dry and sandy, and planted with fine Kellogg oaks, which frequently attain a diameter of six or seven feet. On the talus slopes the pines give place to the mountain live-oak, which forms the shadiest groves in the valley and the greatest in extent. Their glossy foliage, warm yellow-green and closely pressed, makes a kind of ceiling, supported by bare gray trunks and branches gnarled and picturesque. A few specimens of the sugar pine and tamarack pine are found in the valley, also the two silver firs. The Douglas spruce and the libocedrus attain noble dimensions in certain favorable spots, and a few specimens of the interesting *Torreya Californica* may be found on the south side. The brier-rose occurs in large patches, with tall, spiky mints and arching grasses. On the meadows lilies, larkspurs, and lupines of several species are abundant, and in some places reach above one's head. Rock-ferns of rare beauty fringe and rosette the walls from top to bottom — *Pellæa densa*, *P. mucronata* and *P. Bridgesii*, *Cheilanthes gracillima*, *Allosorus*, etc. *Adiantum pedatum* occurs in a few mossy corners that get spray from the falls. *Woodwardia radicans* and *Asplenium felix-fœmina* are the tallest ferns of the valley—six feet high, some of them. The whole valley was a charming garden when I last saw it, and the huts of the Indians and a lone cabin were the only improvements.

As will be seen by the map, I have thus briefly touched upon a number of the chief features of a region which it is proposed to reserve out of the public domain for the use and recreation of the people. A bill has already been introduced in Congress by Mr. Vandever creating a national park about the reservation which the State now holds in trust for the people. It is very desirable that the new reservation should at least extend to the limits indicated by the map, and the bill cannot too quickly become a law. Unless reserved or protected the whole region will soon or late be devastated by lumbermen and sheepmen, and so of course be made unfit for use as a pleasure ground. Already it is with great difficulty that campers, even in the most remote parts of the proposed reservation and in those difficult of access, can find grass enough to keep their animals from starving; the ground is already being gnawed and trampled into a desert condition, and when the region shall be stripped of its forests the ruin will be complete. Even the Yosemite will then suffer in the disturbance effected on the water-shed, the clear streams becoming muddy and much less regular in their flow. It is also devoutly to be hoped that the Hetch Hetchy will escape such ravages of man as one sees in Yosemite. Ax and plow, hogs and horses, have long been and are still busy in Yosemite's gardens and groves. All that is accessible and destructible is being rapidly destroyed — more rapidly than in any other Yosemite in the Sierra, though this is the only one that is under the special protection of the Government. And by far the greater part of this destruction of the fineness of wildness is of a kind that can claim no right relationship with that which necessarily follows use.

John Muir.

OUR NEW NAVAL GUNS.[1]

THE interest in military and naval affairs due to the general awakening of the public to the pitiful condition of the national defenses warrants a brief notice of the modern gun-building begun in America in 1883 at the Washington Navy Yard.

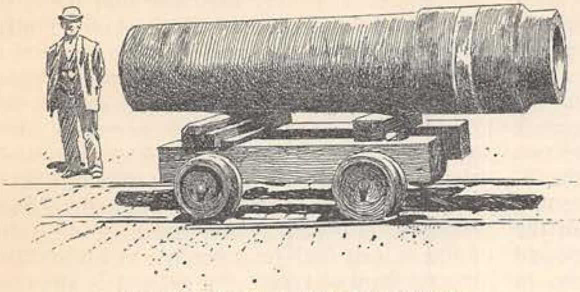
For years this country had been standing still in the matter of cannon, trusting to the creations of Rodman and Dahlgren, those former masters of gun-construction, while other nations were adopting weapons of greater and constantly increasing power. The change from the old to the new has at last set in on our side of the Atlantic, and to-day the efforts of those charged with the armament of our ships and forts are bent towards restoring us to at least a creditable position in the race wherein once we led all competitors.

The gun has developed steadily along certain well-defined lines. It will tend to brevity and clearness to devote a few words to the reasons why, following these lines, the cast-iron muzzle-loading smooth bore has given way to the forged-steel breech-loading rifle. Through its greater weight an elongated shot holds its velocity better than a round shot of the same caliber. If fired from a smooth bore, however, the former is apt to turn end over end and miss its mark; so the bores of guns designed to throw such projectiles are *rifled*, which means that they have spiral grooves that engage a

[1] Thanks are due to Ensign Philip R. Alger, U. S. N., for invaluable assistance, particularly in those parts of this article relating to recent developments.

soft metal band on the shot and cause it to spin about its longer axis. The gyroscopic principle thus invoked keeps the point foremost.

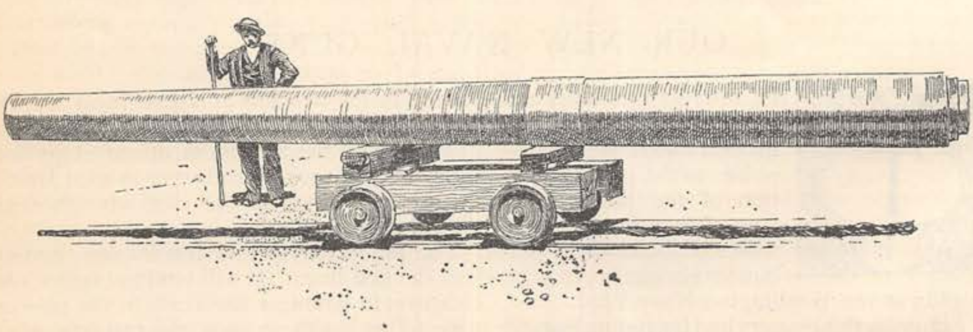
As cannon grew stronger through the em-



TEN-INCH JACKET. WEIGHT 15,935 POUNDS.

ployment of better metal more powder could safely be burned in them. This advantage necessitated a larger space behind the shot to hold the increased charge. Lengthening this space entailed certain grave technical drawbacks and needlessly extended the gun at its heavy end. Better results followed from widening the space, and so the enlarged chamber was adopted. As a full-width cartridge would not enter the muzzle, loading at the breech became imperative.[1] A modern gun is, therefore, a breech-loading rifle.

