	inch	0.4	0.4	0.4	....	0.4	0.4	0.4
	centimeters	1.016	1.016	1.016	....	1.016	1.016	1.016
Diameter of neck	inch	0.625	0.625	0.625	....	0.625	0.5625	0.5625
	centimeters	1.587	1.587	1.587	....	1.587	1.429	1.429
Distance of center of gravity from base.	inches	6.22	6.25	6.25 / 6.38	6.25	6.25	....	7.
	centimeters	15.799	15.875	15.875 / 16.205	15.875	15.875	....	17.78
Weight, about	pounds	10.	10.	10.	8.75	14.25	11.	13.
	kilograms	4.536	4.536	4.536	3.963	6.464	4.99	5.897

Weights of 2-inch smooth-bore projectiles.

Number.	Marks.	Weight.		Remarks.
		Pounds.	Kilograms.	
1	LL. 1	10.406	4.72	Wrought iron.
2	LL. 2	10.437	4.734	Do.
3	LL. 3	10.375	4.706	Do.
4	LL. 4	10.406	4.72	Axial cavity.
5	LL. 5	10.562	4.799	Do.
6	LL. 6	8.75	3.963	Modified Cordes shot.
7	LL. 7	8.75	3.963	Do.
8	LL. 0	14.25	6.464	Made of lead.
9	LL. 8	11.156	5.06	Axial cavity.
10	LL. 9	13.156	5.967	Axial cavity, 13″.5 long.
11	LL. 10	13.156	5.967	Do.
12	LL. 11	13.156	5.967	Do.
13	LL. 12	13.219	5.996	Do.
14	LL. 13	13.281	6.024	Do.
15	LL. 14	13.25	6.01	Do.

Table of 2.5-inch smooth-bore projectiles.

Dimensions.		Experimental projectile. No. 10.	No. 11.	No. 12.	No. 16.
Number of projectiles made		2	1	1	9
Caliber	inches	2.5	2.5	2.5	2.5
	centimeters	6.35	6.35	6.35	6.35
Marks, both inclusive		L. 1 & L. 2	L. 3	L. 4	L. 5 to L. 13
Total length	inches	13.3	14.7	15.7	15.7
	centimeters	33.781	37.337	39.877	39.877
Length of ogival head	inches	2.17	2.17	2.17	2.17
	centimeters	5.512	5.512	5.512	5.512
Radius of head	inches	2.5	2.5	2.5	2.5
	centimeters	6.35	6.35	6.35	6.35
Length of cylindrical part	inches	10.03	11.43	12.43	12.43
	centimeters	25.476	29.031	31.571	31.571
Diameter of cylindrical part	inches	2.5	2.5	2.5	2.5
	centimeters	6.35	6.35	6.35	6.35
Length of frustum	inches	1.1	1.1	1.1	1.1
	centimeters	2.794	2.794	2.794	2.794
Diameter of smaller base of frustum	inches	1.35	1.35	1.35	1.35
	centimeters	3.429	3.429	3.429	3.429
Shank:					
Total length	inches	6.5	6.5	6.5	6.5
	centimeters	16.51	16.51	16.51	16.51
Length of screw	inches	1.5	1.1	1.1	1.5
	centimeters	3.81	2.794	2.794	3.81
Diameter of screw	inch	0.5	0.5	0.5	1.
	centimeters	1.27	1.27	1.27	2.54
Length from plane of base	inches	5.	5.	5.	5.
	centimeters	12.70	12.70	12.7	12.7
Distance from base to center of eye-hole	inches	4.5	4.5	4.5	4.5
	centimeters	11.43	11.43	11.43	11.43
Diameter of eye-hole	inch	0.4	0.4	0.4	0.4
	centimeters	1.016	1.016	1.016	1.016
Width at eye	inch	1.	1.	1.	1.
	centimeters	2.54	2.54	2.54	2.54
Thickness at eye	inch	0.4	0.4	0.4	0.4
	centimeters	1.016	1.016	1.016	1.016
Diameter of neck	inch	0.5625	0.5625	0.5625	0.625
	centimeters	1.429	1.429	1.429	1.587
Distance of center of gravity from base	inches	6.3	7.	7.45	7.45
	centimeters	16.	17.78	18.923	18.923
Weight, about	pounds	15.	17.	18.	19.
	kilograms	6.804	7.711	8.159	8.618

Weights of 2.5-inch smooth-bore projectiles.

No.	Marks.	Weight. Pounds.	Weight. Kilos.	Remarks. Pounds. Kilos.	Remarks.
1	L. 1	15.406	6.998	15.5 = 7.031	Weights after being fitted with the shank used in experimental projectile No. 16. The new shanks were put in before sending them to Sandy Hook.
2	L. 2	15.406	6.998	15.562 = 7.059	
3	L. 3	17.109	7.761	17.343 = 7.867	
4	L. 4	18.437	8.357	18.531 = 8.400	
5	L. 5	18.75	8.499		
6	L. 6	18.75	8.499		
7	L. 7	18.75	8.499		
8	L. 8	18.75	8.499		
9	L. 9	18.781	8.513		
10	L. 10	18.75	8.499		
11	L. 11	18.75	8.499		
12	L. 12	18.75	8.499		
13	L. 13	18.75	8.499		

CHAPTER III.

GUN-CARRIAGES.

SECTION I.—CARRIAGES FOR 3-INCH M. L. RIFLED MORTAR.

I. CARRIAGE No. 1.

(Plate XXIII.)

The 3-inch M. L. rifled mortar was mounted on this carriage when received. The carriage had been used in making some preliminary experiments before being sent to the National Armory.

It consists of two cheeks and three transoms made of oak; and of two trunnion plates, two cap-squares, twelve assembling bolts, twelve washers and twelve nuts, made of wrought iron.

The front and rear transoms project beyond the cheeks to form handles for convenience of transportation.

The middle transom is placed vertically between the cheeks, and is almost directly beneath the trunnions.

The ends of this transom are let into the cheeks. Two assembling bolts passing through the cheeks, and longitudinally through this (middle) transom, give rigidity to the cheeks.

The nuts and ends of the assembling bolts, which project below the cheeks, tend to check the recoil by sinking into the earth or sand.

The drawings furnish the dimensions and the details of construction.

Weight of carriage and quoin, 77 pounds.

II. CARRIAGE No. 2.

(Plate XXIV.)

This carriage was made at the National Armory. It differs in some of the details of its construction from carriage No. 1.

The cheeks are thicker, are not so long, and the number of parts is diminished. Iron handles are placed at the sides to be used in moving the gun and carriage from place to place.

The following are the component parts of this carriage, namely:

Two cheeks and front transom of wood (oak); two trunnion plates, two cap-squares, four handles, twelve assembling bolts, twelve nuts, one washer, and one rear transom of wrought iron.

A wooden quoin is used for giving elevations.

Weight of carriage and quoin, 68 pounds.

(See plate for dimensions, &c.)

SECTION II.—CARRIAGES FOR SMOOTH-BORE GUNS.

The carriages or beds for the smooth-bore bronze guns were all made at the National Armory, Springfield, Mass. The materials are oak and wrought iron.

I. CARRIAGE FOR BRONZE GUN A.

(Plate XXV.)

Nomenclature.

a. Wood.

2 cheeks, same size.
1 front transom.
1 quoin.

b. Wrought iron.

2 trunnion plates, same size.
2 cap-squares, same size.
2 hinge plates, same size.
2 hinge pins, same size (riveted).
2 cap-square keys, same size (rotating).
4 assembling bolts, long, same size.
4 assembling bolts, short, same size.
1 assembling bolt, transverse.
2 washers.
8 nuts.
1 rear transom.
4 handles.
2 cheek bands.

The two rear assembling bolts (long) screw into the hinge plates.

The cap-square keys rotate about the front assembling bolts (long) and lock the cap-squares when in position.

The cheek bands pass around the edges of the cheeks and are fastened to the latter by wood-screws.

These bands are made to fit closely.

The dimensions and details of the construction are given in the plate.

Weight of carriage and quoin, 63 pounds.

II. Carriage for bronze gun B.

(Plate XXVI.)

This carriage is similar in form to the preceding one, but is smaller and lighter. The rods that serve as handles for transportation are made long, in order that the load may be balanced by slipping the hands along the rods when two men carry the gun and carriage with the projectiles lying on the rear transom.

The nomenclature of this and the following carriage is the same as that of gun A.

Weight of carriage and quoin .... 35 pounds.
Weight of carriage alone .... 33.5 pounds.

(For details see plate.)

III. Carriage for bronze gun C.

(Plate XXVII.)

This carriage differs but slightly from that designed for gun A.

The trunnion beds and transoms in this carriage are placed farther forward, and the cheeks are cut away more in rear of the trunnions.

The drawings give all the details of construction and the dimensions

Weight of carriage and quoin .... 54.25 pounds.
Weight of carriage alone (49.41 pounds), say .... 50 pounds.

Recapitulation of the weights of gun-carriages.

No.	Gun-carriage, with quoin.	Weight. Pounds.	Weight. Kilograms.	Remarks.
1	No. 1 for 3" M. L. R. mortar	77	34.93	
2	No. 2 for 3" M. L. R. mortar	68	30.84	
3	For S. B. gun A	63	28.58	
4	For S. B. gun B	35	15.88	Without quoin, 33.5 pounds (15.2 kilos).
5	For S. B. gun C	54.25	24.61	Without quoin, 50 pounds (22.68 kilos).

CHAPTER IV.

POWDER, AND CARTRIDGE BAGS.

I. POWDER.

Two kinds of powder were used during the first series of experiments: Dupont's mortar powder and Hazard's United States Government musket powder.

The Dupont mortar powder used was a sample on hand when the experiments began.

The qualities of the Hazard musket powder used in this series of experiments are shown below in the report of Mr. R. T. Hare, in charge of the experimental apparatus at this armory. The arm and ammunition used, though not conforming to the actual conditions of service with life-saving guns and projectiles, afford relative tests of the values of different powders.

The pressures in all cases were taken with the Rodman pressure plug, with musket housing, using the National Armory circular cutter. There was no "internal-pressure gauge" suitable for use with the life-saving guns. The Le Boulengé chronograph, the Benton electro-ballistic machine, and the Benton thread velocimeter were employed in obtaining the initial velocities. These machines were used simultaneously for taking velocities.

Record of initial velocities.

[Station: National Armory, Springfield, Mass. Date: February 26, 1878. Kind of arm: Springfield rifle. Ammunition: Prepared. Weight of powder: 70 grains. Kind of powder: Hazard's United States Government musket. Weight of ball: 405 grains. Object of experiment: To test velocity, pressure, and specific gravity of powder. Specific gravity: 1.80.]

Number of shot.	Le Boulengé.	Electro-ballistic.	Thread velocimeter.	Pressures per square inch.
	Feet.	*Feet.*	*Feet.*	*Pounds.*
1	1381.0	1393.2	1369.2	....
2	1330.8	1333.7	1334.9	....
3	1344.6	1345.3	1340.5	28,000
4	1361.2	1363.1	1357.5	27,000
5	1359.3	1363.1	1363.2	28,200
Mean	1355.3	1359.6	1353.0	27,733
Extreme variation	50.2	59.5	34	....
Mean variation	7	8	6	....

Distance between targets for Le Boulengé: 98 feet. Distance between targets for electro-ballistic: 97 feet. Distance between targets for thread velocimeter: 100 feet. By whom taken: R. T. Hare.

Second series of experiments.

Four kinds of powder were procured from the Hazard Powder Company for this series of experiments, namely:

1. F. G., duck size ("Sea shooting duck").
2. U. S. Government musket.
3. Mortar.
4. Navy cannon.

The tests, as before, were made by Mr. Hare. They are given serially below.

The coarser grained powders were slightly compressed in putting up the metallic cartridges, which somewhat affected the resulting velocities and pressures.

No. 1.

Record of initial velocities.

[Station: National Armory, Springfield, Mass. Date: April 30, 1878. Kind of arm: Springfield rifle. Ammunition: Prepared. Weight of powder: 70 grains. Kind of powder: Hazard sample, marked F. G., Duck Size.* Weight of ball: 405 grains. Object of experiment: To test velocity, pressure, and specific gravity of powder. Specific gravity: 1.79263.]

Number of shot.	Le Boulengé.	Electro-ballistic.	Thread velocimeter.	Pressures per square inch.
	Feet.	*Feet.*	*Feet.*	*Pounds.*
1	1325.9	1322.4	1323.7	31,000
2	1318.1	1316.7	1318.3	28,000
3	1335.7	1333.7	1334.9	25,700
4	1335.7	1339.4	1334.9	....
5	1335.7	1339.4	1329.3	....
Mean................	1330.2	1330.3	1328.2	28,233
Extreme variation....	17.6	22.7	16.6	....
Mean variation.......	3.2	4.3	2.8	....

* Sometimes called "Sea Shooting Duck."

Distance between targets for Le Boulengé: 98 feet. Distance between targets for electro-ballistic: 97 feet. Distance between targets for thread velocimeter: 100 feet. By whom taken: R. T. Hare.

No. 2.

Record of initial velocities.

[Station: National Armory, Springfield, Mass. Date: April 30, 1878. Kind of arm: Springfield rifle Ammunition: Prepared. Weight of powder: 70 grains. Kind of powder: Hazard's sample, marked Musket Powder. Weight of ball: 405 grains. Object of experiment: To test velocity, pressure, and specific gravity of powder. Specific gravity: 1.81132.]

Number of shot.	Le Boulengé.	Electro-ballistic.	Thread velocimeter.	Pressures per square inch.
	Feet.	*Feet.*	*Feet.*	*Pounds.*
1	1354.4	1351.2	1375.0	33,900
2	1353.4	1351.2	1346.1	33,900
3	1367.1	1375.1	1375.0	33,900
4	1356.3	1363.1	1363.3	....
5	1357.3	1357.1	1351.7	....
Mean................	1357.7	1359.5	1362.2	33,900
Extreme variation....	13.7	23.9	28.9	....
Mean variation.......	3	3.8	5.3	....

Distance between targets for Le Boulengé: 98 feet. Distance between targets for electro-ballistic: 97 feet. Distance between targets for thread velocimeter: 100 feet. By whom taken: R. T. Hare.

No. 3.

Record of initial velocities.

[Station: National Armory, Springfield, Mass. Date: April 30, 1878. Kind of arm: Springfield rifle. Ammunition: Prepared. Weight of powder: 70 grains. Kind of powder: Hazard's sample, marked Mortar Powder. Weight of ball: 405 grains. Object of experiment: To test velocity, pressure, and specific gravity of powder. Specific gravity: 1.91202.]

Number of shot.	Le Boulengé.	Electro-ballistic.	Thread velocimeter.	Pressures per square inch.
	Feet.	*Feet.*	*Feet.*	*Pounds.*
1	1300.5	1300.3	1296.9	24,500
2	1307.0	1311.1	1313.0	25,000
3	1289.7	1294.8	1286.5	25,000
4	1313.2	1322.4	1307.6	....
5	1297.5	1300.3	1307.6	....
Mean	1301.5	1305.7	1302.3	25,000
Extreme variation ...	23.5	27.6	26.5	....
Mean variation	3.4	4.5	4.2	....

Distance between targets for Le Boulengé: 98 feet. Distance between targets for electro-ballistic: 97 feet. Distance between targets for thread velocimeter: 100 feet. By whom taken: R. T. Hare.

No. 4.

Record of initial velocities.

[Station: National Armory, Springfield, Mass. Date: April 30, 1878. Kind of arm: Springfield rifle. Ammunition: Prepared. Weight of powder: 70 grains. Kind of powder: Hazard's sample, marked Navy Cannon. Weight of ball: 405 grains. Object of experiment: To test velocity, pressure, and specific gravity of powder. Specific gravity: 1.77061.]

Number of shot.	Le Boulengé.	Electro-ballistic.	Thread velocimeter.	Pressures per square inch.
	Feet.	*Feet.*	*Feet.*	*Pounds.*
	1359.3	1357.1	1351.7	28,500
	1328.9	1333.7	1334.9	29,500
	1350.4	1363.1	1340.5	27,500
	1329.9	1339.4	1323.7	....
	1350.5	1322.4	1318.3	....
Mean	1343.8	1343.1	1333.8	28,500
Extreme variation ...	30.4	40.7	33.4	....
Mean variation	5.7	6.8	5.1	....

Distance between targets for Le Boulengé: 98 feet. Distance between targets for electro-ballistic: 97 feet. Distance between targets for thread velocimeter: 100 feet. By whom taken: R. T. Hare.

II. CARTRIDGE BAGS.

(Plate XXVIII, Figs. 1, 2.)

The cartridge bags are made of twilled serge, or some other woolen material.

The texture should be close enough to prevent the powder from sifting through.

Each bag is made of two pieces, identical in size and shape; one end of each half-bag is semicircular. The half-bags are cut out by means of sheet-iron or tin patterns. Marks for the seams are traced out by the cutter.

The seams are half an inch from the edge. After sewing, the edges are turned down on the same side of the seam and basted, to keep the powder from escaping through the seam.

Two sizes of bags are used.

Dimensions (of half cartridge bag).

For 3″ gun (Fig. 1).

	Inches.	Centimeters.
Length	7.5	19.05
Width	4.5	11.43

For 2″ and 2″.5 guns (Fig. 2).

	Inches.	Centimeters.
Length	7.0	17.78
Width	3.8	9.65

Shorter cartridge bags may be used for practice with small charges.

CHAPTER V.

SABOTS, FRICTION PRIMERS, AND IMPLEMENTS.

I. SABOTS.

(Plate XXIX.)

1. Three-inch sabots, wood. These were circular disks of dry pine. Two thicknesses were made, 0″.75 and 0″.5. (Figs. 1–4.)

2. Three-inch sabots, Cordes. This sabot is 3″ in diameter and 0″.55 thick. It has a disk of iron placed between two disks of sole leather, the whole held together by a copper rivet. (Figs. 5, 6.)

3. Two-inch sabots. Two kinds of sabots of this diameter were made; one was a plain wooden sabot and the other a Cordes sabot, similar to those above described. (See Figs. 7–10.)

4. Wads. In firing rifle projectiles and when using smooth-bore projectiles with the rifled mortar, wads of paper (newspapers) were used without any previous preparation.

II. FRICTION PRIMERS, ETC.

Three kinds of primers were used during the experiments, namely:

1. Service friction primer, short.
2. Service friction primer, long.
3. Electric primers.

III. PRIMING WIRE.

(Plate XXVIII, Fig. 3.)

This implement is made of brass or steel wire 0″.15 in diameter, and is 7″.7 in length.* One end is pointed and the other is formed into a ring 2″.25 in diameter.

* Length 9″.7 in figure, but it has been found to be too long for convenience.

IV. SPONGE AND RAMMER.

(Plate III, Fig. 6.)

This is a staff of ash or elm 30″ long. The rammer head is cylindrical, 4″ long and 1″.75 in diameter. The end for the sponge is also cylindrical, and is 5″ in length with a diameter of 1″.5. The shaft between the heads is turned down to a diameter of 1″.25.

The sponge-head is made of coarse, well-twisted woolen yarn woven into a kind of webbed cloth, or of sheepskin with the wool on.

The thickness of the sponge-head may be so regulated that the same rammer may be used for the 2″ and 2″.5 guns.

V. POWDER MEASURES.

These are made of sheet-copper or brass. Two sizes are made, one holding one ounce (avoirdupois) of powder (size of Navy cannon*), and the other two ounces.

VI. LANYARD.

This is made of strong cod-line or of Nos. 3½, 4, or 4½ Silver Lake Company's braided linen line. A small hook of iron wire with an eye for the line is attached to one end of the lanyard, and to the other end a wooden toggle, 4″ long and 0″.75 in diameter. The lanyard should be 30 feet long. It is used for pulling off the friction primers.

VII. COMBINATION LEVEL.

(Plate XXVIII, Fig. 4.)

This is a foot-rule made of box-wood and bound with brass. It is a combination rule, level, and octant. A steel arm which closes like a knife blade is graduated into degrees from 0° to 45°. Half degrees may be estimated. It is used for obtaining elevations of guns and mortars when the chase or exterior near the muzzle in cylindrical. In the figure it is shown in position for an elevation of 30 degrees.

VIII. GUNNER'S HAVERSACK.

(Plate XXX.)

This haversack is intended to be used for carrying cartridges, friction primers, lanyards, priming wire, and the combination level. It is made of black bridle-leather, except the pocket for the friction primers, which is made of black grain leather.

The back, bottom, front, and flap are cut in one piece. The ends are lined with leather to give them the requisite stiffness. On the inside of one end is a pocket for the combination level.

The inside flap has small pads sewed to the ends of the upper part to screen the inside of the haversack from the effects of a driving rain. Two loops are sewed or riveted to the back for the reception of the waist-belt. A tongue or "billet" fastens the outside flap to a brass button on the bottom. Sheaths for the priming-wire are sewed to each corner at the back of the haversack. A waist-belt and buckle complete the equipment. (For dimensions, &c., see plate.)

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* Hazard's Life-Saving Service powder is now used.

Nomenclature.

(Plate XXX.)

Fig. 1. Flap, back, bottom, and front, one piece.
Fig. 2. Inside flap.
Fig. 3, *a*. *b*. Pads on inside flap near top; should be same size.
Figs. 4, 5. Ends; lined.
Fig. 6. Pocket in front.
Fig. 7. Pocket for level.
Fig. 8. Lining for bottom.
Fig. 9. Sheath for priming-wire; one at each end.
Fig. 10. Tongue or billet.
Fig. 11. Loops for waist-belt; two.
Fig. 12. Waist-belt and buckle.
Fig. 13. View of haversack, complete.

NOTE.—If made for the service, the haversack will be made of russet leather.

CHAPTER VI.

SHOT-LINES.

These lines are intended to be used in connection with a gun or mortar and a projectile, to effect communication between the shore and stranded vessel, or, in exceptional cases, between vessels at sea.

They should be made of the very best materials.

The English method of faking has been adopted in laying up these lines for firing.

Rockets may be used instead of a gun and projectile for carrying the line.

The lines used in each series of experiments are given separately.

SECTION I.—LINES USED IN FIRST SERIES.

The cords or lines used in the first series of experiments were made expressly for the United States life-saving service.

The materials used were stated to be the best linen and Italian hemp thread. The cords are *braided* instead of being twisted, and each cord is made in one continuous piece. The first four lines were sent to the writer by Capt. J. H. Merryman, United States Revenue Marine, inspector of the life-saving service. These four lines are numbered serially for reference; the linen and hemp lines having a separate set of numbers. The manufacturer's numerical notation, when given, indicates the diameter of the line expressed in 32ds of an inch. Thus, when a line is designated as "No. 7," a line $\frac{7}{32}$ds of an inch in diameter is meant. The linen shot-lines had invariably a smooth finish; the hemp lines appeared to be less smooth upon the exterior.

1. *Linen line No.* 1.

Manufacturer unknown, probably Silver Lake Company, of Newtonville, Mass.

Maker's number not given, probably No. 7.

Theoretical diameter	0.21875	inch.
Measured diameter	0.22	inch.
Length	600	yards.
Weight of line	34	pounds.
Weight of faking-box, A 1	37	pounds.
Weight of faking-box and line	71	pounds.

2. *Linen line No. 2.*

Manufacturer unknown, probably Silver Lake Company.
Maker's number, No. 7.

Theoretical diameter	0.21875	inch.
Measured diameter	0.22	inch.
Length	600	yards.
Weight of line	33	pounds.
Weight of faking-box, A 2	36.5	pounds.
Weight of faking-box and line	69.5	pounds.

3. *Italian hemp line No. 1.*

Manufacturer unknown, probably Silver Lake Company.
Maker's number not given, probably No. 4½.

Theoretical diameter	0.125	inch.
Measured diameter	0.13	inch.
Length	700	yards.
Weigh of line	16	pounds.
Weight of faking-box, B 1	24	pounds.
Weight of faking-box and line	40	pounds.

4. *Italian hemp line No. 2.*

Manufacturer unknown, probably Silver Lake Company.
Maker's number not given, probably No. 4½.

Theoretical diameter	0.125	inch.
Measured diameter	0.13	inch.
Length	700	yards.
Weight of line	13.5	pounds.
Weight of faking-box, B 2	24	pounds.
Weight of faking-box and line	37.5	pounds.

5. *Linen line No. 3.*

This small line was made especially for trial with a light gun to ascertain the maximum range that could be obtained without breaking the line, and also to learn if so small a line would stand the shock of discharge. It was made of bleached linen thread under the direction of Mr. H. W. Wellington, the agent and manager of the Silver Lake Company, of Newtonville, Mass. It is what rope-makers term *hard-laid;* that is, it is made very hard and compact in braiding and finishing. It was made in a single piece.

Dimensions, &c.

Maker's number	No. 3½	
Theoretical diameter	0.109375	inch.
Measured diameter	0.1	inch.
Length	800	yards.
Weight of line	7.625	pounds.
Weight of faking-box, B	24	pounds.
Weight of faking-box and line	31.625	pounds.

6.—*Time required for faking the different shot-lines.*

Date, 1877.		Shot-line.		Time of faking.	Faking-box, size.	Remarks.
Month.	Day.	Kind.	Length.			
			Yds.	*Mins.*		
October....	12	Linen, No. 1.	600	40	A	Line in coils taken up by winding around hand and elbow after firing.
	12	Hemp, No. 1	700	31	B	Line in coils taken up by winding around hand and elbow after firing.
	17	Hemp, No. 1.	700	28	B	Line in box; not carried out by shot.
	17	Hemp, No. 2.	700	28	B	Line in box; not carried out by shot.
	25	Hemp, No. 2.	700	40	B	Line on reel; assistant absent ten minutes.
	25	Linen, No. 2.	600	21	A	Line on reel.
November.	4	Hemp, No. 1.	700	28	B	Line in coils; wound up on arm.
	4	Hemp, No. 2.	700	27	B	Line in coils; wound up on arm.
	4	Linen, No. 1.	600	24	A	Line in coils; wound up on arm; piece broken off line.
	4	Linen, No. 2.	600	22	A	Line in coils; wound up on arm.
	22	Linen, No. 1.	600	20	A	Line in coils; wound up on arm; piece broken off line.
	22	Linen, No. 3.	800	40	B	Line in coil as received from maker; interrupted by snarls.
	27	Linen, No. 3	750	28	B	Line in coils; wound on arm; fifty yards broken off.
	27	Hemp, No. 2.	700	17	B	Line on reel.
	27	Linen, No. 2	600	22	A	Line on reel.

NOTE.—The writer did the faking in each instance. An assistant was required to press down the loops on the side of the box opposite to the faker, while a helper paid the line out of the coils or from the reel.—D. A. L.

SECTION II. LINES USED IN SECOND SERIES OF EXPERIMENTS.

1. *Experimental shot-lines.*

The braided shot-lines used in the second series of experiments were manufactured by the Silver Lake Company, of Newtonville, Mass.

The lines having the "ordinary finish" were procured by the Treasury Department, while those having the "water-proof finish" were furnished free of expense to the government by Mr. H. W. Wellington, of the firm of Wellington Bros., of Boston, Mass., who requested that they be tried at the same time with the other lines for the purpose of determining their relative merits.

The braiding of these lines is done by an ingenious machine, the invention of the late James Amiraux Bazin, of Canton, Norfolk County, Mass.

Referring to this process of making lines or ropes, the inventor states:

In the usual method of making ropes it is necessary to give the yarns a much harder twist than would be essential for binding the separate fibers together in order to compensate for what is taken out by the countertwist of the strand, thereby making it necessary, in laying these strands up into a rope, to give them a much harder twist than would otherwise be required, as it is the tendency of each strand to untwist that keeps them all firmly bound together; a hard-twisted rope necessarily requiring an equally hard twist in the strands, and thereby causing a constant strain upon all the fibers of which it is composed.

But where a soft and pliable rope is required, as the twist in the strands must be proportionally reduced, the strands will be liable to be thrown out of place and into kinks by careless usage.

To obviate this, ropes are sometimes made by braiding, which, though it prevents the strands from being thrown out of place, is still more objectionable, as the strands in this case run around spirally in contrary directions, and consequently a slight twisting of the rope either way will throw all the strain upon *one-half* the number of strands.

To overcome the above-mentioned difficulties is the object of my invention, which consists in combining the strands of any fibrous material by an interlocking twist, in which the strands all take the same spiral form that they would have in a twisted rope of ordinary manufacture, and yet hold each other in place more effectually than can be done by braiding; this interlocking twist being formed by successively passing each strand around two others, so that each of the two so entwined shall, in its turn, entwine two others; and as the strands all maintain the same spiral form irrespective of the twists in each, there can be no unnecessary strain upon the fibers of which they are composed, while, under all circumstances, each strand will bear an equal amount of strain with all the others, and cannot possibly kink or become misplaced.

And my invention also consists in a new machine for forming the above-described interlocking twist, in which the spools that carry the strands are so actuated that two of the strands are held stationary while another is passing around them, thereby interlocking the strands as above described; and my invention furthermore consists in so arranging the mechanism as to permit of its being operated in either direction, as may be desired, according to the twist in the yarns of which the strands are composed.

The spool-carriers are always made to revolve in the same direction as the twist of the strands.

The inventor does not limit himself to any particular number of spools, provided only that the number shall be *a multiple of three.*

The number of "*travelers*" or spool-carriers employed in the machines for braiding the experimental lines for the United States Life-Saving Service were *nine* and *twelve*, depending upon the size of the lines.

2. *Materials.*

Linen and Italian hemp threads were used in the fabrication of the experimental lines.

The linen yarns were all furnished by the Smith & Dove Manufacturing Company, of Andover, Mass., and the Italian hemp yarns by the Boston Flax Mills.

In the process of braiding, a core of the same material is sometimes inserted.

The lines made on the twelve "*traveler*" machines are a little firmer, and the strands come to their places better with a core; but this is not indispensable, and, unless the yarn is harsh, the core is often omitted.

3. *Finishing.*

1. "Ordinary finish."

The lines are finished by being drawn rapidly twice through wheat starch.

The extra starch is wiped from the line by passing it through a piece of India rubber. It is then passed through a closely-fitting steel die, two inches in length. After drying a few moments, the cord is passed twice through another steel die, slightly smaller than the first. The latter operation gives the cord a polish and smooths the exterior.

2. "Water-proof finish."

The "water-proofed" lines are passed slowly through a hot mixture of linseed oil, bees-wax, and paraffine before receiving the usual finish.

The writer is indebted to Mr. James Tolman, of Boston, for the above details, as well as the following tabular statement in regard to the manufacture of braided lines:

4. *Materials, &c., used in the manufacture of shot-lines from Wellington Bros. & Co., agents for Silver Lake Company.*

Maker's number.*	Material.	Color.	Yarn.	Number of "travelers" in the braiding-machine.	Length.	Weight.
					Yds.	Lbs.
3½	Linen	Bleached	Andover, 3 cord, No. 16	9	700	7.
4	do	do	Andover, 5 cord, No. 16	9	700	12.5
4½	do	do	Andover, 5 cord, No. 10	9	700	13.
5	do	do	do	12	700	24.
6	do	Unbleached	Andover sail twine, 3 ply, 2 ends	12	600	31.5
7	do	do	Andover sail twine, 7 ply	12	600	33.
8	do	do	Andover sail twine, 3 ply, 3 ends	12	600	50.5
9	do	do	Andover sail twine, 3 ply, 4 ends	12	600	55.5
10	do	do	Andover sail twine, 3 ply, 5 ends	12	600	63.5
3½	Italian hemp	Natural	Wet spun, 6 cord	9	700	7.
4	do	do	Wet spun, 6 cord, 2 ply	9	700	13.
4½	do	do	Dry spun, 6 cord, 3 ply	9	700	15.5
5	do	do	Dry spun, 6 cord, 4 ply	12	700	26.
6	do	do	Dry spun, 6 cord, 5 ply	12	600	31.
7	do	do	Dry spun, 6 cord, 6 ply	12	600	38.
8	do	do	Dry spun, 6 cord, 7 ply	12	600	41.5
9	do	do	Dry spun, 6 cord, 8 ply	12	600	53.5
10	do	do	Dry spun, 6 cord, 10 ply	12	600	64.5
4	Dark linen	Unbleached	Andover, 3 ply, sail twine	9	700	14.5

* The maker's number indicates the diameter of the cord in thirty-seconds of an inch.

5. *Dimensions, weights, tests, &c.*

The following sets of tables give all the details in regard to these lines.

The two tables forming each set belong to the same group of lines. Lines Nos. 8, 9, and 10 of each group were not provided with faking-boxes, from motives of economy. The breaking weights and "stretch in six feet" are approximations only. The former was obtained by taking sections of each cord and carefully attaching them to two small grooved pulleys in such a way as to avoid cutting the cord at the knots. The length of cord between the knots was invariably six feet. One pulley was hung from a beam, and to a hook on the other was attached a large bucket. Lead weights were gradually placed in the bucket until the cord broke. The total load was carefully weighed in each instance.

