Brooke's Reports

upon the construction of Rifle

And other Cannon

for the Naval Service of the

Confederate States.

Richmond 1863.

Brooke on Rifle & other Cannon.

Brooke, John M

Manuscript – with tracings of Cannon, Projectiles &c.

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Office of Ordnance & Hydrography.
Richmond, Va. January 10th 1863.

Sir

I have the honor to transmit herewith an interesting and valuable report from Commander J. M. Brooke, upon the construction of Rifle and other Cannon for the Naval Service of the Confederate States.

I am Sir, Very Respectfully,
Your Ob't Serv't.
(Signed) George Minor,
Chief of Ordnance & Hydrography

Honorable S. R. Mallory
Secretary of the Navy.

Navy Department,
Office of Ordnance & Hydrography.
Richmond. January 8th 1863.

Sir

In accordance with your order of the 21st ulto, I have the honor to submit the following report on the construction of Rifle and other cannon for the use of the Naval Service of the Confederate States.

The sustained efforts made during the past few years to improve the Ordnance of England, France and the United States, have placed at our disposal the results of numerous experiments, demonstrating the applicability of certain principles of construction, by which sufficient strength may be obtained, to permit the employment in rifles of heavy elongated, solid shot; with the high charges required to give them velocities nearly equal to those hitherto obtained with smooth bore 64 pdr. guns with the usual service charges.

It will be proper to give, in addition to some account of the most important of these experiments, such illustrations from the published history of Ordnance, as will enable me to present without confusion a general view of the subject.

The introduction of the Paixhan shell, which against wooden vessels is esteemed the most formidable missile yet devised, appears to have been the immediate cause of the active efforts made in France and England to protect vessels by the application of iron plating. It was shown that.. hollow projectiles broke into fragments on striking plates of iron not more than an inch or two in thickness, by which, their effect was so weakened as to render them inferior to solid shot. It was then soon discovered, that when increased in thickness to four and one half inches, the iron plating resisted single solid shot of 68 pounds, at ranges of less than two hundred yards; but a number of such shot, striking simultaneously or consecutively, shattered the plate. The probability of being so struck in naval engagements is small, and the French government perceiving the advantages which would attend the possession of sea-going vessels comparatively invulnerable to the heaviest ordnance then in use, caused several to be constructed. England followed the example, and since then numerous vessels of large size and heavily armed have been built.

The introduction of armor thus depriving the shell of its supremacy, and practically protecting ships from solid shot, the attention of ordnance men was naturally turned to the invention of projectiles which would penetrate it, and eventually to the construction of guns which would possess sufficient strength to throw them.

As in the employment of armor, France was the first to apply generally the system of rifling to small arms and cannon. The impulse given by the discoveries and improvements of Delvigne, Thouvenin and Minie', was communicated to other countries, each seeking to maintain its relative strength by the importation of improvements or by invention.

In England, Blakely, Sir Wm Armstrong, Whitworth and others, chiefly with the view of obtaining range and accuracy, were engaged in constructing, and experimenting upon, rifle cannon, The Armstrong and Whitworth guns, would, it was supposed by many, prove most effective. But, although the long bolt of the latter, from its small surface of resistance as compared with its weight, penetrated armor similar to that of the "Warrior," 4½ inch plate, its effect was not great. The Armstrong 100 and 180 pdrs. failed to penetrate at 200 yards. Smooth bores of moderate calibre at the same distances produced greater effects,

This much was known of what has been accomplished in

England, when to meet the demands of the service, the construction of rifles was commenced here. The inference drawn from the results of the English experimental firing, was, that with higher charges than the guns then made were capable of bearing, the rifle would be more effective than smooth bores of the largest calibre, which could be cast with the limited means at our command. The results of experiments by Longridge, Blakely, Armstrong and others, as I have observed, afforded ample proof of the practicability of constructing rifle cannon of sufficient strength to bear charges greater than were ever before used.

The simplest and most direct method of proceeding was therefore, first to determine what form of projectile of sufficient size to produce destructive effect was best adapted to the penetration of armor.

It was evident that the "bolt," which presents small surface of resistance as compared with its weight, promised the best results, by change of proportion of length and diameter we may produce a penatrative or crushing effect as desired.

Experiments here as well as abroad, had shown that cast iron projectiles were generally broken against iron plates. It was therefore necessary to employ, although deficient in hardness, the only available material, wrought iron. In determining the form to be given the head of the "bolt," that employed in machines for punching cold iron, was considered. The punching machine used at the Tredegar Works, punches, at a single blow, clear holes of 1¼ inches diameter through plates of iron two inches thick. But the tempered steel die of this punching machine is nearly cylindrical; wrought iron "bolts," so formed would be upset, and on the circumference of the head, the iron would roll back. To avoid this, the forward end of the "bolt" was slightly tapered, the result of which would be to compress the iron in upon the axis of the "bolt," thus condensing the head. To obtain rotation, which is essential to direct flight, metal was turned out of the base, leaving a thin lipped cup similar to that of the Minie ball; and to ensure expansion, a groove was turned around the "bolt" just in front of the cup. (See Fig. 1. a. pl. 1.)

On the 11th of March 1862, "bolts" of this form were fired from a three inch Parrott gun at a target of oak 9 inches thick, faced with iron plates six inches wide and two inches thick, firmly bolted. The target was fifty feet from the muzzle of the gun. With a charge of 1½ lbs of powder, the "bolt" weighing 8½ lbs. perforated the plate and splintered the timber backing. Its form was changed by the shock, as shown in the drawing. (Fig. 1. b. pl. 1.) But as the iron was of the description known as rolled iron, the fibres running longitudinally, portions of the rim of the cup were in some instances blown or torn off. It was however found that the cups would take the rifling perfectly without the aid of the groove. The results of these experiments were satisfactory; and "bolts" were forged for 7-in. and 6.4 inch rifles. There happened to be no gun here at the time with which to test them; they were therefore sent to Norfolk for trial, the lips of the cups being left thicker than would probably be required, in order that the proper thickness in "bolts" of that size might be determined by experiment. It is obvious that if made too thin, the error could not be rectified. As anticipated, several tumbled, but on reducing the thickness of lip no further difficulty was experienced. The experiments were made under the direction of an accomplished artillerist, Catesby ap R. Jones, of the Navy. The range attained with these "bolts" at 8° was but little inferior to that of the cylindro-conic shell.

Reserving further details of experiments with bolts of this description, and hollow projectiles, for future consideration, it will be well to refer here to the elements of weakness which attend large guns made of single castings. Barlow has shown that hollow cylinders, of the same material, do not increase in strength in the ratio of increase in thickness; that the strain produced by the action of a central force at different points are inversely as the squares of their distances from the centre. Consequently, in large guns of homogeneous material the metal of the bore is sometimes broken, before the exterior iron has born more than one ninth of the strain.

Mallet, in his work "On the construction of Artillery," says; "It is a law of the molecular aggregation of crystaline solids, that when "their particles consolidate under the influence of heat in motion their "crystals arrange and group themselves with their principal axes in "lines perpendicular to the cooling or heating surfaces of the solid. When "crystals perpendicular to different surfaces join, the crystals abut "or interlock. Along these lines the crystalization is confused and "irregular," and Gibbon, referring to the usual course of lines of fracture in bursted guns, remarks, that, "however incapable the unaided eye may be to discern any difference in the chrystaline arrangement of one part of the gun more than another, such plan[es] of weakness do exist."

The importance of considering this law ingiving form to guns was illustrated very fully in proving several 8 inch Columbiads and 9 inch Navy guns at Boston.* Any irregularity in form, involving variations in quantity of metal, and unequal rapidity in cooling, tends to produce unequal strains, which weaken the gun. With the lapse of time these strains from the property which iron possesses of gradually accomodating itself to them, are diminished.+

*App. p. 28. a. +App. p. 28. b.

Wade adopting this view, says: "If these conclusions are well "founded, as they are believed to be, we must in making large "guns, cast solid, select a softer and weaker iron to commence "with and then impair its density and strength, by a very "slow process of cooling: in order to prevent the dangerous con- "-sequences of straining the iron by unequal contractions in "cooling. ‡ This involves an abandonment of the harder and the "stronger iron, because of our ignorance in the art of mana- "-ging it. These are conditions which should not be willingly "submitted to; but efforts should rather, be made to learn how "we may so manage the best material, that it shall retain its "superiority in the completed weapon. The obstacle in the way "is the irresistible law of contraction under differences of temper- "-ature, and the remedy it is believed, can be found only in "conforming to that law."

But however regular and well adapted the external form of a gun may be, if it be cast solid, the interior metal coo- -ling last, will as it contracts, draw from the center, in conse- -quence of which, as Mr. Mallet observes; "In a casting of 2 or 3 "feet, or more in diameter, it is not unusual (with the founder's "best care) to find a central portion of from 6 to 8 or more inches "in diameter, consisting of a spongy mass of scarcely coherent "crystals of cast iron, usually in arborescent masses, made up of "octohedral crystals; the whole so loose that upon a newly cut sec- "-tion dark cavities can be seen by the naked eye in all directions, "out of which, often, single or grouped crystals can be picked "with the hand, and so soft that a sharp pointed chisel of steele "may be easily driven into the mass some inches, as if into bad

‡ It should not be forgotten that slow cooling tends to produce large crystals. — J. M. B.

or soft stone."

The effect of cooling from the exterior is thus described by Rodman; "Since iron diminishes in bulk as its temperature de-"creases, it follows that a gun cast solid and cooled of necessity, "from the exterior and in a limited time, will be thrown upon "a strain, the exterior being under a force of compression, while "the interior is under one of elongation and the greater the dif-"ference of temperature between the exterior and the interior, "during the process of cooling, or the more rapidly the cooling "is effected, the greater will be the strain."

Now this condition is precisely the reverse of that re-quired to compensate for the loss of effective strength, due, in accordance to the theory of Barlow, to an increase of thickness. Capt. Rodman's method, which has been successfully applied in casting guns of extraordinary calibre, consists in accelara-ting the cooling of the interior of guns, by passing a stream of water through them, while at the same time the cooling of the exterior is retarded by the application of heat. The strength of large guns is materially increased by this process, but its ap-plication will be of most importance in casting guns of great calibre, ... throwing large shot with moderate velocities; such as are earnestly advocated by Barnard, who treats the subject at length in his "Notes on Sea Coast Defence."

Accepting the preceding views, the required conditions as to form would be most nearly fulfilled by a cylinder terminated by a hemisphere. But as that portion of the gun forward of the trun-nions is subject to but comparatively slight strains, it is usual to give the chase the form of a truncated cone, of greater diameter, however, at the muzzle, than required for the finished piece, the surplus metal being turned off as in the Dahlgren shell gun. But the strength of such a casting is materially diminished by the trunnions and their rimbases, which invariably produce planes of weakness and unequal strains. In addition to this, as the recoil of the gun in firing is restrained by them, there is a tendency to produce cross fracture. Recently the rimbases have been filleted to avoid the sharp reëntrant angle formed by the rimbase and the body of the gun.

Experience has shown that smooth-bore guns of 11 inches calibre, cast solid, and bored out, weighing 15,700 pounds, and throwing spherical projectiles of 138 pounds, may be employed with safety, provided the charge does not exceed one ninth the weight of the projectile. These guns would not safely bear charges of one-sixth the weight of the projectile. The initial velocity with service charge of 15 lbs. – one ninth the weight of the projectile – is for the XI inch gun about 1100 feet. Whereas, to be effective against iron plating, such as has been already applied, a velocity of not less than 16 or 1700 feet would be required.

In constructing a gun to throw heavy elongated projectiles, we have to provide for an increase charge, and the additional strain due to the suppression of windage by the close fitting rifle projectile or its sabot, and the resistance it encounters from the inclination of the grooves from which it derives rotation, whilst the grooves themselves are elements of weakness.

We will now refer to a principle of construction which appears to have been first applied by Prof. Daniel Treadwell of

Cambridge, who, in a communication, "On the practicability "on constructing canon of great calibre capable of enduring "long continued use under full charges." presented to the American Academy in 1856. says, referring to theory of Barlow; "To obviate the great cause of weakness arising from the con- "-dition before recited. and to obtain as far as may be the strength "of wrought iron instead of that of cast iron for cannon, I propose "the following mode of construction; I propose to form a body for "the gun, containing the calibre and breech, as now formed of "cast iron, but with walls of only about half the thickness of the "diameter of the bore. Upon this body I place rings or hoops of "wrought iron in one, two or more layers. Every hoop is formed "with a screw or thread upun its inside, to fit to a correspon- "-ding screw or thread formed upon the body of the gun first, "and afterwards upon each layer, that is embraced by another "layer. These hoops are made a little, say $\frac{1}{1000}$th part of their di- "-ameters, less upon their insides than the parts that they enclose, "They are then expanded by heat, and being turned on to their "places, suffered to cool, when they shrink and compress, "first the body of the gun, and afterwards, each successive layer "all that it encloses. This compression must be made such, that "when the gun is subjected to the greatest force, the body of the gun "and the several layers of rings will be distended to the fractu- "-ring point at the same time, and thus all take a portion of the "strain up to its bearing capacity."

"There may at the first view, seem to be a great practical "difficulty in making the hoops of the exact size required to "produce the necessary compression. This would be true if "the hoops were made of cast iron or any body which fractures, when "extended in the least degree beyond the limits of its elasticity. But "wrought iron and all malleable bodies are capable of being exten-"ded without fracture, much beyond their power of elasticity. They "may, therefore, be greatly elongated without being weakened."

"Hence we have only to form the hoops small in excess, "and they will accomodate themselves under the strain with-"out the least injury. It will be found best in practice, therefore, "to make the difference between the diameters of the hoops and "the parts which they surround, considerably more than $\frac{1}{1000}$th "part of a diameter. The fixing the hoops in their places by the screw, "or some equivalent, is absolutely necessary, not merely to re-"inforce the body against cross fracture, but to prevent them "from starting with every shock of the recoil. I know, by experi-"ment, that the screw thread will affix them effectually. The "trunnions must, of course, be welded upon one of the hoops, "and this hoop must be splined, to prevent its turning by the re-"coil. Small splines should likewise be inserted under every "hoop. It will moreover, be advantageous to make the thread "of the female screw sensibly finer than those of the male, "to draw by the shrink, the inner rings together endwise".

In confirmation of the opinions of Prof. Treadwell, we may now refer to the experiments of Longridge, by which he de-termined, with considerable precision, the strength of coils of wire, the strongest form in which iron or steel could be em-ployed, in restraining the expansive force of inflamed gun-powder. In 1855. Mr Longridge found, that cast iron cylin-ders, 1 inch in diameter and $\frac{1}{10}$th of an inch thick, with ten coils of iron wire of $\frac{1}{28}$th of an inch in diameter upon them, laid on with the initial strain, which his calculation led him to believe would at the moment of bursting cause all the coils to give way together, could not be burst. The strength of this cylinder was 16.6 tons. Its interior diameter being exactly one inch, it appears that the ultimate strength of the powder did not exceed 17 tons per square inch. Mr. Longridge does not however, wish it to be understood, that he holds this to be the maximum effect that may be produced. The experiments of Longridge, which are described minutely in his work on "Construction of Artillery," were considered of great importance by the most distinguished ordnance men of England, (see Minutes of Proceedings of Civil Engrs Feb. 14th 1860) but while they demonstrated conclusively the superior strength of such barrels, the liabilities to derangement of the coils, and the difficulty of providing an efficient breech, precludes the construction of a gun on that principle. Further, Mallet arrives at the conclusion, from experiments made to determine the elastic limits and tensile strength with reference to the direction of the fibre," that for artillery purposes the ultimate strength "of a firearm in which the explosive strains are all resisted by "wrought iron in the direction of the fibre, is to the resistance "in transverse direction as 234.80 is to 30.47 or 7⅓ to 1."