The value of a moving projectile depends on its weight and its velocity. The faster a shot travels the farther it can range before coming to the ground, the harder will be the blow it delivers, and the nearer its path will approach a straight line. The extreme ranges of guns to-day reach far beyond the limits of the gunner's vision, and are only useful in bombardments where the target is a large



TEN-INCH TUBE FINISHED. WEIGHT 18,112 POUNDS.

area that cannot easily be missed. On the other hand, a moment's reflection will show that if a shot could be thrown fast enough to travel in a straight line, in spite of the action of gravity, to aim directly at the enemy would be equivalent to striking him. The nearer we can approach this impossible condition the less essential is a knowledge of the distance of the object and the greater the likelihood of hitting it. Increased velocity is therefore sought by the artillerist mainly because yielding more striking energy, a flatter trajectory, and a longer danger space, as they are called. To obtain high velocities large quantities of powder must be used. With ordinary powder this means recourse to unsafe pressures in the gun. At first the difficulty was, in a measure, remedied by compressing the powder into large prisms, which burn more slowly and uniformly than irregular grains. A limit was soon reached in this direction, and changes were sought in the composition itself. The Germans were the earliest to make and use "cocoa powder," the general but not universal standard at present, the process of the manufacture of which is a well-kept trade secret.[2] This powder differs from the familiar black powder in having somewhat more nitrate and charcoal and much less sulphur, and in the charcoal, which is underburnt. Its chocolate color gives the name by which the new substance is known. Cocoa powder furnishes in the gun a comparatively moderate pressure, which decreases gradually towards the muzzle. To obtain the full value of such a powder the shot must be kept under its influence for a longer time than was needed with the older and quicker black powder. The length of the bore, measured in calibers, has therefore grown from twelve and less to thirty and more — a striking proof that the design of the gun is

1 Breech loading is an old device, found, for instance, in one of Hernando Cortez's guns. The main reason for its re-introduction, stated above, was but one of many. It offers so many incidental advantages in connection with security to the gunners in action and the service of ammunition that it would be retained on their account alone.

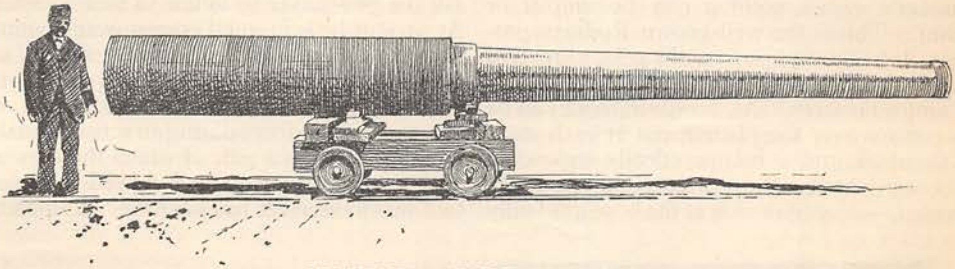
2 The Duponts of Wilmington have produced a similar article which gives distinctly better results than its German forerunner.

controlled by the character of the powder, and that the gun is but a machine for transforming the latent energy of the powder into motion of the projectile.

Still more recently a powder called "Chilworth Special," which promises to eclipse the German cocoa, has been produced abroad. This differs from ordinary powder in having ammonium nitrate in place of part of the potassium nitrate, and a much less weight of it gives the same velocity to the shot as that given by the cocoa powders. Arrangements have been made to produce the powder in the United States.

Besides this "ammonia powder" a number of so-called "smokeless powders" have been produced abroad, mainly for use in small arms. The ingredients and mode of manufacture of these powders are kept secret, but, generally speaking, they consist of high explosives, such as guncotton or nitroglycerin, so treated as to restrain and diminish the violence of their action. The endeavor is being made to use these powders in large guns, and the English "cordite" has been successfully employed in guns as large as the six inch, giving, it is stated, a velocity at the muzzle of 2800 feet per second without increase of chamber pressure beyond that occasioned by cocoa powder when urging the projectile to only 2000 feet per second velocity. A simple calculation shows the striking energy of the shot to be nearly doubled, while the advantage of smokelessness can hardly be overestimated. After making the most liberal deductions from these statements on the score of exaggeration — and it is wiser to magnify your adversary's force than your own — it will be seen that a new departure in powder is at hand.