Very small weights were used as the load neared the breaking weight or stress.

The *stretch* or increase of length of the cord was obtained by a vertical scale properly adjusted; an index or pointer attached to the side of the pulley on the lower end of the line assisted the observer in following the indications and taking the readings.

In other respects the tables are self-explanatory.

TABLE I.

A.

Experimental braided shot-lines of Italian hemp, made by Silver Lake Company, ordinary finish.

Number of lines.	Maker's number.	Material.	Length. Yards.	Length. Meters.	Diameter measured. Inches.	Diameter measured. Millimeters.	Weight. Pounds.	Weight. Kilograms.	Faking-box. Size.	Faking-box. Weight. Pounds.	Faking-box. Weight. Kilograms.
1	3½	Italian hemp	700	640. 068	0. 095	2. 413	7. 0	3. 175	D	19. 5	8. 845
1	4	......do	700	640. 068	. 125	3. 175	13. 0	5. 896	B	23. 5	10. 659
1	4½	......do	700	640. 068	. 145	3. 683	15. 5	7. 030	B	24. 0	10. 886
1	5	......do	700	640. 068	. 190	4. 826	26. 0	11. 793	C	33. 0	14. 968
1	6	Italian hemp, sash	600	548. 63	. 215	5. 461	31. 0	14. 061	A	42. 0	19. 051
1	7	......do	600	548. 63	. 235	5. 969	38. 0	17. 236	A	36. 5	16. 556
1	8	......do	600	548. 63	. 265	6. 731	42. 0	19. 051	......	......	....
1	9	......do	600	548. 63	. 285	7. 239	53. 0	24. 040	......	......	....
1	10	......do	600	548. 63	. 325	8. 255	64. 5	29. 257	......	......	....

B.

Tensile strength and elongation of braided shot-lines, made of Italian hemp by Silver Lake Company, ordinary finish.

Number of lines.	Maker's number.	Material.	Breaking weight. Pounds.	Breaking weight. Kilograms.	Stretch in six feet of line. Inches.	Stretch in six feet of line. Millimeters.
1	3½	Italian hemp	70	31. 751	9. 0	228. 60
1	4	......do	90	40. 823	6. 0	152. 40
1	4½	......do	90	40. 823	7. 5	190. 50
1	5	......do	252	114. 306	11. 0	279. 39
1	6	Italian hemp, sash	300	136. 079	12. 0	304. 79
1	7	......do	350	158. 759	10. 5	266. 70
1	8	......do	467	211. 829	14. 0	355. 59
1	9	......do	530	240. 406	12. 0	304. 79
1	10	......do	673	305. 270	11. 5	292. 09

TABLE II.

A.

Experimental shot-lines, linen, braided, made by Silver Lake Company, ordinary finish.

Number of lines.	Maker's number.	Material.	Length. Yards.	Length. Meters.	Diameter measured. Inches.	Diameter measured. Millimeters.	Weight. Pounds.	Weight. Kilograms.	Faking-box. Size.	Faking-box. Weight. Pounds.	Faking-box. Weight. Kilograms.
1	3½	Bleached linen	700	640. 068	0. 092	2. 3368	7. 0	3. 175	D	18. 0	8. 164
1	4	......do	700	640. 068	. 127	3. 226	12. 5	5. 670	B	24. 0	10. 886
1	4½	......do	700	640. 068	. 133	3. 378	13. 0	5. 896	B	23. 5	10. 659
1	5	......do	700	640. 068	. 160	4. 064	24. 0	10. 886	C	33. 0	14. 968
1	6	Unbleached linen, sash	600	548. 63	. 210	5. 334	33. 0	14. 968	A	34. 0	15. 422
1	7	......do	600	548. 63	. 225	5. 715	33. 0	14. 968	A	35. 0	15. 875
1	8	......do	600	548. 63	. 275	6. 985	50. 5	22. 906	......	......	....
1	9	......do	600	548. 63	. 283	7. 188	55. 5	25. 174	......	......	....
1	10	......do	600	548. 63	. 322	8. 179	63. 5	28. 803	......	......	....

B.

Tensile strength and elongation of braided shot-lines, made of linen thread by Silver Lake Company, ordinary finish.

Number of lines.	Maker's number.	Material.	Breaking weight.		Stretch in six feet of line.	
			Pounds.	Kilograms.	Inches.	Millimeters.
1	3½	Bleached linen	102.0	46.266	6.0	152.40
1	4	......do	160.0	72.575	9.0	228.60
1	4½	......do	143.5	65.091	9.0	228.60
1	5	......do	245.0	111.131	8.5	215.90
1	6	Unbleached linen, sash	323.0	146.511	13.0	330.19
1	7	......do	391.0	177.356	12.5	317.49
1	8	......do	542.0	245.849	14.0	355.59
1	9	......do	683.0	309.806	13.0	330.19
1	10	......do	795.0	360.609	13.0	330.19

TABLE III.

A.

Experimental braided shot-lines of Italian hemp, made by Silver Lake Company, water-proof finish.

Number of lines.	Maker's number.	Material.	Length.		Diameter measured.		Weight.		Faking-box.		
										Weight.	
			Yards.	Meters.	Inches.	Millimeters.	Pounds.	Kilograms.	Size.	Pounds.	Kilograms.
1	3½	Italian hemp	700	640.068	0.100	2.540	8.0	3.628	D	18.0	8.164
1	4	......do	700	640.068	.120	3.048	14.0	6.350	B	23.0	10.432
1	4½	......do	700	640.068	.140	3.556	14.5	6.577	B	24.5	11.113
1	5	......do	700	640.068	.200	5.080	27.5	12.473	C	32.0	14.515
1	6	Italian hemp, sash	600	548.63	.210	5.334	27.0	12.247	A	36.0	16.329
1	7	......do	600	548.63	.225	5.715	37.5	17.009	A	35.5	16.102
1	8	......do	600	548.63	.274	6.985	42.0	19.051	......	......	....
1	9	......do	600	548.63	.295	7.493	53.0	24.040	......	......	....
1	10	......do	600	548.63	.320	8.128	55.5	25.174	......	......	....

B.

Tensile strength and elongation of braided shot-lines, made of Italian hemp by Silver Lake Company, water-proof finish.

Number of lines.	Maker's number.	Material.	Breaking weight.		Stretch in six feet of line.	
			Pounds.	Kilograms.	Inches.	Millimeters.
1	3½	Italian hemp	60	27.215	5.0	127.00
1	4	......do	110	49.896	5.0	127.00
1	4½	......do	157	71.215	6.0	152.40
1	5	......do	232	105.688	6.0	152.40
1	6	Italian hemp, sash	258	117.028	7.0	177.80
1	7	......do	320	145.151	8.0	203.20
1	8	......do	434	196.861	8.5	215.90
1	9	......do	476	215.912	11.0	279.39
1	10	......do	600	272.158	10.0	254.00

TABLE IV.

A.

Experimental braided linen shot-lines, made by Silver Lake Company, water-proof finish.

Number of lines.	Maker's number.	Material.	Length.		Diameter measured.		Weight.		Faking-box.		
			Yards.	Meters.	Inches.	Millimeters.	Pounds.	Kilograms.	Size.	Weight. Pounds.	Weight. Kilograms.
1	3½	Linen, bleached	700	640.068	0.100	2.540	8.0	3.628	D	18.5	8.39[illegible]
1	4	......do	700	640.068	.122	3.094	14.5	6.577	B	24.	10.[illegible]
1	4½	......do	700	640.068	.139	3.530	15.5	7.030	B	24.	10.[illegible]
1	5	......do	700	640.068	.175	4.445	24.0	10.886	C	31.5	14.2[illegible]
1	6	Unbleached linen, sash	600	548.63	.225	5.715	31.5	14.288	A	36.5	16.[illegible]
1	7	......do	600	548.63	.225	5.715	33.5	15.195	A	35.5	16.1[illegible]
1	8	......do	600	548.63	.280	7.112	51.0	23.133	......	......	......
1	9	......do	600	548.63	.285	7.239	54.0	24.494	......	......	......
1	10	......do	600	548.63	.335	8.509	70.0	31.751	......	......	......

B.

Tensile strength and elongation of braided shot-lines, made of linen thread by Silver Lake Company, water-proof finish.

Number of lines.	Maker's number.	Material.	Breaking weight.		Stretch in six feet of line.	
			Pounds.	Kilograms.	Inches.	Millimeters.
1	3½	Linen, bleached	91	41.277	5.	127.[illegible]
1	4	......do	137	62.142	8.	203.2[illegible]
1	4½	......do	145	65.771	7.5	190.[illegible]
1	5	......do	268	121.563	7.5	190.[illegible]
1	6	Unbleached linen, sash	337	152.862	12.	304.7[illegible]
1	7	......do	410	185.974	12.	304.7[illegible]
1	8	......do	480	217.726	11.	27[illegible]
1	9	......do	624	273.044	13.	3[illegible]
1	10	......do	769	348.816	13.	33[illegible]

TABLE V.

A.

Experimental braided shot-lines, unbleached linen thread, made by Silver Lake Company.

Number of lines.	Maker's number.	Material.	Length.		Diameter measured.		Weight.		Faking-box.		
			Yards.	Meters.	Inches.	Millimeters.	Pounds.	Kilograms.	Size.	Weight. Pounds.	Weight. Kilograms.
1	4	Unbleached linen	700	640.068	0.127	3.226	14.5	6.577	B	23.5	10.[illegible]
1	4	Unbleached linen, W. P.	700	640.068	0.125	3.175	16.5	7.484	B	25.0	11.[illegible]

NOTE.—These lines are invoiced as "Dark linen."

B.

Tensile strength and elongation of braided shot-lines, made of unbleached linen thread by the Silver Lake Company.

Number of lines.	Maker's number.	Material.	Breaking weight.		Stretch in six feet of line.		Remarks.
			Pounds.	Kilograms.	Inches.	Millimeters.	
1	4	Unbleached linen	172	78.018	7	177.8	Ordinary finish.
1	4	Unbleached linen, W. P.	145	65.771	9.5	241.3	Water-proof finish.

III. Reel for shot-lines.

(Plate XXXV.)

It was found necessary during the experimental firing to have some method of taking up the lines rapidly, and, at the same time, one that would keep them from becoming entangled.

A light reel was designed for this purpose which answered all the requirements. This simple contrivance consists of a frame, reel, and crank of wood, and of two wire pins.

The frame is dovetailed together, and has four small D-rings attached to it by bits of leather. These rings engage with the snap-hooks of the carrying-braces. The reel is composed of an arbor, carrying cross-pieces at each end. The arbor is retained in the frame by the wire pins.

A strip of leather passes over the extremities of the cross-pieces at each end to keep the radial arms from catching in the line when winding it up.

Dimensions and details of construction may be seen in the drawings.

Weight of reel complete, 8 pounds.

IV. Carrying-braces for reel.

(Plate XXXVI.)

These braces were made to carry the reel and frame.

They consist of a waist-belt and a set of light cross-belts or braces, with snap-hooks for attaching the reel-frame.

The operator walks along, winding up the line as he proceeds, thus preserving the line from injuries which would result from dragging it through the sand, over rocks and bushes. (See plate for details.)

Weight, 1 pound.

CHAPTER VII.

FAKING-BOXES.

These boxes are designed for placing the shot-lines in position for firing. The lines are stowed away in the boxes in a peculiar manner, called "faking." The method is one adopted by the English for the stowage of their rocket-lines.

I. FAKING-BOX A (large).

(Plate XXXI.)

1. *Description.*

		Inches.	Centim'rs.
External dimensions	Length	36.0	=91.438
	Width	19 9	=50.545
	Depth	12.75	=32.384
Internal dimensions	Length	34.9	=88.644
	Width	18.8	=47.751
	Depth	12.2	=30.937

2. *Weight.*

	Lbs.	Kilos.
Average weight, empty	35	=15.874
Average weight, with "braided linen line, Silver Lake Co., No. 6," about	66.5	=30.163
Average weight, with "braided linen line No. 7"	68	=30.843

3. *Material.*

This box is made of well-seasoned white pine. The faking-pins are made of hickory, and the frame for these pins of ash.

4. *Nomenclature and dimensions.*

		Inches.	Centim'rs.
1 top	Length	36.0	=91.438
	Width	19.9	=50.545
	Thickness	.55	= 1.397
2 side pieces, same size	Length	36.0	=91.438
	Width	12.2	=30.937
	Thickness	.55	= 1.397
2 end pieces, same size	Length	19.9	=50.545
	Width	12.2	=30.937
	Thickness	.55	= 1.397
1 "false bottom"	Length	34.6	=87.882
	Width	18.6	=47.243
	Thickness	.55	= 1.397

Frame for faking-pins.

		Inches.	Centim'rs.
2 side pieces, same size	Length	38.0	=96.519
	Width	3.75	= 9.525
	Thickness	.9	= 2.286
2 end pieces, same size	Length	21.0	=53.339
	Width	4.2	=10.668
	Thickness	.9	= 2.286

Faking-pins.

				Inches.	Centim'rs.
48 pins, same size...	Total length			12.4 =	31.495
	Body.....	Length		11.5 =	29.209
		Greatest diameter		1.0 =	2.540
		Least diameter		.35 =	.889
	Screw	Length		.9 =	2.286
		Diameter		.7 =	1.778
2 cleats for rope handles, same size.		Length		6.2 =	15.748
		Width		2.0 =	5.080
		Thickness		1.4 =	3.556
2 handles, hemp rope		Length		18.0 =	45.719
		Diameter		.5 =	1.270

2 hasps, metal, for fastening box to frame.

5. *Construction.*

The sides and ends are dovetailed together at the corners. The top is nailed to the ends and sides with one-and-a-half-inch and six-penny finishing nails. The cleats carrying the rope-handles are fastened to the box, one at each end, by four small screws.

The "false bottom" has a row of holes, 1".2 (3.05 centimeters) in diameter around the perimeter. Along the sides and ends the centers of these holes are situated 1".3 (3.3 centimeters) from the edges. The distance between the centers of any two consecutive holes is 2" (5.08 centimeters).

The sides and ends of the frame for the faking-pins are put together with mortises and tenons.

Along the sides, the centers of the screw-holes for the faking-pins are placed 2".5 (6.35 centimeters) from the outer edges; the centers of these holes are 3" (7.62 centimeters) from the outer edges along the ends of the frame.

The distance between the centers of any two consecutive screw-holes is 2" (5.08 centimeters).

The holes are bored and tapped to form a coarse-threaded female screw.

There are seventeen holes on each side and seven at each end of both the bottom and the frame, making forty-eight holes in each.

The faking-pins are turned in a lathe from pieces of hickory of the proper length. The body is a frustum of a cone. The upper end is slightly rounded off. A coarse, cylindrical screw is cut upon the lower end.

A metallic hasp which passes over a button attached to the end of the box is fastened to each end of the frame, and serves to hold the frame and box together in transportation and handling.

In the boxes usually made for the United States Life-Saving Service an iron staple takes the place of the hasp, and a staple and hook of the same material supplants the button; but they form a very insecure fastening. In handling the boxes the hooks are apt to become disengaged and let the frame and line fall, thus increasing the chances of entangling the latter.

The outside of the box is painted a deep blue, with narrow marginal stripes of red.

6. *Marks.*

The letters "U. S. L. S. S." are painted in *white* upon the top.

II. Faking-box B (small).

(Plate XXXII.)

1. *Description.*

		Inches.	Centim'rs.
External dimensions	Length	24.0	= 60.959
	Width	16.0	= 40.639
	Depth	12.8	= 32.511
Internal dimensions	Length	22.8	= 57.911
	Width	14.8	= 37.591
	Depth	12.2	= 30.937

2. *Weight.*

	Lbs.	Kilos.
Average weight, empty	24	= 10.886
Average weight, with "linen line No. 4," about	36.5	= 16.556
Average weight, with "linen line No. 4½," about	37	= 16.782

3. *Materials.*

The box and "false bottom" are made of white pine; the faking-pins of hickory; the frame of ash; all well seasoned.

4. *Nomenclature and dimensions.*

		Inches.	Centim'rs.
1 top	Length	24.0	= 60.959
	Width	16.0	= 40.639
	Thickness	.6	= 1.524
2 side pieces, same size	Length	24.0	= 60.959
	Width	12.2	= 30.937
	Thickness	.6	= 1.524
2 end pieces, same size	Length	16.0	= 40.639
	Width	12.2	= 30.937
	Thickness	.6	= 1.524
1 "false bottom"	Length	22.6	= 57.403
	Width	14.6	= 37.083
	Thickness	.6	= 1.524

Frame for faking-pins.

		Inches.	Centim'rs.
2 side pieces, same size	Length	26.0	= 66.039
	Width	3.7	= 9.398
	Thickness	.9	= 2.286
2 end pieces, same size	Length	17.0	= 43.179
	Width	4.3	= 10.922
	Thickness	.9	= 2.286

Faking-pins.

			Inches.	Centim'rs.
32 pins, same size	Total length		12.4	= 31.495
	Body	Length	11.5	= 29.209
		Greatest diameter	1.0	= 2.540
		Least diameter	.35	= .889
	Screw	Length	.9	= 2.286
		Diameter	.7	= 1.778

		Inches.	Centim'rs.
2 cleats for rope handles, same size	Length	6.2	= 15.748
	Width	2.0	= 5.080
	Thickness	1.4	= 3.556
2 handles, hemp rope	Length	18.0	= 45.719
	Diameter	.5	= 1.270

2 hasps, metal, for fastening box to frame.

5. *Construction.*

The general construction of this box differs from the one given above in the following particulars only, viz:

1. In having 32 instead of 48 faking-pins.
2. In having 32 instead of 48 holes in bottom.
3. In having 32 instead of 48 screw holes in frame.

The distances of the holes, etc., from the outer edge of the bottom and of the frame, and from each other, are identical in the two cases. The painting and marks are also the same.

NOTE.—The two sizes of faking-boxes given above are issued to life-saving stations at the present time, and correspond to the two sizes of shot-lines issued.

III. FAKING-BOX C (large, square).

(Plate XXXIII.)

1. *Description.*

		Inches.	Centim'rs.
External dimensions	Length	24.0	= 60.959
	Width	24.0	= 60.959
	Depth	12.8	= 32.511
Internal dimensions	Length	22.9	= 58.165
	Width	22.9	= 58.165
	Depth	12.3	= 31.241

2. *Weight.*

	Lbs.	Kilos.
Average weight, empty	33	= 14.968
Average weight, with "linen line No. 5," about	57	= 25.854

3. *Materials.*

The materials for this box are the same as those used for the preceding boxes.

4. *Nomenclature and dimensions.*

		Inches.	Centim'rs.
1 top	Length	24.0	= 60.959
	Width	24.0	= 60.959
	Thickness	.5	= 1.270
2 side pieces, same size	Length	24.0	= 60.959
	Width	12.3	= 31.241
	Thickness	.55	= 1.397
2 end pieces, same size	Length	24.0	= 60.959
	Width	12.3	= 31.241
	Thickness	.55	= 1.397
1 "false bottom"	Length	22.6	= 57.403
	Width	22.6	= 57.403
	Thickness	.6	= 1.524

Frame for faking-pins.

		Inches.	Centim'rs.
2 side pieces, same size	Length	25.8	= 65.531
	Width	3.7	= 9.398
	Thickness	.9	= 2.286
2 end pieces, same size	Length	24.75	= 62.86
	Width	4.3	= 10.92
	Thickness	.9	= 2.286

Faking-pins.

			Inches.	Centim'rs.
40 pins, same size	Total length		12.4	= 31.495
	Body	Length	11.5	= 29.209
		Greatest diameter	1.0	= 2.540
		Least diameter	.35	= .889
	Screw	Length	.9	= 2.286
		Diameter	.7	= 1.778
2 cleats for rope handles, same size		Length	6.2	= 15.748
		Width	2.0	= 5.080
		Thickness	1.4	= 3.556
2 handles, hemp rope		Length	18.0	= 45.719
		Diameter	.5	= 1.270

2 hasps, metal, for fastening box to frame.

IV. FAKING-BOX D (small, square).

(Plate XXXIV.)

1. *Description.*

		Inches.	Centim'rs.
External dimensions	Length	16.0	= 40.639
	Width	16.0	= 40.639
	Depth	12.8	= 32.511
Internal dimensions	Length	14.9	= 37.845
	Width	14.9	= 37.845
	Depth	12.3	= 31.241

2. *Weights.*

	Lbs.	Kilos.
Average weight, empty	18	= 8.164
Average weight, with "linen line No. 3½," about	26	= 11.792

3. *Materials.*

The materials for this box do not differ from those of the preceding boxes.

Nomenclature and dimensions.

		Inches.	Centim'rs.
1 top	Length	16.0	= 40.639
	Width	16.0	= 40.639
	Thickness	.5	= 1.270
2 side pieces, same size	Length	16.0	= 40.639
	Width	12.3	= 31.241
	Thickness	.55	= 1.397
2 end pieces, same size	Length	16.0	= 40.639
	Width	12.3	= 31.241
	Thickness	.55	= 1.397

Item		Dimension	Inches.		Centim'rs.
1 "false bottom"		Length	14.55	=	36.956
		Width	14.55	=	36.956
		Thickness	.6	=	4.064

Frame for faking-pins.

Item		Dimension	Inches.		Centim'rs.
2 side pieces, same size		Length	18.0	=	45.719
		Width	3.7	=	9.398
		Thickness	.9	=	2.286
2 end pieces, same size		Length	16.9	=	42.925
		Width	4.35	=	11.049
		Thickness	.9	=	2.286

Faking-pins.

Item	Part	Dimension	Inches.		Centim'rs.
24 pins, same size	Total length		12.4	=	31.495
	Body	Length	11.5	=	29.209
		Greatest diameter	1.0	=	2.540
		Least diameter	.35	=	.889
	Screw	Length	.9	=	2.286
		Diameter	.7	=	1.778
2 cleats for rope handles, same size		Length	6.2	=	15.748
		Width	2.0	=	5.080
		Thickness	1.4	=	3.556
2 handles, hemp rope		Length	18.0	=	45.719
		Diameter	.5	=	1.270

2 hasps, metal, for fastening box to frame.

NOTE.—The square faking-boxes C and D do not differ materially in construction from boxes A and B. They are experimental boxes.

PART III.

RECORD OF EXPERIMENTS.

The experiments are divided into two series; the first series comprising those made at Springfield, Mass., in the autumn of 1877; the second, those made at Sandy Hook, N. J., in the spring of 1878.

CHAPTER I.

FIRING-GROUNDS.

I. FIRING-GROUND AT SPRINGFIELD, MASS.

(Plate XXXVII.)

Considerable difficulty was experienced in finding a suitable firing-ground in convenient proximity to the National Armory. The grounds possessed by the United States Government afforded too limited a range to be of any practical utility. The government for its own purposes used ranges over water in experimental firing; but though the ultimate object of the present trials was to determine the best means of throwing lines over an intervening space of water, it was especially undesirable during these trials to have such an inconvenient obstruction between the initial and objective points of the firing.

Some of the chief requisites of a good firing-ground for making experiments in throwing lines are:

1. That it should present an adequate range.
2. That it should be nearly level.
3. That there should be no obstacles to interfere with the attainment of a good view of the shot and line throughout the trajectory, nor with taking up the line after firing. This condition rejects a range over water not only on account of wetting the line, thereby increasing its weight and rendering the result of the subsequent shot incomparable with one made with the dry line, but also by increasing the physical difficulties of taking up the line and replacing it in the faking-box.

It also rejects ground covered with briars or other prickly plants or shrubs whose prickles penetrate and break off in the line when it is drawn through them, thus rendering the handling of the line both difficult and painful.

4. That the extent of the range should be great enough to enable the observer to note the point of fall of those shot that break the line and pass far beyond the limits which they would attain if the line remained intact, in order that the shot may be easily recovered for subsequent use.
5. That human habitations should not be in or near the plane of fire.

After some time spent in prospecting for a spot suited to the object in view, one was selected about one mile from the city of Springfield, Mass., but still within the city limits. It consisted of two strips of meadow-land nearly level for about 700 yards; the extremity of the range farthest from the gun having the greater elevation. The ground presented a very clear range of 687 yards between the two tracts of timber land at its extremities.

The disadvantages were, that the firing had to be done over a much-traveled road, that the land closely adjacent was often occupied by laborers, that the nearness of the city enabled many idlers, especially boys, to congregate in the vicinity of the plane of fire. The delays and annoyances due to these causes were many and oftentimes very troublesome. All the appurtenances of the range had to be set up and removed at each visit to prevent their wanton destruction by tramps or thoughtless boys.

No difficulty was experienced in obtaining the necessary permission from the municipal authorities to fire within the city limits and over the roadway. They merely required that sentinels should be stationed on the road to warn passers by, in order to prevent accidents.

The land occupied was owned by Mr. E. W. Bond, president of the Massachusetts Mutual Life Insurance Company, and Mr. James Kirkham, president of the First National Bank of Springfield, both of whom very kindly and generously allowed it to be used without asking for any compensation.

At the firing point a gun platform was constructed to avoid the tearing up of the ground due to the recoil in continued firing.

This platform was 8 feet long and 6 feet wide, made of 2-inch deck plank spiked down upon 4 sleepers. The sleepers were 8 feet long, with a cross-section of 10 inches square, and were bedded in the ground flush with the surface. Immediately in front of the center of the platform was driven the initial stake from which the range was measured. The muzzle of the piece was placed directly over this stake in firing. From this point the range was laid off by means of a tape-line 100 feet long; and a stake, with its distance in yards from the origin marked upon it, was driven down at 100 yards, and at each additional hundred yards from the initial point. Intermediate stakes were driven at intervals of 25 yards between those which designated the 100-yard points. This arrangement greatly facilitated the measurement of the ranges of the shot.

Later a second range was laid out from the same origin, but so inclined as to clear the point of the woods, in which several shot had been lost by the breaking of the lines. This range was marked at each hundred yards by an appropriately-numbered stake.

The ranges were remeasured, to preclude any possibility of error.

To the right and rear of the gun platform was erected a shelter 7 feet long and 6 feet high, made of 10-inch timber, to screen the firing party when testing new guns with heavy charges. Every precaution was taken to prevent accidents. The guns were always fired with a lanyard and service primer. When firing, range flags were placed at the 300, 400, and 500-yard stakes, to mark the line of fire. In *every case* the gun was pointed so as to bring the plane of fire to coincide with the line of flagstaves. Twenty-five yards to the right of the 200-yard stake was placed a Casella anemometer, to measure the approximate surface velocity of the wind. This instrument was placed a little over five feet from the ground. It occupied a clear space, removed from any obstructions that would modify the velocity of the surface current of air. The direction of the wind with reference to the line of fire was estimated from the position assumed by a vane five feet long, situated at the same spot as the anemometer.

General method of firing.

The practice usually observed in firing was as follows:

1. To set up and align the range flags.
2. To place the anemometer in position and take the initial reading.
3. To place the faking-box containing the line in position for firing.
4. To point the gun so that the vertical plane through its axis would coincide with the line of flags as closely as possible.
5. To charge the piece with a cartridge containing the powder.
6. To attach the line to the shot and insert it in the piece.
7. To give the proper elevation.
8. To prick the cartridge and insert the friction primer.
9. To fire the gun.
10. To take the reading of the anemometer.
11. To measure the range. The distance from the nearest stake to the point where the shot fell is measured with a pole 10 feet long and then reduced to yards, and added *algebraically* to the number of yards on the stake.
12. The deviation of the shot to the right or left of the line of fire is measured in feet with the same pole.
13. The bowing or drift of the slack of the line from the plane of fire at the 300-yard stake is measured.

II.—FIRING-GROUND AT SANDY HOOK, N. J.

The second series of experiments were conducted at the ordnance "proving-ground" at Sandy Hook, N. J.

Permission to use these grounds was granted by General S. V. Benét, Chief of Ordnance, and Col. S. Crispin, constructor of ordnance, United States Army.

A range was laid out along the sandy beach, carefully measured, and marked by stakes, as in the preceding instance at Springfield, Mass.

Range-flags were used to indicate the plane of fire.

A gun-platform 13 feet square was placed at the firing-point, which, though it allowed the gun and carriage to recoil more in firing, was a necessity where continued experiments are carried on in the yielding sand.

A Casella anemometer was mounted on a staff 5 feet high and placed about 20 yards to the right of the 200-yard stake, for the purpose of obtaining the velocity of the wind at the surface of the ground.

A vane was placed at the same point, to determine the direction of the wind with reference to the plane of fire.

The velocity of the wind at an altitude of about 50 feet above the surface of the ground was taken, whenever possible, at the office of the Ordnance Board, a short distance in rear of the firing point.

On a subsequent page are given the velocities of the wind during the hours of experimental firing, as indicated by the self-registering apparatus in the office of the signal-service observer.

The two instruments last referred to are Robinson anemometers, and are by no means so delicate in their indications as the Casella air-meter used for the surface velocities.

In the tables giving the results of the firings, the long arrow, running the whole length of the column, marked "Wind direction," represents the intersection of the plane of fire with the surface of the ground and the direction in which the guns were pointed.

The short arrows indicate the direction of the wind with reference to this line.

1 *Synoptical transcript of notes from the firing record.*

3 INCH M. L. RIFLED MORTAR—BRONZE.

Date.	No. of round.	
1877. Sept. 22.	1	Rifle projectile.—Gas entered axial cavity notwithstanding sabot, and blew the cap off; cutting the retaining-screw entirely off, carrying the knot, rubber tube, and washer out at the front end of the shot. When the resistance of the line drew the rubber tube and knot back, the former caught on the forward end of the shot, introverting a portion of the tube and cutting off the line. About 20 yards of line carried out. Rubber tube found about 150 yards in front of gun. A good line-shot, ranging 723 yards and striking a tree, 40 feet from the ground. Projectile recovered.
	2	Rifle projectile.—The cap was not blown off, nor was any trace of gas found in the axial cavity. The shot and line were recovered; the rotation of the shot due to the rifled motion twisted the line badly. The line assumed a spiral fusiform shape in rear of the projectile; the spirals near the shot being very small and increasing in amplitude with their distance in rear of it, until a point within about 50 yards of the faking-box was reached, from which point to the box the amplitude of the spirals decreased. This tapering of the spirals in rear of the shot increased greatly the resistance of the air and diminished the range.
	3	Rifle projectile.—Line carried out 25 or 30 yards; end appeared as if burned off; shot lost. One sabot recovered.
27.	4	Rifle projectile.—Copper-wire rope interposed between shot and line, broke. Forty yards of line carried out. Gas entered axial cavity and started the brazing of the cap. Projectile rotated about its shorter axis and struck upon its side.
	5	Rifle projectile.—The cap being lost the line was knotted over a lead washer and inserted in the gun point first, with two sabots to rest upon and prevent the gas burning off the knot. The shot was fired base first, took the rifled motion, and when it felt the strain upon the line it reversed, but retained the rifled motion and undulated up and down in the trajectory. The line was twisted as before.
	6	Rifle projectile.—This shot was placed in the gun like the preceding one and fired base first, but when it reversed it did not proceed point foremost, but continued to rotate about its shorter axis. The rotation of the shot twisted the line.
Oct. 6.	7	Smooth-bore projectile.—The bowing or drift of the shot-line from the line of fire at the 300-yard stake was 129 feet to the right. The shot kept point foremost after reversing and the resistance of the line kept it so.
	8	Rifle projectile.—Used one wooden and one Cordes sabot. Gas penetrated axial cavity, burning off the line, which was found to be still burning when examined. Shot lost. Range unknown. Action in trajectory unknown.
	9	Smooth-bore projectile.—This shot rotated about its shorter axis during its whole flight; the line did not experience resistance enough to keep the shot point first. Wind directly across line of fire, velocity about 6.37 miles per hour. The line bowed 226 feet to the right at the 300-yard stake.
10.	10	Rifle projectile.—The shot was fired base first. The base was turned off, forming a frustum of a cone, and the longitudinal groove for the line (along the side of the shot) was partially filled with lead. The escape of gas in firing cut out lead. The shot rotated about its shorter axis in the first part of the trajectory and kept point first during the latter part of its flight. Shot penetrated two feet into

1. *Synoptical transcript of notes from the firing record*—Continued.

3-INCH M. L. RIFLED MORTAR—BRONZE—Continued.