But referring again to the essay of Treadwell, we find that if the barrel can be made sufficiently strong to restrain the force exerted by the charge, there is comparatively little difficulty in providing a secure breech; for, says Treadwell, "Let us suppose we have a hollow cylinder, say twelve inches "long, the calibre being one inch in diameter, and the walls one "inch thick, giving an external diameter of three inches. Sup- -pose this cylinder to be perfectly and firmly closed at its ends, by "screw plugs, or any efficient means. Let this be filled with gun- -powder and fired. The fluid will exert an equal pressure in "every direction upon equal surfaces of the sides and ends of the "hollow cylinder. Let us next examine the resisting power "of a portion of this cylinder, say one inch long, situate in "the middle, or equally distant from the ends, so that it shall "not be strengthened by the iron, which is beyond the action of "the powder. The fluid enclosed by this ring of one inch long "contains an area of one square inch, if a section be made thr- -ough it in the direction of its axis; and the section of the ring "itself, made in the same direction, will measure two square in- -ches. We have then the tenacity or cohesive force of two square inches of iron, in opposition to an area of the fluid measuring "one square inch; and if we take the tenacity of the iron at "65,000 lbs, the cylinder will not be burst in the direction of "its length, unless the expansive force of the fluid exceed 130,- -000 lbs, to each inch. Next let us suppose a section made through "the cylinder and fluid transversely. The area of the fluid equal "to the square of the diameter of the hollow cylinder, is one circular "inch, and the area of the whole section, the diameter being three "inches, is nine inches. Deduct from this the area of the calibre, and "we have eight circular inches. That is, the section of the iron is "eight times greater than that of the fluid; whereas in the for- -mer case of longitudinal section, the iron gave but twice as "much surface as the fluid; and if we take, as before, the iron at "65,000 pounds, per inch cohesive force, it will not be broken, unless

"the force of the fluid exceed 520.000 pds. It will be found upon a
"further examination, that the relations of these sections to each
"other may be varied, as we take the diamter of the calibre to
"be greater or less, as compared with the thickness of the sides.
"that their difference can never be made less than as two to one.
"Here then is a principle or rather a fact. of the utmost importance
"in forming canon of any material, the strength of which is differ-
"-ent in different directions; for as a cannon made in the propor-
"-tions above specified, if the materials be in all directions of equal
"strength. will possess four times as much power to resist a cross
"fracture as it does to resist a longitudinal fracture, it follows,
"that a fibrous material which possesses four times the strength
"in one direction, that it does in another, will form a cannon
"of equal strength, if the fibres be directed round the axis of the
"calibre. It is this fact which gives the great superiority to the va-
"-rious kinds of twist gun barrels. For in these although the fibres
"do not enclose the calibre in circles. yet they pass around it in
"spirals, thus giving their resisting force a diagonal direction,
"which is vastly superior to the longitudinal direction in which
"the fibres are arranged in a common musket barrel."

In support of this view, we may, apart from the experience of Treadwell himself.+ quote the experience of Blakely: "The gun "(Fig. 1. pl. 2.) was simply a cast iron gun. cylindrical from the breech "to the trunnions, having three wrought iron hoops shrunk on it. "with a tension not very accurately ascertained. Yet that gun was "proved to be one of the strongest ever made. For the sake of compar- "-ative experiments. the Ordnance select Committee had a cast "iron gun and a brass gun of the same size fired. round for round;

+ App. p. 28.

"with this gun. This experiment was made at Shoeburyness in 1855,
"and 1856, and lasted over a period of nineteen months. The result
"showed that this gun was more durable, than the cast iron gun, in
"the proportions of about 7 to 1, and than the brass gun, by about 3 to 1.
"Guns made on that model would be of simple construction and
"be useful for many purposes, particularly for naval rifled cannon"

"The result of the experiment just alluded to caused Lord Panmure, then Secretary of State for War, to order a 68 pdr. and a 10 inch "gun to be made at Woolwich, further to test the principle, and now, "he was happy to say, large numbers of similar guns were being made "for the Royal Navy."

Still further to illustrate the strength of guns constructed of bands shrunk upon a tube, we may refer to the Whitworth and Armstrong guns. Of the first Mr Whitworth says; "The 80 pdr. gun "was purposely made so strong, that it could be submitted to any "proof, without injury. It was made of homogeneous iron. Upon a "tube, having an external taper of about one inch, a series of hoops, "each about 20 in, long, were forced by hydraulic pressure. Experiments "enabled him to determine accurately what amount of pressure "each hoop would bear. All the hoops were put on with the greatest "amount of pressure they would stand, without being injured. "A second series was forced over those first fixed, and thus the 80 "pdr. gun was constructed. At the present time it was not necessary to have the second series of hoops, but it was thought better, in "the case of the first large rifled cannon, to have it stronger "than was practically necessary; in fact, to make it so strong "that gunpowder could not burst it. In the 12 pdr there were not any "hoops at all, and Mr Whitworth believed, that a large size gun

"could be made with this homogeneous metal, without hooping it.
"The inside of the 80 pdr. gun was made of a tube of homogeneous metal, and the external rings were of fibrous iron, except two hoops "next to the breech, which were made by Mr Clay of puddled steel. "The hoops were put on cold."

Sir William Armstrong in answer to questions from various members of the Institute of Civil Engineers, said that "The weight "of the 100 pdr. (Armstrong) gun would be about 70 cwt. The outer layers "and rings of metal were not put on with any calculated degree "of tension; they were simply applied with a sufficient difference "of diameter to secure effective shrinkage. The grounds for concluding that the range through a resisting atmosphere, was greater "than "in vacuo" were, that at a low elevation the actual range exceeded "the parabolic. The bore was not of uniform diameter throughout the gun. "There was a slight contraction immediately in front of that part where "the shot was lodged, the object of which was to mould the lead covering "into the grooves to a sufficient depth, at the first instance of motion, "to give the shot freedom in passing through the remainder of the bore".

In view of the preceding facts, we are justified in assuming that a vast iron cylinder, terminated by a hemisphere, and bored out to the calibre required, with walls of sufficient thickness to give such proportions between the areas of longitudinal and transverse sections as will tend to equalize the strength of the gun to resist longitudinal and cross fracture, will bear charges of one sixth the weight of a well proportioned projectile, which, with the expanding sabot, is sufficient to give the required velocity.

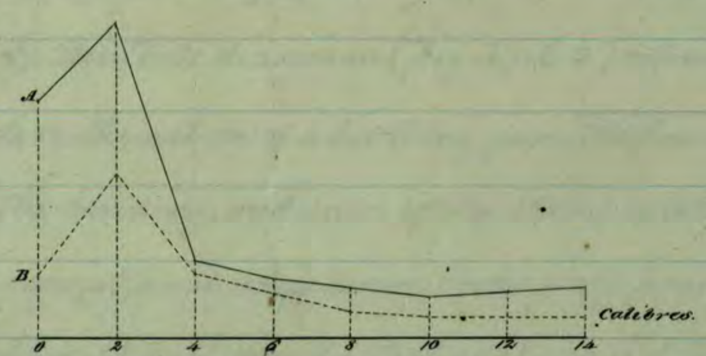
It does not appear however, that Treadwell considered in connection with the area of cross section, the compressibility of the

metal forming the bottom of the bore, by which the power of resis-
-tance to cross fracture at the breech is very materially diminished. We may therefore give a greater thickness of cast iron, than would otherwise be required; and in so doing, are enabled to adjust the weight of the gun with reference to recoil, which should never be violent. The additional mass of cast iron serves also to modify the shock of explosion, which may be supposed to act more or less injuriously upon the bands. The screw thread which Mr Treadwell considers necessary to maintain the bands in position, may be dis-pensed with, as the fibres of the wrought iron hoops shrunk upon the gun, and lying transversely, serve the purpose of the screw thread. There is as yet no instance of a band, properly placed, slipping from its position. Mr Treadwell proposes to weld the trunnions to the bands shrunk upon the cast iron. But it has been considered pref-erable to weld the trunnion to a band thicker than the others, bored to fit smoothly without shrinking; and to transfer the shock of recoil from the body of the gun to a strap closely fitting round the breech and attached to the trunnions. We thus avoid disturbing the bands, and do away with the strain of recoil tending to produce cross fracture. In fact the breech derives support in recoil from the strap. The principle has been applied by Dahlgren, but nothing is known here of the peculiar method of application adopted by him.

As before remarked, the strain produced by the discharge of a gun on that portion forward of the trunnions, is comparatively small, the cylindric form may therefore terminate in the frustum of a cone.

Experiments made in accordance with the plan devised

by Col, Bomford, have shown, that in smooth bores the strain dimin-
-ishes rapidly as the projectile passes along the bore, being probably at its maximum, at the instant of starting the projectile. It is this sudden decrease which permits the thickness of the chase of the Dahlgren shell gun to be determined solely with reference to resisting the effect of shells balloting or bursting in the bore; and the adjustment of pre-
-ponderance without weakening the gun, in the vicinity of the charge, by placing the trunnions nearer the breech. The following diagram, from Benton's "Ordnance and Gunnery" showing results obtained by Capt, Rodman's method, exibits clearly the sudden diminution of strain, and also indicates in connection with the second dia-
-gram (Fig. 3. pl. 2) from Benton's work showing the action of the strains, the proper disposition of the wrought iron bands.



"The ordinates of the curve A, show the pressures on the bore at inter-
-"vals of two calibres, commencing at the bottom of the bore for the grain "powder; and the curve B. the same for the "cake powder". The gun being suspended as a pendulum, and the recoil being equal, or nearly so, it follows, that nearly the same velocity was communi-
-cated to the projectile by the "cake" as by the grain powder, with only about one half the mean pressure on the length of the bore.

No. of Fires.	Distance from bottom of the bore.	Caked Powder. Pressure per square inch.		Grained Powder.	Pressure per square inch.
			Recoil.	Recoil.	
3	0	10.989	22°24	22°58	41.289
3	2 calibres	26.001	24°21	22°56	57.512
3	4 "	12.457	22°57	22°59	14.103
3	6 "	8.620	25°43	23°05	10.878
3	8 "	5.801	24°12	22°53	10.417
3	10 "	4.870	21°43	22°49	7.127
3	12 "	4.071	22°07	22°55	8.932
3	14 "	4.071	21°42	22°49	9.007

It must however be borne in mind that as the charges of rifles occupy a greater length of bore, in proportion to the calibre, than those of smooth bores, the point of maximum strain will be advanced perhaps several calibres, So that when, as in the case of the Parrott gun, the banding is limited to a few inches, it should be placed not on the solid breech and partially around the charge (See Fig. 1. pl. 3) but as in the Blakely gun (Fig. 2. pl. 3) If Benton's diagram (Fig. 3. pl. 2) represents truly and it is supposed to do so, the action of a bursting gun, the band which acts as a hoop, preventing "the bending outward of the staves, of which the piece may be "supposed to consist, and which are broken off from the breech", should be placed where it will most effectually resist the first tendency to change of form, as at the point, A.

The flatness of the breech of the Parrott gun, which renders the casting weak at that point, may make it necessary to reinforce it there with bands; but a slight change in form would probably serve the same purpose.

Recently the Parrott guns have been improved in this and other respects.

Having stated the considerations determining the general form to be given rifles intended to bear high charges, we will now refer to the rifling or the grooves cut in the bore, which winding spirally, cause the projectile to turn upon an axis coinciding with the axis of the bore, and materially weaken the gun.

Whilst Armstrong and Whitworth were engaged in perfecting their breech-loaders, and seeking strength to resist the enormous strains to which their methods of obtaining rotation of projectiles subjected them, Haddan, Bashley Britten, Capt. Scott R. N. Mr. Jeffries and others; were attempting so to rifle the service guns of the British Navy as to permit the employment of elongated projectiles, without banding or otherwise strengthening them. It is obvious that a gun constructed for a certain purpose - in this case to throw spherical projectiles of a given weight - can not be expected to throw with safety projectiles weighing fifty per cent more. It may be said that the six or seven pound charge was less, and therefore the strain not greater than that to which smooth bores of the same calibre were subjected with the service charge of 10 lbs; as in the case of the 32 pdr. But the experiments of Rodman+ indicate that with equal charges the expansive force of powder is directly as the weight of the projectile. And moreover, the expanding sabot, suppressing windage, adds greatly to this force; so that notwithstanding the nominally low charge, the strain must considerably exceed that of the smooth bore; and further, the ranges obtained at low elevations by Britten prove this to be the case. Mr. Britten contended however that "these guns did not absolutely need strengthening previously to being rifled, because the recoil of a gun afforded "a comparative indication of the strain from within". But this is not the case; for if we suppose a projectile jammed in the bore of a gun, it is easy to see that although strained to bursting, it would have no recoil.

+ U. S. Manual 1861.

But if we differ from Mr Britten on this point, we may nevertheless agree with him when he says. "If the bore of a gun be "converted into a female screw, having a sharp pitch and the "attempt be then made to drive through it a hard iron shot with a velocity of "2000 feet a second, the friction on the sides of a gun would be so enormous "that the gun must have extraordinary strength to withstand it; this he imagined was the case with the cast iron 95 Cwt, guns having bore of "only about 5 inches in diameter, rifled and burst by Mr Whitworth."

From Mr Britten's experiments † we may infer that shallow grooves, each 1/16th of an inch deep, cut down the bore, are sufficient to produce rotation of lead sabotted projectiles in guns of 6.4 in. and 8 in. bore, with charges of 6 and 8 pds of powder.

Haddan started with this axiom. "That for a cast iron gun "the rifle twist should be as slow as possible, so as to establish only "such an amount of rotation of the projectile as would insure its travelling point foremost throughout its flight, and that any greater extent of rotation was useless. Another essential point was, that the rifling "should weaken the gun as little as possible. He assumed, that if the rifle "cuts or grooves, were angular or square they would have the same effect "as nicking a bar of iron intended to be broken; whilst broad or shallow "grooves or cuts, would not destroy the elasticity of the gun. An ordinary 68 "pdr. cast iron gun had stood firing with shells of 115 pounds weight and "considerable charges of powder, without bursting. He believed the plans "of Mr Whitworth and Sir Wm Armstrong were inapplicable to cast iron "guns, and hence resort was had to build guns of mallable metal. The "large cast iron guns which had been bored on the Whitworth system, and "the calibre of which was small, had burst, owing as Mr Haddan believed, "to the quickness of the rifle twist. He had fired a shell (of which a speci-

† App. p. 29.

"men was exhibited) weighing 90 pounds, with the rifle twist, only about
"one turn in 40 feet. The government report upon the experiments
"with a service 68 pdr. cast iron gun, rifled, upon the principle he had
"adopted, showed that he had obtained equal ranges, charge for charge,
"with the Armstrong gun. He believed that the length of range depended
"upon the charge of powder used; and on that ground, he invited com-
"-parison with the results of Mr. Whitworth and Sir Wm. Armstrong's ex-
"-periments."

The results of these experiments whilst they do not warrant the employment of rifled cast iron guns, unstrengthed, happily enable us so to rifle our guns, intended to bear very high charges, as to weaken them but little. Bearing in mind the fact, that the nearer the bore of a rifle approaches that of a smooth bore, the stronger the gun, we may proceed to the consideration of the means employed to give rotation to the projectile, which is of iron or steel.

In the Whitworth gun, the bore is hexagonal, the twist in the 80 pounder one whole turn in 100 inches. The objection to the application of this system to guns of large calibre is its effect in weakening the gun by concentrating the strain upon the re-entrant angles. The friction incident to the Whitworth must be very great as compared with that of other systems, particularly as the metals of the projectile and bore are similar.

Armstrong's guns are <u>many grooved</u>, and as the bore is contracted to ensure the <u>slugging</u> of the lead-coated projectile, the resistance is probably even greater than that in the Whitworth gun. Sir Wm. Armstrong contends that the power of his gun is increased by this contraction; but if so, the increase would probably be obtained with less strain upon the gun by increasing the charge. It is said that a pressure of $1\frac{1}{2}$ tons is required to force the projectile through the bore.