How very few persons, by the way, appreciate the latent power of a modern projectile when in motion. Those who have visited the *Atlanta* and have seen her smaller guns, of six inches caliber, whisked about by one man, will be even the less likely to realize that their shot can pierce an iron plate over eight inches thick at the distance of a thousand yards. Try to imagine for a moment the number of men who would have to pull on a line that, arranged in any conceivable way, could be made to throw the hundred-pound shot with force enough to make such a hole. Yet all of this power is stored up in a cartridge weighing less than fifty pounds. To contain and restrain such a power we must, it is evident, use the best material obtainable; the best at the beginning, best in the midst of the firing, and best at the close. It must stand the sudden and heavy first shock; must yield a little, without rupture or permanent distortion, when the pressure is at its greatest; must return to its original shape when all is over; and it must offer, at all times, the greatest possible resistance to fracture. Technically cur metal must be tough, elastic, and of great tensile strength. These qualities find their highest development in forged *steel.*



TEN-INCH TUBE AND JACKET ASSEMBLED.

The term *elastic* needs, as used, a word of explanation. Solids possess the faculty of recovering themselves if not taxed beyond a certain point called the *elastic limit.* The calculated strains in a gun are not allowed to exceed a given fraction of the strength of the gun metal at the elastic limit. Where great local strains are to be encountered in any structure, materials are chosen whose elastic limit is high. For this reason forged steel has forced itself into general use for ordnance. How and to what end is the metal disposed in our new gun?

The strains exerted in the gun when the charge is fired are in two directions. The first and more dangerous, called the *transverse* strain, tends to burst the gun; the second, or *longitudinal,* to blow the breech off. Speaking of the first in particular, it acts so quickly that the inner layers of metal in a solid gun are stretched before the outer layers have time to come to their aid; and, no matter how the gun be constructed, the former must always bear the larger share of the burden. If a gun be made of several concentric cylinders, and if the outer ones can be made to compress the inner, the powder will have to overcome this compression at the bore before it can exert a strain of tension. Such a state of things is secured by making each cylinder smaller, by an amount called the *shrinkage*, than the one it must embrace. The outer cylinder is expanded by heat and slipped over the inner. The contraction on cooling sensibly squeezes the latter and produces the desired compression. Shrinkages and the resulting strength of the compound structure are based on mathematical formulæ of which the truth has been fairly well established by repeated experiment. It may be added that the ideal gun is one in which all of the concentric layers of metal reach the elastic limit at the same instant.

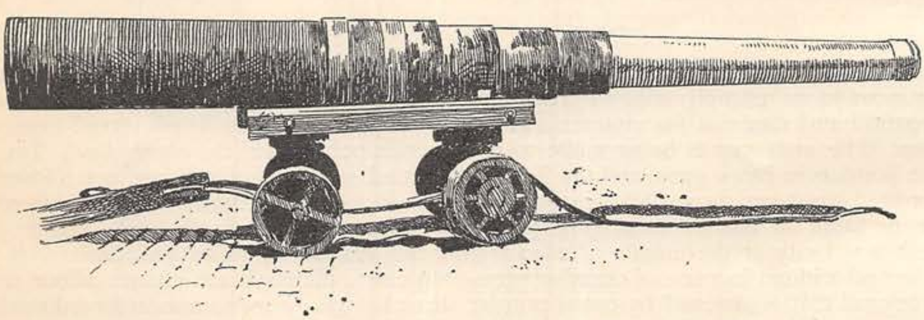
Theoretically the same condition of affairs[1] can also be reached by casting the gun of steel or iron,— each has its advocates,— and causing the metal to begin cooling at the bore while the exterior is kept hot. As each layer solidifies it compresses those under it, and if the solidifying takes place in accordance with the founder's wishes, nothing can be simpler or better. This is the well-known Rodman process. It has always possessed a great attraction for gun-builders whose facilities consist mainly of ample furnaces. As, however, there can be no control over the phenomena at each stage of the work, and as it is practically impossible to know whether the object sought is really secured,— a compression at the bore gradually diminishing towards the exterior,— the great gun-makers of the world have preferred the somewhat more costly but certainly more trustworthy method of building the gun up of parts each known to be sound and true.

And the same may also be said of the process with which General Uchatius's name is associated,— as partisan rather than inventor, — of expanding the casting by steel plugs or mandrels forced through the bore. In small bronze guns this worked fairly well. On a large scale it failed completely.

In view of the recent improvement in steel castings it may be asked why they should not make good guns,— that is, good enough guns,— for the cast steel of to-day is as much better than cast iron as cocoa is better than black powder.

To discuss this question adequately or fairly would lead us too far afield.

Broadly speaking, forging seems to be essential in order to produce toughness and a fibrous structure in steel. It would be presumptuous to say that no substitute for forging will ever be found, but it is correct to say that no substitute has as yet been found. Piston rods, connecting rods, crank shafts, and other moving parts of machinery which are subject to great and sudden changes of stress, are almost universally of forged steel or wrought iron. When the engineers all over the country adopt castings for such members and the bridge builders use the unworked product of the furnace in spanning great rivers it will be time to ask the gun-maker to follow in their footsteps. At present he is in good company and content to make his guns of the best material he can get; for, after all, that gun is cheap, no matter what the price, alongside of which men will stand with confidence during an action, and that gun dear, even as a gift, of which the crew are afraid. And at this point it is well to remark that much discredit has been thrown upon the built-up gun by the advocates of other systems who have widely circulated the account of every failure of guns of this type. The fact remains that no properly designed gun of this kind has ever failed. Poorly designed guns have failed. So have steel bridges. But because steel bridges by the score have collapsed are we to clamor for bridges of cast iron?