Date.	No. of round.	
1877.		the ground in falling. Line twisted and lay in loose coils in the vicinity of the point where the shot struck. The line bowed 68 feet to right of 300-yard stake.
Oct. 10	11	Smooth-bore projectile.—Line ran out beautifully. Bowing of line, 14 feet to right of 300-yard stake. Escape of gas through rifles diminishes range.
	12	Smooth-bore projectile.—Bowing of line, 33 feet to left of 300-yard stake. Velocity of wind probably greater than given, as the interval between readings in this case was 63 minutes, and the wind was increasing all the time. Escape of gas through the rifles affected the range.
13	13 14	Smooth-bore projectiles.—Line burnt off in each case and shot lost. Range uncertain, probably over 800 yards. Both shot rotated about shorter axis. Faking-box placed 9 feet to left of platform on windward side. Line burned off in loop in each case; end of line on fire when examined. The length of the powder-charge was such that it greatly increased the gas-escape through the grooves.
24	15	Smooth-bore projectile.—Bowing of line, 13 feet to right at the 300-yard stake. The line was all carried out and the end dragged 115 feet from the box towards the front. Shot penetrated earth 18 inches. Reading of anemometer uncertain, not properly adjusted; but result varies but little from the truth.
	16	Smooth-bore projectile. Bowing of line, 9.5 feet to left at 300-yard stake. The line was all carried out, the loose end being dragged to the front a distance of 128 feet. Shot buried 2 feet in the ground. Projectile rotated about its shorter axis three or four times in the first part of the trajectory. Wind-velocity 5.2 miles per hour.
Nov. 3	17	Smooth-bore projectile.—The shank broke off close to base of shot. It broke when the shot reversed and brought the strain upon the shank, which accidentally had been made of steel instead of wrought iron. Shot lost. About 100 yards of line carried out.
	18	Smooth-bore projectile.—Shot with very long shank (10 inches). Faking-box to left of gun-platform. Bowing of line, about 200 feet to right at 300-yard stake. Wind, 10.864 miles per hour.
12	19	Smooth-bore projectile.—Shot carried away 75.5 feet of hemp line, which probably broke at or near a spot that had been partially cut through previously by whipping against edges of box. Shot recovered. Range over 900 yards.
	20	Smooth-bore projectile.—Bowing, 70 feet to right at 300-yard stake. Shot had 10-inch shank.

1. *Synoptical transcript of notes from the firing record—Continued.*

GUN A.—2 INCHES CALIBER.

Date.	No. of round.	
1877.		
Nov. 3	1	Line broke. Shot carried away 22¼ yards of line. The detached portion of the line was partially cut through in two places; one cut or break was 4¾ yards from loose end (or 18 yards from projectile), and extended half-way through the line; the other was a slight cut nearer the shot and not so deep. A few yards of the line was faked upon the ground in about 18-inch lengths. The vibrations of the line were violent, whipping badly across the edges of the box and cutting off the line. Projectile recovered.
	2	The bowing of the line at the 300-yard stake was 119 feet, and was a little greater at the 400-yard stake. Velocity of wind, 9.71+ miles per hour.
	3	Broke linen line No. 1. Shot lost.
	4	Bowing of the line 136 feet to the right of the 300-yard stake. Velocity of the wind, 10.2 miles per hour. Line knotted badly by some of the fakes slipping under others. The line was cut half off about 20 yards from the projectile by striking the edge of the faking-box. The vibrations of the line were so violent as to split the end of the box 4 inches from the top.
	5	Line burnt off by flames of gas escaping around shot through the windage. Burnt off at point of attachment to shot. Projectile lost. Range over 1,000 yards. Faking-box placed 15 yards in front of the gun.
7	6	Shot turned over and over about its shorter axis.
	7	Projectile rotated three or four times about its shorter axis in a plane nearly horizontal and then oscillated up and down during the remainder of its flight, keeping its head or point to the front.
	8	Wind, light and variable, changing direction often.
	9	A knot in the line from the fakes slipping under each other and looping.
	10	Bowing of line, 24 feet to the left at the 300-yard stake. The bore of the gun noticed to be slightly enlarged.
	11	Bowing of the line, 22 feet to the left at the 300-yard stake.
	12	Bowing of the line, 54 feet to the left at the 300-yard stake.
	13	Bowing of the line, 67 feet to the left at the 300-yard stake.
	14	Italian hemp line No. 2. Broke near box. No line carried out. Probable range over 750 yards. Projectile rotating about shorter axis.
	15	Same remark as preceding shot.
	16	Linen line No. 2. Bowing of line, 50 feet to the left at the 300-yard stake.
12	17	Bowing of line, 23 feet to the right at the 300-yard stake. Elevation of piece too great. Trajectory too high, requiring more line than was necessary for the range attained. The resistance of the air on the falling line was so great that, when descending, the projectile appeared to fall almost vertically for quite a distance.
	18	Line broke. Projectile lost.
	19	Line (linen No. 1) broke. Initial velocity of projectile too great. The rapidity of vibration of the rope in running from the faking-box was so violent as to knock out the upper part (4″ wide) of one end of the box, though the corners were dovetailed together. The fakes in the rope were too long to be used with projectiles having such great initial velocity as this shot. The sabot (Cordes) was a failure, the gas passing it and entering the axial cavity; the pressure of the gas inside the shot was so great that the head was blown off and lost. A portion of the shot and sabot were recovered.

1. *Synoptical transcript of notes from the firing record.*

GUN A.—2.5 INCHES CALIBER.

Date.	No. of round.	
1877.		
Nov. 21	1	No remarks.
	2	Line broke; shot carried away 90 feet of line; shot recovered. Range, over 900 yards.
	3	Forty-six feet of linen line (No. 1, diameter 0″.22) tied, one end to shot and the other to the Italian hemp line No. 1, to receive the first shock of discharge. When fired the knot came loose with a noise like the explosion of a friction primer.
	4	The bowing or drift of the line from the line of fire was 110 feet at the 300-yard stake.
	5	Linen line No. 1 cut off at 105 feet from the shot by whipping against the edge of a slight notch in the side of the faking-box; shot and attached portion of line recovered. Range over 900 yards.
	6	Bowing of line at 300-yard stake, 71 feet.
	7	Bowing of line at 300-yard stake, 84 feet.
22	8	New braided line, "No. 3½ linen, bleached." Deviation of line from plane of fire, 75 feet at 300-yard stake and 86 feet at 400-yard stake. About 775 yards of line carried out of box. Six knots found in line; These were small loops formed by some of the fakes slipping under others and being drawn into a knot by the rapid vibrations of the line. The projectile penetrated two feet into the ground. The gun and bed turned upside down after sliding from the platform, due to the surface of the latter being 6 inches above the ground in rear of it.
	9	Line broke; shot carried away 27.5 yards of line. A small knot found 20 yards from projectile. The range was about 1,000 yards, deviating slightly to the left of the line of fire. The shot struck a tree, breaking the shank off at the beginning of the screw-thread; both shot and line recovered. The shot and attached piece of line described an undulatory path, in a vertical plane.
	10	Line broke; shot carried away 21 yards of line. The line (the detached portion) was found to be nearly cut through at 13 yards distance from the shot, probably due to a knot which pulled out before the line was severed; a small knot was found 20 yards from shot. The range was about 40 yards greater than the preceding shot; the deviation was slightly to the right; the projectile rotated horizontally about its shorter axis. In this and the preceding case the frayed ends of the broken line were 1″.5 long, appearing as if combed. This length (1″.5) was greater than any hitherto found to occur with any line used; the braided lines having usually broken sharply off without leaving the ends frayed more than a fraction of an inch. Several knots were also found in different parts of the line. The faking-box testified to the violent vibrations of the line in running out, by the indentations made in the edges, sides, and ends of the box by the line. From these facts it would appear probable that some of the fakes caught each other and looped, and were drawn sharply against or across the edge of the box, forming a knot whose resistance was sufficient to cause the severance of the line.
27	11	Line drifted 353 feet to left of plane of fire at 400-yard stake. All the line (751 yards) was carried out, together with part of piece of old line (0″.22 in diameter) which had been attached to the shot-line. The shot in the last portion of the trajectory fell in a line closely approaching a vertical; in fact, it appeared from the firing-point as if suspended by the line. After the projectile had passed over about one-half of its descent, the light line becoming slack, was

1: *Synoptical transcript of notes from the firing record*—Continued.

GUN A.—2.5 INCHES CALIBER—Continued.

Date.	No. of round.	
1877.		drifted off by the wind, whose velocity near the upper part of the trajectory was much greater than that near the surface of the ground. Six small knots or loops were found in the line. The great bowing of the line was due to its lightness, the high angle of elevation, the velocity of the wind high above the surface of the plain, and the fact that when the shot was descending there was little or no longitudinal strain.
Nov. 27	12	Line broke; shot carried away 37 yards of linen line No. 2; both recovered. Faking-box is too long for use with this initial velocity for projectile. The vibrations of the line were very violent; the box showed indentations where the faked loops had been sunk into the wood by the whipping.
	13	With six ounces of Hazard musket-powder the base of the projectile (L. 3), experimental No. 11, was flush with the face of the muzzle.
	14	Shot carried away 28 yards of line (Italian hemp No. 2).
	15	Linen line No. 2: The line bowed 65 feet to the left of the 300-yard stake. This line was faked in the small boxes "B," filling two of them. By placing in this size box the amplitude of the lateral vibrations is much diminished.
	16	Italian hemp line No. 2: The bowing measured at the 300-yard stake was 124 feet to the left; angle of elevation too great for the wind that was blowing.

1. *Synoptical transcript of notes from the firing record.*

GUN A.—CALIBER, 3 INCHES.

Date.	No. of round.	
1878.		
May 14	1	Italian hemp line No. 4½ emptied into a pine packing-box before firing. Lateral vibrations of line sufficient to loosen the nails in both ends of box. End of line found in crack between end and side of box. The line was probably cut off by being drawn violently across sharp corners and through the crack—uncertain, may have been broken. Shot ranged 850 yards, carrying 27 yards of line with it.
	2	Base of projectile flush with the face of muzzle. Vibrations of line knocked the bottom and end out of the faking-box (A).
	3	Line (hemp No. 7) broken squarely off. Sixteen yards of line left attached to shot, which struck the ground 980 yards from the piece. The vibrations of the line split the end and side of the faking-box (A) into 4 or 5 pieces. The two faking-boxes above mentioned were rendered useless for further service in transporting lines.
	4	No remarks.
	5	Line (hemp No. 10) emptied into the two faking-boxes (A) mentioned in rounds 2 and 3. [These boxes will be referred to in following shots as "old faking-box A," &c. They were used (or at least one of them) until the 14th round to avoid breaking up new boxes.] Bevel on rear end of shot extended beyond face of piece.
	6	Line (No. 8) emptied into 2 old faking-boxes A, and part left in box B. Half of bevel at base of shot exposed beyond muzzle of piece.
	7	Line (No. 9) put in 2 old faking-boxes A for firing. Half of bevel on rear of shot exposed.
	8	Line in one old box A. Base of shot flush with muzzle of piece.
	9	Line (No. 10) in 2 old boxes A.
	10	Line (No. 8) in 2 old boxes A. One electric primer failed to explode.
	11	Line (No. 7) in 1 old box A. Could not tell whether the line was cut on the broken box or was broken by vibrations; 25 yards of line carried off by shot. Range, 704 yards; deviation, 5 yards to right.
	12	Line (No. 7) in 1 old box A.
	13	Line (No. 6) in 1 old box A. The gun was probably not pointed properly by the assistant. The line caught on the broken end of the box, which may have changed the direction of the shot somewhat, but not enough to account for the marked deviation of the shot. The box was on the right of the gun. From the insignificant difference between the deviation of the shot and the "drift," as measured from the 300-yard stake, the writer is inclined to the opinion that the gun was not properly pointed. The assistant did not recollect whether he verified the alignment of the gun or not.
	14	Line (No. 5) in 1 old box A. In the above cases the line was emptied from their own faking-boxes into those designated in this transcript of remarks. Wind at office at end of 14th round, 20.6 miles per hour.
21	15	Line put in tray before firing. The line (No. 9, linen) was fired from the coil as received from the manufacturer. The line run out in a fusiform helix, each coil putting one twist in the line. For this and the subsequent rounds the *Casella* air meter for determining the surface velocity of the wind was placed 50 yards in front of the gun instead of 200 yards in front, as before.
	16	Line emptied into tray. Nearly all of the line carried out.
	17	Line emptied into tray. Three tiers of fakes left in tray.
	18	Line emptied into tray. Line broke 18¼ yards on shot. Projectile rotated about shorter axis; shank slightly bent when shot struck the ground. Range, 920 yards.
	19	Line emptied into tray before firing.

1. *Synoptical transcript of notes from the firing record*—Continued.

GUN A.—CALIBER, 3 INCHES—Continued.

Date.	No. of round.	
1878. May 21	20	Line emptied into tray before firing. In faking, about a dozen coils had been placed in the bottom of the box before proceeding with the faking; when ready to fire, these loose coils were on top of course, and not being faked in small lengths, allowed excessive amplitude of vibration at the instant of discharge. The line broke short off, not even taking out all the coils. The fakes below were undisturbed. Range of shot, 930 yards, carrying 6¾ yards of line with it.
	21	Line put in tray before firing.
	22	Line put in tray before firing, in three lots. [Was faked in three boxes.]
	23	Line put in tray before firing.
	24	Line put in tray before firing.
		The above 24 shots were fired with "electric primers" for convenience.
22	25	Fired out to sea. Estimates of range made in this and three succeeding shots by 4 different persons, all accustomed to estimating distances on the water. The recorded range (300 yards) is below all estimated ranges given, so as to be sure to fall within the limits of truth. The writer places little faith in estimated distances, as they generally are very inaccurate, especially upon water.
	26	Fired out to sea. Line wet, rough, stiff, and covered with sand. It lay in loose coils on the beach where it had been hauled in "hand-over-hand" through the water and sand. Action of the line pretty good; a few snarls were seen, but they were very small. Range variously estimated from 275 to 300 yards by those present.
	27	Fired out to sea. Same line hauled in and placed on the sand in two loose coils. Line wet and sandy, kinked badly. Range variously estimated from 180 to 275 yards; recorded as between 180 and 200 yards.
	28	Fired out to sea. Line hauled in and placed in one coil on the beach. All kinks or snarls removed. Action of line very good, no snarls. Estimated range "about same as last shot," but recorded as 175 yards. Absorption of water by the line evidently tells more or less upon the range.
		"Service primers, long," used for the last four shots. The same line (Italian hemp No. 4½) and projectile were used in firing the four shots to sea. Heavier charges of powder would have been used, but none heavier happened to be at hand at the time. The object of the shot was more to witness the action of the line when wet and sandy than to obtain any definite range. Action of gun-carriage on sandy beach very good.

1. *Synoptical transcript of notes from the firing record*—Continued.

GUN B.—CALIBER, 2 INCHES.

Date.	No. of round.	
1878. March 8	1	For this and the four succeeding rounds the smooth-bore bronze gun B was mounted upon a block of wood weighing 48 pounds. Italian hemp line No. 3½ broke close to the shot. Projectile ranged over 700 yards, and was lost in a wooded tract of land.
16	2	Shot had no cap and was placed in the gun with its base toward the muzzle. One ½-inch wooden sabot used. A good line shot.
	3	No cap on shot; one sabot used; base of shot toward muzzle. About 100 yards of old linen line (diameter 0".22) used, between the shot and hemp line No. 3½, to receive the first shock of the discharge. The large line broke—probably burned off inside the shot by the gas which entered the axial cavity.
	4	Lead projectile "upset" slightly by the shock of discharge. Only one rotation of shot about shorter axis could be detected. Flight of shot and action in the trajectory excellent. Bore of gun found to be "leaded," due to the upsetting of the shot and the consequent friction.
	5	Same projectile used. It had probably been bent slightly by striking the ground, and had to be filed a little in order to enter the bore.
May 11	6	Velocity of wind 18.18 miles per hour as indicated by a Robinson anemometer upon the ordnance office at Sandy Hook. This instrument was about 50 feet above the surface of the ground and 200 yards from the firing point.
13	7	Velocity of wind 15 miles per hour by office anemometer just before experiments began. Base of shot flush with the face of the muzzle when the gun was loaded. Wind variable.
	8	Base of shot flush with face of piece. Wind almost calm at instant of firing.
	9	Base of shot flush with face of piece. Wind increasing.
	10	Base of shot flush with face of piece.
	11	Base of shot flush with face of piece. Vibrations of line started the dovetailing in end of faking-box.
	12	Base of shot flush with face of piece.
	13	Base of shot flush with face of piece. Powder charge compressed in loading. Wind at office 12.4 to 13.9 miles to 20 miles per hour as taken within 10 minutes after round 13 was fired, from the anemmometer on the building. Wind very variable during the whole forenoon.
	14	Base of shot flush with face of piece. Projectile rotated about its shorter axis throughout the greater part of the trajectory. Vibrations of line No. 3½ started dovetailing of box D on side next to the gun.
20	15, 16, 17, 18, 19, 20	Readings of Casella anemometer not taken at 200-yard stake—no time. Direction of wind variable within small azimuthal limits—general direction, "head wind." Velocity of wind at office (Robinson anemometer, elevation about 50 feet) varied from 18 miles to 24 miles per hour; wind came in gusts; weather damp, and showery part of the time. S. I. Kimball, general superintendent United States Life-Saving Service, and Capt. J. H. Merryman, United States Revenue Marine, inspector of that service, both present.
22	21	Fired directly against the wind and out to sea. Line either cut on button of box or broken; appeared to be cut; uncertain. Shot lost.
	22	Fired out to sea directly against wind. Range estimated by those present to be from 400 to 450 yards; true range unknown; lowest estimate inserted in table. Velocity at office 20 miles per hour.
23	23	Reading of anemometer uncertain; probably too great. Shot rotated several times. Line in tray.
	24	Line emptied into tray before firing. Shot rotated in horizontal plane.
	25	Line emptied into tray before firing.

1. *Synoptical transcript of notes from the firing record.*

GUN C.—CALIBER, 2.5 INCHES.

Date.	No. of round.	
1878.		
May 6	1	Reading of anemometer uncertain, instrument not leveled. The gun was discharged by means of "service friction primers, short," from the 1st to the 6th round, both inclusive.
	2	Anemometer reading uncertain.
	3	Gun probably aimed to the right.
	4	No remarks.
	5	No remarks.
7	6	No remarks.
	7	"Service primer, long"; one failed to explode. These primers were used from the 7th to 20th round, both inclusive. Lanyard used in connection with these primers.
	8	A couple of fakes caught and knotted.
	9	Two small knots in line.
	10	One large knot; fakes got looped over each other and carried out a long knot. Velocity of wind 15 miles per hour, by instrument on top of office (about 50 feet above the ground), distant about 200 yards from firing point.
	11	No remarks.
	12	Vibrations of line split the end of the faking-box next to the gun.
	13	No remarks.
	14	No remarks.
	15	Velocity of wind 18.95 miles per hour, by instrument on office.
8	16	Wind very light.
	17	Wire pulled out of primer, and the gun "hung fire."
	18	Two knots in line, one small and one large; fakes caught each other.
	19	One large knot in line; fault of man who faked the line.
	20	Loosened end of faking-box. Line whipped out in knots, but all the knots came out while the line was in the air.
10	21	Line No. 3½ (Italian hemp) broke near the knot where it was tied to linen line No. 7. A piece of new linen line No. 7, 150 yards in length, was fastened to the shot to receive the first shock of the discharge, and the other end was made fast to Italian hemp line No. 3½. The small line broke, and the shot ranged 550 yards, carrying the 150 yards of heavy line with it. The shot fell 20 feet to the left of the plane of fire. A careful examination of hemp line No. 3½ disclosed the fact that it was quite brittle in fiber, harsh to the touch, and that it could be broken easily by using the hands alone. Dipping the line in water increased its tensile strength very much. The fibers of the Italian hemp appeared to be so brittle that the smallest lines made from it are almost worthless. Commenced using "electric primers" with this round.
	22	The same piece of linen line (150 yards of No. 7 line) used in above round was tied as before to a No. 3½ linen. Either one of the lines broke at the knot, or else the knot slipped and came untied. There was nothing in the appearance of the ends of the lines to indicate which had actually occurred. The shot with the large line attached ranged 541¾ yards, and fell 6 feet to the left of the plane of fire.
	23	Velocity of wind at office (elevated anemometer) 12.81 miles per hour. The shot carried out all the line (linen No. 3½), the end being found 30 yards from the faking-box There were seven kinks found in the line, two of which were pretty bad ones.
	24	Line (Italian hemp No. 4½) broke; cause, lateral vibrations and brittleness of fibers. Shot carried away 30½ yards of line. Range of projectile, 807 yards; deviation from plane of fire, 60 feet to the left.
	25	Velocity of wind at office 15.93 miles per hour.

1. *Synoptical transcript of notes from the firing record*—Continued.

GUN C.—CALIBER, 2.5 INCHES—Continued.

Date.	No. of round.	
1878.		
May 10	26	Started the dovetailing of faking-box C, near the top, on the side nearest to the gun. This box had one hasp broken in transportation. The brass hinge-pin had been riveted too tightly.
	27	No remarks.
11	28	Italian hemp line No. 7. The line broke squarely off, leaving 27 feet attached to the shot. The violence of the up-and-down vibrations of the line was sufficient to split the bottom of the faking-box. Range of shot, about 1,100 yards.
	29	Broke end of faking-box. Velocity of wind at office, from observations two minutes apart, was 34.6 miles and 36 miles per hour. Five minutes after shot was fired, surface velocity of wind was 25 feet and 31.66 feet per second.
	30 31 32 33	Wind gusty. Direction of wind ("side wind") caused the line to drift badly to one side of the plane of fire. A strong rear or side wind allows the projectile to move more or less sidewise, thus exposing more surface to the action of the air, and, consequently, increasing the resistance of the air and diminishing the range. With a strong head wind, the strain of the line upon the oblong projectile appears to keep the point up and to extend the range somewhat. During one hour the velocity of the wind was taken at equal intervals at the office (anemometer 50 feet above the ground) with the following serial results, viz: 11.54, 19.0, 17.47, 21.18, 26.86, 22.8, 22.0, 19.8, 11.92, 18.7, 24.3, 12.5, 24.6, 22.5, 30.5, 26.4, and 22.5 miles per hour. In round No. 33, Italian hemp line No. 4, "ordinary finish," drifted so far to the left that it fell into the salt water. The exact "drift" could not be measured, but was a little more than 75 yards. The line caught on an old jetty under the water; two men pulling on the wet line could not break it, though each of them took a couple of turns around his arm and placed the line over his shoulder in order to exert more fully his strength. The line was cut in order to recover it. The wet line was very difficult to fake, being stiff and rendered sticky by the loosened starch finish.
22	34	Line emptied from faking-box into tray before firing. Shot rotated three or four times.
	35	Line emptied into tray as before. Shot rotated about five or six times. Velocity of wind at office 21.9 miles per hour.
	36	Line emptied into tray as before. All of the line carried out except 4 tiers of fakes.
	37	Line emptied into tray as before. All of the line but about 50 yards carried out.
	38	Line emptied into tray as before. All of the line carried out. End of line 10 yards from tray. Line had too much paraffine on it; felt very greasy.
	39	Line emptied into tray as before. All of the line (No. 5) except 9 tiers carried out.
	40	Line emptied into tray as before. All but 7 tiers of the line carried out. Wind gusty during the above experiments for this day. Velocity of wind at office 17 miles per hour, immediately after fortieth round.
	41	Fired out to sea directly against the wind. No drift to the line. About 600 yards of line drawn out of box. Range unknown; lowest estimate given by those present was over 450 yards. Probably did not vary much from that distance. Action of projectile in the trajectory during its flight, excellent. Shot recovered by hauling in line. Recoil of gun and carriage, 15 feet.

1. *Synoptical transcript of notes from the firing record*—Continued.

GUN C.—CALIBER, 2.5 INCHES—Continued.

Date.	No. of round.	
1878. May 22	42	Fired to sea directly against the wind. The line was in loose coils on the sandy beach. The wet line was hauled in through the water and sand "hand-over-hand" and coiled without any care whatever, in order to ascertain what could be done in a similar case when the circumstances required great haste. This line, with the "water-proof finish," was stiff, but held less sand and was not nearly so sticky as that having the "ordinary finish." It was deposited in three coils near together, and was fired. The first coil, though somewhat kinky, ran out pretty well; part of second coil ran out, when the remainder was caught up by a vibrating loop, forming a bad tangle, through which the cord was drawn tightly until it broke or was cut by the other coils. This large mass of rope, over a foot in diameter, was carried out to sea over 80 yards before the line parted. The recoil of the gun-carriage was about the same as in the previous shot. The action of the gun-carriage upon the sand was unexceptionable; it slid to the rear easily without any tendency to turn over whatever.

CHAPTER III.

VELOCITY AND FORCE OF THE WIND.

In this chapter will be given tables containing the velocities of the wind from one-hundredth of one foot per second to one hundred and fifty feet per second, with their equivalents in miles per hour; also the pressure per square foot in pounds for the different velocities of the wind from one mile to one hundred miles per hour.

The velocities of the wind as recorded by the signal-service self-registering anemometer are given for the days upon which experiments were made at Sandy Hook, N. J.

The data for Sandy Hook, N. J., were kindly furnished by the Chief Signal-Officer of the Army and by Sergeant P. J. Huneke, United States Signal Service.

I.

Table of velocities of the wind

VELOCITY OF THE WIND.							
Per second, feet.	Per hour, miles.	Per second, feet.	Per hour, miles.	Per second, feet.	Per hour, miles.	Per second, feet.	Per hour, miles.
.01	.007	1	.68	16	10.91	10	6.82
.02	.014	2	1.36	17	11.59	20	13.64
.03	.021	3	2.05	18	12.27	30	20.45
.04	.027	4	2.73	19	12.95	40	27.27
.05	.034	5	3.41	20	13.64	50	34.09
.10	.068	6	4.09	21	14.32	60	40.91
.20	.136	7	4.77	22	15.00	70	47.73
.3	.205	8	5.45	23	15.68	80	54.54
.4	.273	9	6.14	24	16.36	90	61.36
.5	.341	10	6.82	25	17.05	100	68.18
.6	.409	11	7.50	26	17.73	110	75.00
.7	.477	12	8.18	27	18.41	120	81.82
.8	.545	13	8.86	28	19.09	130	88.63
.9	.614	14	9.55	29	19.77	140	95.45
1.0	.681	15	10.23	30	20.45	150	102.27

II.

Velocity and force of the wind.

Velocity per hour.	Pressure per square foot.	Character of wind.	Velocity per hour.	Pressure per square foot.	Character of wind.
Miles.	*Pounds.*		*Miles.*	*Pounds.*	
1	0.005	Hardly perceptible.	17	1.422	
2	.020	Just perceptible.	18	1.594	
3	.044	Do.	19	1.776	
4	.079	Gently pleasant.	20	1.968	
5	.123		25	3.075	Very brisk.
6	.177	Pleasant.	30	4.429	
7	.241		35	6.027	High wind.
8	.315		40	7.873	
9	.399		45	9.963	Very high wind.
10	.492		50	12.300	A storm or tempest.
11	.595		60	17.715	A great storm or strong gale.
12	.708		70	24.500	Violent gale.
13	.831	Pleasant; brisk breeze.	80	31.490	Hurricane.
14	.964		90	40.500	
15	1.107		100	49.200	Most violent hurricane.
16	1.260				

III.

Statement showing the hourly velocity of the wind at Sandy Hook, New Jersey, on the dates and at the hours below given, compiled from the records on file in the office of the Chief Signal-Officer, U. S. A.

[Elevation of anemometer above ground, 40 feet 7 inches.]

Date.	8.30 a. m. to 9 a. m.	9 a. m. to 10 a. m.	10 a. m. to 11 a. m.	11 a. m. to 12 noon.	11.30 a. m. to 12 noon.	12 noon to 1 p. m.	1 p. m. to 2 p. m.	2 p. m. to 3 p. m.	3 p. m. to 4 p. m.	4 p. m. to 5 p. m.	5 p. m. to 6 p. m.	Total.
	Miles.	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*
May 7, 1878	....	....	....	15	....	17	15	13½	16	19	....	95½
May 8, 1878	....	4½	6	....	....	....	....	....	....	....	....	10½
May 10, 1878	7	15	15	15	....	....	....	....	....	....	....	52
May 11, 1878	....	....	27	11½	....	20½	17	28	29	....	....	133
May 13, 1878	....	....	....	....	8	16	14	14	....	....	....	52
May 14, 1878	2½	4	1½	1½	....	½	11½	13	13	13	12	71

War Department, Office of the Chief Signal-Officer, U. S. A.,
Washington, D. C., May 28, 1878.

OFFICE OF OBSERVATION SIGNAL SERVICE U. S. A.,
Sandy Hook, N. J., May 23, 1878.

LIEUTENANT: I have the honor to submit the requested information in regard to the velocity of wind on stated dates and hours, as far as the records now at this station enable me to do so. I have written to the Chief Signal Office for the missing data [*i. e.*, for May 7 to May 14, 1878].

Elevation of anemometer above ground, 40′ 7″.

Date.	Time.	Hourly velocity.					Total number of miles.	Average hourly velocity.
		10 to 11.	11 to 12.	12 to 1.	1 to 2.	2 to 3.		
May 21	10.00 a. m. to 2.00 p. m.	12	10	13	12	....	47	11.75
May 22	10.00 a. m. to 3.00 p. m.	23	19	22	20	15	99	19.80
May 23	10.00 a. m. to 12.00 m.	18	13	....	....	....	31	15.50

Very respectfully, your obedient servant,
P. J. HUNEKE,
Sergeant Signal Service United States Army.

D. A. LYLE,
Lieutenant of Ordnance,
Sandy Hook, N. J.

IV. REMARKS ON THE EFFECT OF A CURRENT UPON THE SHOT LINE.

After communication has been established between the shore and a stranded vessel by means of the shot-line, another troublesome factor often intrudes itself into the problem. By this is meant the effect upon the line of an inshore current running parallel to the coast and between the shore and vessel, commonly called by surfmen the "set."

There is little doubt that the influence of this current has been usually underrated in those attempts to haul off a whip-line or hawser which have failed. No definite calculations upon the effect of this current can be made at the present time from the lack of the necessary experimental data. This subject has already engaged the attention of the Chief of the Life-Saving Service, and steps have been taken for the purpose of eliciting information upon this important point.

PART IV.

HISTORICAL.

NOTE.

This part of the report is devoted to the history and use of the Manby apparatus, to some others of more recent date, and to the Boxer life-saving rockets.

The Manby apparatus is described in detail in books not generally accessible to those most interested in the results of Captain Manby's experiments.

The same may be said in regard to the Boxer life-saving rocket, which is now generally used in England, and is also used to some extent in this country.

The descriptions transcribed have been accredited to the sources from which they were taken, and have, by preference, been given in the phraseology of their authors.

These extracts exhibit the results of many valuable experiments. It is of the first importance that those charged with the use of such apparatus should be in possession of all the knowledge upon the subject that can be obtained.

The desire of the writer to place these instructive papers within the reach of the keepers of life-saving stations must be his apology for introducing them.

D. A. L.

CHAPTER I.

SECTION I. HISTORY OF MANBY'S LIFE-SAVING APPARATUS.

[Extract from Encyclopædia Britannica, eighth edition, Vol. XIII, pp. 440–445.]

It had occurred to Lieutenant Bell, in 1791, that a rope might be thrown from a ship which had struck, by means of a mortar carrying a heavy shot, and upon the principle of the gun-harpoon; and he showed the practicability of the suggestion by an actual experiment, in which a deep-sea line was carried to a distance of about 400 yards. (Trans. Soc. Arts, XXV, p. 136.) He recommended that every ship should be provided with a mortar capable of carrying such a shot, and observed that it might be placed on a coil of rope to be fired, instead of a carriage. The line was to be coiled on handspikes, which were to be drawn out before the mortar was fired.

In 1792 he received a premium of fifty guineas from the Society of Arts (Transactions, X, p. 204); and he obtained his promotion in the ordnance as an acknowledgment of his merits. The shot was to weigh about 60 pounds or more, and the mortar 5 or 6 cwt. The experiments of the French artillery at Lafere were subsequent to those of Mr. Bell, though they have sometimes been quoted as the first of the kind. * * *

The means to be employed by persons on shore, in cases of shipwreck, depend either on projecting a line over the ship or on the use of a life-boat. Mr. Bell had cursorily observed that a line might be carried over a ship from the shore by means of his mortar; but for the actual execution of this proposal, in a variety of cases, we are indebted to the meritorious exertions of Capt. G. W. Manby, whose apparatus, according to the report of a committee of the House of Commons, dated in March, 1810, appears "to be admirably adapted to its purpose, and to have been attended with the fullest success in almost every instance." In consequence of this report, Captain Manby was thought worthy of a Parliamentary reward; and he afterwards published a description of his inventions, under the title of "An Essay on the Preservation of Shipwrecked Persons. 8vo. London, 1812." He had previously received a gold medal from the Society of Arts in 1808 (Transactions, XXVI, p. 209). His success makes it expedient to extract from his essay a detailed description of the apparatus, and it will be easy to make it somewhat more intelligible by a slight alteration of the order of arrangement:

The method of affixing a rope to a shot for the purpose of effecting communication, when projected from a piece of ordnance, over a stranded vessel, was at length succeeded in by introducing a jagged piece of iron, with an eye at the top, into a shell, and securing it by filling the hollow sphere with boiling lead; and in another way, by drilling a hole through a solid ball, and passing a piece of iron, with an eye to it, as before described, to the bottom, where it should be well secured by riveting.