The sabots employed by Haddan appear to have been of wood. Britten used lead, so applied to the nearly hemispherical base of the projectile as to be packed tightly by the explosion of the charge, cutting off the escape of gas, and taking the grooves.

Projectiles so arranged, but with the addition of raised bosses on the hemispherical base, to prevent slip, were thrown at our batteries on the Potomac. Similar sabots were successfully applied here and until recently were preferred to any others. Lead is however objectionable from its liability to batter, its great weight and tendency to lead the bore; although this latter difficulty is partially remedied by lubrication and the use of a scraper of peculiar construction devised by Lt. Murdaugh, C.S.N.

Many attempts have been made to apply the "Reed" cup to projectiles of the larger calibres, but ineffectually, as the wrought iron Cup, on which the projectile was cast, broke and failed to give rotation. A series of experiments were made by Comdr. Fairfax with sabots of various kinds, the preference being finally given to what is known as the Tennessee Cup, (Fig. 1. pl. 4.)

This concave disk, of soft bronze, is attached to the base of the shell by a central screw. To prevent turning, the first used were perforated to receive three corresponding projections on the base of the shell.

As it was supposed that much gas escaped by these apertures, Comdr. Fairfax reversed the arrangement, making three cavities in the base of the shell and casting three projections on the forward part of the disk. In the absence of lead, which was more effectually used in the small arms of our troops, the Tennessee sabot served its purpose. The objections to it are the severe strain to which, in certain conditions, it subjects the gun — acting as a wedge — the small bearing surface which it presents to the bore, the difficulty of adjusting the projections to bear equally, and its liability to become loose and to break in firing, Notwithstanding its wedging properties, the ranges of projectiles fitted with this sabot are inferior to those fitted with lead.

Several other forms of sabots, including the simple brass band; with projections fitting into the iron, to prevent slip, cast upon the base of the projectile, have been employed; but without favorable results. The system of rifling which involves wings or buttons on the projectile to fit the grooves, and which appears to have found more favour in France than elswhere, presents apparently too few advantages to compensate for its defects.

The sabot now adopted (Fig. 2. pl. 4.) in the Confederate service is termed the "ratchet sabot" from the manner in which it is attached to the projectile. The success attending the attempt to ensure rotation of the wrought iron bolt, led to the application to cast iron projectiles of a bronze sabot presenting the same form to the action of the powder; but secured firmly to the base of the projectile with the aid of a central screw. The expansion of this sabot is generally uniform, it takes and preserves a mold of the grooves and lands; the slip is hardly perceptible.

With projectiles of 128 pounds weight and charges of 17 and 20 pounds, of powder, this sabot has perfectly performed its office. (Fig. 5. pl. 1.) The friction of brass on iron is less than that of iron on iron, and in this respect the bronze possesses advantages over the wrought iron cup.

We will now endeavor to ascertain, within certain limits, the amount of strain to which the gun will be subjected in throwing projectiles of such proportions and weight, as will probably, without producing too violent a recoil be most effective.

The difficulty of determining the expansive force of gunpowder is so great that the results obtained by different persons vary widely; we can therefore consider the most reliable of these results as but approximations. When confined in a space equal or nearly equal to its bulk, its force has been estimated at from 15.000 to 750.000 pds. to the square inch.

Count Rumford determined that in a closed cavity two thirds filled, the pressure amounted to 150.000 pds. on each square inch, and in a cavity entirely filled, he estimated the pressure at 750.000 pds Prof. Treadwell alluding to this estimate; says; "My own experience in bursting wrought iron "cannon, the strength of which was known to me leads me to believe, that he has "not overestimated its power; although I am aware that it is generally con-"sidered as excessive".

Robins estimated the ultimate strength of gunpowder at 15.000 pds to the square inch. Dr Hutton at from 30 to 36.000 pds. In 1855. Mr Longridge in testing the strength of coils of wire found that the ultimate strength did not exceed 38.000 pds. In Mr Longridge's experiments the gases were not absolutely confined, as the powder was fired by a vent of the size of a pinhole, but so limited an escape, when we consider the rapidity of developement, could hardly produce an appreciable effect.

Gibbon says: "During some recent experiments with percussion "fuzes, an 8 inch shell was charged with half a pound of fine rifle powder and "a bronze fuze plug screwed in. The shell did not explode, but on being recov-"ered and an attempt made to unscrew the fuze plug, it was found impossible "to remove it. An attempt to remove an iron screw, which stopped a small hole "used for charging the shell met with a similar result. By means of cold chisels "and punches, a hole was now drilled through, but no sooner was an entrance "made than the tool was hurled from the workman's hand across the room, he "himself was knocked backward with a feeling on his hand and arm as if burn[ing] "and the escaping gas made a noise like the escape pipe of a small steam engine. "This powder therefore in a gaseous form, had been bottled up for several hours in "the shell. The same thing recurred several times, and the workmen soon became "more careful in opening recovered concussion shells". A simple remedy was soon found, however, by increasing the charge to 1 pd.

The following results of experiments by Capt. Rodman, are extracted from the United States Ordnance Manual of 1862: "The pressure on a 42 pdr. at the bottom "of the bore, when fired with 10 pds. of powder and a solid shot weighing 43 pounds "is 44.535 pounds.

"8 pds. of powder, of a grain, 1 inch diameter, with the same gun & shot, gave "a pressure of 51.800 lbs.

"8 pds. of powder, of a grain, 4 inches in diameter, with the same gun & shot, "gave a pressure of 31.900 lbs.

"12.67 pds. of powder, of a grain, 6 inches in diameter, and a solid shot "weighing 186.3 pounds, fired from 11 inch gun, gave a pressure of 21.370 lbs.

"The same weight of .3 inch diameter, gave a pressure of 35.330 pounds.

"The same weight of .3 inch diameter, of different powder, gave a pressure "of 65.900 lbs.

"Half the weight of powder of the ordinary charge, with double the weight of shot, gave the same pressure as the ordinary charge.

"1 pound of powder, burned in a space equal to twice that occupied by the "powder, gave a pressure of 42.500 pounds.

"2 lbs, burned in the space occupied by it, gave a pressure of 133.590 lbs.

"1 lb, of powder burned in the space occupied by it, .1 inch grain, gave a pressure of 185.000 pounds.

"The actual pressures are probably greater than those above given".

"It has been found that the size of the grains and density of the powder exercise a remarkable influence on the pressure sustained by guns in firing.†

A slight difference in the density of powder, even of the same sized grain, may double the strain upon the gun, combustion being more rapid as the density is less. It is the almost instantaneous expansion of quick powder, which so severely strains the gun, and renders it so difficult to deter-

† Appendix, page 48.

-mine the actual force exerted.

The indentations in bronze obtained with Rodman's indenting apparatus, appear to afford the best means of comparing the pressures exerted by different powders. But the published results of experiments made with it throw but little light upon the effect due to increase of charge, the weight of projectile remaining the same.

If we compute the pressure required to give an initial velocity of 1600 feet to a wrought iron bolt, 12 inches in length, taking the whole force of the powder as equal to its maximum force acting through one third of the length of the bore of the gun - 45 inches, we shall find it to be about 36.000 pounds to the square inch.

It would appear that we might compute approximately with the aid of Rodman's observed pressures in the case of the 42 pdr. before cited, the pressure which would be exerted on the 7 inch rifle by given high charges. But according to the formula, by which Capt. Rodman determined the strength of cannon cast solid,+ the 42 pdr. gun, estimating the tensile strength of the metal at 25.000 pds, will bear with safety a pressure of about 17,000 pds. to the square inch, whereas the pressures of 44.535 - 51.800 and 31.900 were given by the indenting apparatus with charges of 10 and 8 pds. - the service charge of the gun being 10½ pounds. It thus appears that while the indenting apparatus may serve to determine the relative force of powders, it is evident that the pressures which produce equal indentations in the same piece of bronze, by the testing machine applied slowly, and by the gases in the gun acting quickly, cannot be considered directly applicable in determining the strength of guns as compared with the strains due to their charges.

The drawings accompanying this report, which were executed by Mr. Frederick Volk, whose services in giving form and expression to ideas suggested by experiment, I am happy to acknowledge, represent the various

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+ Wade's Report.

forms of cannon, projectiles, fuzes, etc. designed in this office; and in addition, for purposes of comparison, the Parrott 30 pdr, and the Blakely gun of 7.5 inch Calibre.

The 6.4 inch rifles of 9.000 pounds and the 7 inch rifles of 15.000 pds weight, single banded, were designed in October 1861. The former were intended to serve as broadside guns, throwing shells of 65 pds. and bolts of 80 pds. — The latter as pivot guns, throwing shells of 110 pds and bolts of 120 pds.

There have been completed of the 6.4 inch, fourteen, and of the 7 inch, sixteen: Two of each were placed on board the "Virginia", and an extract from the report of Lieut. Jones. Executive and Ordnance officer of that vessel, in relation to them is appended, An average of 30 rounds was fired in her engagement with the Monitor from these guns, one of the 7 inch rifles was accidentally charged with two cartridges, 24 pounds, and a shell of 110 pounds, weight, and although the recoil was slightly increased, no injurious effect was perceptible.

It was believed that wooden vessels only, would be encountered by the "Virginia", and the various foundries and workshops were so fully occupied in meeting other pressing demands, that shells and round shot alone, the latter for her smooth bores, were supplied.

When, however, Commodore Tatnall challenged the "Monitor" she was amply supplied with them, and from experiments since made here, it is probable, that had the "Monitor" accepted the challenge, her turret would have been demolished. As it was, however, shells only were fired, from the rifles.

The impenetrability of the "Monitor's" armor to projectiles of that character, seems to have served in the United States as evidence of its suffiency for general purposes; otherwise the turrets of the numerous vessels now building, similar to the "Monitor", would have been made stronger.

The treble banded 7 inch rifle (Fig. 1. pl. 8) was designed in March 1862. but, owing to the want of facilities, in the foundry, was not completed until the 10th of November, when the strength of the trunnion straps &c. were tested with satisfactory results. (See report of Lieut. A. M. de Bree. App. p. 32.)

The urgent demand for guns possessing power of penetration prevented our making some experiments with this gun to determine the effect of its projectile on armor. But from recent experiments in England, it appears that the principle of giving high velocities to elongated projectiles has been successfully applied. A muzzle loading gun constructed on the Coil system of Armstrong, and rifled on the Whitworth plan, bearing high charges, was tested with the Celebrated smooth bore "Horsefall" gun. The published accounts of these experiments bearing directly upon the subject, are as follows; –

"The gun used on this occasion was an Ordnance muzzle loader, "manufactured at Woolwich on Sir Wm Armstrong's wrought iron coil principle, but with the beautiful hexagonal bore of Mr Whitworth's mode of "rifling. Its weight was 7 tons 8 cwt; its length about 12 feet, and its Calibre a "120 pdr. though in fact capable of, and quite equal to, throwing shot of at least double that weight with perfect safety. It was placed on a platform at a distance "of 600 yards from the "Warrior" target, a longer range by 400 yards than any "gun has hitherto been laid at Shoeburyness to penetrate such formidable mass "of iron and teak. At a distance of 800 yards the great Horsefall or Mersey gun "was also levelled at the same target. This gun it will be remembered, at 200 yards "range, sent its shot through the target, on the last occasion making a huge ragged hole in the very centre of the plate, and crushing through all beyond it. "The admirers of this now very old fashioned smooth bore gun, maintained "that what it had done at 200 yards, it would do again with the same ease at "800. Accordingly after the Whitworth experiments were over, this huge and "most unwieldly piece of Ordnance (its weight is no less than 24 tons) was tried at

"the same mark, but with very different and most unsatisfactory results.
"The target aimed at on this occasion was, as we have said, a built up section
"representing the "Warrior's" side. It was especially made for these experiments
"21 feet long, by 15 high, constructed on the same principle as the old one, namely,
"with 4½ inch iron plates, 18 inches of teak beams, laid transversely, and an in-
-ner skin of iron ⅝ of an inch thick, supported by massive upright angle irons at inter-
-vals of 18 inches apart. It is but fair however to state that the 4½ inch armor plates
"which covered this powerful combination of teak and iron were not manufactured
"by the Thames Iron Co, and were undoubtedly inferior in powers of resistance
"to the splendid plate with which the first "Warrior" target was coated by that Co.

"Some few shots were first fired from the Whitworth with low charges, at a
"wooden target, to get the range, though even these were not without interest, as illus-
-trating the wonderful precision with which it threw its projectiles. The first experi-
-mental shot was fired with a charge of 23 pounds of powder and a solid hexagonal
"shot weighing 129 pounds, the piece being laid at half a degree of elevation. It struck
"the left centre of the target, within an inch almost of the white spot at which it was
"aimed, and at the instant of the tremendous concussion of the metals, a bright
"sheet of flame was emitted, almost as if a gun had been fired from the target in
"reply. This shot passed completely through the armor plate, shattering the teak
"beyond it into minute splinters, and fell back upon one of the massive ver-
-tical angle irons, we have mentioned, which it tore in half as if it had been
"paper, sending its screw bolts and rivets in all directions. The shot however,
"did not pass through the target, but remained buried in the teak, with its
"flat head resting against the broken angle iron. But the fracture it made
"was much worse, than a mere penetration. It was a smash not a hole, and the
"inner skin of the ship was bulged and torn wide in many places, so that in the
"case of an actual vessel, such a shot striking on the water-line would have
"made a leak, which nothing could have stopped. As regarded the effect of

"these flat fronted shot on iron ships, the experiment was conclusive. Such a
"missile against a wooden ship would have gone through both sides, making a clean hole
"and doing little damage, but the iron, without protecting, offered only sufficient re-
"-sistance to make the fracture, if below the water line, an irremediable mischief.
"The next experiment was with a live shell, loaded with 3 pds. 8 oz. of powder. The
"total weight of this projectile was 131 pounds, and it was fired at the same range and
"elevation with a 25 pd. charge of powder. The effect of this shot astounded every
"one. The previous solid shot, at 600 yds. was for Whitworth nothing extraordinary,
"but to get a shell through the target at the same range was regarded as almost an
"impossibility. Yet the shell went completely through everything, bursting apparent-
"-ly, when it encountered the last resistance of the inner skin, which the explosion
"blew completely away, lighting for a moment the timbers at the back which sup-
"-ported the target, and sending the bits of shell onward and over what, had it been
"the "Warrior," would have been her main deck, and therefore right in the midst of
"her crew. — Than this experiment, nothing could possibly have been more conclu-
"-sive. Not only was the armor plate pierced, but the piece opposed to the actual stroke
"of the flat headed shell was driven through teak and inner lining, and in truth
"became another shot of some 30 pounds weight. In fact this last shell might have
"destroyed the whole of one side of the target, had the shell been only capable of con-
"-taining an adequate bursting charge, say 10 or 12 pds. of powder. The latter most
"important requisite, however, the Whitworth shell, from its peculiar construc-
"-tion, is as yet unable to accomplish, and until it is brought about, nearly all the
"advantages gained by its enormous powers of penetration will, comparatively
"speaking, be in a manner lost against iron frigates. Once however, that the
"shell is made to hold a powerful charge of 10 pounds of fine powder, iron vessels
"will become, we believe almost as much at the mercy of this Ordnance, as wooden
"ones now are to the terrible shells of Armstrong. This experiment with the shell was,
"therefore, considered so far satisfactory as to its penetrating powers that no further

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These accounts were received here on the day that the treble banded 7 inch gun was placed on board ship. In considering the method of construction applied in the English gun, which fails to give increased strength to resist cross fracture, it will appear that the heavy cast iron tube of the Confederate gun possesses certain advantages; — The bronze ratchet-sabot enables us to obtain the requisite rotation of the projectile without weakening the gun by the introduction of a polygonal bore.