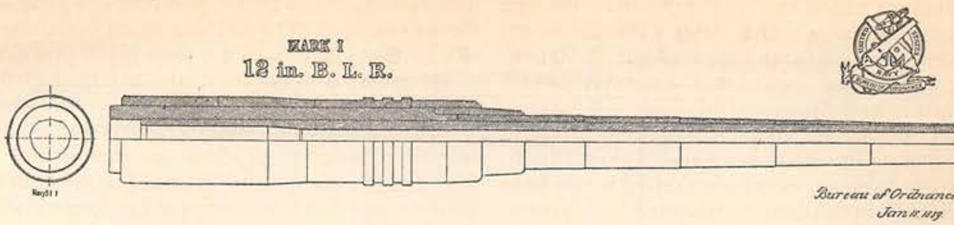


SIX-INCH GUN TUBE, JACKET, AND LARGEST CHASE HOOPS ASSEMBLED.

An experiment on a small scale bearing on this point was tried a year ago in this country. The casting of three six-inch guns was authorized by Congress in 1887, one to be of Bessemer, one of open hearth, and one of crucible steel. No firm expressed a desire to furnish the last named piece. The first was supplied by the Pittsburg Steel Casting Company, and the second by the Standard Steel Casting Company of Chester, Pennsylvania.[2] These guns

[1] Technically called "initial tension."

[2] The *finishing* was done at the Washington Navy Yard. One of these very modest pieces was widely heralded as "Pittsburg's monster cannon."



TWELVE-INCH BREECH-LOADING RIFLE.

were submitted to a firing test of ten rounds with service ammunition The Pittsburg gun burst at the first round. The other held together, but the metal of the bore was stretched, and a number of small cavities were developed in the metal by the searching action of the powder gases, so that the gun lies under suspicion.

It should be remarked that the cost of one of these guns was greater and of the other almost as great as that of the built-up gun. Moreover, even had they not failed, it would by no means have followed that cast steel will answer for larger guns, as the difficulties increase rapidly with the size of the casting.

A word may here be said in regard to the widespread but erroneous impression that modern guns are short-lived. The one cause of deterioration in a well-constructed steel gun is the wearing away of the bore by the powder gases. Now guns as large as the ten-inch have been fired upwards of seven hundred rounds without being disabled, and even when erosion of the bore makes the gun inaccurate a thin lining tube can be inserted and the gun made as good as new again.

In the naval designs the longitudinal strain is delivered by the breech-plug to the *jacket* J, which is held in place by a series of *locking-hoops*, B, C, and D. The last of these engages a projecting collar under D, on the outside of the tube T, as shown in the section of the smallest of our ordinary type guns, the five-inch breech-loading rifle for the *Chicago*.

In the latest models it has been thought advisable to add more strength towards the muzzle of the gun, as the tendency of recent powders is to maintain the pressure behind the shot without very great diminution. The *Chicago's* eight-inch guns, and all the larger guns built subsequently, are hooped to the muzzle like the *Miantonomoh's* splendid ten-inch breech-loading rifle.

Steel guns are not new in America. Three-inch breech-loading howitzers of this metal have been used in the navy since 1879. Our first steel gun, properly speaking (of six inches caliber), was built at the South Boston Iron Works in 1882 for experimental purposes; but the earliest constructed for actual service were begun at the Washington Navy Yard six years and more ago. They were for the *Atlanta*, *Boston*, *Chicago*, and *Dolphin*; in all, two five-inch, twenty-one six-inch, and eight eight-inch breech-loading rifles.[1] Since that time the batteries of the *Charleston*, *Yorktown*, *Petrel*, *Baltimore*, and *Philadelphia* have been completed, and large numbers of four-inch, six-inch, and eight-inch guns are in course of construction for other new ships. Besides these, three of the ten-inch guns for the monitor *Miantonomoh* have been completed, and the fourth is building. The principal characteristics are as follows:

Caliber.	Weight.	Length in		Weight of Charge.	Weight of Projectile.	Velocity at Muzzle.	Energy at Muzzle.	Calculated Perforation of Wrought Iron at 1000 Yards.
In.	Tons	Ft.	Calibers	Lbs.	Lbs.	Ft. Second	Ft. Tons	In.
10	{ 27 / 26	30.7 / 27.4	35 / 31 }	250	500	2100	15,355	21.1
8	3.1	25.3	35	125	250	2100	7,650	16.3
6	5	16.1	30	50	100	2000	2,773	10.6
5	12.8	13.4	30	30	60	2000	1,664	8.6

These guns are built up of a number of separate pieces of open-hearth steel. The

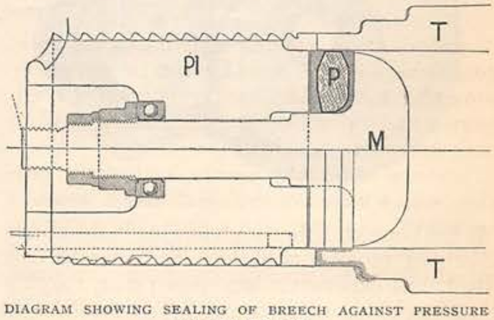
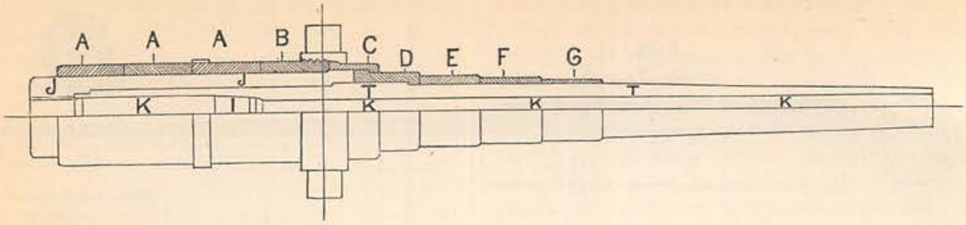


DIAGRAM SHOWING SEALING OF BREECH AGAINST PRESSURE OF POWDER GAS.