To produce the means of connecting a rope to a shot, and prevent its being burnt, and rendering it "irresistible" to the powerful inflammation of gunpowder, was the labor of infinite time, and the number of experiments to accomplish it is beyond all possible conception. Chains in every variety of form and great strength breaking, proved that it required not only an elastic but a closer connected body. At length some stout platted hide (Fig. 5, Plate XLVII), woven extremely close to the eye of the shot, about 2 feet in length beyond the muzzle of the piece, and with a loop at the end to receive the rope, happily effected it.

This method is certainly desirable, as the rope may, immediately [as] it is required, be affixed to the loop, and applied in service. The form of the platted hide may likewise be woven by twisting it in the manner that the lashes of whips or ropes are spun. There is another method, by passing a rope through a case of leather, taking the greatest care that it is so well secured at the eye of the shot as to leave no room for the *slightest play*, as is represented by the annexed *barbed shot*.* (Fig. 6, Plate XLVII.)

When the crews of the distressed vessel are incapable of availing themselves of the benefits arising from communication, they having previously lashed themselves in the rigging to prevent being swept away by the sea, which is repeatedly breaking over them, and when, from long fatigue and the severity of the storm (on which occasion it too frequently occurs), they totally lose the use of their limbs and are rendered incapable of assisting themselves in the slightest degree, the advantages of this shot are, that, on its being projected over the vessel and the people of the shore hauling it in, it firmly secures itself on some part of the wreck or rigging, by which a boat can be hauled to the relief of the distressed objects, and by the counterbarbs it is rendered impossible [that it should] give up its hold, or slip, while that part of the wreck remains to which it has secured itself.

Among the many that have been saved by this shot, the following are testimonials of a few of the cases:

"We, the crew of the brig Nancy, of Sunderland, do hereby certify that we were on board of the said vessel when she was stranded on the beach of Yarmouth, on Friday morning, the 15th of December, 1809, and compelled to secure ourselves in the rigging to prevent being swept away, the sea running so high on the vessel. And we do further declare and certify that Captain Manby, firing a rope with a hooked shot, securely holding on the wreck, enabled a boat to be hauled from the shore over the surf to our relief, otherwise we must inevitably have perished."

This certificate is attested by six signatures.

Facilitating communication is at all times of importance; but when the stranded vessel is in momentary danger of going to pieces, this point becomes a consideration of extreme urgency. I feel a persuasion that this particular service can only be carried into effect by a small and light piece of ordnance, the range of which is conse-

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*The writer can find no record of the adoption by any government or society of Manby's barbed shot, or of any other anchor shot. Thus far the use of this class of projectiles seems to have been limited. Many practical difficulties in regard to their efficient use yet remain to be overcome.—D. A. L.

quently very inconsiderable, when compared with that of a large and heavier piece, as it is weight alone that conveys the rope. In order, therefore, to increase the powers of a shot projected from a small mortar, its natural form must be varied so as to give it additional "preponderance." The annexed shape, in the form of a pear (Fig. 3), has been used with the greatest success; for, by the increased weight, the shot's momentum and power over the line is in consequence considerably augmented in its range; and when made to fit the piece as close as possible, a great increase of velocity is likewise produced from that decrease of windage.

Fig. 3.

Portability in the construction of a piece of ordnance (as just described) is the very essence of this service; and communication with the stranded vessel or wreck may be effected with a cord, by which cord a rope can be conveyed, and by that rope a hawser or cable sent to the distressed vessel; for this purpose the annexed was constructed. (Fig. 7, Plate XLVII.)

A person completely equipped with every necessary apparatus to effect communication with a vessel driven on a lee shore, * * * the horseman, fully equipped, traveled a mile and a half, the howitzer was dismounted, and the line projected 153 yards, in six minutes.

The application of a small piece of ordnance likewise offers particular advantages, capable of being employed from a boat to go to the assistance of a vessel grounded on a bar when running for a harbor, the necessity of which repeatedly occurs, and was twice witnessed at Blakeney on the 10th of November, 1810, when boats endeavored to go to their relief, and were enabled to get out of the harbor on the ebb tide, within 20 yards of the vessel; but it was found impossible to approach them nearer. Had such boats been provided with a piece of this description, and the same firmly secured on a stout piece of plank, by the holes left at each corner of the iron bed, they might have projected a small rope, coiled in a crate or basket made to the form of the bow of the boat; and the persons in the boat so provided would not have remained the distressed spectators of the untimely end of their fellow-creatures without being able to afford them the smallest relief, although so little was then wanted for that desirable purpose.

Although advantages have been pointed out in the use of these small mortars, it is necessary to be kept in remembrance that they are produced for particular services, as the nature of the coast and circumstances attending the distressed vessel will direct what piece is best adapted to the undertaking.

To enable the mind to form a judgment of what can be effected by other pieces, the following are the minutes of experiments made with a 5½-inch brass mortar, stating the quantity of powder used and distance the ropes were projected against a strong wind, at the angle of 17° (elevation), weight of the mortar and bed about 300 pounds:

Ounces of powder.	Yards of 1¼-inch rope.	Yards of deep-sea line.
4	134	148
6	159	182
8	184	215
10	207	249
12	235	290
14	250	310

With a short 8-inch mortar, the weight of which and bed was supposed to be about 700 pounds, the angles of elevation uncertain:

Ounces of powder.	Yards of deep-sea line.	Yards of 2-inch patent Sunderland rope, capable of hauling the largest boat from a beach.
32	439	....
32	479	....
32	....	336

Directions for using the apparatus.—When the rope (which should be pliant and well stretched) is brought on the beach or cliff opposite to the stranded vessel, the most even spot, and free from projecting stones, should be selected to lay it on, and great care be taken that no two parts of it whatever overlay or even touch each other, nor must it be laid in longer lengths than of two yards. But to project a small line or cord, it will be necessary, if it is required, to contract the faker to half a yard at most, to avoid the jerk received at the end of each right line. The best method, with such a escription of cord, is to lay it on the ground in the most short and irregular windings to relieve it from this powerful impulse. To prove the effect of the impulse on a rope, if it is faked in lengths of 10 or 15 yards, it will break each time, as it then becomes a most powerful pendulum. These precautions are absolutely necessary to the success of the service.

The following has, after various trials, been found a certain method of laying the rope, and placing it into compartments. (*French Faking*, Fig. 1, Plate XLVIII.)

A particular attention to this mode will never fail with a good rope, when the impediments are removed that might otherwise obstruct its rapid flight. Its advantages are, that it will allow the eye rapidly (yet correctly, *just before firing*, which is absolutely necessary) to pass over the different compartments, and at once discover if any fake has been displaced by the storm, or by any other casualty or accident come in contact with another part, which would destroy its application by the rope breaking.

It may likewise be coiled in the manner used in the whale-fishery, *whale lair*.(Fig. 2, Plate XLVIII); and in the method called *chain faking* (Fig. 3, Plate XLVIII). It is, however, necessary to add that great attention is required in laying it agreeably to the two latter methods, arising not only from the arm being liable to get under certain parts of the rope, and thereby displace it, but from the great anxiety of mind natural on these occasions, where the lives of fellow-creatures are literally dependent on the correctness with which the rope is laid. It is therefore extremely difficult, in a moment of agitation, to determine whether any overlay has taken place, an error that would infallibly destroy every endeavor, and occasion even the fate of those whose lives we might be exerting ourselves to preserve. Could persons in the performance of this service be always collected, the two latter methods would have a decided advantage over the first mode of faking, they being laid in a much less space of time. As all these methods of laying the rope occupy time to place it with the care necessary, and as it has repeatedly happened that vessels, very soon after grounding, have gone to pieces, and all hands perished, it was necessary to produce a method of arranging the rope so that it could be immediately projected as soon as it arrived at the spot; and none proved so effectual as when brought ready in a basket (Fig. 4, Plate XLVIII).

In this case, the rope should be most carefully laid in alternate tiers or fakes, no part of it overlaying, and it should be well secured down, that in traveling it be not displaced; but, above all, no mistake must happen in *placing the basket properly*. For example, that the end of the basket, from which the shot hangs in the above figure, should be previously marked, and must be placed toward the sea or wreck, that the rope be delivered freely, and without any chance of entanglement. It will be scarcely necessary to add, there will be several tiers of the rope when laid. The utmost care and attention are required in laying the rope in tiers with strict regularity, to prevent entanglement. The next is the application of the mortar. If the wind is sideways to the shore, it must be pointed sufficiently to windward to allow for the slack of the rope lighting on the object, as the rope will, of course, be considerably borne to leeward by the effects of a strong wind, and by its being laid at a low elevation insures the rope falling against the weathermost part of the rigging. While this service is performing, great care should be taken to keep the mortar dry; nor should it be loaded until everything is ready. When that is done, it should be primed; but as it would be impossible to do it with loose powder in a storm, a tube is constructed in the simplest manner of common writing paper (the outer edge being cemented with a little gum) in this form (Fig. 5, Plate XLVIII). It is filled with meal gunpowder, made into paste with spirit of wine; when in a state of drying, run a needle through the center, and take care the hole is left open, for, on the tube being inflamed, a stream of fire darts through the aperture with such force as to perforate the cartridge. The mortar should then instantly be fired; and in order to lessen a difficulty that has often occurred in performing this service, a pistol may be used, having a tin box over the lock, to exclude the effect of wind or rain on the priming; and the muzzle being cut [obliquely], dilates the inflammation, so as to require but little exactness in the direction of the aim.

We will suppose the communication to be secured, although it is scarcely necessary to offer any other assistance than that of a rope, as the inventive genius of a sailor will supply everything else; yet I could expect the people on shore to get a boat ready for meeting the vessel when driven on a beach. It is the promptest and most certain method of relief, as well as the most easy to be accomplished; for by hauling her off with the rope projected, the boat's head is kept to the waves, and not only insures safety by rising to the surge, but prevents her upsetting.

When the rope attached to the shot (not having barbs to it) is fired over the vessel and lodges, let it be secured by those on board, and made fast to some firm part of the rigging or wreck, that they may haul off a boat by it; but should there not be any boat, then haul on board by the projected rope a larger one, and a tailed block, through which a smaller rope is rove. Let the large rope be made fast at the masthead, between the cap and the top of one of the lower masts, and the tailed block a little distance below it; but, if the masts should have been cut or carried away, then it must be made fast to the loftiest remaining part of the wreck. When this is done, there will be supplied from the shore a cot, hammock, netting, basket, hoop, or any of the numerous resources of seamen which will run on the larger rope and be worked by the people on shore. If a cot be used, the men may beso securely fastened to it as to preclude all possibility of falling out, and then be brought from the wreck, one by one, in perfect safety.

While communication is gaining, three stakes should be driven into the ground in a triangular position, so as to meet close at the heads to support each other. As soon as communication has been effected by the crew of the vessel and they have secured the line attached to the shot made fast to these stakes, the crew will haul on board by it a large rope and a tailed block, through which a smaller rope is to be rove, both ends of which (the smaller rope) are to be kept on shore. When they have secured these on board and the larger rope is rove through the rollers, let a gun-tackle purchase be lashed to it, then lash the purchase to the stakes. By the means of the purchase the larger rope may be kept at a fit degree of tension; for, if care be taken to slacken the purchase as the ship rolls out to sea, the danger of the rope being broken will be guarded against; and, on the other hand, if the purchase be gathered in as the ship rolls toward the shore, the slackness of the rope, which would prevent the cot traversing as it ought to do and plunge it in the water more than it otherwise would, will be avoided.

Supposing neither boat nor cot apparatus at hand, first cast off the shot from the projected rope, and with a close hitch let it be put over the head and shoulders of the person to be saved, bringing it close under each arm, drawing it tight, *observing particularly the knot is on the breastbone;* for, by having the knot in that position, on the people of the shore hauling the person from the wreck he will naturally be on his back, consequently the face will be uppermost to sieze every moment for respiration after each surf has passed over the body.

If circumstances compel recourse to this method, care must be taken to free the rope from any part of the wreck and to jump clear away; but should there be more than one on board, each man should make himself fast in the same way about four feet from the other and join hands, all attending to the same directions.

For giving relief to vessels stranded on a lee shore in a dark and tempestuous night.—It will be requisite, first, to devise the means of discovering precisely where the distressed vessel lies when the crew are not able to make their situation known by luminous signals; secondly, to produce a method of laying the mortar for the object with as much accuracy as in the light; thirdly, to render the flight of the rope perfectly distinguishable to those who project it and to the crew on board of the vessel, so that they cannot fail of seeing on what part of the rigging it lodges, and consequently have no difficulty in securing it.

To attain the first object, a hollow ball was made to the size of the piece, composed of layers of pasted cartridge-paper of the thickness of half an inch, having a lid on the top to contain a fuse (Fig. 6, Plate XLVIII), and it was then filled with about fifty luminous balls of star composition and a sufficient quantity of gunpowder to burst the ball and inflame the stars. The fuse fixed in the ball was graduated to set fire to the bursting powder at the height of 300 yards. Through the head of the fuse were drilled holes at equal [distances], to pass through them strands of quick-match, to prevent the possibility of any accident from the match falling out or from its not firing the fuse. On the stars being released, they continue their splendor while falling for near one minute, which allows ample time to discover the situation of the distressed vessel. During the period of the light a stand with two upright sticks (Fig. 7, Plate XLVIII), painted white, to render them more discernible in the dark, was ready at hand and pointed in a direct line to the vessel.

A shell affixed to the rope, having four holes in it to receive a like number of fuses (headed as before described), and filled with the fiercest and most glaring composition, which, when inflamed at the discharge of the piece, displayed so splendid an illumination of the rope that its flight could not be mistaken.

To get a boat from a beach over the surf.—The importance of going to the relief of ships in distress at a distance from the land, or for taking off pilots, was viewed as of the highest consequence by the elder brethren of the Trinity House, and offered to my particular attention by several distinguished characters. After numerous experiments to accomplish it in various ways, the mode following was most approved: About forty fathoms of 2½-inch rope, made fast to two moving anchors, was laid out parallel with the shore, at a distance beyond the sweep of the surf; to the center of this rope was made fast a buoy, of sufficient power to suspend the great rope and prevent it from chafing on the sand, rock, or stones, as well as embedding, a circumstance that has rendered it impossible on a sandy or shingly coast to heave out an anchor with a rope to it from the shore. As this service should be performed in fair weather (to be prepared for the storm,) it may be regulated with the greatest exactness, and should take place at the top of high water, that the upper part of the buoy may be at the full stretch of its power, and only seen at that time. Should the shore be extremely flat, it will be desirable to place another set at a sufficient distance beyond the first to insure the operation of this method in any state of the tide.

The royal mortar, being brought to the spot, is to be pointed in the direction for the buoy, and should be laid at a very low elevation, but such as to insure the range; for the more it is depressed the less slack of rope there will be from the parabola formed in the shot's flight; the basket with the rope ready laid (having a barbed shot to it) is to be placed in the front of the mortar; on its being fixed, instantly haul the slack of the rope in, to prevent the effect produced on it by a strong tide; which being done, let the remainder be gently hauled in to insure the shot's grappling with the great rope; when that is caught and hooked, a power will be acquired fully adequate to the service.

As a cast-iron anchor appears particularly adapted to this method, and would be much cheaper than hammered, Fig. 8, Plate XLVIII, is a plan of one which the honorable the navy board approved, and allowed me to cast at their expense for the purpose of making the experiment.

When a vessel is in that extreme and perilous situation, driven under a rugged and inaccessible cliff, and in danger of going soon to pieces, the most prompt method I should suggest is by lowering to the crew a rope with stiff loops spliced into it (Fig. 9, Plate XLVIII), at the distance of a foot and a half from each loop, of sufficient size to contain the foot, by which they can ascend as a ladder.

This rope ladder is capable of being projected, and one of an inch and a half rope was thrown from a mortar 194 yards. It might also, from the simplicity of its structure, be extremely useful in escaping from a house on fire. By making one end fast to the leg of a bed or a table, the person would come down from the window in safety, and with much less difficulty and quicker than with the common rope ladder, which is heavier and more unwieldy. It has great advantages when employed in saving shipwrecked men in situations just described, when, from extreme cold and almost benumbed limbs, it would be impossible for them to climb up a rock or ascend it even by the aid of a common rope. The holds thus spliced in will support both hands and feet.

The report of the committee of the House of Commons contains also a paper of instructions for the managers of Captain Manby's apparatus on shore, which are somewhat more minute than the directions published in his essay. For example:

If the wind be sideways to the shore, the mortar must be pointed sufficiently to windward to allow for the slack of the rope lighting on the object, as the rope will of course be borne considerably to leeward by the effect of a strong wind.

The distance your judgment decides the vessel to be from the shore should regulate the charge of powder as stated in the scale, taking just a sufficient quantity to clear the object. An attention to this will be more certain of your effecting communication and guarding against the danger of the rope breaking or any other circumstance that might prevent the successful performance of the service. The elevation of 15° is to be preferred, particularly if the wind is sideways, pointing the mortar sufficiently to windward, as the rope would then fall against the weathermost part of the rigging of the stranded vessel.

When a vessel is driven on shore in the night, you will flash gunpowder as often as convenient on your way. This will animate the crew and denote to them you are coming to their assistance. On getting to the spot where you have reason to suspect the vessel lies, as you are not able to discover her from the extreme darkness, and if the people on board cannot [make known] their situation by luminous signals or noises (which they will be directed to make if possible), you will lay the mortar at a very high elevation and fire a light ball.

Just before you fire (the rope) it would be advisable to let off a blue light to put the crew on their guard, to look out, and be ready to secure the rope. The service can be performed with a carronade.

In Chapter IV we have a copy of directions to persons on board vessels stranded on a lee shore, proposed to be delivered to the masters at the custom-house. It is observed that even snapping a pistol, when the powder is wet, may sometimes afford a signal visible on shore from the sparks of the steel alone. The other parts of the directions will be supplied by those who understand the principles of the proposed mode of relief.

Rockets have of late years been much employed instead of the mortar in Manby's apparatus for throwing a line to a ship in distress. "Dennett's rocket apparatus" is supplied to many stations along the coast. The only advantage the rocket has over the mortar is its greater portability;

for, being much lighter, it can be used with greater facility among rocky cliffs, and in positions difficult of access. The disadvantages of rockets are, that they are somewhat uncertain, sometimes exploding as soon as ignited, to the danger of the by-standers; and they are also liable to deteriorate from the effects of damp or of age. Moreover, being expensive, they cannot be often employed in trials, so as to keep up the practice of the people employed in using them. The range of a shot from a 24-pound mortar, which is the ordinary size, is about the same as that of a 12-pound rocket, which is the largest in use. As the management of the mortar and rocket apparatus is much better understood by the officers and men of the coast-guard service than by ordinary boatmen and fishermen, it has been almost entirely left in their hands, and is provided by the board of customs.

Several inventions, or variations, in the Manby apparatus may be just glanced at. M. G. Delvigne uses a howitzer instead of a mortar, while a portion of the line to be carried is contained in the projectile. Mr. Greener has a method of discharging a rocket, with a line attached, from a light harpoon-gun. When discharged, the rocket ignites, and is said to prolong the range to a greater distance than if the gun or rocket were alone employed.

Captain Jerningham, R. N., has an anchor of a particular form, which he proposes to fire from a Manby mortar in sufficient numbers to afford the means of hauling a life-boat through the surf.

Mr. A. G. Carte employs a war-rocket instead of a Dennett rocket.

SECTION II.—MANBY'S SHOT.

[Extract from "Ammunition," by Captain Majendie, R. A., published in London in 1867.]

1. *History.*

The plan of saving lives in cases of shipwrecks by means of a line thrown so as to establish a communication between the ship and the shore seems to have been first proposed about the close of the last century, by Lieutenant Bell, Royal Artillery.[1] This officer proposed to project from a mortar a spherical shell filled with lead and having "a deep-sea line" attached. Some trials were made with the apparatus in 1791,[2] before a committee of the Society for the Encouragement of Arts, Manufactures, and Commerce, and the success of the experiment was so marked and unequivocal[3] that in the following year the society adjudged the inventor a reward of fifty guineas.[4]

Lieutenant Bell's claim to the priority of the invention was also recognized by a committee of artillery officers assembled at Woolwich in May, 1811, to report on "Captain Manby's invention for saving the lives of shipwrecked mariners," this committee reporting that they feel that—

> They should not entirely discharge their duty were they to omit observing that the committee of the honorable House of Commons do not seem to have been informed of all the means proposed by the late Lieutenant Bell, of the Royal Artillery, for the

[1] It appears from Kane's List that Lieutenant Bell was promoted from sergeant to a lieutenancy in the invalid battalion.—(Kane's List of the Royal Regiment of Artillery, p. 21.)

[2] August 29, 1791.—(Repertory of Arts for 1808, vol. xiii, p. 315.)

[3] The line was thrown to a distance of 400 yards.—(*Ibid.*, 315.)

[4] A full account of the experiments and drawings and a description of the apparatus are given under the head of "Account of a method of throwing a rope on shore by means of a shell from a mortar on board a vessel in distress." By Lieut. John Bell, Royal Artillery, in the Repertory of Arts, 1808.

attainment of the same laudable object; it being stated in that honorable committee's report that "Mr. Bell's invention is totally inapplicable in all cases of vessels being stranded," and that Captain Manby's invention is new.[5]

In justice, therefore, to the memory of Lieutenant Bell, and to his surviving family, and with respectful deference due to the judgment of the honorable committee, the concluding of the seven observations inserted in one of the papers of Lieutenant Bell's account to the Society for the Encouragement of Arts, Manufactures, and Commerce, is subjoined in his own words, as published in that society's Transactions, and in the Repertory of Arts for 1808, p. 318, by which observations it appears *that Lieutenant Bell then proposed what Captain Manby has since so ably and so successfully carried into effect.*[6]

The passage "in Lieutenant Bell's own words," referred to by the committee is as follows:

There is every reason to conclude that this contrivance would be very useful at all ports of difficult access both at home and abroad where ships are liable to strike ground before they enter the harbor, as Shields Bar, and other similar situations, when a line might be thrown over the ship, which might probably be the means of saving both lives and property; and, moreover, if a ship was driven ashore near such a place, the apparatus might easily be removed to afford assistance, and the whole performance is so exceedingly simple that any person seeing it done would not want any further instruction.[7]

It is thus placed beyond doubt that Lieutenant Bell's proposition was not limited to throwing a rope from a vessel to the shore, but included the reverse operation of throwing a rope from the shore to the assistance of a stranded vessel, and this by almost exactly the same means as were subsequently successfully applied by Capt. G. W. Manby, R. N.

But if the merit of having been the first to propose this plan cannot, in justice, be conceded to Captain Manby, it is at least indisputable that that officer was the first practically to apply it, and that by his exertions the details were matured and the idea successfully carried into effect;[8] for, in spite of the success which had attended Lieutenant Bell's experiments, his proposition does not appear ever to have received official recognition, or to have been practically entertained or adopted.[9]

Captain Manby worked out the subject with great care and ingenuity, and in 1811 his plan was experimented upon by the committee of artillery officers before alluded to.[10]

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[5] This allusion to the opinion of the "committee of the honorable House of Commons" has reference to a report made by a committee of that house in 1810, in which Lieutenant Bell's claim to any merit attaching to priority of invention is ignored, and his proposition spoken of in the words quoted in the text, viz, as "totally inapplicable in all cases of vessels being stranded," while Captain Manby's proposition is treated as original. The incorrectness of this opinion is sufficiently shown by the passage from the report above quoted and by Lieutenant Bell's own remarks, which I have given farther on.

[6] The Annual Register for the year 1811, p. 521.

[7] Repertory of Arts for 1808, vol. xiii, p. 318.

[8] "Lieutenant Bell then proposed what Captain Manby has since so ably and successfully carried into effect."—(Report of Artillery Committee, Annual Register for 1811, p. 521.) (See, also, extract from Ency. Brit., xiii, &c., on a preceding page, beginning as follows: "Mr. Bell has cursorily observed that a line," *et seq.*—D. A. L.)

[9] It is not impossible that this arose from the fact that the inventor died shortly afterwards, in 1798.—(See Kane's List of Officers of the Royal Regiment of Artillery, p. 21.)

[10] This committee was composed of the following field-officers of artillery: Lieutenant-General Lloyd, Major-General Ramsay, Colonel Borthwick, Lieutenant-Colonel Rion, Lieutenant-Colonel Spicer, Lieutenant-Colonel Colebrooke, Lieutenant-Colonel Beerer, Major Gold, Major Buckner. Their report bears date, Royal Arsenal, Woolwich, 22d May, 1811, and is entitled "Report from the committee of field-officers of artillery, containing an account of the experiments made at Woolwich on the 18th and 20th May last, on Captain Manby's invention for saving the lives of shipwrecked mariners." Printed by order of the House of Commons.—(Annual Register for 1811, pp. 51- to 521.)

The results of these experiments were in the highest degree successful, and the adoption of his propositions was recommended.[11]

This recommendation led to an address being moved in the House on the 14th June, 1811, to the Prince Regent, "praying that he would be graciously pleased to order that Captain Manby's invention should be stationed on different parts of the coast, &c., and assuring him that the House would make good the expense."[12]

The propositions which Captain Manby had submitted to the committee were eight in number, from which the following are selected as being the only ones having a direct bearing upon the history of the present service life-preserving apparatus. A small brass howitzer, 3-pounder bore, which, with its carriage, weighed 62 pounds, and was strapped on to the fore part of the saddle of a mounted man, 200 yards of log-line being coiled upon a deal frame and slung as a knapsack on the back of the horseman, the line being projected from the howitzer by means of a "*kind of pear shot, 1½ diameters in length,*" and weighing 4 pounds 12 ounces 12 drachms. By means of this shot, and with a charge of 2½ ounces of powder, the howitzer threw the line 143 yards. "Next, a method of affording certain relief to vessels stranded in the darkest night, with an improved mode of rendering the life-rope more distinguishable." This arrangement consisted, firstly, in firing what Captain Manby called "light balls," viz, paper shells filled with "stars," from a mortar, to throw a light over the scene; and, secondly, in projecting from the 5½-*inch mortar*, charged with 8 ounces of powder, a deep-sea line attached *to a shell with four fuses in it.*[13]

He also suggested at this time connecting the rope to the shot by means of "*some stout strips of hide plaited extremely close at the eye.*"[14]

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[11] The committee were of "opinion that they cannot too strongly recommend an invention, the partial application of which has been attended with such beneficial effects. * * *. It is also the wish of the committee to render their full tribute of praise to Captain Manby for his ingenuity in so much improving and bringing into practical use this invention, to the perfecting of which he has so zealously and skillfully devoted himself."—(Annual Register for 1811, p. 520.)

[12] The address was moved by Mr. Wilberforce.—(Annual Register for 1811, p. 521.)

[13] Captain Manby's other propositions and experiments, briefly described, were as follows: An arrangement for firing, "by chemical agency, of two substances, which ignite from coming into contact with one another"; a plan for laying and firing from a boat "when the sea is continually breaking over it"; an arrangement by which the rope is coiled in a basket and then carried to the spot required; a rope-ladder "intended to be projected or conveyed to a crew wrecked under a cliff," consisting of a single rope with loops spliced to it at convenient distances for the support of the feet and hands when climbing; "the distance a deep-sea line can be projected from the shortest 8-inch mortar" (in the course of this experiment a deep-sea line, with 68-pounder shot attached, was projected 439 yards; charge, 2 pounds; elevation, 23°); the distance an 8-inch barbed shot, "with a patent Sunderland 2-inch rope attached," could be projected (the distance was 336 yards).

These propositions will be found *in extenso*, as I have already intimated, in the Annual Register for 1811, pp. 518 to 521. Much interesting information will also be found on the subject of Captain Manby's original propositions in the Encyclopædia Britannica, vol. xiii, pp. 441 to 444, where copious extracts are given from an essay published by Captain Manby himself in 1812, entitled "An Essay on the Preservation of Shipwrecked Persons."

[14] Captain Manby's own words respecting this part of the subject are as follows: "To connect the rope to the shot and prevent it from being burned by the powerful inflammation at the discharge of the mortar was most essentially necessary, and success resulted from almost innumerable experiments; chains in every variety of form and size broke, and proved that not only strength, flexibility, and elasticity, but a body at once continuous and entire, was required. At length some stout strips of hide, plaited extremely close at the eye, happily effected the object so indispensably wanted." (Observations, with Directions on the Method brought into use by G. W. Manby.) See also Encyclopædia Britannica, vol. xiii, pp. 441 to 444, where nearly the whole "observations" (extracted from Captain Manby's published essay) are given with illustrations.

It is, therefore, placed beyond doubt that Captain Manby's original propositions included, among other contrivances, 1st. A pear-shaped or oblong shot; 2d. A shell of 5½-inch caliber; 3d. A shell containing four fuses; 4th. A plaited hide thong for the purpose of connecting the line to the projectile.

The immediate connection of these details with the history and origin of the present service pattern, Manby's shot, will at once be perceived, the projectile now used being of an oblong form, 5½-inch caliber, containing four fuses, and having a plaited hide thong. There is no record of the exact form in which Captain Manby's original propositions were adopted, but it would seem, from the "Observations," &c., printed respecting his inventions, as if the majority of them were approved and introduced. It is certain, however, that many were allowed to lapse and become practically obsolete; and it appears that the two projectiles most used were a spherical 24-pounder shot, or shell filled with lead, having an eye-bolt riveted to it, furnished with a stout twisted hide thong, for the purpose of attaching the rope, and a grapnel or oblong shot, with a barbed iron staple, to which the rope was fastened, projecting from one end.

Some demand for this class of stores in 1857-'58 led to experiments being instituted by Colonel Boxer, Superintendent of the Royal Laboratories, the result of which was the introduction and issue, in 1859 or 1860,[15] of an improved and modified Manby's shot, and the pattern then introduced is, with the exception of some slight alterations which were subsequently (in 1863[16]) made in the thong, the present service pattern.

Spherical Manby's shot are not, however, altogether obsolete, a pattern of a 6-pounder having been deposited in the model-room of the Royal Laboratory in 1862,[17] to govern the supply on special demand.

Without entering upon a detailed description of the different plans proposed, from time to time, for establishing communication between a stranded vessel and the shore, it will, perhaps, be well to mention that Manby's apparatus is not the only one which has been used for this purpose. The following passage from the Encyclopædia Britannica will sufficiently indicate the variety and scope of these inventions. * * * [Here follows an extract from the Encyclopædia Britannica, already quoted in these pages.—D. A. L.] * * * Kites have also been suggested as a simple means of carrying a line from[18] a wreck to the shore,[19] and are manufactured for this purpose by the "Shipwrecked Mariners' Society, London Bridge."

The board of trade employed to a great extent, until 1865, Dennett's rockets, in preference to Manby's shot; and there can be no question hat the balance of advantages inclines strongly to the side of the rockets.[20]

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[15] I cannot discover the precise date when these shot were introduced, but it appears that the first issues of them were made in May, 1860, for the use of the coast guard at Lowestoft; and this marks their first *practical* introduction. The proportions of these shot, and of the different stores, fuses, lines, &c., which together constitute a complete "Manby's apparatus," were not officially determined or laid down until the 25th of August, 1862. (See War Office Circular 730, par. 633.)

[16] 12th October, 1863.

[17] 13th January, 1862.

[18] Evidently they are not generally available for carrying a line in the other direction, as the wind will almost invariably be blowing toward the shore.

[19] The Times, 10th of December, 1864, contains two letters on the subject.

[20] Rockets are more portable, as also is the apparatus from which they are fired; they carry their own illuminating agent, and are thus independent of fuses, do not require so long a line as a shot fired from a mortar, where the angle of elevation is greater; and, finally, are more accurate, owing principally to the fact that the deflection caused by the action of the wind upon the line is in a great measure corrected by the rocket having a tendency to fly up in the wind's eye.

In 1832 (3d December) the ordnance select committee experimented with some

In 1865 a rocket proposed by Colonel Boxer, R. A., was adopted by the board of trade to supersede Dennett's rocket, to which it is preferred, because, "1st. The range of Colonel Boxer's rocket is little, if at all, inferior, and in every other respect it is much superior; 2d. The combination of Mr. Dennett's two rockets is very objectionable, and from their velocity they frequently carry away the line, and sometimes both do not ignite. They are also double the expense."[21]

These rockets are fast superseding Manby's shot at all stations, and the latter may shortly be expected to become entirely obsolete.