On the 22d of October 1862, one of the 6.4 inch rifles of 9000 pds. single banded, was fired at a target composed of three layers of 8 + 2 inch iron, rolled, bolted to an oak backing, 17 inches thick, the inner layer of plates arranged vertically, the other two horizontally, distant 100 yards. The first bolt fired, was composed of wrought iron and steel, the head being pyramidal and sharp pointed, as proposed by Mr. Hobson of Texas, and weighed 72 lbs. charge 8 pds. It struck near the centre of the target. The head changing form, made an hemispherical impression in the first plate nearly two inches in depth; the plate breaking across the centre of depression and springing off from the target; the second plate was broken into three pieces, the middle piece in front of the bolt was forced against the inner plates next the wood; bending two of them slightly. — The projectile rebounded from the target. (Figs. 1 & 2 pl. 13) represent the bolt before and after firing.

The second bolt fired, of wrought iron, of the punch form, weighing 80 pounds. charge 8 pds. struck the inner plates, exposed by the first shot, passed through them and the wood, making a ragged hole; fragments of the plate being driven before it. Its form was but slightly changed.

The third bolt, similar to the second, same charge, struck the upper part of the target, where the plates were tolerably firm, broke two pieces out of the two first layers and cracked the plates of the third layer through, breaking the oak backing. The bolt rebounded and fell in front of the target, its head was much enlarged (Fig. 2. pl. 1.)

On the 23^d a bolt in all respects similar to the last used on the 22^d was fired from the same gun with a charge of 12 pds of powder; it passed through the three layers and the oak backing, glancing up through the heavy earth backing in the rear of the target. This bolt (Fig. 3. pl. 1.) was less changed in form by the impact than those fired with charges of 8 pds. of powder, which may be attributed to its higher velocity.

The inference drawn from the results of these experiments, is, that with high charges wrought iron bolts may be driven through the thickest armor yet applied, provided the bolt strikes nearly at right angles to the surface. It is, however, much to be desired that a material similar to that produced by the Bessemer process should be employed in the manufacture of projectiles intended to be used against iron. Cast iron, as experiments here and abroad prove, is unfit for the purpose.

Recently Whitworth has shown that shells fired from rifles may be driven through heavy armor, exploding behind it. The want of mechanical facilities alone prevented the attainment of the same end here a year ago, as the principles applied by Whitworth were recognized.

To render the 6.4 inch guns of 9000 lbs. still more effective, a second series of bands has been placed on such as were not completed prior to these experiments; but as this gives more preponderance than is convenient, a new form has been adopted, represented by pl. 9. increasing the weight to 11.000 pds. and its estimated strength to 65.693 pds. per square inch.

The form of the 7 inch rifle of 15.000 pounds was also changed; the thickness of cast iron being reduced, and a second series of bands shrunk over the first; the weight and preponderance remaining as before. The estimated strength is now 61.642 lbs. per square inch.

The double banded 7 inch gun (pl. 10.) was designed as a substitute

for the 7 inch gun cast with trunnions, and is constructed upon the princi-
ple applied in the 7 in. treble banded gun, being cast without trunnions.
None of these guns have been yet cast.

The X inch smooth bore (pl. 12) is intended to bear a charge of from 15 to 30 pds. of powder with solid shot

Fig. 2. pl. 3 represents the 7½ inch Blakely rifle. It is inferred from the difference of diameters at A and B, that the bands was forced upon this gun by hydraulic pressure. It is too light to throw solid bolts effectively.

Fig. 1. pl. 3 represents the Parrott 30 pdr. The banding does not extend sufficiently far forward. Several guns of this pattern have recently burst between the banded portion and the trunnions.

The exigencies of the service have been such as to prevent our making extended series of experiments. Until recently, powder was so scarce, that not enough could be spared even to prove Navy guns before being sent off. and it was therefore necessary to observe great caution in the selection and combination of metals, and to notice such evidence of the character of the gun, as was developed in the process of boring and fitting.

Happily the scarcity of powder no longer exists, and we can now prosecute such experiments as may be necessary to further progress.

At the time of the secession of these States, there were but few rifled cannon in the Confederacy - The enemy had armed several gun boats with rifles of large calibre, throwing elongated projectiles of the "James" pattern, and occasionally shells with lead sabots. The great range of these guns was fully developed in several instances. At that time under the direction of Comdr. Fairfax, Navy 32 pdrs, of 57 Cwt. were rifled and banded at Norfolk. On the 30th of August, Comdr. Fairfax tested their efficiency in the "Harmony", a small steam tug - Approaching within range of the U. S. Frigate "Savannah", then at anchor off Newport News, Comdr.

Fairfax opened fire upon her with shell. It is reported that serious damage was inflicted upon the Savannah; that in fact the enemy contemplated abandoning the vessel, when the ammunition of the Harmony being exhausted, she returned to Norfolk. None of these rifled and banded service guns have burst, with the exception of one, at Charleston, which was loaded with two cartridges, a shell and a bolt, one or two have been fractured, in the chase, by premature explosion of shells, and in one or two instances a band has broken from defective welding or unequal shrinkage. The Rodman plan for casting guns hollow and cooling from the interior, may so strengthen the casting as to render the application of bands unnecessary, but means and time to apply that plan have been wanting, Although if once put successfully in operation, much time and expense would be saved, and the guns so made would be less liable to injury from exposure &c, we could put less confidence in the strength of individual guns, than if banded, inasmuch that when made of a single casting, a gun may be weak; but the application of a number of wrought iron bands ensures considerable strength.

The Army and Navy are both dependent on the Tredegar works for heavy guns, and the resources of that establishment, taxed to their utmost, are altogether unequal to the demand. The Navy guns made at that establishment are with some exceptions generally well made. The treble banded 7 inch rifle is an evidence of skilful workmanship. I have always found the directors and employees of the Tredegar works apparently anxious to obtain the best results; they impart freely such information as can only be obtained from the practical mechanic. I have not hesitated to avail myself of their experience.

The establishment of the Naval Ordnance Works in Richmond under the direction of Lt. R.D. Minor, C. S. Navy, has supplied a pressing want, and already these works exert an influence upon the productions of private establishments. Lt. Minor is now banding the 6.4 inch guns of 11.000 lbs, by which we shall be enabled to furnish them more rapidly.

The projectiles, fuzes, &c. made at the government works, are of a superior quality. In connection with the subject of projectiles, I may refer to a recent improvement in fuzes by Actg. Master Charles E. McEvoy, which renders the ignition of the time fuze as certain in the rifle as in the smooth bore. It supplies a want long felt, and the Ordnance Bureau of the Army has after trial adopted it for field service.

I regret that owing to the pressure of official duties, I have not been able to devote more time to the preperation of this report. In conclusion I would remark that the guns constructed in the manner herein described would be stronger, if the bands were made of bars wound spirally and welded.

I have the honor to be,

Very Respectfully your obt. Servt.

Commander C. S. N.

Hon. S. K. Mallory
Secy. of the Navy.

Appendix.

A. From Gibbon's Arty. Manual 1860 pl. 100. — As if to completely demonstrate that in the form lay the defect of the pieces, an incident occurred some time ago at Boston, where an opportunity was offered of comparing the two forms of the Army Columbiads and Navy shell guns.

Some of each were cast of the same metal at the same time and by the same persons, and when completed were proved. The Columbiads 8 inch failed under proof, two bursting by service charges at the 180th and 45th rounds. The Navy guns 9 in, succeeded completely, enduring 1500 rounds without bursting. The cause of the failure of the Columbiads being supposed to be due to the high bursting quality (brisante) of the powder used, the Navy Department caused another gun of the same lot to be tested with powder similar to that used with the Columbiads. The gun sustained 1500 service rounds, appeared then to be in good order, and was finally burst with proof charges at the 23d round, the shot having been gradually increased to 7. weighing about 650 pds. The pieces were about the same weight, 9000 pds; a 68 pd. shot and 10 pds. of powder were used with the Columbiads, and a shell weighing 70 pds, and 10 pds of powder, with the Navy guns.

B. Three 8 in. Columbiads of the same form and dimensions, and cast in the same way were tried. One of them had been cast only a few days, the other two were six years old and of metal of inferior strength to the first. The one tested immediately after casting failed at the 72d round; of the other two, the weaker failed at the 800 round, and the other sustained 2582 fires without yielding.

Extract from a communication of Prof. Treadwell to the Am. Academy 1856. My observations upon the lodgement have been made upon wrought iron cannon. Between the years 1841—45, I made upwards of twenty cannon of this material. They were all made of rings, or short hollow cylinders, welded together endwise. Each ring was made of bars wound upon an arbor spirally, like winding a ribbon upon a block, and being welded and shaped in dies, were joined endwise, when in the furnace and at a welding heat, and afterwards pressed together in a mold by a hydrostatic press of 1000 tons force. Finding in the early stage of the manufacture that the softness of the wrought iron was a serious defect. I formed those made afterward with a lining of steel, the wrought iron bars being wound upon a previously formed steel ring. Eight of these guns were 6 pdrs. of the common U. S. bronze pattern, and 11 were 32 pdrs. of about 80 inches length of bore, and 1800 pds. weight. 6 of the 6 pdrs. and four of the 32 pdrs were made for the U. S. They have all been subjected to the most severe tests. One of the 6 pdrs. has borne 1560 discharges, beginning with service charges and ending with ten charges of 6 pds. of powder and 7 shot without essential injury. It required to destroy one of the 32 pdrs. a succession of charges ending with 14 pds of powder and 5 shot, although the weight of the gun was but 60 times the weight of the proper shot. If any of these guns are ever destroyed by firing them, the destruction will commence in the lodgment. . . . .

I cannot leave the subject without observing that I regard the late, and still continued attempts to make wrought iron in Europe by the process of <u>fagoting</u> or <u>piling</u>, as a strange engineering delusion. It may not surprise that amateur engineers, whose whole knowledge of the character of iron is derived from a printed page, should expect useful results from this attempt, but that men practically acquainted with working iron should expect to forge a serviceable gun of wrought iron by the same process that is used to produce a shaft of that material, seems not very creditable to the <u>iron</u>

knowledge of the age.

"From a work "On the construction of Artillery and other vessels". By James Atkinson Longridge. C. E. London 1860. p. 61-62.

Mr. Bashley Britton said, one of the reasons assigned in the paper for its being necessary to discover a better method for making guns, than that which had previously existed, was that for rifled guns, with elongated projectiles without windage, cast iron would not stand. It had recently been asserted, that all the cast iron guns rifled in England had without a single exception been burst before the experimental trials were concluded. This statement was calculated seriously to mislead. At the same time it was remarked, that the French had succeeded in rifling a great number of old iron Ordnance. This fact proved, that cast iron was a better material than it was generally considered to be. He adverted to this point, because for many years past, he had been endeavoring to improve the efficiency of the existing stock of guns, by converting them into rifled cannon. He had made a considerable number of experiments during the last six years, at Shoeburyness, and would state generally the facts elicited. He had altogether tried seven guns, made entirely of cast iron. Five of these were ordinary service guns, not strengthened in any way. They had been put into a lathe, and five shallow grooves, each $\frac{1}{16}$th of an inch deep, had been cut down the bore. Two of these were 9 pdr. field guns, weighing 17 cwt, two were 32 pdrs. weighing about 56 cwt, and one was a 68 pdr, weighing 95 cwt. There had been fired from the 9 pdr guns fifty-four rounds, from the 32 pdrs. one hundred and eighty-one rounds of heavy shells, with heavy charges of powder; and from the 68 pounder, twenty six rounds of shell, weighing from 90 to 100 pds, each, and capable of containing nearly 8 pds of bursting powder. Up to this time, no gun to which this system has been applied, has been burst or injured. The rifling of these guns has enabled conical instead of round shot to be used, and the projectiles were generally about 50 per cent heavier than the service solid shot; whilst the conical projectiles were shells, possessing a capacity for a bursting charge three times as great as that of the spherical shells. With these shells and the rifled guns, and increased range of several hundred yards had been obtained at 10° elevation, beyond the range of similar guns, before they were rifled. The result of some experiments with the 32 pdr. guns, as smooth bores, and the same guns when rifled were given in the following table;

Rifled 32 Pdr. Cast iron Service Gun (Unstrengthened). Weight 55 $\frac{3}{4}$ Cwt. Bore 6.41 in. weight of projectile 49 lbs. Diam. 6.33 in. Charge of powder 6 lbs.						Smooth bore 32 Pdr. Cast iron Service Gun. Weight 56 Cwt. Bore 6.41 inches. Service Solid. Shot 32 lbs. Charge of powder 10 lbs.					
Elevation 4½°			Elevation 10°			Elevation 5 $\frac{3}{8}$°			Elevation 10 $\frac{3}{8}$°		
Recoil.	Range first graze	Deviation from line of aim	Recoil	Range first graze	Deviation from line of aim	Recoil	Range first graze	Deviation from line of aim	Recoil	Range first graze	Deviation from line of aim
Ft. in	Yards	Yards	Ft. in.	Yards	Yards	Ft. in.	Yards	Yards	Ft. in.	Yards	Yards
9 7	2026	In line	8 9	3530	3 left	9 9	2030	6 left	9 0	2768	24 right
9 7	2125	5⅓ right	8 9	3556	5 right	9 8	1969	8⅓ right	9 0	2751	34 "
9 9	2100	2 left	8 10	3690	6 left	9 5	2021	9 "	9 6	2802	22 left
9 4	2078	2 right	8 10	3560	4 right	9 5	1885	10 left	9 5	2676	17 right
9 3	2063	5⅓ left	9 1	3665	In line	9 4	1980	36 right	9 3	2665	14 "
			9 2	3570	1 right	9 6	1980	In line	9 6	2768	40 left

It would thus be seen, that at an elevation of 10° 22′ the smooth bore, with a range of only 2724 yds. varied in accuracy to the average extent of 23 yards from the line of aim, while the rifled gun at 10° varied at the range of 3562 yards, only 3⅔ yards.

Experiments with Gunpowder.

Description of Powders. — The powders tested were of two kinds of manufacture (Hazard and Dupont's) and ten different sizes of grains, as follows

No. 1	2	grains of powder weighed	100 grains Troy.
" 2	4	do	do
" 3	8	do	do
" 4	16	do	do
" 5	32	do	do
" 6	64	do	do
" 7	128	do	do
" 8	250	do	do
" 9	500	do	do
" 10	1000	do	do

The size of the service grain is about 1500 grains to the 100 grains Troy. The mean specific gravity of Dupont's powder was about 1710; that of Hazard's about 1550 as taken with a densimetre ā mercure

Experiments. The instruments employed in the West Point experiments were, Rodman's indenting apparatus, to determine the pressure on the bottom of the bore.

A six pounder gun pendulum, to determine the initial velocity impressed upon the projectile. An Electro ballistic machine (Navaz) to determine the time of passage of the ball over a certain distance in front of the pendulum.

Also, a plane table to obtain the range of the projectile over water.

The position of the diameter passing through the centre of gravity of the ball was determined by floating in a bath of mercury and it was secured in the axis of the bore by means of a grommet wad.

Kind of Powder	Hazard's				Duport's.			
	Pressure in pounds per Square inch	Initial Velocity Feet.		Range in yards	Pressure in pounds per square inch	Initial Velocity Feet.		Range in yards.
		By Gun Pendulum	By Electric Pendulum			By Gun Pendulum.	By Electric Pendulum.	
1	11.277	1319	1233	281	2.846	786	798	223
2	9.170	1319	1253	283	4.250	1056	1036	231
3	8.047	1303	1322	256	5.213	1077	1093	237
4	15.860	1333	1330	289	8.503	1207	1193	274
5	34.423	1446	1532	265	8.180	1224	1203	272
6	47.477	1468	1521	299	8.246	1238	1218	243
7	55.530	1473	1455	285	13.953	1295	1326	258
8	54.140	1476	1474	313	22.730	1345	1345	268
9	59.046	1436	1502	259	41.130	1462	1463	289
10	63.310	1500	1505	202	40.163	1426	1414	293
Mean	35.928	1415	1413	283	15.522	1212	1209	259

Extract from Report of Lieut. Catesby ap R. Jones. C. S. N. Executive and Ordnance officer C. S. St'r. "Virginia", dated April 4th 1862.