Pl, Plug; T, Tube; M, Mushroom; P, Gas check.

pieces are cast into ingots that are forged, turned off, and bored out nearly to size. They

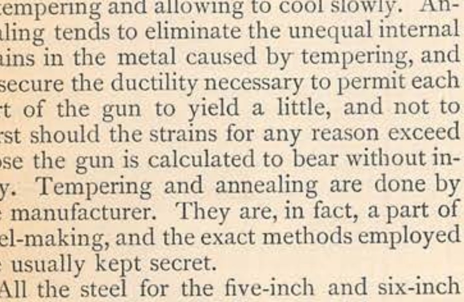
[1] Of these the South Boston Iron Works and the West Point Foundry built four of the eight-inch and eleven of the six-inch caliber.



FIVE-INCH BREECH-LOADING RIFLE FOR THE "CHICAGO."

are then raised to a cherry-red heat and dipped into a tank of oil. This last process, *oil tempering*, increases the elastic limit and ultimate strength. Afterwards they are *annealed*, by heating to a somewhat lower temperature than in tempering and allowing to cool slowly. Annealing tends to eliminate the unequal internal strains in the metal caused by tempering, and to secure the ductility necessary to permit each part of the gun to yield a little, and not to burst should the strains for any reason exceed those the gun is calculated to bear without injury. Tempering and annealing are done by the manufacturer. They are, in fact, a part of steel-making, and the exact methods employed are usually kept secret.

All the steel for the five-inch and six-inch guns already afloat, and for most of those now constructing, was supplied by the Midvale Steel Works, near Philadelphia.[1] No better metal has ever been made into guns. For the larger calibers recourse was had to Whitworth and Cammell of Sheffield, England—not because the steel-producing capacity of this country was inadequate, but mainly because our steel-makers lacked sufficiently powerful hammers.



EIGHT-INCH BREECH-LOADING RIFLE. BREECH OPENED.

As has been said, thorough forging is absolutely essential to give a fibrous character to cast steel, and experience has shown that, roughly speaking, the hammer employed must be as heavy as the finished gun. Now until recently the weight of the largest hammer in the United States was but seventeen tons, and it is in the hands of a firm that has preferred not to undertake the making of gun-steel.

To depend upon foreign establishments for the material of which to make our cannon is an humiliation to which we shall be no longer subjected. The acts of Congress from 1885 to 1887 authorizing the construction of seven new vessels, together with those sanctioning the rebuilding of certain of the old monitors, enabled the Secretary of the Navy, through judicious delay,— severely criticized at the time by the uninitiated,— to mass the gun-forgings into a lot of about thirteen hundred tons, besides over six thousand tons of armor — a sufficient amount to induce some of our large steel works to consider seriously the erection of the necessary furnaces, hammers, presses, etc. to make such heavy forgings. A very spirited bidding was had in March, 1887, in response to advertisements, and shortly afterwards the Bethlehem Iron Company signed contracts by which it agreed to put up all the needed appliances, and to begin the delivery of parts of guns within a stipulated time. These works will be capable of supplying gun-forgings of any size, as well as heavy shafting, etc. for steamers, mill engines, and mine pumps, which till now have been imported. The new plant at Bethlehem is nearly completed and the delivery of forgings has been begun, so that all the guns in course of construction for the navy are now of American steel throughout. The country at large will be a direct gainer by this skillful bit of financiering, which will always remain a monument to the Navy Department of the late Administration. It is gratifying to hear that competent experts pronounce the Bethlehem steel plant the most complete and best equipped in the world.

At every important step in the manufacture of gun-steel small pieces are cut from each forging and pulled apart in a testing machine to determine four things: the elastic limit and breaking strength per square inch of section, and the percentage of ductility and of contraction of area at the place of rupture. Each of these quantities must reach a certain figure or the forging is rejected. It is evident that by making guns in pieces that can be well hammered and tested in detail the quality of the

[1] In "Harper's Monthly Magazine" for June, 1886, in an article on "Our Navy" an unintentional injustice is done this enterprising establishment by attributing all the steel for our guns to foreign makers.

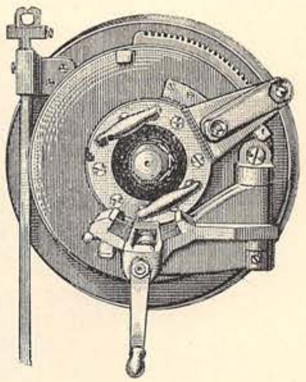
metal as a whole is vastly improved, and flaws and other imperfections are readily detected.

Let us glance briefly at the chief mechanical operations involved in making a gun.