There are two natures of Manby's shot in the service: the 24-pounder oblong (Pl. XXXVIII, Fig. 1), or "cylindrical," and the 6-pounder spherical shot. They are designated 24-pounder and 6-pounder, respectively, from their calibers, not from their weights.[22]

The 24-pounder oblong, or "cylindrical" Manby's shot, is a cast-iron cylindro-conoidal projectile,[23] with a slightly rounded base,[24] and about 1¼ calibers in length.[25]

The shot is drilled down its longer axis for the reception of a wrought-iron bolt, which passes completely through the projectile from end to end,[26] and projects about five inches beyond the base, terminating in an eye, to which is attached a plaited hide thong 2 feet in length. Four holes (Plate XXXVIII, Figs. 1, 2), for the reception of "fuses,"[27] are drilled into the shot at the base, equidistant from one another and from the center of the base, and slightly inclining inwards.[28] These holes are

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Manby's and Delvigne's shot against Dennett's 9-pounder rockets, and "the result was a general conviction on the mind of everybody present, and shared by Mr. Delvigne, of the great superiority of the rockets over either of the other plans."

The rockets were fired singly and in couples at an angle of from 30° to 35°.

"The single rockets carried a line 240 yards, the double rockets 370 yards, with great steadiness of flight, and with less length and weight of line in proportion carried out than the pieces fired at 45°.

"The range obtained with Manby's apparatus, charge 12 ounces, was 200 yards; and with the same mortar firing Mr. Delvigne's elongated shot was 185 yards. The same shot, however, fired from the rifled 5½-inch howitzer at 28°, with 10 ounces, attained a range of 298 yards, but the line broke three times."—(Extract from Reports and Proceedings of Ordnance Select Committee, vol. i, p. 199.)

On the subject of the employment of rockets for carrying a line, see a work published at St. Petersburg, entitled "Application des Fusées au jet des Amarres Sauvetage, par Général-Major Konstantinoff," which contains a good deal of information upon this subject, and explains the construction of a rocket proposed by the author for this purpose very similar to the Boxer life-saving rocket.

[21] Report of Captain Robertson to the board of trade. The construction of this rocket and of the apparatus which is issued with it will be described in the section on rockets in a succeeding volume of this work.

[22] For weights, see farther on.

[23] Perhaps more strictly an obtuse cylindro-ogival.

[24] It is difficult to say whether this end should properly be called the "base" or the "upper end." When the projectile is placed in the piece this end is toward the muzzle, and is, therefore, strictly speaking, the "upper end," but the shot changes its position on leaving the piece, and what was the front of the shot in the gun becomes the base or hinder part during its passage through the air. Therefore, and as the term is a more convenient one to use, I have designated this end the "base" of the projectile. I have also hesitated between the terms "slightly rounded" and "nearly flattened" in describing the form of the base, but have selected the former as conveying, perhaps, a rather more correct impression of the actual shape.

[25] For actual dimensions, see Plate XXXVIII.

[26] A reference to the drawing of the section (see Plate XXXVIII, Fig. 2) will show the manner in which the bolt is secured to the shot, viz, by means of a projecting head or shoulder on the bolt, which is pushed into the shot from the base up to this shoulder, so much of the bolt as projects at the top of the shot being hammered down to form the head, and thus securely riveting the bolt into position.

[27] More properly lights (*vide infra*).

[28] The inclination given is just sufficient to throw the flame of the burnin fuses" free of the hide thong.

conical in form, and are about the same diameter as the fuse-holes of the 13 and 10 inch mortar shells.[29] They are about 3½ inches in length, and are roughed in the interior to afford a better hold to the fuses.[30]

The hide thong, or "strop," which is fastened to the eye-bolt, is made of four strips of raw horse-hide,[31] doubled through the eye and tightly plaited, the plait being further secured by being stitched in several places with hide.[32]

The end of the thong is formed into a loop, which is tightly woolded with fine tarred spun-yarn.[33]

The shot and bolt are painted black before issue; the thong is unpainted. These projectiles weigh (with thong) about 30½ pounds.

The 6-pounder spherical Manby's shot is rarely demanded, and is scarcely to be considered as a service projectile. It consists of a diaphragm shell filled with lead,[34] and having an iron loop fixed into it, to which is attached a thong similar to that of the oblong projectile. This shot has no fuse-holes. It is painted black before issue, and weighs about 8 pounds.

2. *Action of the Manby oblong shot.*

The action of the oblong shot is as follows: The end of a line[35] is made fast to the loop-hole of the thong; the rest of the line being carefully coiled either in a basket or upon the ground or deck,[36] and a fuse (Plate XXXIX, Figs. 1, 6) is placed in each of the four holes made for the purpose.

The fuses being uncapped, the projectile is placed in the piece[37] with

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[29] For the actual dimensions, see Plate XXXVIII, Fig. 2.

[30] This roughing is not effected in the same way as in mortar shells, by means of a sort of thread, but is done by cutting a number of shallow grooves about 0.2 inch apart around the sides of the holes.

[31] The hide is prepared with lime, and is technically known as "horse-hide-raw-lime." The strips are cut with a tapering toward each end, so as to give the required taper to the thong when completed. In the history of this projectile it has been mentioned that Captain Manby tried several materials for the thong before he adopted hide, and it is deserving of notice that Captain Jerningham, R. N., who carried on a large number of experiments with the apparatus, preferred manila-rope thongs to hide. In a report upon the subject he says, "Strops of manila rope were found to be the most serviceable."—(Captain Jerningham's report, Her Majesty's ship Cambridge, Devonport, April 27, 1860.)

[32] In a 4-plait of double hide. The hide known technically as "white horse," or "whit leather," is used for this purpose; it is the same material as is used for whip-thongs. Until 1863 fine wire was used for this purpose; hide is preferred to wire because the latter had a tendency to cut the thong.

[33] It was not woolded until 1863; by woolding the end, any chance of the line being cut is diminished.

[34] Diaphragm shells are used because there are no other shells of this caliber; and it has not been thought necessary to manufacture a separate projectile when a diaphragm shell answers the purpose perfectly well.

[35] The line generally used is a "deep-sea line"; but there is issued with each apparatus 113 fathoms of 1¼-inch rope. (See War Office Circular 793, par. 633.)

[36] The coiling of the line so that it may run out free without check is a matter of considerable importance. There are several ways of coiling it; in a basket, or, if the beach be even and free from large stones, as follows: The length of the fakes not to exceed two yards (Fig. 1, Plate XLIX), as if they are longer the rope is more liable to be broken "by the proportionately increased vibration."—(Instructions for the use of Manby's apparatus.)

Another way, as used in the whale-fishery, is as follows: [Shown in Fig. 2, Plate XLIX.—D. A. L.]

A third method, called "chain-faking," is sometimes employed. [See Fig. 3, Plate XLIX.—D. A. L.]

A fourth method is shown in Plate XL, Figs. 1, 2.

[37] A 5½-inch (Coehorn), mortar specially prepared (with a crutch for firing quill-friction tubes), was used for projecting these shot (see W. O. C. 793, par. 598) until 1866, but by 21-2-66, 51-20-8742, it was intimated that metal friction-tubes might be used with them. On an emergency they could be fired from a 24-pounder gun or howitzer.

its base toward *the muzzle*, and upon the discharge of the piece carries out the line, one end of which being retained, a communication is thus established between the vessel and the shore. The use of the hide thong is to remove the line from the immediate flash of the discharge, and so prevent it from being burned.[38]

The fuses serve, by the bright light which they give forth, to indicate the path of the shot and guide the firing party in laying the piece. The strength and direction of the wind must be considered in determining the direction to be given, the trajectory being affected by them to a very great extent, owing to the influence which the wind has upon the line.

With deep-sea line, and with the ordinary charge of 12 ounces, the range varies from 400 yards downward, according to the strength and direction of wind.[39]

The 6-pounder is used in the same way, with the exception that, having no fuses, the operation of fixing and uncapping them is dispensed with.[40]

These projectiles are mainly used to establish a communication between the shore and a stranded vessel,[41] but the principle is applicable to a variety of other purposes, &c.

3. *Charges for Manby's shot.*

The maximum charge for the 24-pounder oblong Manby's shot is only 12 ounces, giving, with 45° of elevation, a range from 400 yards downward, according to the strength and direction of the wind.[1] If a higher charge is used, the line is generally broken.[2] There are no data on the subject of the charge for the 6-pounder spherical Manby's shot. ("Ammunition (English), 1867," by Captain Majendie, R. A.)

[38] To connect the rope to the shot, and prevent it from being burned by the "powerful inflammation at the discharge of the mortar."—(Observations, with directions, on the method brought into use by G. W. Manby.)

[39] In some experiments carried on in the Royal Laboratory, 1859, with a charge of 12 ounces, elevation 45°, the range varied from 260 to 400 yards.

"For the Manby 24-pounder cylindrical shot the charge is 12 ounces, giving a range of about 300 yards."—(Captain Frazer's Notes on Matériel, p. 6.)

In Captain Manby's *Observations, with Directions, &c.*, he gives the following charges and ranges for the spherical 24-pounder shot. (As this shot consisted of a shell of 5½-inches caliber filled with lead, it must have weighed considerably over 24 pounds, and probably was about the same weight as the present oblong 24-pounder.)

Charge.	With deep-sea line.	With 1½-inch rope.
8 ounces	220 yards	180 yards.
10 ounces	270 yards	220 yards.
12 ounces	320 yards	250 yards.

It also appears that in the determination of these ranges the most unfavorable conditions had been taken, for in another part of his Observations Captain Manby says, "An iron mortar * * * will project a 24-pounder shot, with an inch and a half rope attached to it, 250 yards, or a deep-sea line 320 yards, *against the utmost power of the wind.*"

[40] No charge is laid down for the 6-pounder, nor are there any data to enable me to assign even approximate charges and ranges to this projectile.

[41] With respect to this, the natural and simplest application of the projectile, the value of the invention will be more readily perceived if we bear in mind that "the most fatal cases of shipwreck and the most frequent are those which occur within the distance of from 300 to 60 yards off the land."—(*Observations, &c.*)

Captain Manby quotes several instances in which lives have been saved by his apparatus; and doubtless our naval annals and the records of the board of trade would afford many other instances of its successful application.

[1] *Vide supra*, foot-note 39.

[2] In some *experiments* which were carried on in the Royal Laboratory at Woolwich in 1859 with elongated 24-pounder Manby's shot and deep-sea line, the line broke with a 1-pound charge. With a stouter line than deep-sea line (1½-inch rope, for instance) a heavier charge might perhaps be used.

4. *Fuse for Manby's shot.*

a. Old pattern fuse.

The Manby fuse was adopted at the same time as the Manby shot, viz. about 1859 or 1860, but no *official* approval of the fuse is to be found until 1862. An alteration was effected in this fuse in 1864, when the present pattern with paper lining was introduced. (Ammunition, 1867 (English), p. 238.)

b. New pattern fuse.

The fuse for Manby's shot[1] (Plate XXXIX, Figs. 1 to 6) is a frustum of a large mortar-fuse cone, taken at its thickest part,[2] and rather over three inches in length. The composition bore is concentric with the longer axis of the fuse, and is considerably larger in diameter than that of the mortar fuse[3], in order to increase the quantity of burning composition and the illuminating power of the fuse. The composition bore is lined with a hollow cylinder of rolled paper,[4] to prevent the fuse exploding on the principle of a tube, in the event of the wood shrinking away from the composition.[5] The composition bore is pressed[6] or driven with 2.5 inches of solid fuse composition, matched (Plate XXXIX, Figs. 1–5), primed, bored into, and capped (Plate XXXIX, Fig. 6), like a large mortar fuse.

The Manby fuse contains no side holes or powder-channels, not being intended to be prepared for any particular time of burning. The position of the first and second inches are indicated by rings cut round the fuse.

The fuse is painted drab all over, except the cap, which is not painted; a black ring is painted round the junction of the cap and fuse.

They are marked with the numeral, number of thousand and month and year of issue, in the usual way.

These fuses are intended for use with Manby's 24-pounder[7] life-saving apparatus at night. They are placed in the holes prepared in the base of the shot, four fuses in each shot, and being uncapped become ignited by the flash of the discharge, and serve to distinguish the path of the shot through the air and indicate any error that there may be in "laying." Strictly speaking, therefore, they are rather lights than fuses.[8]

The Manby fuses are issued in zinc cylinders, 16 in each, with a paper containing the following printed directions for use:

Fix the fuses firmly in the shot with the mallet and setter. Remove the caps from the fuses by giving the tape a sharp pull, when the shot is ready for firing.

NOTE.—Care must be taken to protect the priming of the fuse from moisture.—(Ammunition (English), 1867, p. 270.)

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[1] Present pattern (with paper lining), adopted 14th February, 1864.—[War Office Circular No. 1 (new series), par. 875. Respecting adoption of original pattern, see *supra*.—D. A. L.]

[2] As nearly as possible, the largest diameter of the mortar fuse is 1.565 inches: that of the Manby fuse, 1.59 inches; the development of cone of the two fuses is the same.

[3] The bore of the mortar fuse is .37 inch in diameter, that of Manby's fuse .75 (measuring outside of paper lining), or .6 inch (measuring inside of paper lining).

[4] 100-pound paper.

[5] "I find, in consequence of the largeness of the bore for the composition of the Manby fuse, the wood is liable to shrink, and thus cause the fuse to explode instead of burning. To obviate this I propose to insert a paper lining similar to that used in my naval time-fuse."—(Letter from Colonel Boxer to Director of Ordnance, 21st January, 1864.) This alteration was adopted 14th February, 1864.—(War Office Circular No. 1 (new series), par. 875.)

[6] By hydraulic pressure.

[7] The 6-pounder Manby shot have no fuse-holes.

[8] These fuses burn 12½ seconds. Limits 12 to 13 seconds.—(Ammn., 1867, p. 286.)

[N. B.—Some unimportant foot-notes have been omitted in making this extract.—D. A. L.]

CHAPTER II.

FRENCH LIFE-SAVING GUNS AND PROJECTILES.

The French life-saving service is in the hands of the "Société Centrale de Sauvetage des Naufragés," and according to Capt. R. B. Forbes, of Milton Lower Mills, Mass., this society only dates back to 1865.

Twopieces of ordnance, "le perrier" and "l'espingole," have been used by the French society for projecting lines over shipwrecked vessels.

Below are given the principal weights of these guns, projectiles, and charges, together with the greatest ranges obtained by an experimental commission of French officers in 1866.

Le perrier.

	French.	English.
Weight of gun	83 kilos.	182.98 pounds.
Elevation	30 degrees.	30 degrees.
Weight of powder charge	140 grams.	4.93 ounces.
Weight of projectile (flèche)	5 kilos.	11.02 pounds.
Extreme range	325 meters.	355.43 yards.
Deviation	17 meters.	18.59 yards.
Diameter of shot-line	4.5 millimeters.	0.1773 inch.

L'espingole.

	French.	English.
Weight of gun	20 kilos.	44.09 pounds.
Elevation	25 degrees.	25 degrees.
Weight of powder charge	50 grams.	1.76 ounces.
Weight of projectile (flèche)	2 kilos.	4.4 pounds.
Extreme range	180 meters.	196.85 yards.
Deviation	36 meters.	39.37 yards.
Diameter of shot-line	4.5 millimeters.	0.1773 inch.

In their report of November 17, 1866, the French commission appointed to consider the subject of life-saving apparatus expressed the opinion that *le perrier* with a projectile weighing 5 kilograms (11.02 pounds) and 140 grams (4.93 ounces) of powder, for ranges of 300 meters (328.089 yards), and *l'espingole* with a projectile of 2 kilograms (4.4 pounds) and 50 grams (1.76 ounces) of powder, for ranges of 180 meters (196.853 yards) and below, would be sufficient for all their needs. The French recognized the fact that a line 4.5 millimeters (0.1773 inch) in diameter will require a larger line to be hauled out to the wreck before attaching the "whip" or hauling line.

Delvigne's gun.

More recently M. August Delvigne invented a gun for projecting line carrying arrows. The following description of this piece is taken from Capt. R. B. Forbes's work entitled "Life-boats, Projectiles, and other Means for saving Life," published in 1872:

The new piece of ordnance got up by Delvigne weighs only 20 kilos., is made of gun-metal, almost a straight cylinder, about 18 inches long, and has an iron tail-piece screwed into the breech and pointed, so that in firing it is simply thrust into the soil until the square breech brings up; the elevation is regulated by a quadrant and plummet put into the muzzle; the bore is about 1¼ inch, or half that of the perrier; the piece carries wooden arrows, fitted with an iron tail to reach the charge, and at the muzzle these are much larger than the tail-piece, so that the shock of the explosion operates on the square base of the arrow, which is protected by a ring of metal.

In loading this piece a vacant space is left as in the others (*le perrier* and *l'espingole*), and the cartridge is fired near its outer end; the piece being very short, this brings the vent about in the center of the length. The iron arrows are about one-third longer than the gun, and about half the length of the arrow is in the gun when ready to fire. The advantages claimed by Delvigne in this little piece over the long *perrier* and *l'espingole* are its cheapness and portability, while with sufficient charge it gives an equal or better range; besides the wooden and iron arrows, he fires a wooden arrow out of the *perrier*, or almost any gun, which has cross-bars of round iron made malleable to resist the shock. These cross-pieces are fixed at right angles to the arrow, near the outer end, and are about as long as three diameters of the arrow. It is found that in firing this, the cross-pieces are bent to an angle of about forty-five degrees with the plane of the arrow, and thus form an anchor or grapnel, useful for many purposes. I saw one projected at Vincennes about two hundred yards from a four-pound rifle-gun, which held on to the soil sufficiently to have broken the line of about inch stuff.

Having briefly described the various arms in use in France for casting lines, it becomes necessary to go a little into detail as to the means of attaching the lines, which without due knowledge and practice of the system will be quite useless.

The wooden "flèches," or arrows, are made both round and eight-square; the former must be accurately turned and the latter planed true; therefore the latter are more simple and easy to make on board ship, or on shore.

The "coulant," or, literally, *slider*, consists of half a dozen turns of line put on something, as a whipping is put on a rope, only the ends overlaid by the rest must be left out, so that the turns can easily be pulled taut; much depends on this being done right; if the turns are too tight, the becket with its double bight and the line moves too slowly, and the "coulant" jams half way, causing the flèche to wabble and turn over; and if put on too loose, it runs down when the gun is fired, so fast as to break when it arrives at the projecting ferrule at the base. It is not too much to say that all depends on this being done right; the flèche should be slightly greased and the line either fired from a ball or from the ground, as in mortar exercise. Practice has made this so perfect that in France failures seldom occur from this cause.

Arrows of wood have the advantage of floating if they drop near the wreck, and of being readily recovered when they go beyond or fall short. The iron flèche is intended for long ranges or strong contrary winds. The distance depends so much on weather, on the amount of charge, elevation, and the line running clear, that I will only say it varies from 180 to 350 meters (196.85 yards to 382.77 yards).

In 1872 Delvigne's new gun, weighing 20 kilos. (44.09 pounds), gave a range of 300 meters (328.09 yards), with a wooden flèche weighing 8 kilos. (17.63 pounds), and a shot-line 8 millimeters (0.315 inch) in diameter.

CHAPTER III.

SECTION I. 3-INCH PARROTT MORTAR—SMOOTH BORE.

1. DESCRIPTION.

This mortar is the invention of Mr. R. P. Parrott, of the West Point Foundry, Cold Spring, N. Y. It is made of cast iron and lined with a steel tube. The piece is cylindrical about the seat of the charge, gradually tapering to the face of the muzzle. The breech is hemispherical. The trunnions are placed near the breech; their projection upon a plane through the vent and axis of the bore, being in front of and tangent to a plane perpendicular to that axis and containing the front end of chamber. The chamber has the form of the frustum of a cone.

2. SHOT.

The projectile is of cast iron, cylindrical, with the ends rounded. An eyebolt is screwed into the base for the attachment of the line. The eye of this bolt is close to the base of the shot. The cylindrical portion is turned in a lathe so as to be almost a perfect fit for the bore.

3. SAFETY ATTACHMENT.*

This contrivance consists of a piece of rubber, rectangular in cross-section, about 1′ long, 0″.75 wide, and 0″.5 thick, and of three or four galvanized-iron wires about 6′ long, laid parallel to each other, loosely twisted and coiled into a helix of from 18 to 19 turns. The rubber strap is sometimes placed inside the coil, and at others outside of it.

This combined strap and spring is interposed between the shot and line in firing. The object of the combination is to absorb the shock of the discharge, and thus prevent the breakage of the line, by letting the first jerk come upon the rubber, which will generally break, and then upon the coiled wire spring. The wires will be straightened out before the full strain falls upon the line.

4. DIMENSIONS, WEIGHTS, &C.

3-inch R. P. Parrott mortar.†

Exterior diameter at breech	8.2	inches.
Exterior diameter at muzzle	5.8	inches.
Steel tube: Thickness of walls	0.6	inch.
Thickness at bottom of chamber	1.4	inches.
Thickness of cast iron at breech	3	inches.
Total thickness of metal at breech, iron and steel	4.4	inches.
Diameter of bore	3	inches.
Chamber, frustum of cone: Length	0.9	inch.
Greatest diameter	3	inches.
Least diameter	1.4	inches.
Weight of mortar	201.5	pounds.
Weight of carriage, or bed, wood, about	65.5	pounds.
Total weight, mortar and bed	267	pounds.

Projectile.

Length	14.95	inches.
Diameter, scant	3	inches.
Weight, with safety attachment	24	pounds.

The writer is indebted to Mr. Kemble, of the firm of Paulding, Kemble & Co., for the above information in regard to the Parrott mortar.

5. EXPERIMENTS WITH 3″ PARROTT MORTAR, MADE AT THE WEST POINT FOUNDERY, COLD SPRING, N. Y., JUNE 20, 1877.

This trial took place under the immediate supervision of Capt. J. H. Merryman, United States Revenue Marine, inspector of the life-saving service, and in the presence of Mr. S. I. Kimball, of the Treasury Department, general superintendent of the United States Life-Saving Service. The writer also was present.

a. Firing-ground.

The firing was done over a marshy piece of ground; the mortar being placed upon a raised platform near the edge of the marsh. A flag was

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* This device was invented by Capt. Douglas Ottinger, of the Revenue Marine, in the course of his experiments at the West Point Foundery. It is referred to by Mr. S. I. Kimball, in his "Annual Report of the Operations of the United States Life-Saving Service, 1876," p. 24.

† Mr. Parrott constructed two mortars of larger caliber, one for the station at Peaked Hill Bar and the other for a station adjacent to it, upon Cape Cod, Mass.

The following data are available in regard to these two mortars, viz:

Caliber, 3.5 inches; weight of mortar, 300 pounds; weight of bed, 222 pounds; total weight of mortar and bed, 522 pounds; weight of projectile, 33 pounds; charge of powder, 8 ounces; range, 496 yards.

posted 400 yards distant, to indicate the direction to be observed in pointing. After each shot a man was sent out to measure the deviation from the line of fire and to ascertain the range of the shot. The platform for the mortar was made of loose earth overlaid with 2-inch plank placed parallel to the plane of fire. Its arrangement and lack of solidity was such as to make the recoil of the piece appear more severe than it would have been under more favorable circumstances. The mortar platform was over 10 feet above the level of marsh.

b. Pointing.

The direction was given by the eye of the gunner, the elevation was obtained by means of a wooden quadrant and plummet. No great accuracy was observed in taking the elevations.

c. Shot-lines.

Three different kinds of lines were used upon this occasion.

1st. This was the smallest line—Diameter, 0″.22 (estimated). It was braided like sash-cord. It was manufactured by the Silver Lake Company of Newtonville, Mass. The material is linen thread. Its exterior finish was very smooth and hard. The length was 600 yards, and weight about 35 pounds.

2d. The diameter of this line was a little greater than that of the above. The material, Italian hemp; the length, 600 yards; weight, about 50 pounds. It was twisted in the usual manner. It is the kind heretofore employed in the service. It was manufactured by Cummings, of Philadelphia.

3d. An English rocket-line of Italian hemp, strands very loosely laid up; line very flexible. Diameter greater than that of either of the other lines. Length, 560 yards; weight, about 42 pounds.

d. Charges of powder.

These were measured, not weighed. Hazard's Standard "musket powder" was stated to have been used.

e. Record of firings with 3″ Parrott mortar, at Cold Spring, N. Y., June 20, 1877.

[Projectile, weight: 24 pounds. Elevation: 25° in every case. Kind of powder: Hazard musket.]

Number of round.	Powder charge. Ounces.	Powder charge. Grams.	Range. Yards.	Range. Meters.	Deviation of shot. Right or left, yards.	Deviation of shot. Right or left, meters.	Kind of line.	Direction of wind with reference to line of fire.*	Remarks.
1	4	113.40	370	338.33	17 L.	15.50 L.	Linen, Silver Lake (new).	W.	Light breeze.
2	6	170.10	350	320.04	10 R.	9.14 R.	Italian hemp (new)	W.	Light wind.
3	6	170.10	(Wire broke.)		......	....	English rocket line	W.	Very light wind.
4	6	170.10	(Wire broke.)		......		......do	W.	Barely perceptible.
5	6	170.10	281	256.95	6 R.	5.49 R.	......do	W.	Do.
6	6	170.10	434	396.85	6 R.	5.49 R.	Linen, Silver Lake	W.	Almost calm.
7	8	226.80	473	432.51	11 R.	10.06 R.	......do	W.	Light wind.

* The force and directions of the wind are approximations only, being estimated.

f. Action.

First shot.—Silver Lake linen line ran out beautifully, without kink or knot. Shot kept point first in latter part of trajectory. Recoil of mortar and bed about 6 feet.

Second shot.—Recoil, 7 feet; tore up platform and slid up bank in rear.

Third shot.—Wire broke near the projectile. Recoil of piece, 6 feet. Projectile rotated about its shorter axis.

Fourth shot.—Recoil of mortar severe, upset carriage and broke it slightly. Part of line carried out, wire broke again; shot rotated about shorter axis.

Fifth shot.—Same line tied directly to the shot without the interposition of the rubber and spiral spring. Line carried out all right. Recoil severe, mortar and bed turning upside down.

Sixth shot.—Line tied to shot. Violent recoil, mortar and carriage turning upside down upon the platform.

Seventh shot.—Same line used (Silver Lake), and tied directly to the shot. Line kinked, a large knot being found about 100 yards from the point of firing. Probably due to bad faking. Recoil very violent, mortar jumping from platform and turning upside down.

NOTE.—In his later projectiles Mr. Parrott has changed the form of the base, making it more pointed, and drilling a hole through it for the attachment of the line.

g. Result.

In regard to the above record of firings with the Parrott mortar, Mr. Kimball, the general superintendent of the United States Life-Saving Service, says: "At the trial a range of 473 yards was obtained. In view of this gratifying result, twenty-five of these guns were ordered and have been properly distributed."*

[Copy from printed record.]

SECTION II.—IMPROVEMENT IN PROJECTILES.

Specification forming part of letters patent No. 175742, dated April 4th, 1876; application filed March 6th, 1876.

To all whom it may concern:

Be it known that I, Robert P. Parrott, of Cold Spring, in the county of Putnam and State of New York, have invented a new and useful Improvement in Combined Projectiles and Life-Lines; and I do hereby declare that the following is a full, clear, and exact description of the same, reference being had to the accompanying drawing, which forms part of this specification.

This invention relates to those means for saving life by establishing communication from the shore or elsewhere with a vessel which has been wrecked, in which a shot or projectile having a line attached to it is thrown from a mortar. Ordinarily a round shot, having the line attached to it by a coiled wire, has been used for said purpose, but there has always been a difficulty in reaching a distant vessel, as the charge of powder, if increased, is apt to break the line at its attachment to the shot. In order to get greater range without thus exposing the line to breakage or disconnection, numerous attempts to attain the desired end

* See "Annual Report of the Operations of the United States Life-Saving Service for the fiscal year ending June 30, 1877," p. 40.

have been made with an elongated shot, which, owing to the reduced resistance it presents to the air over or as compared with the round shot, has a greater range for a given charge of powder. But in the previous use of elongated shots for the purpose practical difficulties have arisen, either as regards the disposition or connection of the line and in other respects, which have involved so much complication or otherwise been so defective, that objections have been raised to the use of them.

My invention not only obviates these defects, but combines, in the use of an elongated projectile for the purpose named, cheapness, facility, and efficiency. Thus I use a simple or plain elongated projectile, having no groove cut lengthwise in it for reception of the line as in a certain other method, but I attach the line by its coiled wire to the point or front end of the elongated projectile as inserted in the mortar, so that, when firing, the check which is produced as the shot feels the draw of the line causes the shot to be turned over end for end. This, by reason of the elongated form of the shot, materially eases the strain or reduces the first shock upon the line's attachment to the shot, and the shot, which draws the line after it, goes perfectly true to its destination. In this way, or by these means, I get a long range, and avoid breakage of the line's attachment to the shot, also secure a true travel for the latter.

In the accompanying drawing (Plate L), Fig. 1 represents a longitudinal section of a mortar with an elongated projectile having a life-line attached and as about to be thrown, the whole being constructed in accordance with my invention. Fig. 2 is a view on a reduced scale, showing the projectile after it has been turned end for end as it first feels the draw of the line upon it, and showing said shot with its attached line in the course of its flight. In Fig. 1, A is the mortar; B the elongated projectile, having the line C connected through the interposition of a spring or coiled wire D with the forward end of the shot as the latter is inserted in the mortar; and E is the charge of powder by which the projectile, with its attached line, is thrown from the mortar, said line being laid in a loose coil outside of the mortar. In Fig. 2 the same letters apply to like parts, but the shot has been turned end for end as it first feels the draw upon the line.

It is not necessary that the coiled wire D should of itself be the spring or only spring interposed between the end of the projectile and the line, inasmuch as a rubber strip or spring, F, may be independently applied to connect the line with the projectile and such elastic strip or spring be passed through the coiled-wire connection D.

I claim—

The combination with the elongated projectile B, of the line C, and interposed spring or coiled wire D, applied to connect the line with that end of the elongated projectile which is forward or outermost when the projectile is inserted in the mortar, substantially as and for the purposes herein set forth.

ROBERT P. PARROTT.

Witnessse:
HENRY JAYCOX.
ALEXANDER SKENE.

CHAPTER IV.

HUNT'S LIFE-SAVING APPARATUS.

SECTION I.

Mr. Edmund S. Hunt, of Weymouth, Mass., has invented a line-throwing apparatus, intended for life-saving purposes. A full description of this invention is given below in the specification forming part of the letters patent, and in the letter from Mr. Hunt to the Secretary of the Treasury, dated February 7, 1878.

The writer was present at several trials of this projectile. The results of his observations will be found upon subsequent pages.

IMPROVEMENT IN LINE-THROWING APPARATUS.

Specification forming part of letters patent No. 203274, dated May 7, 1878; application filed January 25, 1878. (See Plate LI.)

To all whom it may concern:

Be it known that I, Edmund S. Hunt, of Weymouth, in the county of Norfolk and State of Massachusetts, have invented certain improvements in line-throwing apparatus, of which the following is a full, clear, concise, and exact description, reference being had to the accompanying drawings, making a part hereof.

My invention is more especially designed for throwing a line from the shore to a wreck or from a wreck to the shore, but is, of course, adapted to other uses.

The drawings illustrate a shot having my coil-case applied to it, also one of my hand coil-cases, and also a line-support attached to the gun.

The distinguishing characteristic of my invention consists in the projectile made up of a short heavy shot and a long light case containing the line, the case being open at the mouth, and the projectile adapted to be fired with the shot next to the powder and the coil-case at the mouth of the cannon, and to reverse itself soon after it leaves the gun.

The minor features of my invention relate to the mode of coiling the line and the mode of holding it and of preventing injury to it from the gases which escape from the mouth of the gun.

In that form of projectile shown in the drawings, A is the powder, B the shot, C the coil-case, and D the coil. E is a wooden mouth-piece attached to the case C, in order to make it sure that the sharp edge of C shall not injure the line.

The end *d* of the line is, where a light line is used, attached to a short piece of stouter line d^2, the line d^2 being less likely to be injured by the escaping gases, &c., near the mouth of the gun when fired. For a like reason the line d^2 is supported, as shown, by the supporter G, which prevents it from lying directly across the mouth of the gun, that being the most unfavorable position for it.

The coil is formed by winding the line upon a mandrel, the line passing through a vessel containing melted paraffine or other like substance, and also passing through a proper tension mechanism, to make the coil compact. A single coil is first wound of the desired length; next a second coil over but the reverse of the first; then a third like the first but over the second; then a fourth like the second but over the third, and so on, forming a compact cylindrical coil, containing the desired length of line, the size of coil varying, of course, with the length and size of the line. The hand-coil is made in the same way. After the coil is put in the case a small amount of melted paraffine is appplied between it and the case, and it is thus held securely in the case.