In obedience to the order of the bureau, I submit the following report of our rifle guns, &c. in the action of the 8th and 9th of March:-

The rifle guns are of Brook's pattern, the bow and stern guns are 7 inch calibre, and are mounted on pivot carriages

The charge was 12 lbs. Weight of shell 104 pds. recoil moderate, rendering the breeching unneccessary, except as a precaution. There was no difficulty in loading or working the gun, the carriage worked well. I consider the gun one of great power and accuracy, as do Lts. Sims, Davidson and Wood who had charge of the gun in action.

A rifle gun of 6.4 inch calibre was on each broadside, mounted on the Marsilly carriage. Charge of powder 7 lbs. Weight of shell 64 pounds. The recoil was not violent, but rather more than the IX inch."

Letter of Lieut. A. M. De Bree. C. S. Navy, Assistant Inspector of Ordnance, dated. Tredegar Works. November 24th 1862. addressed to Comd'r Geo.

Minor, Chief Bureau of Ordnance & Hydro.

Sir

I have the honor to submit the following report of experiments with the 7 inch treble banded gun No 1597 of Brooke's pattern. The gun was mounted on a carriage similar to the Army Casemate Carriage. The chassis had an inclination of 4°. The gun was pointed at a target of pine boards one inch thick and placed against a hill on the opposite side of the river, distant 675 yards from the gun. The first discharge was made with 17 lbs. of powder and a cast bolt of 116 pds. weight, with ratchet sabot; this shot passed over the target, and penetrated 16 feet into the solid earth. The second discharge was made with 20 pds. of powder and a cast bolt of the same description as the first, the sabot somewhat defective; this shot also passed a few feet above the target, penetrated a solid rock four feet, and then through twelve feet of earth. The third discharge was made with 17 lbs. of powder and one cast bolt with Tennessee sabot weighing 128 pounds. This shot penetrated the target a little to the right and below the center, and also twelve feet of earth. The greatest recoil of the gun on the inclined chassis was three feet; the breech and trunnion straps and keys stood the test well and bore no evidence of strain. The experiment was highly satisfac-tory, and I cannot doubt but the gun will stand a 25 pd. charge with perfect safety, and a higer charge if necessary.

I am, &c.

(signed) A. M. De Bree, Lt. C. S. N.

Asst. Ins. Ordnance.

Plate I.

Fig. 1.

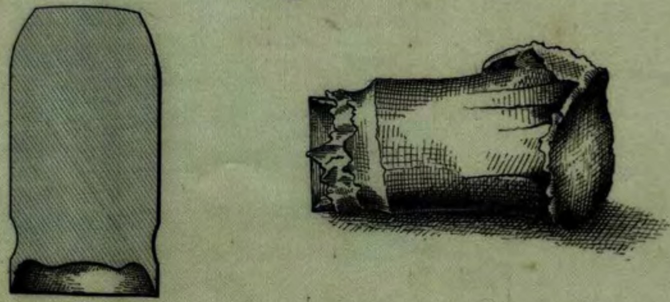


Fig. 2.

Fig. 3.

Fig. 4.

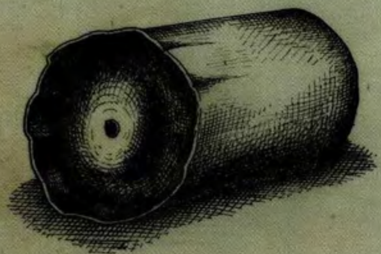


Fig. 5.

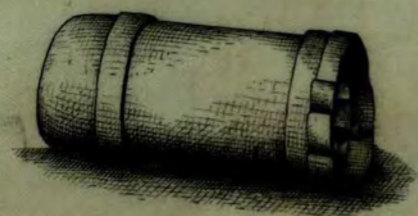


Fig. 1.

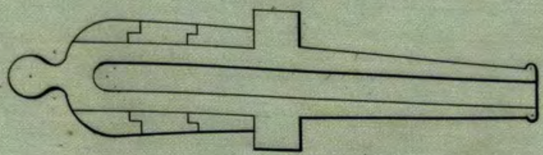


Fig. 2.

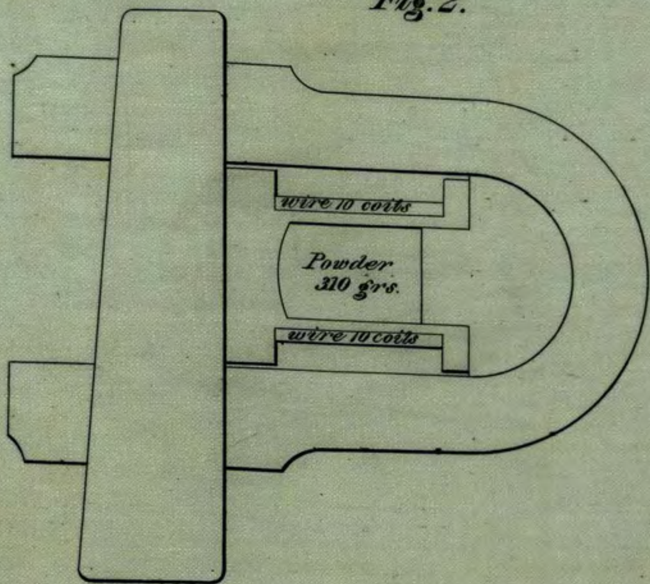


Fig. 3.

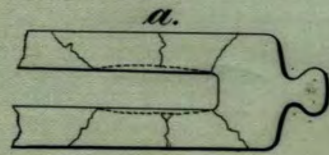


Fig. 4.

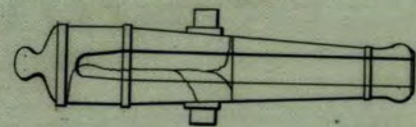


Fig. 1.

4.2 RIFLED GUN.

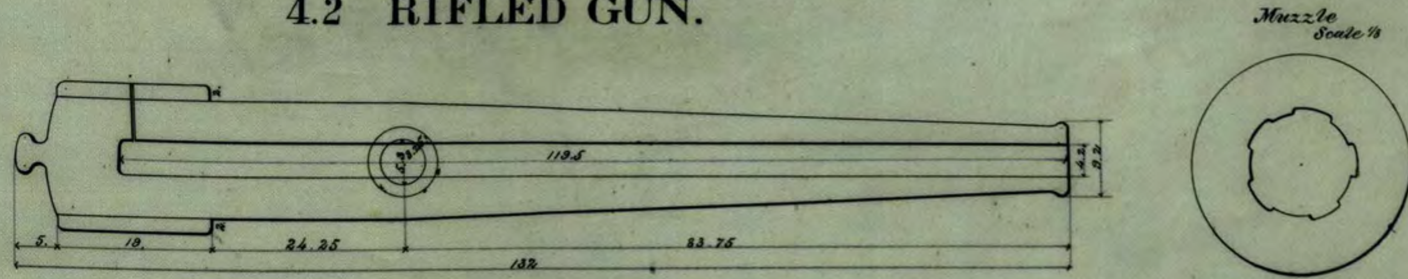
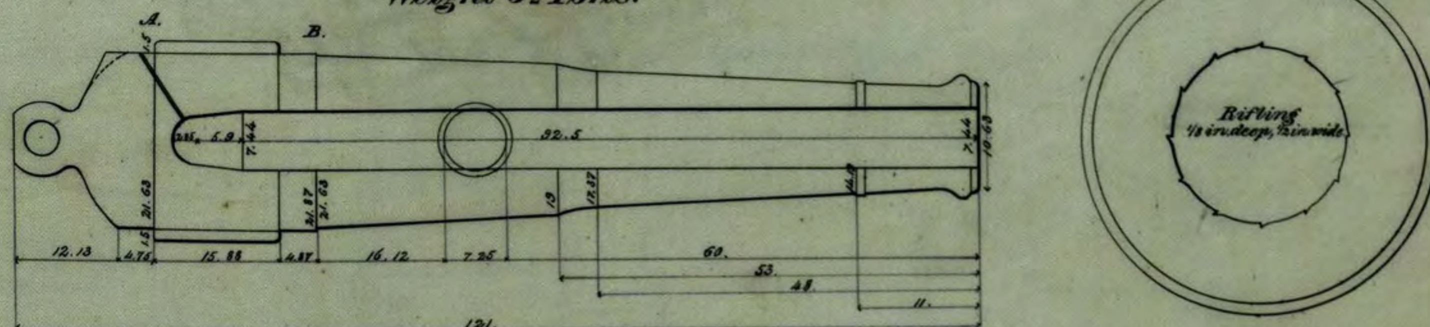


Fig. 2.

BLAKELY GUN.

Weight 3½ Tons.

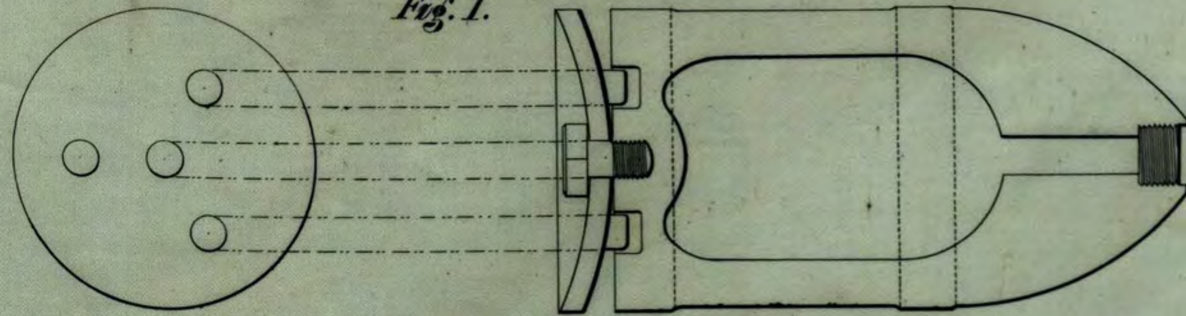


Scale 2 feet 1 inch.

RIFLE SHELLS.

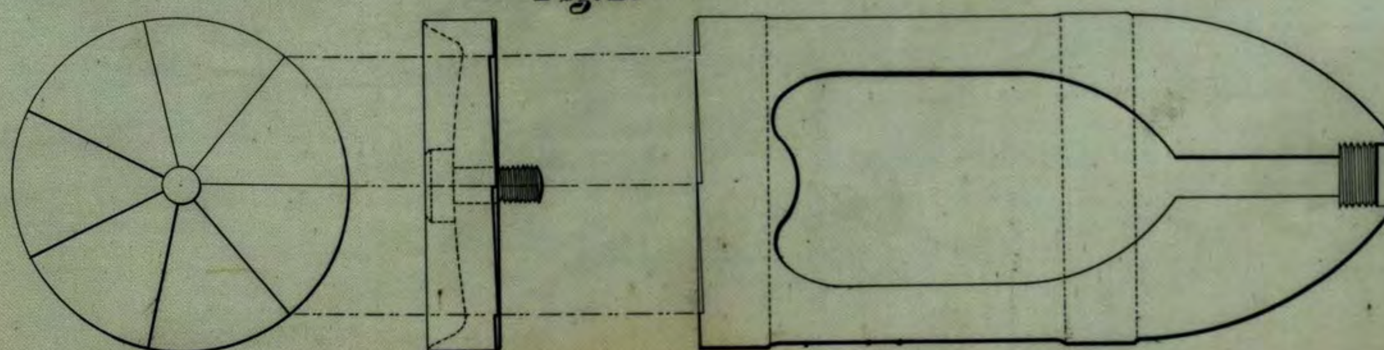
64 Calibre with Tennessee Sabot.

Fig. 1.



7 in. Calibre with Brooke's, ratchet Sabot.

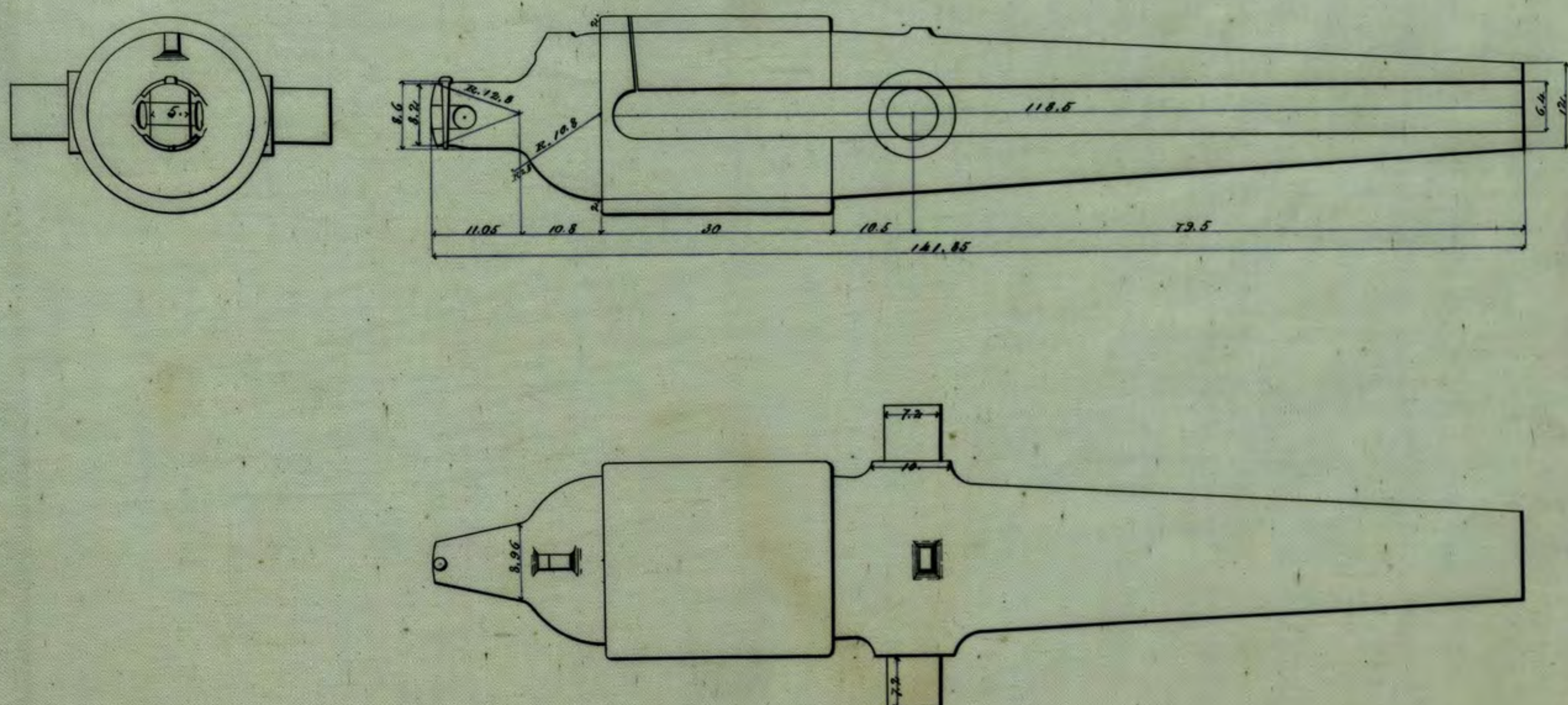
Fig. 2.



Scale ¼.