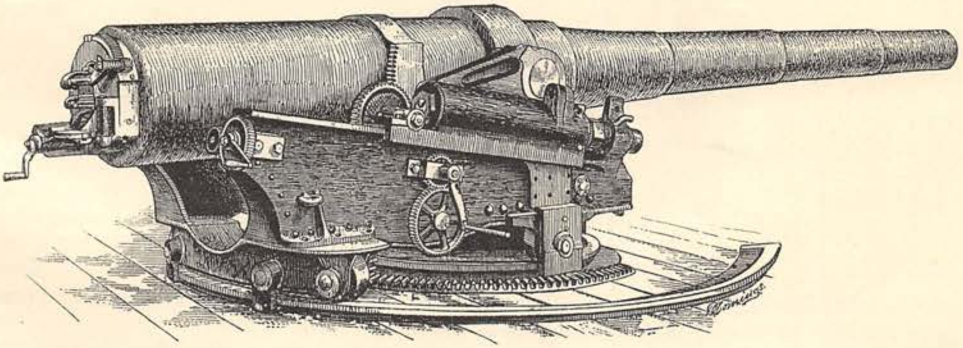
In rough boring, the tube, as it comes from the hammer, is accurately centered in a lathe and turned down on the outside to within three-eighths of an inch of its final size. A cutting tool is then held by a machinist against its muzzle as the gun revolves, making a round axial hole a few inches deep, into which is entered a hog-nose bit carried on a long bar and fed automatically into the tube as the small steel cutter bolted to its front end drives the hole deeper and deeper. As this bit will inevitably follow the direction of the original cut, a mistake at the outset would involve serious consequences. The bore of the tube is left three-fourths of an inch smaller than the caliber. After tempering, these processes are repeated, leaving the bore within about two one-hundredths of an inch of the finished size, and the outside exact.

In first, or rough, boring the jacket, a hollow pipe is used, which is furnished with thin cutters on its front edge that drive an annular hole into the body of the metal about an axial core, afterwards made into a howitzer. In fine boring, a simple bit armed with steel cutters at opposite extremities of its diameter is employed. The jacket is not finished externally until joined to the tube, except that the front end is accurately cut off.

The next step in the growth of the gun is to place the jacket over the tube, the latter being, as already explained, some thousandths of an inch larger than the hole in the former.



EIGHT-INCH BREECH-LOADING RIFLE. BREECH CLOSED.



EIGHT-INCH GUN AND CARRIAGE OF THE "BALTIMORE." (BUILT AT THE WASHINGTON NAVY YARD, OF AMERICAN STEEL.)

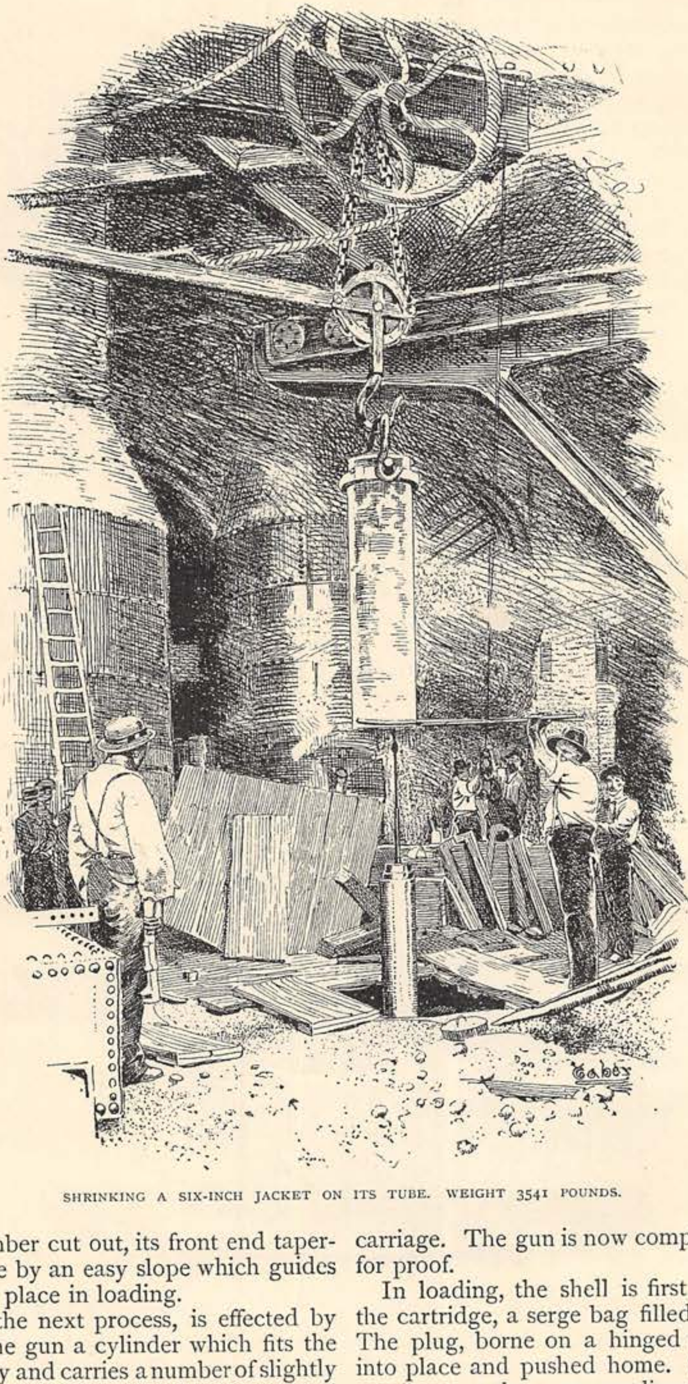
The tube is lowered, muzzle down, into a deep pit and braced vertical. The jacket is slowly warmed in a cylindrical stove. When its bore is found by measurement to be sufficiently expanded, the jacket is picked up by a crane, swung over the tube, and lowered into place. The combination is now, for the first time, spoken of as a gun.