I propose in practice to make the hand-coil of considerably heavier line than the shot-coil, using for the hand-coil the line d^2.

I prepare my improved apparatus by putting the hand-coil and shot-coil mouth to mouth and covering the joint with a short metal cylinder, and make the whole water-tight by a proper casing.

To use the apparatus, separate the hand-coil from the projectile, load the projectile mouth outward, place the line d^2 over the supporter G, as shown, and hold the hand-coil in the hand, its mouth in the same direction as the mouth of the gun. When the gun is fired, only a small portion of the line from the hand-coil will be drawn out. The length of coil in the shot should be considerably in excess of the travel of the shot, which will, of course, depend upon well-known principles.

I am aware of patent No. 23726, of 1859, to Trowbridge, which describes a sounding apparatus on a principle closely analogous to the principle of my new projectile; and I disclaim all that is described and shown in that patent.

I am also aware of the French patent to Delvigne, A. D. 1847, vol. 10, plate xlii, which shows a shell or hollow shot with a coil of line and a hole at the base of the shell through which the line extends. This I disclaim, as my projectile has the coil-case at that end of the shot farthest from the powder, and the mouth of the coil-case is at its front end when the shot is in the cannon, the shot proper being so much heavier than the coil-case and coil that when fired the projectile will reverse itself as soon as it leaves the gun, that is, when loaded the shot is behind the coil-case and the mouth of the case is forward, but during nearly the whole of its flight the shot is in front and the coil-case behind it, the mouth of the case being then at the rear of the projectile. In this way the coil-case can be made of sheet-metal, which is altogether too weak to resist the shock of the explosion, and the center of gravity of the projectile be brought very near the powder, thus protecting the coil and coil-case from the shock and from the gases without the use of a sabot or any other contrivance, besides greatly reducing the cost of the projectile.

What I claim as my invention is—

1. The projectile above described, composed of the shot B and coil-case C and coil D, the coil-case being open in front, and the shot B being much heavier than the coil-case and coil, the whole constructed and arranged substantially as shown, and adapted to be fired with the mouth of the coil-case outward, and to reverse itself as soon as it leaves the gun.

2. The coil composed of a series of coils, packed with paraffine or its equivalent, substantially as described.

3. The supporter G, in combination with the gun H, substantially as and for the purpose specified.

4. The improved mode of throwing a line above described, consisting in using a hand-coil in connection with a shot-coil, the latter coil being in a case or holder forming a part of and traveling with the shot and the former coil being held stationary, the lines composing the two coils being joined together at their contiguous ends, all as above described.

SECTION II.

[Mr. Hunt's letter to the honorable Secretary of the Treasury.]

WEYMOUTH, MASS., *February* 7, 1878.

SIR: Inclosed is a copy of my shell (3-inch) for carrying a line for life-saving purposes, a description of which I will now give.

The case of the shell is made of tin, with wings of the same. In the end is cast a leaden shot, made so as to fit the gun accurately without windage. The tin shell contains the line, wound, as the model shows, in the closest possible space. The line being prepared in paraffine and drawn from the center, comes out without fouling and without any drag on the shot, it traveling about as far with the line as without it. The wings are to keep the shell in line, and in so doing goes a much greater distance than if turning in the air. The coil. No. 2, I hold in my hand when the gun is fired, between which and the shell is a stout cord connecting the two small lines. On my gun is a rod, carried out from the gun in a line with the bore, with a fork or crotch in the end, that this connecting line is carried over, saving the line from breaking at the moment of discharge. The coil in the shell is the same as the 2-inch, only there is much more line in the shell.

In using, I place the powder in the gun and put in the shell shot end down; then carry the heavy line over the rod and hold the coil No. 2 in my hand, and apply the match. The result is this: the shell leaves the gun and immediately turns over and takes its course, the line paying out from it until it strikes the object intended. The explosion of the powder seems to throw the heavy cord that connects the two lines some two or three hundred feet from the gun, and then you find the end of line in the shell, so that a small part of the line is taken from the hand; and that is taken out by the fire explosion, and after the shell has reached the ground and the line being in the air, in falling draws from the coil. A shell size of the model will carry a line size of one now in it 1,000 feet with ¾ ounce powder at a very low elevation; with a shell of 2-inch diameter and a charge of 2½ ounces powder a range of one-half mile, carrying the same line, which, though being smaller, is very strong, being the same used by me for drawing a rope of sufficient size to tow a hawser in an exhibition before the Humane Society at Hull last week.

In this method of throwing line, a sufficient amount of line to reach the object must be always coiled in the shell, as, if the wind is directly ahead, but little, if any, line will be taken from the hand, and the slack of the line will fall behind you. For this reason it is always better to have ready more line in the shell than what is wanted for the distance the shell goes, a side wind taking up more line than a head wind or one with you.

The advantages I claim over the old methods are these:

1st. The line has no effect on the direction of the shell, it simply paying the line out, the shell going as directed with a side wind as with one with it.

2d. The shell goes seemingly as well with the line as without, so that distance is overcome very easily.

3d. The gun is a very small affair, my largest 3-inch gun for experiments weighing but 30 pounds. One that has thrown a shell and line ½ mile weighs 10 pounds without the carriage.

4th. The lines are all put up in paraffine, so that the weather cannot injure them from wet, cold, or heat.

5th. The whole affair, gun, shell, and line, can be carried by one man, requiring neither horse nor carriage.

Very respectfully, your obedient servant,

EDMUND S. HUNT.

Hon. JOHN SHERMAN,
Secretary of the Treasury, Washington, D. C.

N. B.—The above is a transcript of an official copy of Mr. Hunt's letter:—D. A. L.

SECTION III.—TRIALS OF HUNT'S APPARATUS.

I. FIRST TRIAL.

The first trial of this apparatus in the presence of the writer occurred at Weymouth, Mass., during the latter part of February, 1878.

The following is an abstract of a report of that trial made to the General Superintendent of the Life-Saving Service:

1. *Firing-ground.*

The firing-ground was very uneven, was covered by a growth of bushes and trees, and was intersected by a strip of swampy ground. At the point where the shot usually fell the ground was considerably higher than it was at the firing-point. A flag was placed at (an estimated) 400 yards distance from the guns. This flag was on or near the crest of the hill. No range had been *measured.*

2. *Guns.*

There were two of these:

1st. A 2-inch caliber, weight about 10 pounds; length of bore about 12 inches. This piece was made of a short length of "drawn" brass tubing, and had a reinforce of steel or wrought iron around the breech. The breech-plug was a piece of cast iron fastened to the cylindrical portion of the gun by two wrought-iron pins.

2d. This gun had a caliber of 3 inches; its length was a little greater than the 2-inch gun, and its weight was about 40 or 45 pounds.* It also was made of brass tubing. It had two reinforcing bands, the inner of steel or wrought iron, the outer one of brass. The cast-iron breech-plug was held in position by pins. It was stated by the inventor that these guns were only temporary contrivances to show the principle of his invention.

Though the whole gist of his invention is contained in his projectile, it has been deemed necessary to a definite understanding of the subject to give some of the more prominent correlative details.

3. *Projectiles.*

These were tin cylinders with leaden heads cast upon them. The coils of line were stored inside the shells. The total length is between 16 and 18 inches. Two-inch and three-inch calibers were used. The 2-inch shell with line weighed about 7 pounds, the 3-inch with line about 10 pounds.

* The above weight, 40 or 45 pounds, was the one given me by the inventor on the date of trial. It may be noted that in his letter to the Secretary of the Treasury the inventor states the weight of the 3″ gun to be "but 30 pounds." It is probable that the latter was the weight before the outer reinforcing band was added to the gun.—D. A. L.

4. *Shot-lines.*

Two sizes of lines were used. The smaller line was made of pack-thread and used in the small shells. The larger line, used in the 3″ shells, weighed about 3 pounds. After firing it appeared to be about the size "Silver Lake No. 3½." The material was linen thread, loosely laid up in three strands, without much twist.

The lines were put up in coils 6 inches long, and were saturated with paraffine. The lines were prepared for use by coiling around a spindle placed in a lathe. The ends of the lines in the coils were tied together, after which the coils are inserted in the shell one above the other, three in all. A similar coil was held in the hand of the operator when about to fire. The ends of the lines in the shell and hand coil were made fast to the extremities of a larger piece of line (No. 7) about three feet in length, which was passed over the line-supporter that projects over the gun. This device is to prevent the burning off of the small line by the escaping gases at the instant of discharge.

5. *Powder.*

The Oriental Powder Company's "Duck" powder was used for firing. Charge, 2½ to 3½ ounces, by measure. No cartridge-bags were used.

6. *Recoil.*

As these experiments were only to test the line-carrying properties of the projectiles, no gun-carriages had been provided. The guns were mounted in a notch or groove cut in a log. This piece of timber was imbedded in the earth flush with the surface; of course no recoil was apparent.

7. *Experiments.*

Five shots were fired.

1. This was with a 2-inch projectile and pack-thread fired from the small gun. The projectile, notwithstanding the "wings," turned over and over about one of its shorter axes. Range between 350 and 380 yards. A portion of the force of the powder was expended in blowing out the breech of the gun. The bowing or drift of the light line was considerable, though the wind was very light. The line paid out well from the coils.

2. Three-inch projectile from larger gun. Shot turned over three or four times and then proceeded point foremost. Shot deviated but little from plane of fire, but the line drifted badly. Range, estimated, nearly 400 yards.

3. Three-inch projectile used. Shot turned over two or three times. Line paid out in bunches, from the coils catching on each other. Line did not drift so badly as in last shot; operator drew in part of the slack from the rear. Range about the same as the above.

4. Two-inch shot. Shot turned over once or twice and then kept point direct to the front. Range good, about 400 yards.

5. Two-inch shot. Projectile turned over twice, and attained a good range, estimated by those present at 600 yards. There was a difference of opinion as to where it fell. No one went out to see where it struck at the time. The writer thought it fell inside of 500 yards, but the shadow of the woods rendered the point of fall uncertain.

8. *Remarks.*

The line was not broken or cut in a single instance, and Mr. Hunt stated that it had never been cut during any of his experiments.

The first spring of the projectile into the air generally carried a portion of the line from the coil which was held in the operator's hand. After the reversal of the shot the line was paid out from the coils in the shot.

There are two chances for the line to be carried out instead of one, namely: 1st. From the coils in the shot; 2d. From the coil in the hand in case the first line should foul in the projectile. The line was badly twisted by being drawn from the center of the coils, as every turn in the coil counted as one twist. This trouble has been obviated by Mr. Hunt by winding the coils in opposite directions. It would not be easy to prepare the line for a second shot, as it would require a lathe to do the work expeditiously.

[NOTE.—Later Mr. Hunt stated that in actual service he intended that the line and shot should be sacrificed after once firing, the value of which is a small matter as compared with a single human life.]

Mr. Hunt pointed out where various shots had fallen that had attained greater ranges than any procured during this trial. The largest line used by Mr. Hunt upon this occasion had a breaking weight of 88.5 pounds, and a stretch of 3 inches in a length of 6 feet.

SECOND TRIAL.

The second trial took place at Weymouth, Mass., May 7–8, 1878. At this trial Mr. Hunt had a new gun, caliber 3½ inches. He stated that he had not weighed it, but gave its weight as "about 70 pounds" and the weight of the carriage as "about 80 pounds." The plan of the construction of the gun was similar to the 3-inch gun before described, but it was a much better gun. The reinforce band was of bronze. The carriage was made in two parts—the upper part of iron, in form resembling a mortar-bed as usually constructed; the lower part was a piece of heavy plank about 40 inches long, about 12 inches wide, and about 3 or 3½ inches thick. The iron portion was bolted to the wooden part. Rope loops fore and aft served as handles for transportation. The whole weight the inventor estimated at 150 pounds.

1. *Projectiles.*

Outside length	21.5	inches.
Inside of shell—length	19	inches.
Diameter, exterior, little less than	3.5	inches.
Coil of line for shot, No. 4½—length	17.6	inches.
diameter	3	inches.
Weight of shot, empty	9. 1 +	pounds.
Weight of shot with line inside, about	15	pounds.

The above dimensions and size of coil (for inside of shot) are those of the projectiles and coils used in the third series of trials at a later date. At the second trial at Weymouth, some of the shells had more than one coil inside—probably three. For his later experiments with larger lines (Nos. 4½ and 7), Mr. Hunt used but one coil in the shot. After placing the line in the shot, a wooden plug with a hole in the center for the line to pass through was put in the shell over the cord and held in position either by indenting the tin case around it or by folding down the rim by a slight blow to prevent the plug from coming out when the shot was reversed. These projectiles had a reinforce of galvanized sheet-iron around the lower end of the tin shell to strengthen it sufficiently to stand the shock of discharge without upsetting. There is about 1 inch of lead cast upon the head (point) of the projectile, and then 6 inches in length of the sheet-iron. The head is flat, the plane of its face being perpendicular to the axis of the projectile. Even this sheet-iron envelope does not prevent a certain degree of upsetting when large charges of powder are used.

Firing record at Weymouth, Mass.

Date.	No. of round.	Elevation, degrees.	Powder charge, ounces.	Size of line, No.	Wind, direction.	Range, estimated, yards.	Remarks.
1878. May 7	1	22½	3½	4½	W. Wind very light.	About 400	Shot rotated two or three times about shorter axis.
7	2	22½	4	4½		450	Shot rotated two or three times.
7	3	15	4	8½		400, 440	Shot rotated three or four times.
7	4	20	4	3½		Over 400	Wind on May 7 very light and variable; wind blowing almost directly from the rear.
8	5	22½	3	3½		450	Velocity of wind = 6.66 feet per second = 4.49 miles per hour; flight of shot good; wind in rear; no sustaining-rod used.
8	6	17½	3	4½		380	Shot rotated three or four times; very little drift of line; wind light, and variable in direction; shot fell on soft ground; was picked up in good condition; velocity of wind after last shot = 9′.1 per second = 6.14 miles per hour.

THIRD TRIAL.

Firing record at Marblehead, Mass.

Date.	No. of round.	Elevation, degrees.	Powder charge, ounces.	Size of line, No.	Action of line.	Wind, direction.	Range, estimated, yards.	Remarks.
1878. July 2	1	25	3	3½	Good	W. Wind very light.	*400	Boats anchored 300 yards from shore.
2	2	24	3½	4½	....do		Over 300	Shot rotated two or three times.
2	3	20	4	4½	Parted at a splice.		....	Parted line at a splice in hand-coil.
2	4	25	4½	7	Cut		....	Line parted 77 yards from shot; probably cut off by sharp edge of hole in plug at end of shot.
2	5	20	3	4½	Good		Over 300	

* These ranges are all estimated, but as they went beyond the line of boats, which were 300 yards out, no attempt was made to secure any greater accuracy.

First shot.—Line drifted to left about 20 yards at 200-yard range.
Second shot.—Line drifted to left but fell over boats.
Third shot.—Six hundred feet of line said to be in coil in shot.
Fourth shot.—Three hundred feet of line said to be in coil in shot.
Fifth shot.—Only about 20 feet of drift in line.

The trial at Marblehead, Mass., July 2, 1878, took place over water. Four boats were anchored, end to end, 300 yards from the beach. The boats were each 13 feet long, and were 23 feet apart, making a line of 121 feet long parallel to the beach, over which to throw the shot-line. The wind, though very light, was from the right and rear. The gun was pointed over the boat on the extreme right of the line.

2. *Remarks.*

The shock of discharge is often sufficient to drive the wooden plug in the outer end of the shell down several inches; in one case, when measured, it was found to be six inches from the mouth of the shell.

Mr. Hunt uses lines which are termed "soft laid" from the manner in which they are put together without much tension upon the strands. These lines have no "finish" upon them when received from the maker, but are passed through melted paraffine as they are coiled upon the spindle. Opinions differ in regard to the manner of laying up cords for shot-lines, some claiming that the lines should be "soft laid," others that they should be "hard laid."

A "soft-laid" line is probably not so apt to be cut in hauling it across the side of a ship as the solid-braided line. It is, however, easily compressed, which, for a small line, makes it a little more difficult to grasp.

It is but just to Mr. Hunt to say that he has not yet perfected all the details of his projectile. At the writer's suggestion, the inventor laid aside the "supporting rod" attached to the upper side of the gun, and discarded the intermediate piece of large line which connected the coil in the shot with the hand-coil. These devices were intended to keep the line from being burned off at the instant of firing. No difficulty was experienced from their omission, as the shell projects about six inches beyond the muzzle of the piece; a sufficient distance to prevent the escaping gas from burning off the line. This projectile has a *flat* surface at the front end to oppose the wind in its flight. This form of head is objectionable on account of the increased resistance of the air which it develops. The form of the point of a shot has a great influence upon the intensity of the resistance which a projectile will experience in moving through the air. The following facts in regard to the further efficiency of this projectile should be made the subject of a more extended experimental investigation, namely:

1. The action of the projectile in windy weather, with both cross and head winds. This is especially desirable when it is borne in mind that the wind's force varies directly as the square of its velocity. "Thus, when the wind's velocity is 20 miles per hour, its force is four times as great as that of a wind blowing 10 miles per hour."

2. The maximum charge that may be used without upsetting the projectile.

3. The effect upon the strength of the lines by having a knot tied at the junction of the coils in the hand and shot. Knots are generally points of weakness.

4. The effect of the free use of paraffine upon the ease of handling.

It is probable that this projectile, from its lightness and compactness, may be best suited to carry on board vessels for use in cases of stranding. The wind, in such instances, is generally blowing on shore, and the small weight of the shot would not be such a serious disadvantage to it as when firing against the wind. It is a well-known fact that the heavier the projectile, for the same caliber, the greater will be the range, other things being equal. The mass of the Hunt projectile is rather small for the area of its cross-section, and it is constantly diminishing during flight. The ballistic capabilities of this projectile against a strong wind can only be demonstrated by experiment.

CHAPTER V.

CHANDLER'S ANCHOR-SHOT.

(Plate LII.)

In the Army and Navy Journal of April 27, 1878, page 607, the writer finds the following:

Capt. Ralph Chandler, U. S. N., has invented a shot which is intended for the use of ships on shore (aground), where the surf is too heavy for boats to land without the assistance of a line. It can also be used at life-saving stations to throw lines over beached vessels or vessels in distress. As an implement of war, it will be useful in waters where torpedoes are supposed to be located. A ship can anchor near the supposed torpedoes, throw the shot two or three hundred yards toward them, and haul it home, breaking such wires as it may encounter. It is very simple, and its simplicity insures its successful working, and its cost is very little more than that of an ordinary shot. It is merely a shot with hinged anchor-flukes projecting from its sides and folding back into slots, so as not to interfere with the entrance of the shot into the gun. To the rear of the shot a chain or wire-rope is attached, and carried to the front of the shot through another slot.

In using it, the shot is to be inserted into the muzzle of the gun far enough to bring the ends of the arms inside the muzzle, the chain or wire-rope attached to the rear of the shot brought out through the slot, the strap taken off, and the shot pushed gently home. The springs under the arms, always bearing or pushing them outwards, will extend the arms as soon as the shot leaves the muzzle of the gun or mortar, and a perfect anchor will be projected. If in its flight the arms are brought in contact with anything, they will close until the obstacle is passed, and where the shot lands, its holding power will be equal to any kedge anchor of the same weight. It appears to be a most useful invention. If the Huron could have landed a shot of this description, by it the balsa could have been hauled ashore with a hawser or large line attached to it. One of these shots made for an eleven-inch gun would have power enough to carry a two-inch rope ashore, and after the shot was once ashore and well hooked, all the boats of the ship could be hauled ashore without any other line.

The flukes of this anchor-shot are three in number, placed equidistantly around the circumference of the shot.

The writer has been informed that up to the present time (July, 1878) this projectile has not proved to be as satisfactory as was anticipated.

NOTE.—The illustrations of the Chandler anchor-shot were taken from Harper's Weekly of June 15, 1878.—D. A. L.

The following account of experiments made with Chandler's anchor-shot has appeared in the Army and Navy Journal since the above was written:

Experiments were made with Chandler's anchor-shot off Paddock's Island, Boston Harbor, July 20, 1878. Gun, 32-pounder, of 33 cwt.; junk wad behind shot at each fire; size of line, 2¼ inches; whale line. Elevation of gun, 12°; wind across line of fire, moderate breeze.

Fires.	Weight of powder.		Weight of shot.	Length of line thrown straight.	Slack line.	Total fathoms.
	Lbs.	*Oz.*	*Lbs.*	*Fathoms.*	*Fathoms.*	*Fathoms.*
1	1		78	94	15	109
2	1	2	78	112	18	130
3	1	6	78	Line broke close	to shot.	
4	1	4	78	127	15	142
5	1	6	78	137	10	147
6	1	8	78	150	10	160
7	1	10	78	160	15	175
8	1	10	78	157	15	172
9	1	14	78	157	15	172

Towards the end of the experiment the line became soaking wet, which increased its weight to that extent that four ounces increase of charge in the last fire did not increase the range.

To make these experiments perfect, a new and dry line ought to be used at each discharge.

It is evident that with a heavy shot and a large calibered gun there is nothing to prevent four hundred fathoms of line being thrown. In the first seven fires a short section of wire rope was attached to the shot and the line spliced to that, but in the last two the line was fastened directly to the shot, and served with rope yarn well soaked in water. The line was not burnt in the least, and a large eight-oared cutter was hauled ashore by the line.—(Extract from Army and Navy Journal of August 10, 1878.)

CHAPTER VI.

LIFE-SAVING ROCKETS.

I. LIFE-SAVING ROCKET (BOXER, 12-POUNDER).[1]

[Extract from "Treatise on Ammunition," by Major W. R. Barlow, R. A., published in London, in 1874.]

(Plate XLI.)

The life-saving rocket.

Dennet's "twin" rockets were superseded by Boxer's on 15, 3, '65. This consists of two rocket bodies, one being fixed in prolongation of the other, to give great length of burning and flight, without any sudden violence, which might break the line which it carries,[2] or irregularity from uneven burning.

Thus it will be seen that "instead of making one cavity in the rocket, two cavities (*c c'*) are formed, the one behind the other, with a portion of solid composition (*b*) between them, so that when the solid composition (*b*) is burnt through, the front cavity (*c*) is ignited, thereby imparting to the rocket an additional impulse." The stick (*d d*) is fixed at the side of the rocket. The line (*e e*) is passed through a hollow at each end of the stick, as shown in the annexed cut (Fig. 1, Plate LIII), and the end of the line is secured by a common overhand knot; two India-rubber and one brass washers (*f*) are placed between the knot and the stick, to reduce the effect of the sudden jerk which is given to the line when the rocket is fired. The arrangements for the use of this rocket are the same as those hitherto carried out with Dennet's rockets.

A second knot is usually made in the rope near the hinder end of the stick, in case the line should be burnt through by the flame issuing from the rocket.

N. B.—All Boxer life-saving rocket cases are protected from the action of the composition by an internal coat of anti-corrosive paint, consisting

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[1] Time of burning, about 4¼ seconds.

[2] General Boxer writes in letter of 25, 5, '65, that his object is "the continuance of the propulsion through a much longer period, without any excessive strain upon the line."

Captain Robertson, R. N., writes to secretary marine department board of trade, 9, 2, '65, that Dennet's rockets "frequently carry away the lines, and sometimes do not ignite; they are also double the expense of Boxer's rocket." Inspecting Commander Earle reports on a trial between Boxer's and Dennet's rockets: "Of the three double Dennet rockets only one was any use; two broke their lines and struck the ground. The mean of the five shots with the Boxer rocket gave a range of 370 yards very true, and with much less strain on the line, as it never broke with Boxer's rocket." Reports from Inspecting Commanders Charles and James, from Yarmouth and Lydd, are confirmatory of this statement—19, 10, '65. At Whitby, on 27, 3, '66, one of the Dennet rockets, igniting before its twin rocket, came back and struck the inspecting commander.

Captain Robertson, in letter 9, 2, '65, reports that Dennet's rocket attained a greater range than Boxer's.

of copal varnish, ¼ pint; gold size, 1 pint; turpentine, 1¼ pints; white lead (dry), 7 pounds, being the same as is now applied to the interior of Hale's rockets. All rockets manufactured since 22, 9, '60 have their cases further protected by blackening by burnt oil.

BOXER'S LIFE-SAVING ROCKETS.

1. *Details of patterns.*

The pattern in the wood-cut known as Mark I was approved 15, 3, '65. Mark II, approved 9, '66, differs from mark I in having no hole to take the keep-pin through the "clip," the pin being passed through the stick in front of the "clip," because it was sometimes found troublesome to bring the hole in the stick and "clip" exactly to cover one another. The sealed pattern is nearly .5 inch shorter than Mark I, so as to enable the rockets manufactured to conform with it, it having been found that the act of pressing the composition slightly shortens the whole case; hence that of the dummy pattern was longer than the same case would be after pressing.[3] Mark III,[4] approved 1, 9, '68, differs from Mark II in having the case made of Atlas (*i. e.*, Bessemer) metal. All manufactured since October, 1870, have the vent covered with paper (instead of the serge plug). The paper is to be broken before firing. It is important to distinguish Pattern III clearly from I and II; the cases of rockets of the latter pattern having been found liable to deteriorate, and even to split, from their being taxed beyond their strength by the pressure of the composition, are ordered to be very carefully examined from time to time for rust spots and indications of cracks.[5]

Paint: formerly two coats of black varnish; since 5, 11, '70, two coats of red paint, for better protection.

The 12-pounder life-saving rocket stick[6] is deal, 9′ 6″ long, square, with corners shaved off; it is the same size from end to end. It is bound at the bottom end with an iron ring, and is plated at the head or front end with plates, which, as well as the stick at the front part, are hollowed to fit close to the rocket. The second or hinder plate is 3 inches long; it has a flange to rest against the base clip of the rocket. Over the half of the stick next the rocket is tacked a sheet of tinned iron for a length of fourteen inches, to protect the stick from the flame escaping from the rocket.

2. *Iron pin for life-saving rocket Mark I.*

This is an iron pin 1.″2 long, No. 8 Birmingham wire gauge; the end is bent over at a right angle, thus bringing the length down to .85″.

3. *Brass washer.*

The brass washer shown in the wood-cut of the rocket * * * is 1″ in diameter, with a hole in the center .5″ diameter; they are about .15″ thick.

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[3] To prevent mistakes arising from comparing an empty pattern with a filled rocket.

[4] The numeral marked on the pattern sealed as II was altered in place of sealing a new pattern.

[5] The crack is generally developed in a longitudinal line running parallel to and within one or two inches of the seam or joint of the rocket.

[6] Mark III stick is strengthened by having the part next the base of the rocket more covered by the tin sheet, which is also passed under and clamped by the iron socket.

4. *India-rubber washer.*

The vulcanized India-rubber washers referred to in the description of the rocket are both alike, each being 1″ in diameter, with a hole in the center .5″ in diameter; they are about .7″ thick.

II. Machine for firing life-saving rocket.

(Plate XL, Figs. 3, 4.)

The machine for firing the life-saving rocket consists of a bed to hold the rocket, in prolongation of which is fixed a pry-pole, and from the rear end of which spring two legs, one opening to the right and one to the left. Both bed and pry-pole are made of sheet-iron, the former being an open rectangular trough 3.2 inches broad[7] and 4 inches deep; the latter one, of more rounded form, being 1.65 inches broad at the top and 1.5 inches deep.

The front end of the pry-pole enters the bed for a length of 7 inches, the upper edges of the former standing about .2 inch above those of the latter, so that the bottom of the larger trough is 2.7 inches beneath that of the smaller, to allow for the rocket resting in the bed while the stick lies in the hollow of the pry-pole. The two troughs are fixed together by three rivets on each side, the spaces between them on each side, owing to their difference of width, being filled up by a piece of wrought iron, through which the rivets pass. The front edge of the bed trough is iron-strapped, and its remaining edges as well as those of the pry-pole trough are "wire-edged." With the exception of a strengthening bar running from bed to pry-pole, the rear end of the bed trough is left open beneath the front of the pry-pole, so as to allow of a free passage to the gas escaping from the rocket base. Two pieces of wrought iron 7 inches long are riveted along the after part of the sides of the bed, close to the angles formed with the bottom, their rear ends projecting sufficiently to allow of a bolt secured with a screw washer to pass through them, on which hinges a small flat piece of iron, taking two other bolts screwed and nutted, and each long enough to allow of a socket (ending in flanges) which admit the flat iron between them to be hinged on it. Thus the flat iron hinges longitudinally on a bolt transverse to the direction of the troughs; while the leg sockets move transversely on hinges longitudinally placed.

In each socket is fixed an ash leg with a ferrule, having a foot projection and spike; while beneath the pry-pole runs a strengthening bar from end to end, which is at the hinder extremity bent down to form a groundspike. In the right side of the bed is cut an opening to admit of the entrance of a portfire to fire the rocket, and behind this is fixed a brass quadrant plate, on which is hung a plummet and line to give elevation.

On the left side of the bed, protected by a copper cover, is a strong lock of simple construction, with a lever trigger, to which is attached a line, led through one sheave on the left-leg socket, and another near the left foot. Near the right foot is fixed by two screws a strong strap and buckle to enable the two legs and pry-pole to be strapped together, for more convenient stowage when not in use.

Mark I trough or machine has long existed; it was sealed in November, 1865. This pattern has a very small block fixed to a ring near its left foot. It is difficult to pull the trigger-line from the right side, owing to the stiff movement of the little block.

[7] Interior measurement.

Mark II was approved 21, 10, '70; it differs from Mark I as follows:

1st. The trigger-lever is prolonged to a length of about 4 inches, so as to allow of the lock being worked with a lighter pull.

2d. The pulley-block on the left foot is replaced by a sheave of much larger size fixed through the middle of the wood (which is supported by a band); this pulley enables the machine to be fired from the right side.

3d. The opening in the right side of the trough is furnished with a sliding cover.

Mark III machine differs from the previous pattern only in having an arrangement for causing the flash from the detonating tube to strike direct up the axis of the rocket. This is effected by making the vent or channel for the tube in a circular form instead of straight across the machine.

N. B.—A spare spring is ordered to be supplied. A priming wire for life-saving rocket machine was approved on 20, 5, '70, and a pattern, Mark I, sealed. It is formed from iron wire No. 5, Birmingham gauge. It is about 4 inches long, being formed into a loop at one end. On 21, 10, '70, a pattern, Mark II, was approved, differing from Mark I in being twisted to form a screw at the part near the point. On 4, 9, '72, Mark III was approved; it is curved to fit the vent in Mark III machine. It is used to clear the vent of the life-saving machine of any portions of the quill tube that may remain in it after firing.

III. Stores, etc.

1. *Life-saving rocket-tube.*

The life-saving rocket-tube consists of a goose-quill body about 1¼′ in length, driven and pierced in the usual way. The large end of the quill is closed by a disk of tissue paper being varnished over it. Into the smaller end of the quill is secured with diamond cement a pigeon-quill about an inch long, which enters the large tube to a depth of about 1 inch. This tube is filled with detonating composition.[8] Round the extreme small end runs a small band of kamptulicon. These tubes are used for firing life-saving rockets. The body of the tube is inserted into the vent of the lock at the side of the machine, being held in its place by a small piece of brass which shuts on its neck just below the kamptulicon band. The descent of a spring-hammer edge crushes the detonating end of the tube and fires the same. They are packed, by the special request of the board of trade, in larger quantities than other tubes, viz, 150 in a (No. 27) tin cylinder, which is closed by a calico band attached by shellac over the junction of lid and body.

2. *Fuse for life-saving rocket, Mark I.*

This is 1″.5 long; it is made of paper; it contains an inch of ordinary fuse composition; it is conical in shape, and its sides are covered with kamptulicon, being brought up to fit the vent in the base of the life-saving rocket; it has a paper cap tied on with twine, which need not be removed before firing; it burns for about five seconds, and is required for use with the portfire.

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[8] Detonating composition for quill friction tubes: Potash, chlorate of, 6 ounces; antimony, sulphide of, 6 ounces; ground glass, 1 ounce, 10 drams. Damped with varnish, of spirits, methylated, 1 quart; shellac, 357 grains, in the proportion of 75 minims to 1,000 grains of composition.

STORES CONNECTED WITH THE LIFE-SAVING ROCKET.

3. *Light for illuminating wrecks* (*Mark I*), *March*, 1874.

The light (Fig. 2, plate LIII) is about 28½ inches in length and 2.65 inches in diameter. It consists of a cylindrical case of 1 X tin sheet in 6 lengths of 4½ inches each, fitted together and connected by small bands of tin sheet, half an inch in width, soldered over each joint. The case is filled with the following composition, viz: saltpeter, ground, 7 pounds; sulphur, sublimed, 1¾ pounds; orpiment, red, ½ pound. One end is fitted with a piece of wood, with a loop of iron wire attached to it for suspending the light; the other end is primed with mealed powder, and covered with a kit plaster.