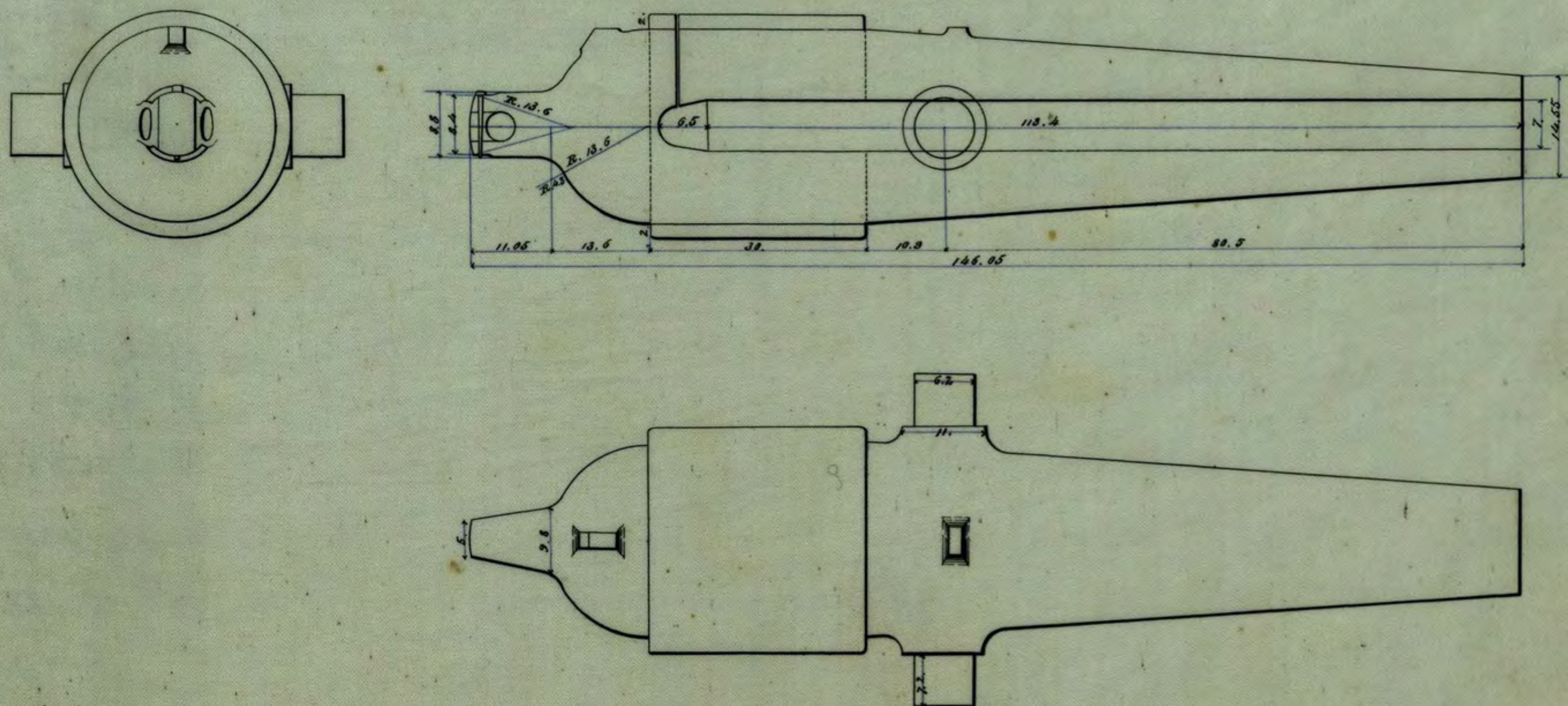
6.4 INCH RIFLE.

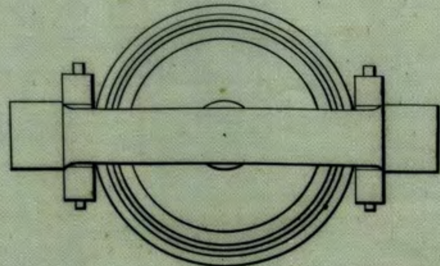
Weight 9000 lbs.

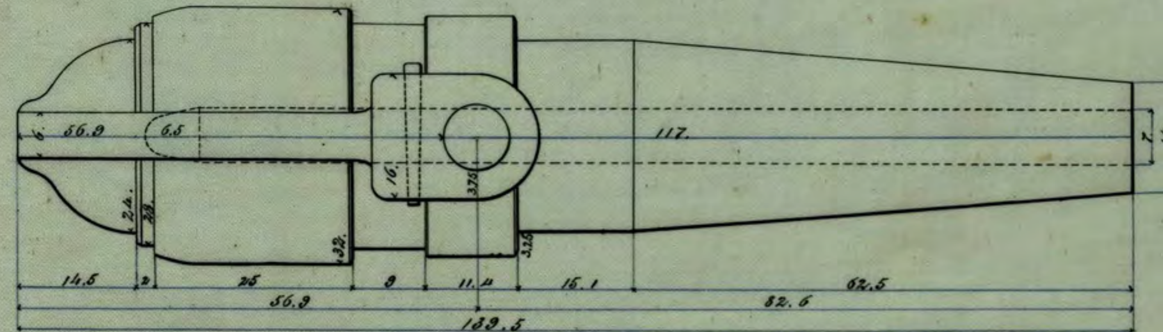


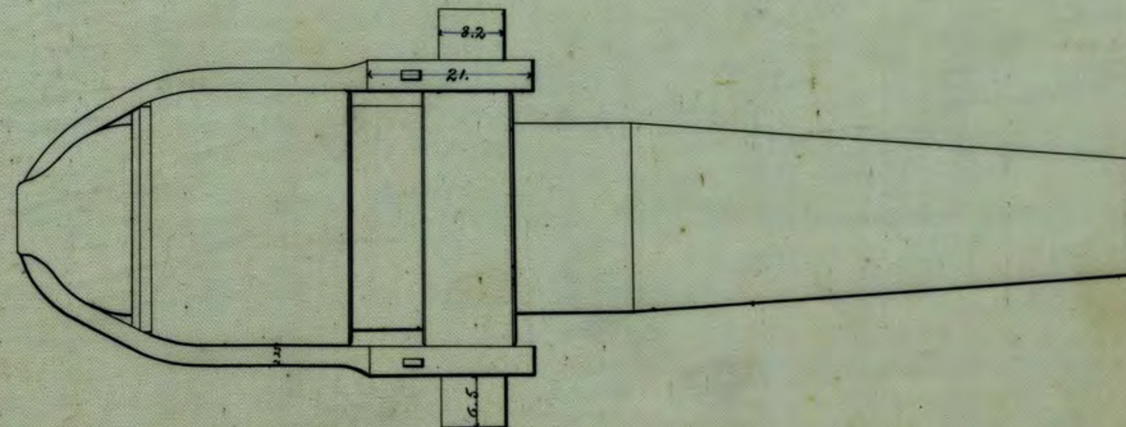
7 INCH RIFLE.

Weight 15000 lbs.







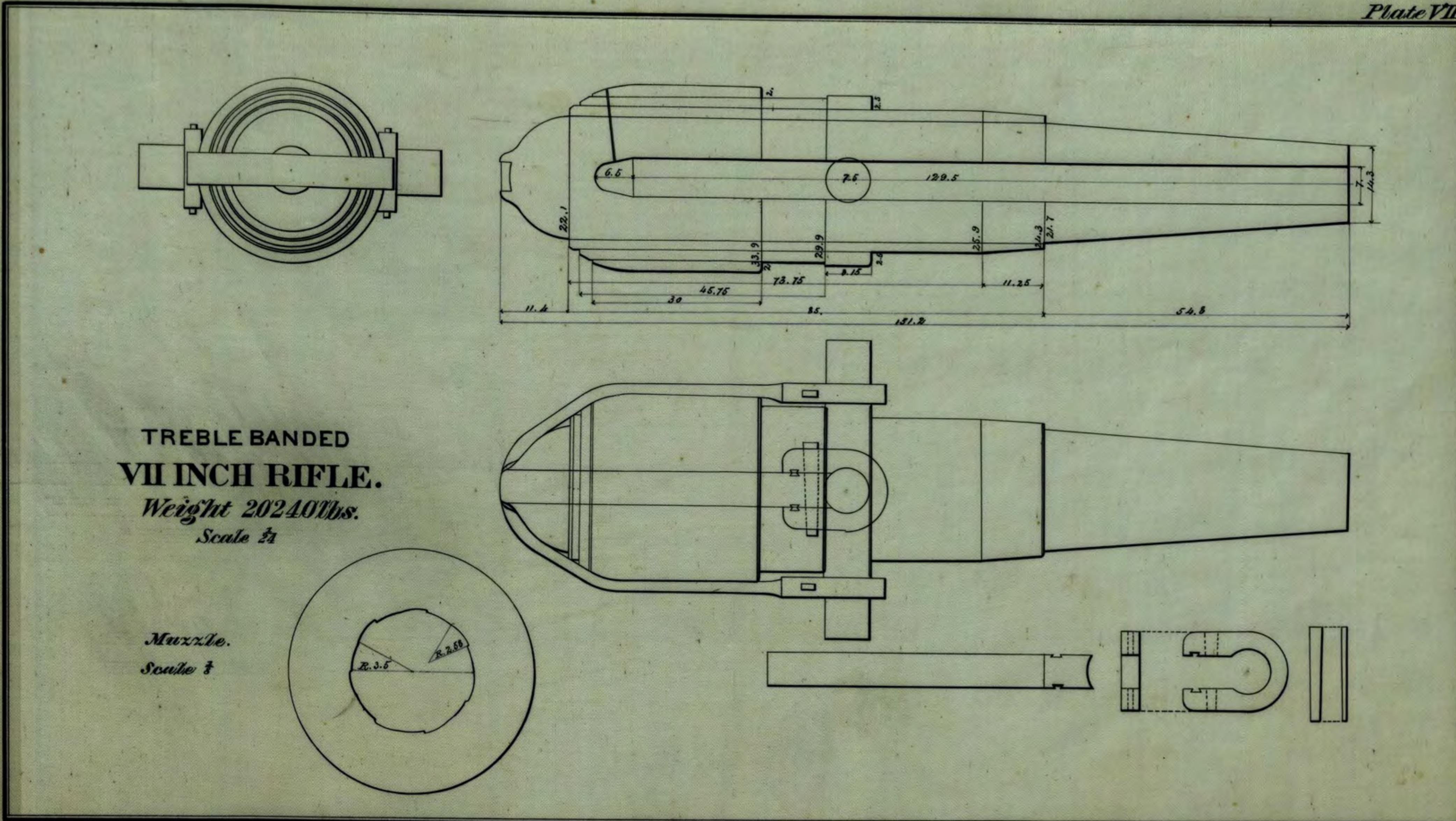


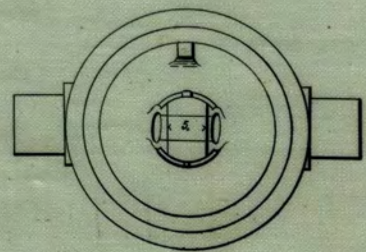
DOUBLE BANDED

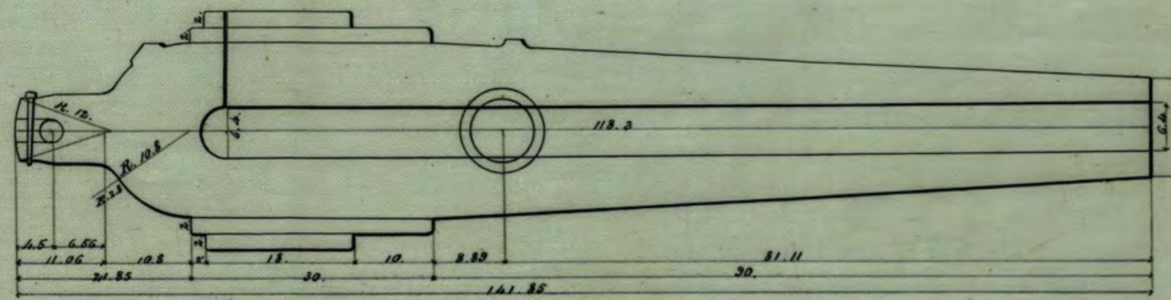
VII INCH RIFLE.

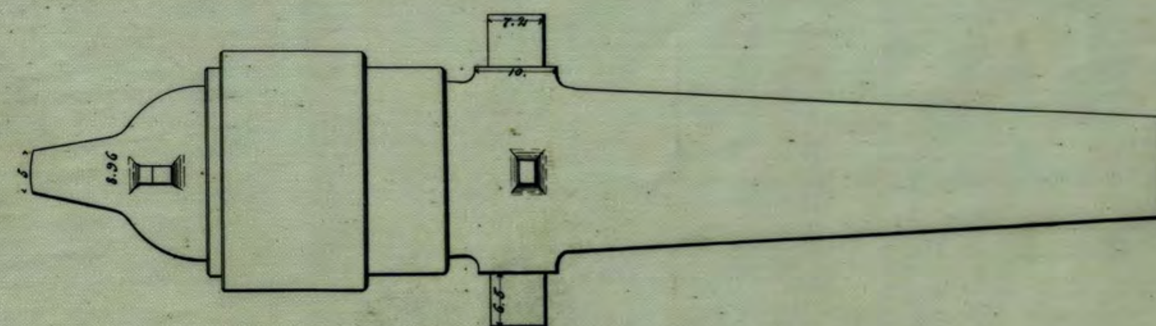
BRASS TRUNNIONS.

Weight 15000 lbs.


TREBLE BANDED
VII INCH RIFLE.
Weight 20240 lbs.
Scale 1/24
Muzzle.
Scale 1/8
2.
2.5
6.5
7.5
129.5
7.
14.3
22.1
33.9
2
29.9
2.4
25.9
24.3
21.7
9.15
73.75
11.25
45.75
30
11.4
85.
54.8
131.2
R. 3.5
R. 2.58



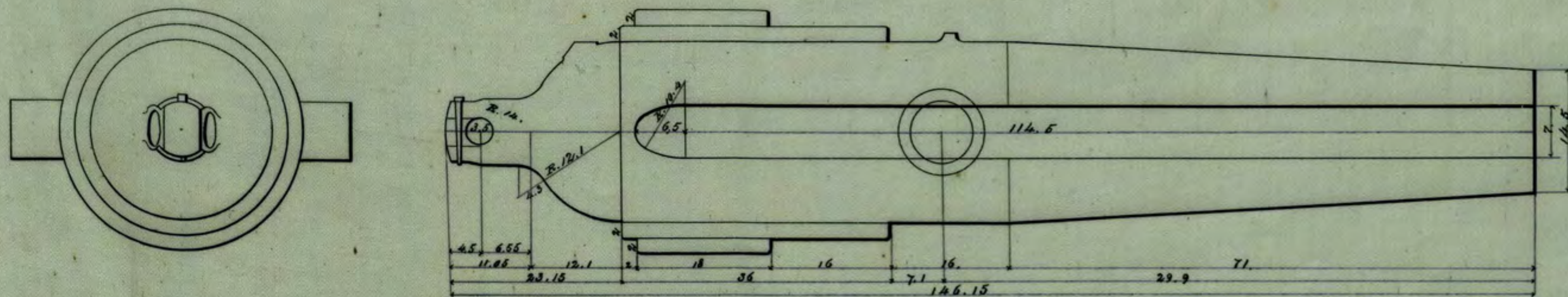




DOUBLE BANDED

6.4 INCH RIFLE.

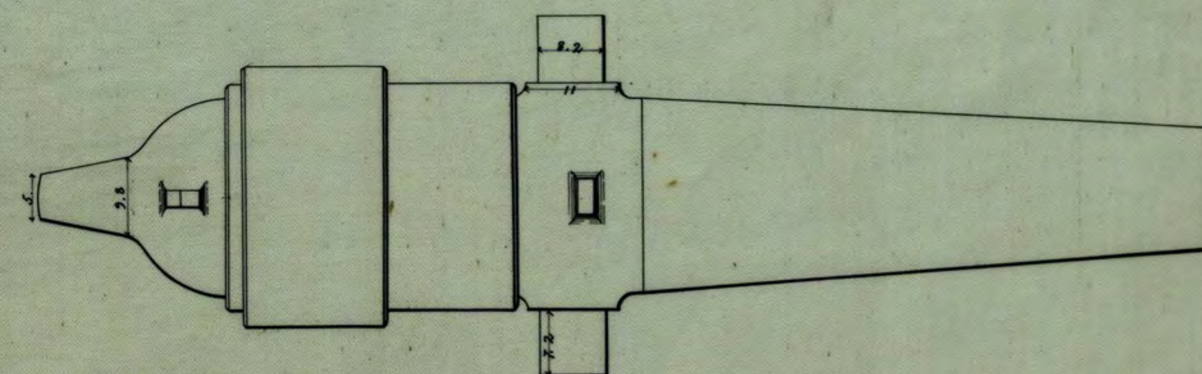
Weight 11000 lbs.