To make a gun-hoop a round ingot of the proper weight is raised to forging heat, and a hole punched through its center by a steam-hammer. Through this hole a heavy steel bar is placed, whose ends rest on anvils. The hoop is gradually expanded under the hammer, or else it may be squeezed between the rollers of a locomotive-tire mill. After rough boring and turning to within an eighth of an inch of the finished dimensions, tempering, annealing, and testing, it is sent to Washington. Here it is carefully machined, leaving the bore smooth, straight, and cylindrical.

Each hoop on a gun is known by a letter. There are two sets, the first going over the front of the tube or *chase*, and the second over the jacket. None are finished on the outside until put on the gun. The first are shrunk on as soon as the tube and jacket are cooled. The gun is then put in a lathe, the exterior turned off to the required size, and the remaining hoops placed.

The five-inch, six-inch, and eight-inch guns rest in their carriages on projections called *trunnions*. A stout screw thread is cut over the center of gravity of the gun and the trunnion band screwed on. The *assembling* of the gun is now complete.

The gun is bored to its final caliber, and the



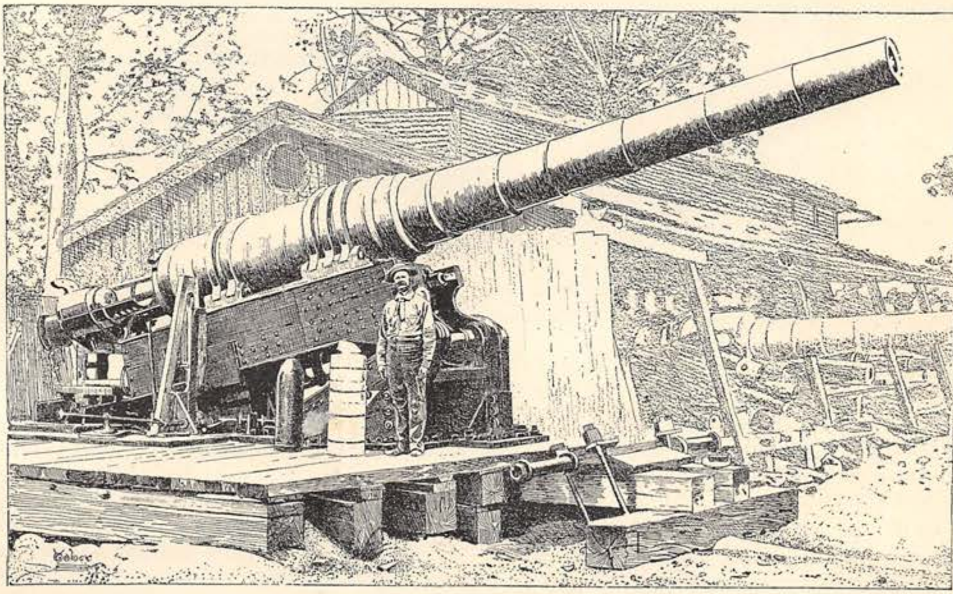
SHRINKING A SIX-INCH JACKET ON ITS TUBE. WEIGHT 3541 POUNDS.

enlarged chamber cut out, its front end tapering to the bore by an easy slope which guides the shot to its place in loading.

"Rifling," the next process, is effected by forcing into the gun a cylinder which fits the bore accurately and carries a number of slightly projecting cutters. The cylinder is mounted on a long bar that revolves as it passes through the bore, and thus gives the spiral character to the grooves. The breech is prepared to receive the plug which closes it, the sights are fixed, and a light band is shrunk on for coupling the gun to the elevating gear of the carriage. The gun is now complete and ready for proof.

In loading, the shell is first inserted, then the cartridge, a serge bag filled with powder. The plug, borne on a hinged tray, is swung into place and pushed home. One-sixth of a turn engages the corresponding threads of plug and gun, and the breech is closed. The plugs of the smaller guns are easily worked by hand. In the larger calibers mechanical appliances are necessary.

To seal the breech against the searching pressure of the powder gas a ring of canvas filled with suet and asbestos is placed in front of the plug, between it and the head of a *mushroom*, so called. The stem of the mushroom passes through an axial hole in the plug. When the gun is fired the soft ring or *pad* is squeezed against the walls of the chamber and the gas effectually prevented from leaking.



ONE OF THE "MIANTONOMOH'S" FOUR TEN-INCH BREECH-LOADING RIFLES.

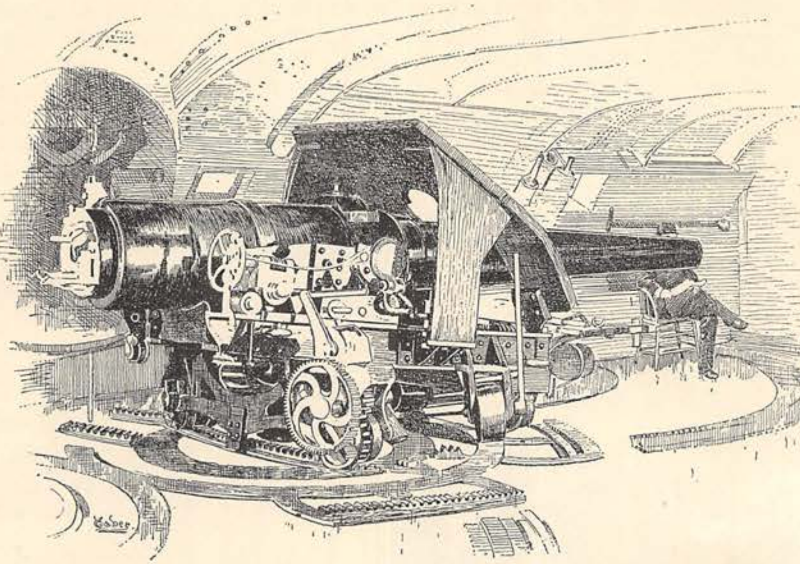
The mechanical processes so briefly described exact great skill and care. The workman is held, by constant and strict inspection, to the dimensions given in thousandths of an inch, from which departures are tolerated only in the largest parts, where they are not important.