The stand is a simple tripod, consisting of three wooden legs about 6 feet in length, connected at the top by a piece of iron wire having a small hook attached to it, on which the light is suspended; there are three iron rods which are hooked to and connect two of the legs, forming an incline for the light to rest on, so as to hang in a sloping direction—not vertically downward.

The light, if hung as described, clears itself of dross when burning, and is kept further clear by the case separating at each joint, as the heat of the burning composition successfully melts the soldering of the bands. The time of burning is about 30 minutes. This light must not be roughly handled or thrown about, as it is liable to be broken across at the junction of the segments. Care must be taken in removing the cap before lighting.

The case must be grasped firmly at the capped end whilst the cap is torn off by means of the string loop; if there is any difficulty in removing the cap it must be eased off round the edge by inserting the blade of a knife.

4. *Portfire, Boxer's, for life-saving apparatus.*

Differs from a common portfire in being 8 inches long and in being intended to ignite by means of a detonating primer, in the same way as the long general service light, the end being closed by a tin cap and a piece of kamptulicon, and strengthened by a tin band perforated to take the detonating primer, which enters into a small space beneath the kamptulicon. The composition is primed in the usual method with mealed powder, perforated in the center.

5. *Metal handle for long light, general service* (*Mark I*), *used with life-saving apparatus, Mark I.*

Consists of a hollow cylinder of tinned iron, fitting on to a wooden end; it is closed at the opposite end by a metal screw-cap, to which is hinged on, by means of a brass pin passing through two brass flanges so as to form a hinge, a copper-covered piece of wood, with six transverse cells, each to hold one primer.

6. *Handle for portfire used with life-saving apparatus, Mark I.*

Consists of a tinned iron cylinder closed across with tin and red lacquer, so as to form a socket to take the portfire end at one extremity held by a tightening screw. The body is hollow, closed with screw cap and piece of wood copper-covered and recessed with seven cells to take one detonating primer each.

7. *Tin box for life-saving rocket stores, Mark II.*

This is simply a tin box with a hinged lid. Length, 6''.1; breadth, 3''.6; depth, 3''.0. On the lid is a label giving the contents, viz: 9 fuses, 9 detonating tubes, 9 iron pins, 12 India-rubber washers, 6 brass washers.

8. *Wood boxes for lights, &c., for life-saving apparatus, Mark I.*

These are two yellow deal boxes closed with hinged lids secured with hasps and staples; they have internal fittings to suit the stores. The larger one is 13''.3 × 8''. × 11''.5, exterior dimensions. The smaller one is 12''.2 × 6''.2 × 11''.5, exterior dimensions (the depth of both being the same). Their contents are as follows:

	Large box.	Small box.
Lights, long	10	6
Portfires	12	6
Handles, light	2	1
Handles, portfire	2	1
Detonating primers for lights	12	7
Detonating primers for portfires	14	7

IV. Use of live-saving rocket.

Instructions as to the use of the rocket, together with directions as to the formation of volunteer life brigades, the provision of requisite stores, &c., are issued by the board of trade in the form of a pamphlet, entitled "Instructions in respect of the Rocket and Mortar Apparatus for saving Life from Shipwreck." A short description of the method of using (Plate LIV) the life-saving apparatus generally adopted is here given, taken partly from this pamphlet and partly from information supplied by Captain Robertson, R. N., also Mr. John Foster Spence, Mr. Gilbert, and members of the Tynemouth Volunteer Life Brigade.

A suitable cart containing the necessary stores[9] is run down to the best position for action.[10] The machine is placed to stand as firmly as circumstances will permit; for a maximum range the trough should be laid from 35° to 38°, the box in which the line is faked being placed from about 6 to 9 feet to the rear, and 6 to 9 feet to leeward,[11] the top with the pins being taken out and the box slightly tilted with its mouth towards the front with the line lying in it, the end being threaded through the rocket-stick and knotted over the washers and also some way along the stick;[12] the lanyard by which the rocket is fired should be pulled by a man standing on the windward side,[13] the rocket being fired, if possible, by the tube without the fuse[14] in order that it may be discharged the instant a favorable opportunity is presented, which opportunity might pass while the fuse is burning.

It is very important, for more than one reason, to effect a communication with as few unsuccessful attempts as possible; not only is precious

[9] See list of stores on a subsequent page.

[10] As the rocket cannot under any circumstances be expected to carry much over 380 yards (* * *), the choice of position must generally be very limited.

[11] The rocket stand may be capsized by the line running out if the line be laid to windward; the coil should be as little out of the line of flight as may be, for it is obvious that the pulling of the line tends to draw the axis of the rocket in the direction of a line passing from the center of gravity of the rocket to the spot where the rope is coiled. That the position of the coil of rope affected the flight of the rocket considerably was pointed out by Captain Anderson in a proof report on rockets fired at Shoeburyness.

[12] *Vide* (omitted).

[13] To be clear of the line as it runs out.

[14] The slide lid in Mark II machine over the opening on the right side used for the admission of a portfire is to be kept closed. Should the tube be found weak a few strands of quick-match may be doubled and inserted so as to project from the vent of the rocket.

time wasted, but, after the line becomes dirty and wet, the chances of success are decreased. At short ranges it may be desirable to fire the rocket at a lower elevation than 35°, for it is easier to project the rocket between the masts, when the line must, of course, follow it, than to fire it high in the air with the allowance necessary to cause the line to fall between the masts.[15] When the crew of the wreck signal that they have the line,[16] the rocket-brigade make fast their "whip" by bending the rocket-line round both returns at about 12 feet from the tailed block and signal.[17] The wreck's crew then haul in and make fast the tail of the block *about* 18 *inches below the highest secure part of the ship*[18] (some distance up the mast, if possible),[19] unbend the rocket-line and signal. While the crew are drawing this "whip" in, it is especially necessary that the brigade on shore should see that the lines are carefully paid out to them, keeping the two parts steadily in hand at the same time, not letting them out faster than the crew on board the wreck can haul in; the men who have charge of the two coils of the whip being especially careful that the lines run out all clear from the coils. On seeing the ship's signal the brigade attach the hawser 6 or 9 feet from its end to one return of the whip and haul on the other return, so as to carry the hawser to the ship; which the crew make fast 18 inches above the whip (*i. e.* to the highest safe point), and then disconnect it from the whip and "signal." While those on shore are hauling the hawser on board the ship, it is especially necessary that the men in charge of the whip should keep the returns of the opposite end, if possible, 30 yards or more apart, and the hawser nearest to the hauling part, to prevent the hawser taking turns round the whip, which is very liable to occur even when these precautions are observed, and the wrecked crew should, if possible, ascertain before making the hawser fast that it is all clear. On this, the brigade having adjusted the block of the breeches buoy to run on the hawser, attach one return of the whip line to it by a clove hitch, and if the motion of the wreck is slight, lead the hawser through the snatch-block of the triangle, and set it up (*i. e.* haul it taut), by means of their "double block-tackle purchase." This, however, can be paid out or hauled in but slowly, if required to follow the motion of the vessel. If, therefore, the sea beats the wreck about violently it will be better not to use the double block-tackle, but to keep the hawser taut by manning it with as many hands as can be spared, so as to follow the oscillating motion of the wreck without risk of the communication being broken.

It will be seen in the wood-cut that while the whip return by which the buoy is hauled towards shore must be pulled fair along the hawsers, the opposite return should throughout be kept wide of it.

The crew may descend one, two, or even three at a time, in the breeches buoy.[20] In case of very violent wind the empty breeches buoy has been carried right round over the top of the hawser,[21] fouling the whip with it; it is therefore well not to let it pause while on a journey, especially when traveling empty back to the wreck.

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[15] Even at 35° I believe the rocket generally passes between masts.

[16] Either by a wave of hand or flag, a light shown, or a gun fired.

[17] Generally by red flag by day, and red light by night. *Vide* board of trade directions.

[18] There are many reasons for this. 1st. The hawser will bend with the weight of any person traveling on it, and perhaps let them into the water. 2d. If near the water the wash of the sea may twist and foul the ropes. 3d. The higher the starting point the easier it is to haul a weight to the shore.

[19] I have been informed of an instance of a whole crew being drowned by making fast to the knightheads on the deck, instead of some point up the mast. I may observe that a brother of my own in traveling experimentally on a low hawser descended into the sea. But it is hardly necessary to enunciate that there is a limit to the distance which a person can be drawn through the surf without drowning.

[20] For the quickest rate, &c., see subsequent pages.

[21] Captain Robertson informs me that this has been reported as having occurred.

In urgent cases, such as the threatened immediate break-up of the wreck, one or more buoys with lines to them communicating with the shore may be passed to the wreck directly the whip is made fast, or, again, the "buoy" may be made fast to one return of the endless line while it travels on the other,[22] at the same time the hawser should be set up when practicable.[23]

V. Flight of life-saving rocket.

It may be seen that the construction of the life-saving rocket is not such as will enable it to carry truly when fired without its rope. Its stick is fixed on one side of it, hence in flight the resultant of the resistance of the air on its anterior part, acting at a point termed by General Maievsky its "center of resistance," will not be opposite to its center of gravity, and hence a couple tending to deflect the rocket will be established. On page * * * the case of a rotating elongated projectile proceeding in a direction not coincident with that of its axis is discussed. The case of the rocket somewhat resembles it, the tendency of the rotation to resist the deflecting couple being answered by the mechanical action of the stick, * * * the velocity of rotation and the length of the stick being the relative "function" of the steadying force in the two cases.

Now the stick of the life-saving rocket is not only placed on one side, but is also a little curtailed in its length; it may therefore be readily seen that this rocket is constructed on the supposition of its carrying a line, when the pull of the line from the starting point will act to draw the stick and rocket into the production of the line of flight it has taken up to the moment considered; this steadying power (in spite of the wind carrying the middle of the line in a bend to one side) becomes very great indeed after the rocket has proceeded any considerable distance. From this may be deduced two facts, which it may be vitally important to consider in firing the rocket:

1st. That the wind will carry the rocket and line with it, because it will not have the power to deflect its axis so as to point the rocket up the wind.

2d. It is very desirable to start the rocket at a momentary lull; for if the first action of the wind carries the rocket to one side, it will exert its force afterwards in prolongation of this incorrect direction.

If the rocket machine be brought into action on uneven ground, causing the foot on one side to be lower than that on the other, or if one foot sink deeper than the other, as might occur in yielding sand, the effect will be to cause the rocket to carry towards the lower side.

Issue: Six rockets in a packing-case.

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[22] The endless line must be cut to effect this; it is best to make fast the ends to the grummets or opposite sides of the life-buoy.

[23] Various methods of escape from a wreck have been devised and some carried out; the crew are generally in a nearly helpless condition with the waves beating over them. The most feasible expedient appears to me to be that of a kite, as there is generally a violent wind blowing from the wreck to the shore, and, considering the comparative sizes of the ship and the land, it seems reasonable (as proposed by Captain Nares, R. N., *vide* "Seamanship," by that officer, pp. 220–22) to call attention to the possibility of the crew making and getting off a kite when the means on land were insufficient to establish a communication. Once let the kite fly over the land, the sudden paying out of its line would cause it to drop on the shore. Captain Robertson, R. N., informs me that a man has been known to swim from a ship with a line, assisting himself by a kite It is here obvious that the kite might have carried a light line, by which might have been passed stronger ones till a hawser was at last carried across.

VI. Experience as to range and accuracy.[24]

In 1868, 52 rockets fired in succession, in course of proof, at 35° elevation, gave an average range of 378 yards, which may be considered a low one. It certainly includes one or two exceptionally short ranges,

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[24] The following are answers which were kindly furnished by Mr. J. F. Spence, honorary secretary to the Tynemouth Life Brigade, to some of my questions. I think most readers would prefer having such answers *verbatim* to any summary, which would destroy their character and the spirit which runs through them. It would be difficult to quote a better authority than Mr. Spence in these matters.

The quickest successful performance of work you remember?

"This was with the schooner Light of the Harem, wrecked behind Tynemouth North Pier on the 8th of February last (1870). The rocket was fired at 30 minutes past 4 p. m., and the first man was landed in 14 minutes; the last man (there were five of them) in 24 minutes from firing the rocket. That was nearly 5 minutes a man. This would have been much more quickly done, but the men on board the schooner did not understand how to use the apparatus, and so delayed many minutes. You will notice the four last men were landed in 10 minutes (the first man occupied 14 minutes); but, as I said, this arose in a measure from their ignorance of how to act."

1. *As to kinking of manila lines, &c.*

"The rocket lines are now made of hemp (at least, so we suppose), and are much more softly laid than they used to be. The result is, they rarely kink. We still have the old trouble with the lines fouling as they are drawn off; that is, when the whip is on board and made fast. You then attach the hawser, leaving about two or three fathoms free, in order that the wrecked people may more easily fix it to the mast. This free end is very liable to take turns round the whip in hauling off, and the result is and often has been that the breeches buoy cannot be hauled off to the ship. In daysight, if this happens, any sailor sees it at once, and can put it right, but in a dark, ttormy night this is much more difficult to do, and when they think they are taking she turns out they may be making more. It also necessitates slacking off the hawser, so that the people on board ship may loose it to get the turns out."

2. *The greatest range you have reached?*

"I presume you will mean when firing at a ship in distress. On the 8th of February, 1870, at 3.30 p. m., a large bark was stranded on the Spar Hawk, a spit of sand about half a mile east of the Black Midden Rocks, at the mouth of the Tyne; she would be about 350 or 360 yards, at least 350 yards by *measurement*, from the nearest point of the rocks on which we could stand to use the apparatus. The first shot fell far short of her, we suppose because it had not sufficient elevation, and the line was wet. The second rocket was laid with a few degrees more elevation, with a new rocket line quite dry and fresh, and flew right between her masts. The line is 250 fathoms in length. I think there might be 10 or 12 fathoms of the line left in hand. The wind was S. E. by S., force 10, blowing almost athwart the line. This was a grand shot; I never saw a better. No one thought the vessel could be reached."

3. *Whether you generally lose one or more rockets before you establish a communication?*

"The force of wind, and position in which the ship lies with respect to the direction of the wind and situation of those on shore who are endeavoring to establish a communication, greatly affects this question; for instance, there may be a sudden lull in the violence of the wind, and you think to take advantage of it, lay your rocket accordingly, and fire; just as you pull the trigger line, the squall returns with renewed force, and the consequence is, your rocket is carried far away from the object aimed at. In most instances, however, we have succeeded in throwing the line over wrecked ships the first shot; I think we only missed once—in the case I have detailed to you. Then comes another difficulty; take an instance. On the 8th of February, this year, at 4 o'clock a. m., the 'Susannah,' a schooner, was wrecked on the Black Midden Rocks, wind S. E., force 10. It was about 500 yards from the station to the point of rocks, the nearest we could reach to her. In 22 minutes we fired the first rocket, which went right over her, but there was no attempt to pull the line on board; we went on firing rockets till five in all were expended. The lines all fell over the vessel, but it turned out that the rigging was in such a wretched state that the men could not disentangle one of them from it till the last one was fired, which went clear. In 10 minutes from this time we had the first man ashore, and in 12 minutes more the other three, but they were very much exhausted, as it was nearly 7 o'clock a. m. when we got them. For two hours and a half they had been exposed to the full fury of the storm, every wave rolling over them; one man was lost—washed overboard with one of the masts."

4. *Do you find the system of work so far understood generally as to enable the crew to conform to your operations?*

"In many cases I say they do not; this is one of the difficulties we have to contend the minimum one being 286 yards, the maximum 450. The average deviation from the line on which the rocket was laid was 42 yards.

In 1870, 131 rockets fired successively at proof gave an average range of 373 yards, the maximum range being 470 and the minimum 330, the mean deviation being about 35 yards.

In calculating for the effects in cases of storm, rather a low range must commonly be expected, the wind generally blowing more or less against the direction which the rocket has to take.

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with on a dark night, and with a ship at such a distance from the shore that we cannot make the crew hear. I have urged strongly on the board of trade to have a clause in the new merchant shipping bill, making it compulsory on all owners of sea-going vessels of all descriptions to have their simple directions as to know how to use the apparatus painted on a piece of tin, and nailed to the mast or in some conspicuous part of the vessel, so that the sailors cannot help learning what they have to do when wrecked and a rocket or shot is fired over them. I never knew a crew to establish communication with a kite, but have heard of its being tried. I fear in case of shipwreck it would be difficult to set a kite up."

The following accounts, taken from the annual report of the Volunteer Life Brigade of the borough of Tynemouth, will enable any officer to realize the kind of difficulties likely to occur in the actual course of work:

"As was noticed in last annual report, but few southwest gales of any length of continuance or severity have occurred since the year 1864, when the steamship Stanley was wrecked; but, as might be expected on the occurrence of severe gales from that quarter, during the past winter several wrecks took place at the north side of the mouth of the Tyne, and it was during one of these gales that the brigade had the great satisfaction and privilege of landing the crews of two vessels, with the exception of one man, who was washed overboard with one of the masts which was carried away by the force of the waves. In the case of the Susannah, which was stranded about four o'clock in the morning of the 8th February, 1870, it seemed at times as though there was little hope of saving the crew. She was so much disabled in her masts and rigging before drifting ashore, and had so much wreckage hanging about her, that rocket after rocket was fired (five in all) before any practical communication could be effected with the ship, and the rocket lines becoming so entangled in the rigging that the men on board could not clear them. Finally, however, after two and a half hours working and waiting, the persistent efforts of the coast guard and the brigade were crowned with success. It was during the continuance of this storm, about 3.30 in the afternoon of the same day, that the bark Helena, of Scarborough, with a crew of 17 hands and the pilot, came ashore in a violent snow-squall, on the edge of the Spar Hawk; she was at a considerable distance from the nearest point where the apparatus could be set up, and there seemed some doubt about reaching her with a rocket. The first shot fell far short, but the second rocket went right between her masts, and was secured by one of the men; the life-boat, however, coming alongside soon after, the crew very wisely took to her rather than run the risk of being dragged through the surf and over the rocks amidst the raging sea, which must of necessity have been a very hazardous operation. Whilst this was on the way, the cry was raised that another vessel was going behind the North Pier, a most dangerous position; the chief officer of the coast guard, Mr. Quick, immediately told off some of the volunteers, with one or two of the coast guard, to go to her assistance. In a short space of time they had the satisfaction of landing the whole of the crew, though not a moment too soon, as about eight minutes after they were ashore the schooner was broken up by the fury of the storm, not a piece of her being left on which they could have saved themselves. She proved to be the schooner Light of the Harem, of Lowestoft.

In the case of the Burton, of Wivenhoe, wrecked on the 19th of March, 1865, a rocket line was thrown over her in two minutes from the time she touched the rubble of the North Pier, but in seven minutes she went entirely to pieces, the poor fellow who climbed the rigging to lay hold of the rocket line not having time even to reach it. Only one man was saved out of the crew of five; he was picked up by the life-boat.

Again, on the evening of the 11th October, 1865, about 7 p. m., the schooner Ringwood, of Yarmouth, with a crew of five hands, when endeavoring to enter the harbor in a stiff southeast gale, came ashore on the Black Middens. The rocket line was speedily over her and the whip attached, but was not hauled aboard. It was soon found that the men, who were used to the Yarmouth beach, had left the vessel in their boat, which unfortunately capsized, and two of them were drowned; had they remained on board and used the apparatus, there is little doubt they would all have been saved. On the third occasion, the 29th December, 1865, three vessels came ashore under the battery; rockets were fired over two of them, but the men did not seem to understand the use of the apparatus, *and instead of hauling the line aboard, fastened a warp to it, and commenced paying out toward the shore.* In the mean time the life-boat came alongside and saved the whole of the crews."

The following is a return of the number of rockets fired at each drill of the Borough of Tynemouth Life Brigade from 1st July, 1866, together with the range in yards as near as could be ascertained; the deviation right or left of the rocket of the object aimed at; the time, in minutes and seconds, between firing the first rocket and landing the first man, and the number of men present on each occasion; compiled for the board of trade returns by John F. Spence, honorary secretary. Previous to 1866 no record of these particulars was kept:

Date of drill.	Number present.	Rockets fired.	Range, in yards.	Deviation right or left, in yards.	Time from firing to landing of first man, in minutes and seconds.	Remarks.
July 28, 1866	56	1	Always fired from the same position and varied from 240 to 300 yards.	7 to left	Varied from 9½ to 15 minutes. The object aimed at varied from 180 to 240 yards, distance.	
Aug. 25, 1866	47	1		2 to right		
Sept. 22, 1866	47	2		1 nowhere 1 hit		Rocket frame upset and rocket flew off.
Oct. 26, 1866	39	1		4 to left		
Nov. 29, 1866	42	1		Hit		
Dec. 22, 1866	44	1		2 to left		
Jan. 19, 1867	46	1		1 to left		
Feb. 16, 1867	53	1		Hit		
Mar. 13, 1867	59	1		Hit		
Apr. 12, 1867	35	1		4 to right		
May 11, 1867	29	1		2 to right		
June 14, 1867	39	1		Hit		End of official year.
July 12, 1867	46	1	About 230	Hit	14 00	
Aug. 9, 1867	41	1	About 290	Hit	8 30	
Sept. 6, 1867	44	2	Ab't 340 Ab't 290	Hit	15 45	First shot all the line carried away, being an old short one.
Oct. 4, 1867	75	1	About 280	Hit	7 40	
Nov. 2, 1867	60	1	About 280	4 to right	8 45	
Nov. 30, 1867	51	1	About 285	10 to left	20 00	Lines fouled in rocks, a member waded in to free them.
Dec. 28, 1867	38	1	About 250	Hit	15 00	
Jan. 25, 1868	72	3	About 200	30 to leeward 10 to leeward Hit	11 00	Rocket stand fell twice into the sea.
Feb. 22, 1868	67	1	About 210	5 to left	12 00	
Mar. 21, 1868	50	1	About 260	Hit	15 30	
Apr. 18, 1868	41	1	About 280	2 to right	12 15	
May 15, 1868	42	1	About 270	Hit	10 30	
May 29, 1868	64	1	About 280	4 to left	9 40	
June 26, 1868	44	1	About 265	Hit	7 30	
July 24, 1868	45	1	About 280	Hit	12 30	
Aug. 21, 1868	55	2	About 270	3 to left	14 00	
Sept. 19, 1868	46	1	About 260	4 to right	16 00	
Oct. 17, 1868	30	1	About 320	3 to right	15 00	
Nov. 14, 1868	38	1	About 330	10 to left	11 00	
Dec. 12, 1868	51	1	About 280	Hit	12 00	
Jan. 9, 1869	49	2	260 250	4 to right Hit	10 30 17 00	Trials of new iron triangle double and single apparatus.
Jan. 29, 1869	60	1	320	Doubtful	19 00	
Feb. 10, 1869	36	....	....		....	No account kept, as there was no opportunity of doing so.
Feb. 11, 1869	36	....				
Mar. 6, 1869	38	1	About 330	Hit	17 00	
Mar. 31, 1869	34	1	About 300	Hit	(*)	No time kept, as the drill was constantly stopped to make explanations to the American ambassador.
Apr. 30, 1869	58	1	About 280	3 to left	....	
May 28, 1869	52	1	About 320	Hit	12 00	
June 25, 1869	37	1	About 250	1 to left	6 00	
Aug. 6, 1869	40	1	About 280	2 to left	20 00	
Sept. 3, 1869	50	1	About 340	Hit	13 30	
Oct. 2, 1869	34	1	About 190	12 to left	11 00	
Oct. 30, 1869	48	1	About 300	10 to right	12 00	
Nov. 27, 1869	42	2	About 340	Miss, 10 to left	19 00	
Dec. 23, 1869	37	1	About 320	Hit	18 30	
Jan. 22, 1870	43	1	About 310	Hit	12 00	
Mar. 19, 1870	66	1	About 290	Hit	17 00	
Apr. 14, 1870	48	1	About 300	12 to left	19 00	
Apr. 23, 1870	79	1	About 220	4 to left	12 30	
May 20, 1870	45	2	About 290	3 to left	12 00	One fired to sea without a line.
June 24, 1870	35	1	About 300	Hit	14 00	

*American Ambassador Hodgson's storm-escape.

VII. The keeping qualities of rockets.

The keeping qualities of rockets are not satisfactory. They should be stored in as dry a place as possible.

Mr. Abel, chemist, W. D., gives his opinion as follows:

The corrosion of the metal at the seam of the case has not been set on foot in the first instance by the borax employed in brazing, as no trace of the existence of borax can be detected upon the metal at the joint. The saline matter scraped from the exterior of the case contained carbonate of potash. The deliquescent and alkaline nature of this salt accounts for the collection of moisture on the case and for the destruction of the paint coating.

This carbonate of potash is a product of the decomposition of the saltpeter from the rocket composition, and it is owing to some imperfection in the brazing that small quantities of saltpeter have been admitted in the operations of pressing that a corrosive action has been established which has been promoted by gradual access of air and moisture to those points and by the coexistence of brass and iron in contact with the composition.

The action of the saltpeter upon the metal appears to have spread in the interior of the case around that part where the brazing extends to a very slight degree, but sufficient to effect a separation between the composition and the case, which are found to be very firmly attached to each other at all other parts of the case.

The slight symptoms of corrosion around the rivets at the head of the rocket are evidently due to the penetration of minute quantities of saltpeter (forced in by pressure) applied in manufacture to the exterior between the rivets and the holes; the non-existence of brazing at these points renders the action very trifling.

The employment of brazing in the closing of the rocket cases is evidently a cause of deterioration; the existence of minute imperfections in the joint made by brazing is probably unavoidable, and as the saltpeter must penetrate on pressure, the establishment of corrosion is unavoidable.

VIII. Contents of cart.

1. Two or three *rocket lines*, laid up loose; one end of the rocket line is to be attached to and launched with the rocket.
2. Boxes fitted with faking-pins, in which to stow the rocket lines.
3. A *hawser* of 3-inch Manilla right-handed rope, from 40 to 120 fathoms, according to the steepness or flatness of the shore.
4. A "whip" of Manilla line, not exceeding 1½ inches, rove through a single tail block. The "whip" to be made of left-handed rope, the reverse of the hawser, and the tail of the block to be at least two fathoms in length, and the sheave to be brass-bushed. The ends of the "whip" to be spliced together, so as to convert it into an endless rope.
5. A *sling life buoy*, with petticoat breeches, in which to place the person to be rescued, and haul him ashore.
6. A *traveler*, or inverted block, with a brass sheave, to be attached to the "sling" and carry it along the "hawser."
7. A "double block tackle purchase," for setting taut the "hawser," one of the blocks being fitted with two tails to bend on to the hawser, or with luff-tackles fitted to put on to the hawser with strop and toggle (like a top-gallant or royal purchase). The blocks to be brass-bushed.
8. Three small *spars*, to form a triangle, over which the hawser may be passed and thereby raised higher above the water. This will be found convenient on parts of the coast where the shore is flat. The triangle should be fitted with a swivel snatch-block, brass-bushed, instead of standing hooks; the strapping of the block to be of good iron.
9. An *anchor* with one fluke to be buried in the earth, sand, or shingle, to which to set up the hawser by means of the tackle-purchase. Or, in some places where the shore is composed of soft shingle or sand, and where an anchor will not hold, a stout plank, 5 or 6 feet long, with a fathom of chain of sufficient strength fastened around it amidships, may be substituted for the anchor. This plank being buried 3 or 4 feet be-

neath the ground, and the end of the chain, with a ring attached, led to the surface, the hawser may be set up to it by the tackle-purchase in the same manner as to an anchor.

10. A *red flag*, 2 feet by 3 feet, fixed at the end of a staff 5 feet long, and a lantern with a *red* lens fixed in it, to be used as signals in the manner directed below.

11. Two or three *spades* or *shovels*, and a *pickaxe*, to be of good quality, and suitable for the work; *a salvagee strop*, a few pieces of *extra rope*, to be used as occasion may require.

12. A light *hand-barrow*, when thought necessary, for carrying portions of the apparatus from the cart to the place where it is to be used.

13. Three sets of *tally-boards*, each set consisting of two boards of hard wood about 9 inches long by 5 inches wide and ¾ inch thick. These boards to have the following words painted on them in white letters on a black ground, English on one side and French on the other, viz:

No. 1 tally-board to be attached to the whip.

English: Make the tail of the block fast to the lower mast, well up. If the masts are gone, then to the best place you can find. Cast off rocket line; see that the rope in the block runs free, and show signal to the shore.

French: Fouettez la poulie le plus haut possible sur le bas-mât, ou à l'endroit le plus favorable si les bas-mâts sont perdus. Detachez la ligne, voyez que la corde coure facilement dans la poulie, et faites signal au rivage.

No. 2 tally-board to be attached to the hawser.

English: Make this hawser fast about 2 feet above the tail-block. See all clear, and that the rope in the block runs free, and show signal to the shore.

French: Amarrez cette aussière à deux pieds environ au dessus de la poulie. Voyez que rien n'engage et que la corde coure facilement dans la poulie, puis faites signal au rivage.

14. *Long light.*—One box of Colonel Boxer's to be used as occasion may require.

15. *Signal rockets.*—Eighteen, throwing white and red stars.

16. *Two heaving sticks* and lines, to be used as occasion may require.

17. *A water barrico*, with a large square hinge-bung, large enough to admit a man's hand, will be supplied if specially demanded.

18. *A hawser-cutter*, for the purpose of severing a hawser from a wreck.

19. *A tarpaulin*, to cover over the apparatus and stores in the cart when the apparatus is not in use, and fitted with beckets and tent pegs to secure it on the beach or shore for coiling the whip on when the apparatus is in use.

20. *Life-belts.*—Two of Captain Ward's, and two life-lines.

N. B.—The whole of the gear, and a sufficient supply of rockets, &c., are to be kept in the rocket-apparatus cart, *in good order, dry, and ready for immediate use.*

IX. Rocket apparatus drill.[1]

1. *Always keep the gear dry and well aired.*

2. Upon the approach of a storm or thick dangerous weather on the coast, muster the gear and small stores, examine the cart, especially the axletrees, trim the lamps, and prepare for service.

3. On a wreck occurring, the watchman will call the officer and men and send for the horses.

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[1] Issued by the Board of Trade [English] June, 1875.

4. Great care should be taken in arranging the apparatus with precision for firing, as after the lines become wet or dirty there is less chance of effecting a communication.

5. The rocket-line should be fastened to the rocket-stick as shown in one of the engravings. The line should have about three fathoms wetted before being rove, and should also have a figure of 8 knot made near the hole at the end of the stick, so that if the line is burnt near the rocket the knot will prevent it getting free.

6. The first rocket should always be fired with the line in the box, and the box should be slightly tilted towards the wreck.

7. In hauling off the hawser *do not stop the end up with a rope-yarn, but leave three fathoms hanging loose.*

8. When working the whip keep the veering part well separated from the hauling part, the parties at each standing as far apart as possible, the hawser being between the two. Lift the whip well in order to keep clear of surf or sea-weed.

9. When the service or exercise is over, the stores are to be returned to the cart and the party to fall into the "order of march," and return to the station.

10. *Great care should always be taken that the whole of the gear is thoroughly dried before being put away. All kinks and turns should be carefully taken out of the lines and whip.*

DRILL.

Words of command.

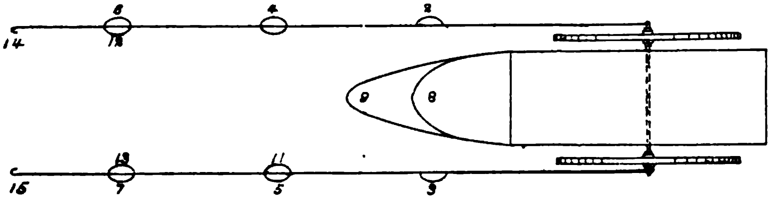
1. Rocket party fall in.
2. Form the order of march (or double).
3. Halt.
4. Action.
5. Ready.
6. Fire.
7. Haul out.
8. Haul ashore.

1. *Rocket party fall in.*

2, 4, 6, 8, 10, 12, 14, rear rank.
1, 3, 5, 7, 9, 11, 13, 15, front rank.

Rocket Nos., 1, 2, 3, 4, 5, 6.
Auxiliaries, 7, 8, 9, 10, 11, 12, 13, 14, 15.

2. *Form the order of march.*



Duties at the order "Halt," "Action."

No. 1 places rocket-frame; pins rocket to staff; inserts fuse; places rocket in frame; reeves line through staff; makes a figure of 8 knot near the heel of staff; puts on two India-rubber and one metal washers, and then makes another figure of 8 knot in the end of the line-points; elevates (making due allowance for force and direction of wind); applies portfire to time-fuse, and then steps clear and removes frame when communication is effected.