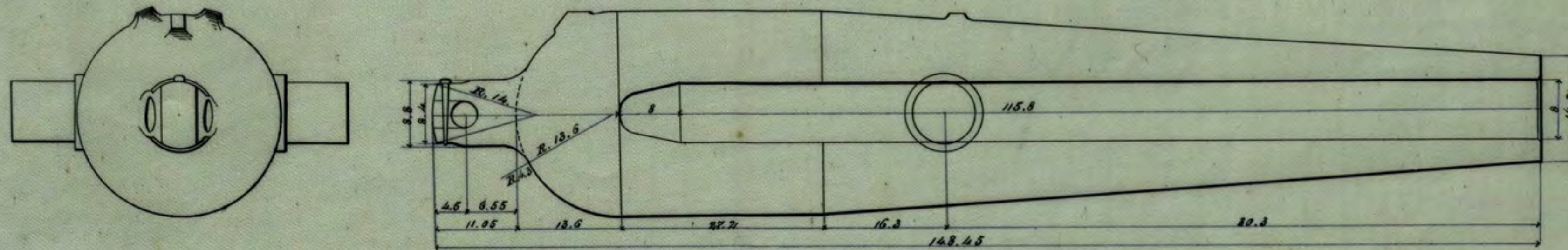


DOUBLE BANDED

VII INCH RIFLE.

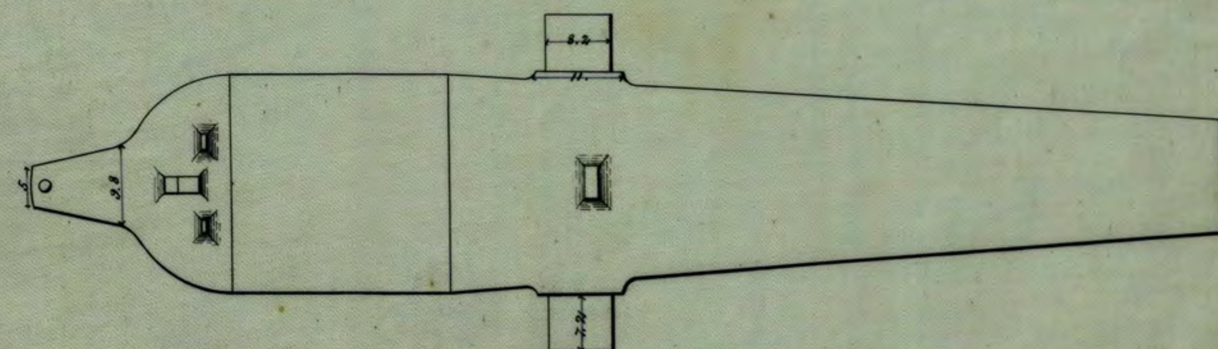
Weight 15000 lbs.

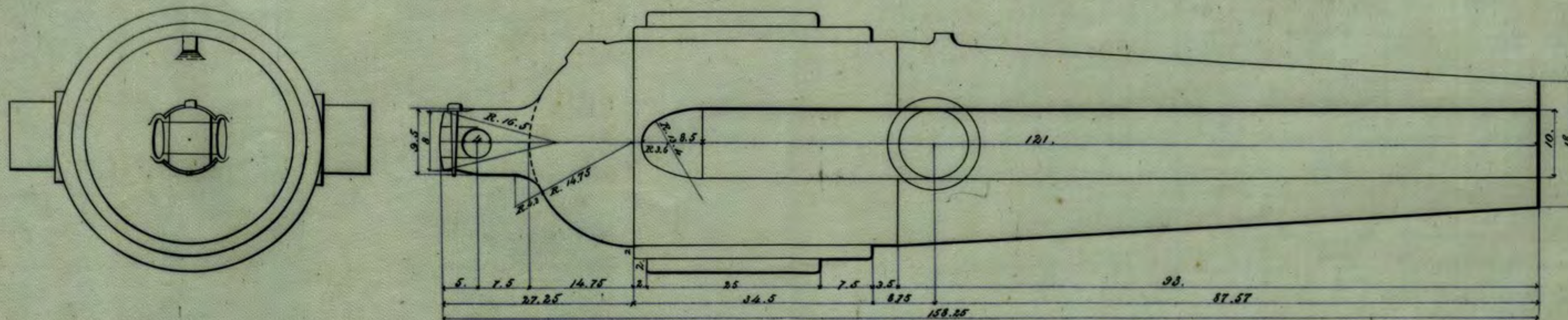


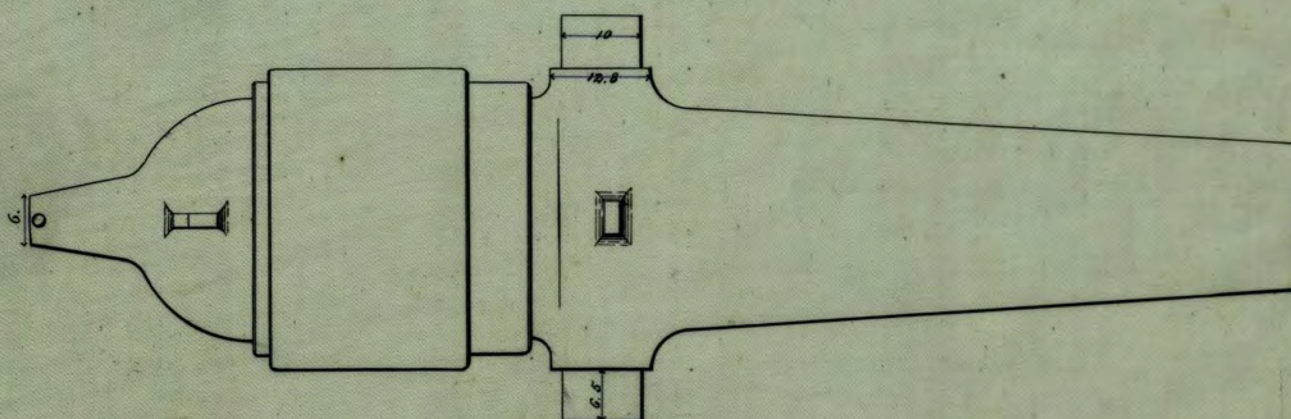


VIII INCH

SMOOTH BORE.





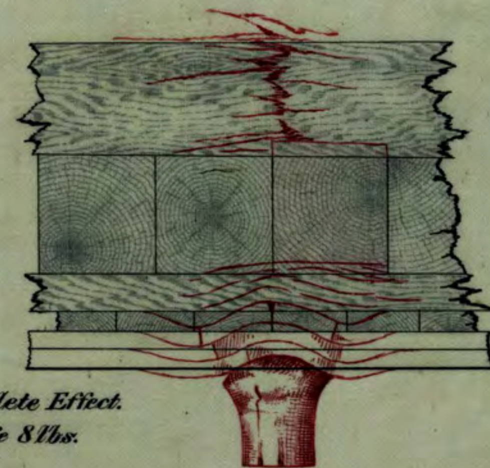


X INCH
SMOOTH BORE.

Fig. 1.

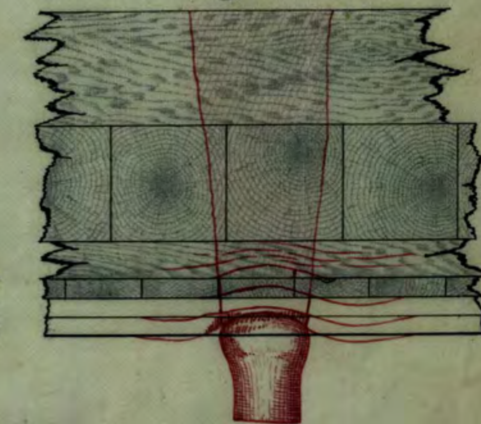
Fig. 2.

Fig. 4.



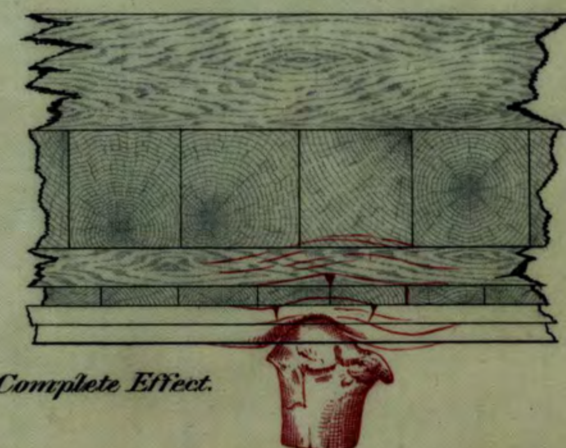
Complete Effect.
Charge 8 lbs.

Fig. 5.



This shot traversed the target.
Charge 12 lbs.

Fig. 3.



Complete Effect.

C. S. Navy Department
Office of Ordnance and Hydrography.
Richmond 1863.

Sir;

Since the date of my report upon the construction of Rifle and other cannon, submitted in January last, events of unusual interest in regard to Ordnance have occurred. Smooth bores of XV-inch calibre and rifles throwing shells and bolts of 200 lbs. weight have been subjected to the test of actual service - The results while they do not entirely fulfil the predictions of partizans, are interesting, and accord very well with the conclusions which were generally drawn from experimental trials prior to the test of actual service.

But, before alluding more particularly to the observed results of the introduction of large smooth bores and rifles, I propose to submit, in connexion with the report referred to, some account of the performance of the rifles of the several classes therein described, their power, accuracy and endurance.

On the 7th of April last, the Federal Squadron, consisting of the frigate Ironsides and monitors armed with 11 & 15 inch guns, attacked the forts of Charleston Harbor, directing their fire chiefly on Sumter - On the east face of this fort, the guns of which were alone available, were mounted two VII-inch rifles of 15,000 lbs. weight, one of the Navy pattern, fig. plate , the other as altered by the Army, fig. and six forty-two pounder service guns, rifled and banded. The contest lasted from until the monitors engaging at the distance of yards.

The Keokuk approached to within about yards, when she was disabled and so damaged, as to sink the next morning. Of the two VII-inch rifles, Col. Rhett in reply to an inquiry addressed him through Lieut. Van-Zandt, Naval Ordnance Officer at Charleston, says—

"I have the honor to inform you that in the engagement of the 7th April, two Brooke guns, one the Navy pattern, the other the Army gun, were used in Fort Sumter.

Charge in each gun was 13 pounds of powder (9 large grained, 4 ordinary cannon powder) — projectile, the wrought iron Brooke bolt-weight, a little less than 120 pounds — Both guns were mounted on the 10-in; Col; wooden carriage.

Forty two shots were fired from one and forty four from the other. Thirteen pounds is the highest charge the recoil of the gun will admit of with safety upon these carriages.

The effect of these was decidedly greater upon the iron clads than any other we had, as seen with good glasses during the engagement, and by observations on the wreck of the Keokuk since.

Six 42 Pdrs, rifled and banded were used — charge 7 pounds — weight of square headed cast iron bolt used ninety odd pounds."

The evidence of the efficiency of these two rifles given by Col. Rhett, is of particular value, as the indentations and scars made upon the armor of the enemy's vessels by the 80 lb. bolts of the 42 pdrs, similar in form to the 120 lb: bolts of the VII-inch rifles would otherwise have been attributed to the latter, which thrown by 13 lbs. of powder were vastly more effective.

It is believed that the Keokuk was sunk by a bolt from one of the VII-inch rifles, one of the three consecutive shots from the same gun, seen to strike that vessel. The observed effects of these projectiles gives weight to the supposition expressed in my report of January last, that had the power of the 7 inch rifle been developed by the employment of bolts in the action between the Virginia and Monitor, the latter would have been destroyed, and the iron clads subsequently built would have been made stronger, and it was with a view to the prospective result that an erroneous opinion of the power of the rifle was permitted to remain uncorrected. That such an opinion existed in the United States is rendered sufficiently evident from the following extract from a report made by Comdr Dahlgren in November 1862, in which referring to the indentations made in the plates of the monitor by the projectiles of the Virginia, he says—

"The end of an elongated shell was also found in the plates of the monitor, showing that such projectiles were fired by the Merrimac (Virginia).

These facts seem to confirm a current rumor, that this vessel had IX inch guns, on the sides and rifled guns at each end; probably 32-pounders, as we find pieces of this desription used very commonly by the Confederates, or else one of the Blakely pattern, a few of which are also known to have been furnished to them— If this be true, then the metal was entirely too light to affect the monitor, and will account in a measure for the little damage she sustained."

The impression that the projectiles described as of polished steel, which were lodged in the hulls of the enemy's iron clads were of English manufacture was equally erroneous, as not a gun or projectile of foreign manufacture was employed in the defence of Charleston on that occasion.

The projectiles were those described in the report.

On the   the monitors again cannonaded Sumter, and on this occasion the VII inch rifle of the Army pattern fig.   pl.   with ratchet breech was cracked and rendered useless - It was severely strained by firing at high elevations - Reports were made upon the bursting of this gun as follows;

Charleston, Aug. 1" 1863.

To Flag Officer
D. N. Ingraham
Charleston, So. Ca.

Sir

In compliance with instructions from the Brig. General Commanding, I have the honor to report that the Army Brooke Gun at Fort Sumter, differing from the Navy Gun only in its having a ratchet breech, burst under the following circumstances - 126 rounds were fired altogether - 45 of which were bolts of 120 lbs. - the rest, shell of 90 lbs. - 13 lbs, powder for bolts - 15 lbs powder for shell - the bolts fired mostly at 2° shell at from 15° to 20° range 3½ miles - the Gun cracked through the vent at 125th round, was fired again, and increased crack to middle of breech, when it was condemned.

The same range has been obtained with 10 lbs. of powder, and same elevation, from a similar gun.

Very Respectfully
Your Obt. Servant,
(signed) C. K. Huger
Major Artill'y. P. A. C. S.

"Head Quarters,
1st Regt. S. C. Artillery
Fort Sumter, Aug. 16th 1863.

Captain

I have the honor to make the following report with regard to Brookes Gun, which burst at this Post, July 15th 1863.

Makers Name	No. of Gun	Foundry	Date of Make	Weight	Style	No. of Shots fired	Kind of Projectiles	Weight of Projectiles	Elevation	Charge		
J. R. Anderson & Co.	1722	Tredegar	1863	15.260	Army single banded	54	Wrought iron Bolts	120	2½° to 3°	13 lbs		
						72	Cast iron Shell Tenn Cap	80	10° to 20½°	13 to 15 lbs		

Besides this several - six or seven - bolts were fired in practice at low elevations -

At the 125th discharge, a crack was noticed, coming from vent beneath the band and extending two and a half inches towards the base of the Gun.