The time consumed in the growth of such large yet delicate mechanisms is measured in months, and when their construction was first undertaken at the Washington Navy Yard a thousand difficulties had to be met and overcome. The work had to be done with old or improvised tools, insufficient in number and deficient in power, and the mere handling of the parts, some of which weigh several tons, was slow and laborious. It then took five months to build a six-inch gun. Here again a landmark is raised. To perform the necessary operations on the great forgings which Bethlehem supplies new shops have been erected at the Washington Navy Yard, now the Naval Ordnance Factory. One of these is over 600 feet long, is provided with the best machinery the country affords, and is served by overhead cranes, one of which can lift and carry to and fro a weight of 110 tons. In them the largest guns can be constructed, and with their improved appliances the time of manufacture of a six-inch gun has been reduced to seventy days. These new shops are second to none in arrangement and equipment. In these shops a thousand men are now employed making the guns, carriages, and projectiles needed to equip our ships, and yet their capacity is only rated at twenty-five six-inch, four eight-inch, six ten-inch, and four twelve-inch guns a year.

Much work will also be done in private shops — an excellent arrangement withal, for the Government must in time of peace foster an industry that will be vitally important on the approach of hostilities; and its own manufactures will be none the worse for the healthy stimulus of outside competition. On the other hand, the Government must have its own shops unless it is to depend on a private corporation, following the example of Germany, which is practically at the mercy of Krupp.

Before parting company with the gun let me quote a few comforting sentences from a brief and very charming technical work.

This type of gun, as we make it to-day, is the embodiment of Professor Treadwell's clear idea of a gun of equal strength, as announced in 1843; of Chambers's mechanical ideas of breech mechanism and of hooping in layers, with the hoops of each layer breaking joints, patented in 1849; of Rodman's elegant exposition of the benefit of procuring initial tension in a gun, published in the same year; and finally of Professor Treadwell's extension of this principle to the application of layers of cylinders or hoops in making a built-up gun. All these men were Americans, and were pioneers in announcing these principles, which cover about all the funda-



SIX-INCH BREECH-LOADING RIFLE ON THE "ATLANTA."

mental ones of the built-up gun. The French worked up the breech mechanism, and Vavasseur's practical application of Treadwell's first idea has introduced the jacket piece.[1]

As in guns, so in what they throw, the tendency is towards larger masses, more perfect material, greater destructiveness. The cannon-ball of our grandfathers gave place to the eight-inch and the nine-inch shell of our fathers. To-day we are using elongated steel projectiles — weighing in some cases a ton each — that will pierce iron armor measured in thickness by the foot, or even the yard; we are charging some with melinite or other frightful explosives that will create untold havoc, or with noxious chemicals to suffocate a whole ship's company.

Other weapons are experiencing the same development. Hotchkiss — an American, of course — brought out his revolver cannon, then his rapid-fire guns. The largest of these was a six-pounder. Mounted on a swivel it could be fired from the shoulder like an old wall piece, delivering about twelve shots a minute. Presto! we now hear of 30-pounders, 70-pounders, and 100-pounders of this type. Imagine shoulder practice with a six-inch gun weighing five tons and three-quarters, at the rate of eight or ten rounds in a minute, each round capable of piercing fifteen inches of wrought iron! Such guns exist, and will constitute a large part of the armament of the most modern ships of war. Every one is inventing some new form of mounting to hold the gun that deals such rapid and powerful blows, or of breech mechanism to lessen the time taken up in loading. Electricity, steam, hydraulic and pneumatic power are used in our new ships to load and handle guns. Maxim — American again — utilizes the recoil of the piece to do all the loading and firing.

The improvements in guns within the last few years have been so great as to amount to a revolution, and their constant end has been increase in the power of the gun and in the rapidity of its fire. In the first direction we appear to have reached a limit in the 110-ton gun, and there is a tendency to recede, for it is generally agreed that a smaller gun will do the work required for naval service. The largest gun contemplated for our new battle-ships is the thirteen-inch 60-ton gun, firing a 1200-pound shell with a velocity of 2100 feet per second. In the second direction we are making constant progress, but it is mainly by improvements in gun mountings and in the service of ammunition. The limit of the rapid-fire principle is reached when the ammunition becomes too heavy to be easily handled by one man, and it is believed that this limit has even been passed in the English six-inch rapid-fire gun. For the present at least we are content with a four-inch gun firing a 36-pound shell, and a large part of the armament of the ships now building will consist of these guns.

C. F. Goodrich.

1 "Gun-making in the United States," by Captain Rogers Birnie, Jr., Ordnance Department, U. S. A.