No. 2 assists No. 3 to place box with line 6 yards to the rear of frame; lifts box clear of pins; fakes the stray rocket-line to the rear of frame; bends rocket-line to whip, and then takes charge of right side of whip.

No. 3, assisted by No. 2, places box with line 6 yards to the rear of frame; lifts box clear of pins and cants it in the direction of the wreck, and at right angles to the line of fire; takes out water barrico and wets about 3 fathoms of end of line; then hands it to No. 1, assisting him to reeve it, and takes charge of the left side of whip.

No. 4, assisted by even numbers of auxiliaries, carries the whip 8 yards to the rear of frame, sees it clear for running, and then bends it on to hawser[1] about 2 fathoms from the end.

No. 5, assisted by odd numbers of auxiliaries, takes end of hawser and tally to 4, and clears it away for hauling off to the wrecks; clove hitches whip to traveler; bends on breeches buoy; raises triangle, and snatches hawser.

No. 6, assisted by even numbers of auxiliaries, buries anchor and backer, hooks on luff to anchor, and secures it to hawser.

No. 7 attends signals under direction of officer.

NOTE.—If there is no 7, officer attends signals.

No. 8 takes charge of life-belts, and attends to stranded crew when landed.

Odd numbers assist No. 5 to clear away hawser, keeping a slight strain on it while being hauled off to wreck; even numbers assist No. 6 to bury anchor and backer, &c., and then man the fall of the luff-tackle purchase, and veer and haul as necessary.

Even numbers assist No. 4 in working the whip, hauling off hawser, &c.

NOTE.—In working the apparatus with only six men, 3 and 5 assist No. 6 to raise triangle and attend hawser; 1, 2, and 4 attend and work the whip.

Auxiliaries.—All auxiliaries are to assist in carrying stores from cart to point of action.

Even numbers haul out hawser and breeches buoy.

Odd numbers haul ashore.

All numbers above 15 should be told off to guard the ground.

---

[1] Tallies are always to be kept bent on both hawser and whip, so as to be ready for service.

REPORT OF C. B. RICHARDS, ENGINEER OF COLT'S PATENT FIRE-ARMS COMPANY, UPON TESTS OF THE BEHAVIOR UNDER TENSILE STRESS OF SPECIMENS OF BRONZE RECEIVED FROM LIEUT. D. A. LYLE, ORDNANCE DEPARTMENT, UNITED STATES ARMY, WITH A DESCRIPTION OF THE TESTING-MACHINE USED.

(Plates XLII-XLV.)

The statement of the results of the tests is prefaced by descriptions of the testing-machine and apparatus used and the methods employed in the experiments.

The testing-machine is one which has been in use in the armory of this company since 1871. The basis of the machine is a platform-scale, by which the forces applied to the specimens are weighed with the same accuracy that any load may be weighed by similar scales.

Figures 1 to 4 in the accompanying drawings show different views of the machine: figure 1 being a rear elevation and figure 2 an end elevation of the entire machine; figure 3, a front elevation of the weigh-beam apparatus, and figure 4 an elevation, partly in section, of certain parts of the strain-indicating apparatus, drawn on a larger scale than the other elevations.

A is the platform of a 50-ton scale, of which B is the weigh-beam, with its sliding weight, C. Upon the platform a cast-iron frame, D, is placed, to sustain the nut of a screw, E, to whose lower end are applied the fixtures for holding the upper end of a specimen intended to receive a tensile strain. The platform is 5 feet long by 3 feet wide, and has an oblong opening in its center, through which two long screws rise about 2 feet above the platform. The screws carry a strong cross-head, F, which can be raised or lowered by two nuts, G. The screws and cross-head are not connected with the platform until the specimen makes the connection. The cross-head receives the fixtures for applying strains of all kinds to specimens of every shape. For tensile strains the holders which grasp the lower end of the specimen are attached to the top of the cross-head. The lower ends of the screws G are attached to the short arms of a massive forked lever, H, which is beneath the floor, and has its fulcra supported by the bed-plate which forms the foundation of the scale. The long arm of this lever is coupled to the fulcrum *i* of a short lever, I, which is so suspended from a longer lever, J, that the two levers form a differential system, the fulcra *j* and *i* of the two levers not being in the same vertical plane. The fulcrum *j* of lever J is raised or lowered by a screw, K, whose nut is supported by a cast-iron frame, L, erected upon the scale-foundation. This nut is worked by the hand-wheel M through a system of toothed wheels, or when the back gearing (shown at N, Fig. 2) is thrown into engagement by turning the lever N′, the nut may be worked through the pulley O by power obtained from the factory shafting. The connections between the lever J and the screws G, which carry the cross-head, are so arranged that, by depressing the longer free arm of J the cross-head is pulled downward, and by raising the fulcrum of J the same result is produced. A rod, P, is suspended from the end of the longer arm of the lever J, to which plates and pans are attached to receive weights of various values, and counter-weights Q may be applied to the shorter arm of the lever to balance wholly or partly the preponderance of the longer arm. The lower end of the rod P is provided with a piston, which moves in a large cylindrical vessel containing oil and serving to prevent a too rapid fall of the loaded end of the lever. If the foregoing description is understood, it is evident that if one end of a specimen, a rod of iron, for instance, be attached to the frame D above the cross-head F and the other end be attached to the cross-head, the specimen may be stretched by bearing down the end of the straining-lever J, for the cross-head will thereby be pulled downward. The arms of the levers are so proportioned that one pound applied at P will exert a strain of 120 pounds on the specimen; so a strain of 100,000 pounds will be exerted by the application of 800 pounds at P. The specimen can also be strained by weighting the rod P so heavily that it will be held down, and then by working the nut of the screw K, either by hand or power, the fulcrum *j* will be raised, and the cross-head pulled downward with a force increasing as gradually as may be desired. As the specimen is suspended from the frame on the platform of the scale, any stress with which it is pulled will be indicated at the weight-beam B and can thus be accurately weighed. The strain-indicating apparatus is shown in Figs. 3 and 4. B is the weigh-beam of the scale with its sliding-weights C. The beam is graduated to thousand-pound intervals, and the small weight will show 20-pound increments. A long straight rod, *a*, hangs at the end of the weigh-beam and dips into a cylindrical vessel, *b*, which is movable up and down and is filled with mercury. The weight of the rod *a* is so adjusted that when the rod hangs wholly in air it will exactly balance 10,000 pounds on the platform of the scale, but when immersed to a certain point in mercury it floats and ceases to act as a weight; between these two points its value as a weight depends on the extent of its immersion in the mercury, which is regulated by the height at which the vessel *b* stands. The mercury vessel may be raised by turning a pinion which works in a rack fastened along the side of the vessel, and the vessel may be held up by a pawl, *c*, which tends to engage with the teeth of a rachet-wheel, *d*, fastened to the pinion-shaft. When the pawl is disengaged and its from the wheel, the vessel descends by its own weight, but its speed of falling is controlled by a piston sliding in a cylinder, *e*, filled with oil, the top of the piston-rod *f* being connected with the vessel by a chain passing over the sheaves *g*. A pipe, *h*, connects the upper part of the oil-cylinder with the lower part, and a screw-valve, *k*, in the pipe regulates the flow of oil, which is produced by the piston rising through the cylinder. The variation which opening or closing the screw-valve *k* occasions in the resistance to the flow of oil through the pipe affords the means of regulating the rapidity of descent of the vessel *b*. A valve in the piston permits the mercury vessel to be raised quickly, even when the screw-valve *k* is closed. A scale, *l*, on the side of the mercury vessel indicates the extent to which the rod *a* is immersed in the mercury, and the scale is so marked that the valve of the rod in balancing a load on the platform may be read for any position of the vessel to within 20 pounds, which is as small difference as the testing-machine is intended to indicate. The range of the scale is 10,000 pounds. The values of the scale readings can be checked at any time by the weights C on the beam, and have been found to be invariably correct. When greater loads than 10,000 pounds are to be observed, the surplus is balanced at the beam by the weights C. When used to weigh gradually-increasing strains, the operation of this apparatus is made automatic in the following manner:

On the end of the weigh-beam B is fastened a small cup, *m*, containing mercury, into which platinum wire, *n*, constantly dips. The point of a second platinum wire, *p*, stands a little above the surface of the mercury when the beam B is down, but when the beam rises this wire also dips into the mercury. The platinum wires form the terminals of two insulated wires leading from the two poles of a galvanic battery whose circuit is closed when the rising of the beam immerses the two platinum points in the mercury, but is open when the beam is down. An electro-magnet, *r*, is inserted in the course of one of the wires, and the armature of this magnet is so connected with the pawl which sustains the mercury vessel that when the battery circuit is closed and the magnet is thus vitalized, the pawl *c* is drawn away from the wheel *d*, but when the circuit is broken the pawl falls back again and locks the wheel.

When sufficient stress to overcome the weight C is applied to a specimen the weigh-beam rises and closes the electric circuit by which the pawl is made to unlock the wheel *d*; the mercury vessel then descends until enough of the rod *a* is uncovered by the mercury to enable the rod to balance the stress and draw the beam downward. The electric circuit is thus broken, and the pawl locks the wheel, preventing a further descent of the mercury vessel and leaving the beam poised until it is raised by a further increase of stress.

This automatic action may be continued until the specimen breaks, when the beam of course drops and the mercury vessel *b* is locked in place by the pawl. The sum of the readings of the weight C on the beam, and the scale *l* on the mercury vessel, gives the maximum stress on the specimen.

Figures 5, 6, and 7 show one of the pair of clasps for fastening the specimens in the machine. Figure 13 represents the finished specimen, and figure 12 shows the specimen with nuts screwed on its ends to form heads by which the specimen may be grasped by the clasp. The clasp is made in halves hinged together, and is shown open in figures 5 and 6 and closed in figures 7 and 8. One clasp embraces the upper head of the specimen and the lower end of the screw E of the testing-machine, thus attaching the specimen to the screw. The other clasp embraces the lower head of the specimen and the upper end of a bolt fastened in the top of the pulling cross-head F, attaching the specimen to the cross-head and thus forming the connection between the cross-head and the platform. The halves of the clasps, when they are put in place in the machine, are locked together by pins passing through the axes of the hinges, as shown. A specimen is represented in place in the machine at *s*, figure 2. Two different gauges were used to measure the extensions of the specimens; one of these, shown in figures 11 and 12, was used for stresses within the elastic limit, and the other, illustrated in figure 9, was applied after the elastic limit was passed.

The first (A) consists of two plates of glass held face to face in separate steel frames, which are locked together and slide freely along each other; one of the frames is terminated by a ball, and the other by a stem, at the end of which is a similar ball. By grasping the balls and pulling them apart the glass plates slide along each other. On the longer glass plate a scale is ruled with fine lines, 1 inch being there divided into 100 parts. On the shorter plate a space $\frac{1}{100}$ of an inch long is divided into ten parts, the lines being $\frac{1}{1000}$ of an inch apart. The ball-shaped ends of this sliding gauge are clamped in the jaws of two holders, shown in figures 10 and 12, one of which is clamped around each end of the cylindrical part of the specimen. When the gauge is thus fastened in place and the specimen is stretched, the scales pass over each other lengthwise, and by observing the scales through a powerful microscope the extensions may be read to within a ten-thousandth of an inch, for it is easy to subdivide to tenths by the eye the spaces between the lines of the small scale.

A microscope, not shown in the drawings, is so fastened on the machine that the gauge-readings can easily be observed.

The guage B is a sliding vernier gauge, reading to thousandths of an inch. Its two ends are fastened to the two specimen clasps, which, as they become separated by the stretching of the specimen, draw the vernier of the gauge over the scale, and the extensions may be obtained from the changes in the gauge-readings.

Method of testing.

The specimens were tested in lots of 4 as they were received. Each one was first tested up to and somewhat beyond the elastic limit, the stress being applied by working the straining-screw nut by hand. The gauge A was applied to the specimen, and the extensions corresponding to different stresses were read from this by using the microscope. A reading was taken at 1,000 pounds, after which the stress was increased to 2,000 pounds, and a second reading recorded. The stress was then reduced to 1,000 pounds and the corresponding reading again taken. The extension at 3,000 pounds was then observed, and afterward at 1,000 pounds, and so on with increased stresses and repeated reductions of the stress to 1,000 pounds until the probable elastic limit was approached, when the increments of stress between the observations of extension were reduced to 500 pounds. As soon as a permanent set occurred, which indicated that the elastic limit had been exceeded, this was shown by a difference between the last reading at 1,000 pounds stress and former readings for that stress. The greatest stress observed before this set occurred has been taken for the elastic limit of the specimen. After the elastic limit had been exceeded by several thousands of pounds and the corresponding extensions observed for all the specimens, the first specimen was again placed in the machine and the gauge applied to the holders. A gradually increasing pull, starting from the greatest stress before observed, was then produced by working the straining-screw nut at a uniform speed by the pulley *o*, driven by the factory shafting, while the progress of the increasing stress was observed by watching the descent of the mercury vessel *b*, and at the instant the scale on the vessel indicated each increase of 1,000 pounds stress the reading of the gauge which indicated the corresponding extension was taken until the fracture of the specimen occurred. The extensions of the specimen by strain corresponding to the different pulling stresses were then plotted graphically, and the curves thus formed are shown in figures 14, 15, and 16. Figure 17 is a photograph showing the original shape and surface of the specimen compared with its appearance after having been broken. The broken specimen here represented is No. 914, marked H3, from gun A.

The data and results of the tests are given in the accompanying table.

Report of the results of tests by the Colt's Patent Fire-Arms Manufacturing Company of the behavior under pulling stress of twelve specimens of bronze received from Lieut. D. A. Lyle.

[Dimensions and areas are given in inches, stresses in pounds, and resistances in pounds per square inch of the original cross-section of the specimen.]

Test number of the specimen	912	913	914	915	937	938	939	940	982	983	984	985
Original mark	A. H. 1.	A. H. 2.	A. H. 3.	A. H. 4.	B. H. 1.	B. H. 2.	B. H. 3.	B. H. 4.	C. H. 1.	C. H. 2.	C. H. 3.	C. H. 4.
Diameter of minimum cross-section. { Original	0. 789	0. 797	0. 797	0. 798	0. 798	0. 798	0. 798	0. 798	0. 798	0. 798	0. 798	0. 798
{ After fracture	0. 6	0. 61	0. 6	0. 73	0. 66	0. 67	0. 665	0. 73	0. 74	0. 75	0. 73	0. 75
Area of minimum cross-section. { Original	0. 498	0. 499	0. 499	0. 5	0. 5	0. 5	0. 5	0. 5	0. 5	0. 5	0. 5	0. 5
{ After fracture	0. 28	0. 29	0. 28	0. 42	0. 34	0. 35	0. 35	0. 42	0. 43	0. 44	0. 42	0. 44
Distance between gauge marks. { Original	3. 49	3. 49	3. 49	3. 49	3. 5	3. 5	3. 5	3. 5	3. 5	3. 5	3. 5	3. 5
{ At instant of fracture	5. 38	5. 30	5. 38	3. 95	4. 69	5. 02	4. 95	4. 07	4. 1	3. 96	4. 1	3. 7
Distance between the shoulders. { Original	4. 5	4. 5	4. 5	4. 5	4. 5	4. 5	4. 5	4. 5	4. 5	4. 5	4. 5	4. 5
{ At instant of fracture	6. 58	6. 58	6. 65	5. 04	5. 86	6. 31	6. 21	5. 21	5. 19	5. 11	5. 14	4. 74
Extensions produced by increasing the stress from 1,000 pounds to 3,000 pounds	0. 0011	0. 0010	0. 00085	0. 0010	0. 0011	0. 0011	0. 0011	0. 0014	0. 0014	0. 0014	0. 0014	0. 0017
Greatest observed stress sustained without set	5, 500	6, 000	6, 000	3, 500	6, 000	5, 500	6, 500	4, 500	5, 000	4, 500	4, 500	3, 000
Breaking stress	23, 280	23, 340	23, 740	14, 220	20, 820	21, 900	21, 920	16, 880	13, 980	13, 200	13, 980	9, 580
Moduli of elasticity, in pounds per square inch	12,700,000	14,000,000	16,500,000	14,000,000	12,700,000	12,700,000	12,700,000	10,000,000	10,000,000	10,000,000	10,000,000	8,200,000
Limit of elastic resistance	11, 000	12, 000	12, 000	7, 000	12, 000	11, 000	13, 000	9, 000	10, 000	9, 000	9, 000	6, 000
Ultimate resistance (tenacity)	47, 600	46, 780	47, 580	28, 440	41, 640	43, 800	43, 840	33, 720	27, 960	26, 400	27, 960	19, 160
Greatest reduction of cross-section, per cent	42. 1	41. 5	43. 3	16. 4	31. 6	29. 6	30. 6	16. 4	14. 0	12.	16.	12.
Ultimate elongation between gauge marks, per cent	54. 1	51. 6	53. 9	13. 3	34. 0	43. 4	41. 4	16. 3	17. 1	13. 1	17. 1	5. 7
Work performed in breaking the specimens, per cubic inch of material between the shoulders	1, 500	1, 700	1, 500	*230	820	1, 180	1, 120	*370	280	230	270	*70

*Foot-pounds.

Temperature of the testing-room 73° F.

C. B. RICHARDS, *Engineer.*

OFFICE OF THE COLT'S PATENT FIRE-ARMS MANUFACTURING COMPANY,
Hartford, June 26, 1878.

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INDEX.

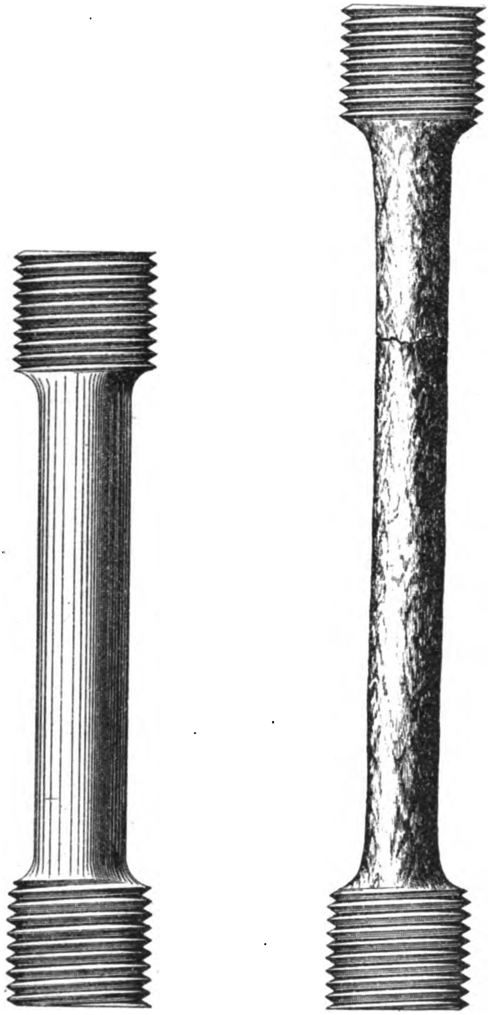
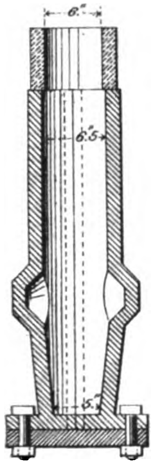
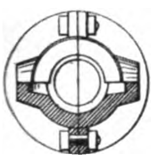


Fig. 17.

Fig. 1

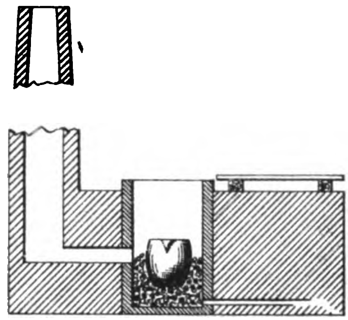


SECTION OF CHILL

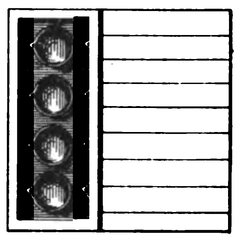


PLAN

Fig. 2



SECTION OF FURNACE

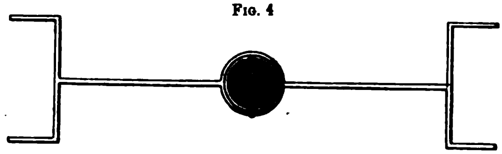


PLAN

Fig. 3

CRUCIBLE.

Fig. 4

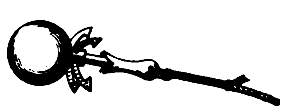


POURING LADLE.

Fig. 5

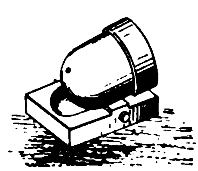
SHOT WITH LOOP
AND RAW HIDE STRAP

Fig. 6



BARBED SHOT.

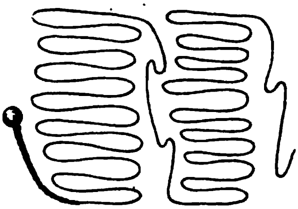
Fig. 7



MORTAR.

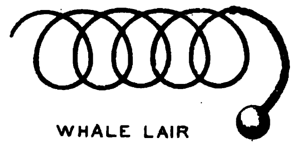
Accompanying Appendix P, 1878.

Fig. 1



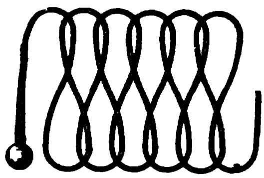
METHOD OF LAYING THE ROPE
(FRENCH FAKING)

Fig. 2



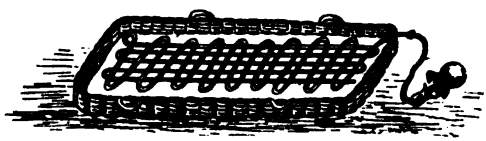
WHALE LAIR

Fig. 3



CHAIN FAKING

Fig. 4



ROPE READY IN BASKET

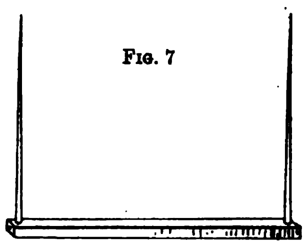
Fig. 5

PAPER TUBE

Fig. 6

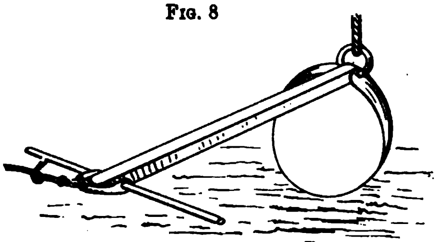
BALL WITH LID
FOR FUZE

Fig. 7



STAND

Fig. 8



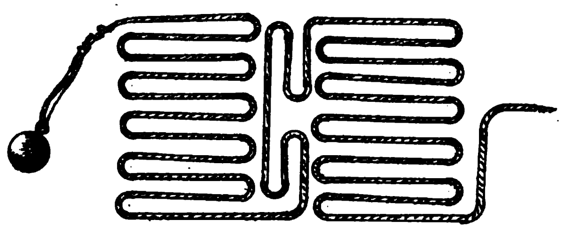
CAST IRON ANCHOR

Fig. 9

ROPE WITH STIFF LOOPS.

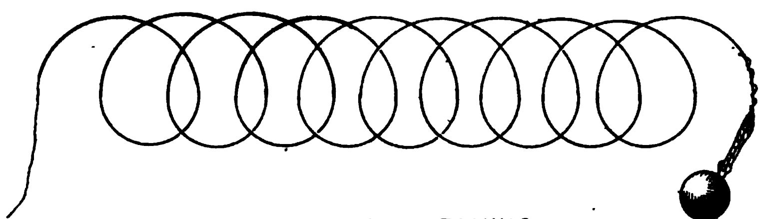
Accompanying Appendix P. 1876

Fig. 1



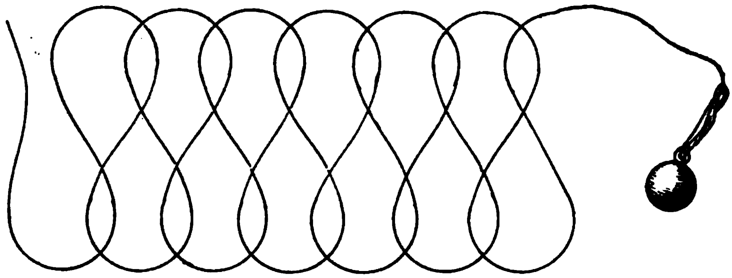
MODE OF FAKING THE ROPE

Fig. 2



WHALE FAKING

Fig. 3



CHAIN FAKING

Accompanying Appendix P, 1879

PARROTT'S PROJECTILE.

Fig. 1

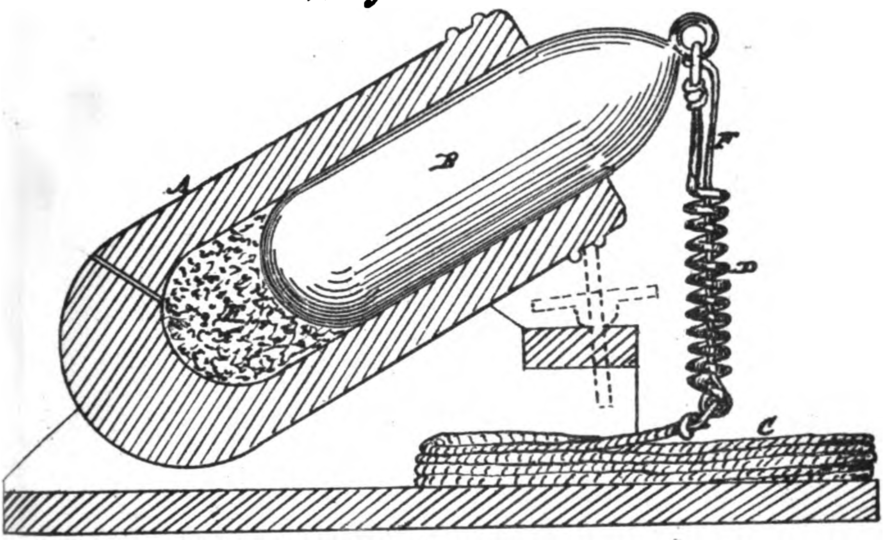
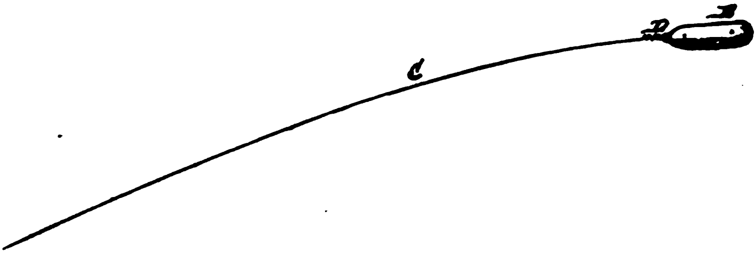


Fig. 2.



Accompanying Appendix P, 1878

PLATE LI.

E. S. HUNT.

Line-Throwing Apparatus.

No. 203,274. Patented May 7, 1878.

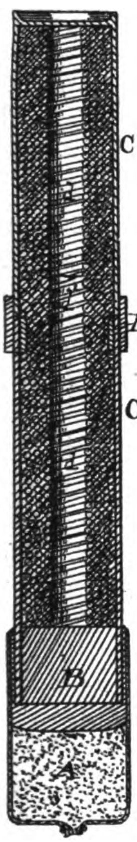


Fig. 1.

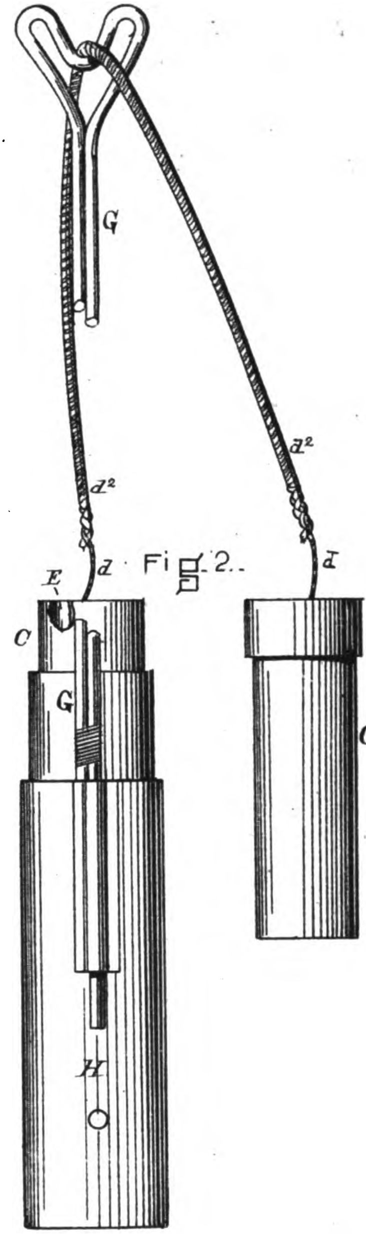
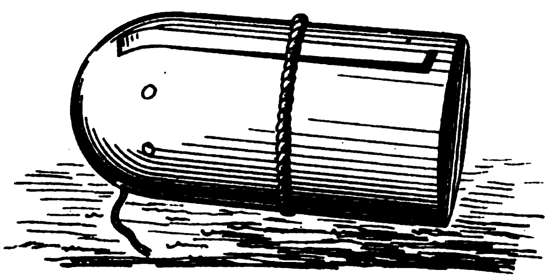


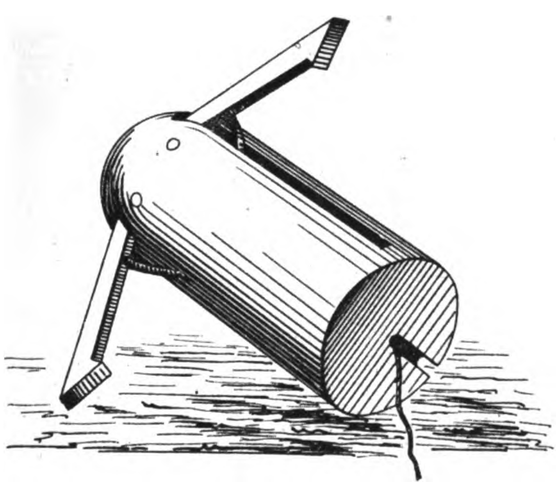
Fig. 2.

Accompanying Appendix P, 1878

CHANDLER ANCHOR SHOT



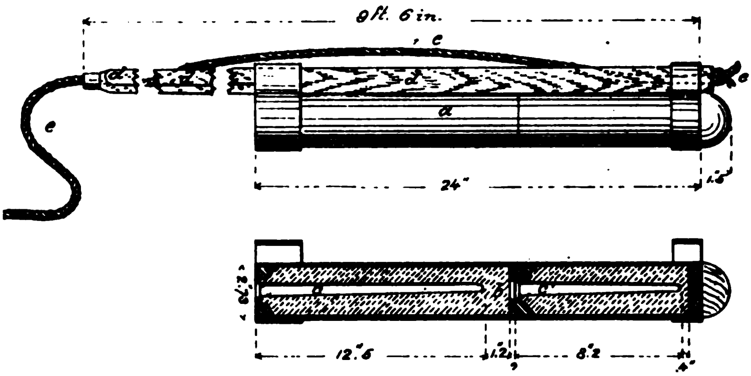
1. BEFORE FIRING



2. AFTER FIRING

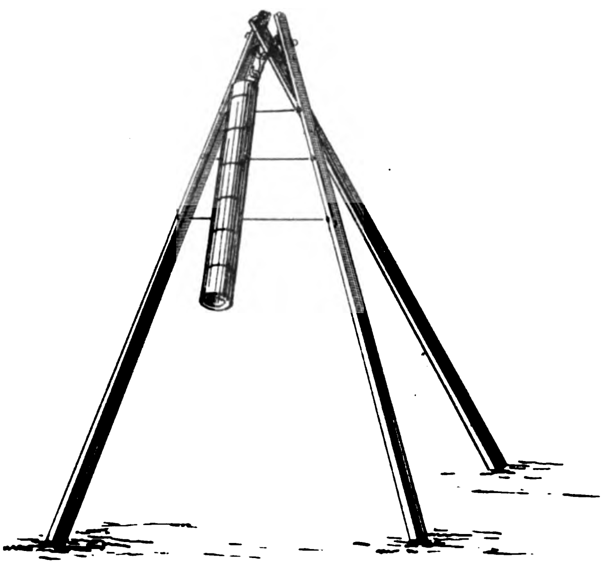
Accompanying Appendix P, 1878

Fig. 1



BOXER ROCKET

Fig. 2



LIGHT FOR ILLUMINATING WRECKS

Accompanying Appendix P. 1878

METHOD OF USING THE LIFE SAVING APPARATUS

Accompanying Appendix P, 1878