At the 126th discharge, the crack extended along the left side of ratchets, and as far down as the middle ratchet - About twenty shell were fired at high elevation, from 17° to 20½° - eleven of these were fired with 15 pounds of powder, and these were the only 15 lbs cartridges used.

This was considered the best shooting gun in Fort.

Very Respectfully
Your Obdt. Servt.
(signed) Alfred Rhett.
Col. Comdg.

To
Capt. W. F. Nance
A. A. G.

It is generally conceded that guns more frequently burst when fired at considerable elevations, than when fired at the usual elevations of three or four degrees, and the increased strain upon the gun is generally attributed to the influence of gravity upon the projectile. But as gravity acts upon the projectile to produce strain upon the gun, only for the very brief interval of its passage to the muzzle, its effect is probably inappreciable. It appears however that as no provision is made for recoil, the strain upon the trunnions is much augmented and this tends to produce cross fracture, which, in conjunction with other strains and the disposition of planes of weakness, results in bursting the gun - This hypothesis derives support from the fact, that mortars of large calibre, the trunnions of which are placed on the hemispherical breech, have more endurance than guns of the same calibre fired at equal elevations with equivalent charges, and it may be inferred that the endurance of guns so fired would be prolonged by supporting the breech and relieving the trunnions, or by so arranging the carriage as to permit recoil - The latter plan would involve some inconvenience.

The other VII inch rifle has stood throughout the siege - I have not yet been able to ascertain how often it has been fired.

On the 26" of July, a 6.-4-inch rifle of the first pattern of that calibre, single banded, and weighing 9000 lbs. but which had been strengthened by a second tier of bands shrunk over the first at Charleston, burst at Battery Simkins.

The official report is as follows:

"Fort Johnson, James I'd.

July 31" 1863.

Capt. W. F. Nance

A. A. Genl. 1st Military District

H. Q. Charleston

Captain,

In obedience to orders direct from Dept. H. Qrs. I have the honor to submit the following report of the circumstances attending the bursting of the 6.4 inch Brooke's Rifle Gun lately in position in Battery Simkins and manned by cannoneers under my command.

The Gun was mounted on the night of the 22d inst. but was not ready for action until the morning of the 24th, owing to the vent having been stopped up with iron filings - On the morning of Saturday the 25th I commenced firing on the enemy's works on Morris Island with at first, five minutes interval between the discharges from each gun. The fire was greatly slackened as the day wore on and about 7 o'clock P.M. ceased.

At Eleven and two O'clock that same night I fired, by special order, Salvos from all my guns and mortars - about three rounds from each piece - In all this fire the Brooke's Gun participated.

The charge used at first was 8 lbs. with all projectiles, but on Saturday evening, I had it increased, when using bolts, to 12 lbs.

I recommenced firing on the morning of the 26th with fifteen minutes interval between the discharges from each gun, and at the second discharge of the Brooke rifle, then under special charge of Lieut. Rush, 2d Art'y. S. C. V. it burst, killing one cannoneer and wounding three. It was then loaded with 12 lbs of powder and a bolt - It had been fired altogether 56 times. The line of fracture in the gun proper runs, in a line nearly perpendicular to the axis of the piece, near and parallel to the front of the rearmost division of the inner band, through the vent, and cuts the lower side of the bore about 4 inches from the bottom; and in a line nearly parallel with axis, through the vent and centre of screw hole in cascable - One half of the breech and the rear division of the inner band flew to the rear; the next division of the inner band was split, but remained in place; the rear division of the outer band was somewhat displaced to the rear not more than a half inch; the remainder of Gun proper from the above fracture was split towards the front, both through the vent and on the opposite side, about six inches, the fracture extending through whole width of metal. The Gun with the exception as above of half of breech and part of inner band, remained in the trunnions; nor did the chassis nor carriage (except one eccentric wheel) seem much shaken.

I was myself present when this gun was first fired from my battery - I then directed that the Cartridge should be always particularly well rammed down, because the bag was shaped like those of the Dahlgren guns and did not properly fit the bottom of the bore; also that each ball before being placed in the muzzle, should be carefully wiped off and greased. Every time that I was at Battery during the day I myself saw that these directions were properly complied with; and after a careful investigation since made, I have every reason to believe that they were in no case neglected.

I am unable to offer any reason which would sufficiently explain the occurrence, but incline to the opinion that the amount of metal in the breech was not enough, considered relatively to the strength of the bands and the large charge of powder (12 lbs.) and that the upper band ought to have extended back as far as the lower one.

I append a diagram, showing dimensions (as nearly as they could be obtained without proper instruments for measuring) and position of bands; also showing line of fracture.

I have Captain, the honor to remain
Very Respectfully
Yr. Ob't. Serv't.
(signed) John C. Mitchell.
Capt. Comd'g. Art'y.

The additional bands fig. pl. would have been placed nearer the breech as in the double banded rifles of the same calibre, but for the difficulty of fitting the vent bouche;

It appears from the report, that this gun was severely strained by 12 pd charges with bolts at an elevation of about 8 degrees; that the cartridge bags were of the Gomer chamber pattern and were particularly well-rammed home - The bottom of the bore of this gun was hemispherical, and if the cartridges were furnished by the navy, they were intended for the VII inch rifle - The cartridges for the VII inch are six inches in diameter and of the form described; they would enter the bore of the 6.4 in. and then have a windage of nearly half an inch. If they were not supplied by the Navy, their dimensions and consequently their windage cannot now be determined; but as they were evidently intended a chambered gun, and no gun of less calibre than the VII inch rifle is so chambered, the presumption is that they were intended for the VII inch rifle. But if they were not, the ramming which they required to set them home would effectually diminish, if not entirely destroy the windage; particularly as the material for cartridge bags now employed in the Confederacy stretches readily - by which the strain upon the gun would be very much increased; probably by one fourth, the areas of cross section of the proper cartridge and cross section of the bore being as the squares of their respective diameters, and the tension of gases being nearly inversely as their volumes.

The importance of this consideration will be appreciated by reference to the remarks of Mordecai in his "Experiments on Gunpowder" published in 1845. He there says;

"The experiments of the Board of Officers at Metz, whose report I have mentioned in the beginning of my journal, show that with charges exceeding one fourth of the weight of the ball, the cartridge of diminished diameter has even the advantage in point of force, and this circumstance assumes great practical importance, when taken in connection with another fact, developed by numerous experiments in France, viz; <u>that by reducing the diameter of the Cartridge, the strain on the gun may be greatly diminished</u>." He further says; "I have permitted myself to make the foregoing remarks on the French Experiments, in order to call the attention of the Ordnance Department to a matter which may be of the greatest importance to us, in reference to giving increased durability to our iron guns, and diminishing the risk of accidents, which have been lately of frequent occurrence from the bursting of these guns."

The existing regulation windage for cartridges was adopted in consequence of his recommendation, and has remained unchanged from that time. Its origin is not generally known, and its importance is not appreciated. The experiments of Rodman, the incident related by Gibbon in his work "The Artillerist's Manual" of the imprisoning of the gases of half a pound of powder in 8-inch shells, all illustrate the general applicability of "Marriott's law" to the purposes of the artillerists; and if further evidence is considered desirable, I may refer to the successful experiments which I had the honor to suggest, first to yourself, made with the second large Blakely rifle at Charleston, the first having burst when charged in the usual manner with 48 lbs of powder and a shell.

These Rifles fig. pl. were constructed with chambers thirty two inches in length and about six inches in diameter. In the case of the gun that burst, the chamber was filled with powder. The charge of the second gun was placed at the mouth of the chamber, which served as a gas chamber; it was filled with charges of from 30 to 55 lbs. with very satisfactory results. It is not yet known that the inventor designed charging the gun in this manner. When the suggestion was made, it was received with some distrust, but subsequently received the approbation of Ordnance Officers, and it is proposed to extend the application.

But returning to the consideration of the circumstances of the bursting of the 6.4-inch rifle, I will state that there was in addition to the causes mentioned another, not the least important. Owing to the want of facilities, skilled labor and the want of time, it has not been possible to secure such results in foundry operations as are desired. In this case defective casting bore an important part. It had been customary at the Tredegar works to mould these guns by patterns divided longitudinally, and it was frequently observed that in consequence of imperfect adjustment, the two halves-sides of the gun did not correspond by nearly half an inch. This of course produced a plain of weakness, dividing the gun longitudinally, and to this plane was added another at the base ring, where a re-entrant angle occurred between the surplus metal, to be turned off prior to banding, and the hemisphere of the breech. The exigencies of the service were such that the guns were received, not however without reluctance. Of this particular gun, which originally formed part of the armament of the Steamer Chatahooche, and was on board when that vessel was sunk by the explosion of her boiler, Commander Jones writes as follows;

"The 6.4-inch rifle gun we had on board the "Chatahooche" was a bad casting, and without knowing the character of the metal I was of opinion, that it would not endure much. The flasks were longitudinal and had slipped so much as to make, judging from my recollection a difference at the point of intersection of at least half an inch"

Upon referring to the foundry records, it was found that the furnace charge for this gun was 9.500 lbs. whereas it should have been not less than 10.000 lbs. Unfortunately in this case, the required samples of metal from the core had not been preserved, but a sample from the neck of the cascable, sent by Commodore Ingraham, was tested with the following results; the fracture presented no appearance of mottle and was unusually soft. The lines of fracture in this gun, as shown in the diagram fig. pl. correspond with the planes of weakness alluded to.

From the above considerations, I am led to believe that the bursting of this gun may properly be considered an exceptional case, and as serving simply to illustrate the necessity of careful attention to details of construction and service.

On the 8th of September last, a triple banded VII inch rifle of the pattern fig. pl. in battery on Sullivan's Island was cracked and rendered useless by the employment of successive high charges. The following official report of the facts was made.

"The construction of this gun is shown by the accompanying drawing, and a detailed description of it is considered unnecessary; it is a cast iron gun banded with wrought iron about two thirds of its length, with a second band from the trunnions to the breech and partly encircling the latter; over the charge is still a third band, which with the stout wrought iron strap from trunnion to trunnion, passing around the extremity of the breech completes the exterior of the gun. The bore is 7 inches in diameter, and rifled with grooves, and terminates at the bottom in a form resembling somewhat the Gomer Chamber.

From the report of Lieut. R. F. Dwight, 1st S. C. Inf. which accompanies this paper, it will be seen that the gun had been subjected altogether to 33 discharges, 21 of which were with 20 lb. charges and wrought iron bolts weighing each 118 lbs., at an average elevation of 3½ degrees. This weight of powder amounting to nearly one sixth of the projectile, is regarded as a heavy charge for a large rifle gun, and the fact of its being repeatedly fired with such charges, is evidence of its strength of construction.

The rupture of the two exterior bands encircling the breech at the extremity of the bore, followed by the rupture of the cast iron at the breech, shows that this portion is relatively weaker than the other parts.

The facts, as regards the rupture, appear to be, that the two bands above alluded to, being respectively the last of the second and third bands of the series, were ruptured at the 22d round, firing the maximum charge as before stated; and that a last charge of 13 lbs. of powder was afterwards used, which caused the cast iron of the breech to crack from the interior of the vent around and through the extremities of the breech, to about half way to the bands on the opposite side.

The principle of banding cast iron guns, when properly executed, has been demonstrated, from the experience gained during the present war, to be a true one and highly advantageous where it can be applied. In the case of a gun triple banded over that portion having the greatest strain, if the bands have been skilfully put on, the relative strength for the metal employment will be much greater than for a single band of equal dimensions. In such cases the maximum strength of the metal employed is more closely approximated; for the bands being so put on, as that on completion, the first on the gun shall be in state of compression, the second neutral and the third in a condition of extension, fulfil the theoretical demands for an equal strain on each at the moment of ignition of the charge, which with a single band would be impracticable. Hence a triple banded gun strengthened by a breech strap to the trunnions, as is the case with the gun under consideration, if properly constructed, combines great strength with comparative lightness.

The line of wrought iron metal at the breech of the ruptured gun over the extremity of the conical portion of the bore is less than that over the remaining parts of the charge; which cannot be considered sufficiently compensated by the approximation of the solid parts of the breech.

As all equal serfaces exposed to the force of the charge at the instant of ignition necessarily sustain an equal pressure, this portion of the ruptured gun would appear deficient in relative strength.

From all the circumstances of the case the Board are of the following opinion:

First — That the triple banded gun had shewn itself to be of great strength.

Second — That 20 lbs. of powder, and the gun being fired at an elevation with a bolt of wrought iron weighing 118 lbs, must be considered a heavy charge; and only to be sustained by a careful manufacture of the gun in all its parts.

Third — That notwithstanding this maximum charge, the gun would have continued to sustain the strain had not the two exterior bands at the breech been ruptured at the 21st round of heavy charges.

Fourth — That the firing of the gun with 13 lbs. of powder at an elevation of 8°, after the cracking of the exterior bands sustaining the breech, caused the rupture of the gun at its lowest portion.

(signed) Geo. W. Rains
Col. &c. Ord.

(signed) Joseph A. Yates
Lieut. Col. Art'y.

(signed). Wm. S. Basinger
Major 18" Ga. Batt'n."

When this gun, originally intended to form part of the armament of an iron-clad, was loaned to the Army, the following letter of instructions was sent to Lieut. Van-Zandt, Naval Ordnance Officer at Charleston, for the guidance of the Artillerist to whose charge it should be committed.

Office of Ordnance & Hydrography,
Richmond. Va. August. 8" 1863.

Sir

The charges for treble banded rifle will be as follows, with shell. 12 lbs; but this gun should be so employed as seldom as possible. With bolts of cast iron against iron clads at distances exceeding one thousand yards, 14 lbs.

When an iron clad approaches within a thousand yards, and there is every probability of striking the turret, 16 or 17 lbs. may be used according to circumstances.

The 20 lb. charge with wrought iron bolt should be used only when a fair shot at close range, say under 700 yds. may be obtained, by which a turret may be penetrated the enemys gun disabled &c. These charges were arranged to meet the usual conditions of Naval Combat. I do not think it would be prudent to issue to the Army more than (10) ten of the 20 lb. Cartridges, reducing the remaining thirty to 17 lb. charges, using 10 lbs. No. 9 or 10 grain powder and 7 lbs. No. 8 or 9.

The velocity of projectiles fired with high charges is quickly reduced by atmospheric resistance, so that the higher charges are really most useful, as compared with low charges, at short ranges. At long range high charges strain the gun and do very little more damage to the enemy than the others.

Respectfully,

Your Ob't. Servant,

(signed) John M. Brooke

Commander in charge.

Lt. N. K. Van Zandt

Ordnance Officer

Charleston, S. C.

The powder alluded to, Numbered 8-9 & 10, made at the Navy powder Mills is dense and of large grain, and its combustion is consequently slow; the powder used by the Army is less dense and much stronger. From the report it will be seen that the instructions were not complied with, and the enemy is not supposed to have been nearer than 1900 yards from the gun. But severe as was the strains to which the gun was subjected, it would probably not have yielded had it been in the condition, as regards tension of the bands, in which it was when first constructed.

17

This Gun No. with No.

of the same kind, after being banded, was unfortunately much heated by the burning of a building at the Tredegar works, in which it had been placed while the trunnions were being put on; the bands expanded, and in cooling contracted, and seperated, the spaces between them being of the width due to contraction from a red heat. Efforts were made while the fire raged, to reduce its intensity in the immediate vicinity of the guns, by playing with the hose upon the burning timbers and flooring; care being taken to avoid wetting the gun. It is probable that notwithstanding the firm grasp which the bands appeared to have after cooling, the relative tension of the three layers was changed; the cooling of the exterior bands first, tending to reverse the condition fulfilled in constructing the gun, when the layers of bands were shrunk upon the core and upon each other, the exterior layers cooling last.