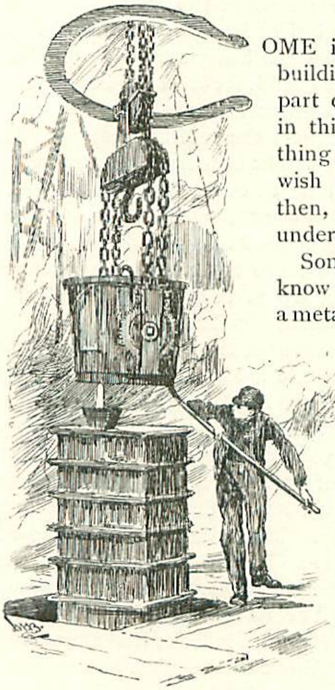
THE MAKING OF A GREAT STEEL GUN.

BY G. F. MULLER.

" From the silence of the ore
To the battle's din and roar."—F. A. M.



CASTING THE CANNON.

SOME into a big, queer building in the upper part of a busy city, for in this building something is going on that I wish you to see; and then, having seen it, to understand it.

Some of you may know how so common a metal as iron is turned into steel, and how, of that finer metal, a great cannon is made. But to those of you who do not know how this is done, these pictures and what I write will, I hope, make plain the different processes by which iron becomes a handsome, shapely, polished cannon: a cannon that will send a big shell far over the hills, so fast that you could not see it go, faster than swallow or humming-bird can fly, and with a force so great that the shot — or shell — will pass through a thick wall of steel, or iron or stone, as easily as the circus-rider leaps through a paper-covered hoop. Come, therefore, and we will watch a little group of men making a man-killer: a steel cannon intended to destroy forts and ships, and with them human beings.

Pittsburgh is called the City of Iron. The street-car takes us to a section where all the houses are of great size, and where tall chimneys rise through vast roofs, as thickly as asparagus-shoots push through a garden-bed in May.

The building we wish to enter is wide and long and high,— so high that if it stood at the edge of a lake or ocean, a schooner could sail straight in without lowering her masts. Everything inside this building—except the workmen—is big in proportion. There are large furnaces along one side of the interior, and through the doors of these red-hot fire shines out, looking like the fiery eyes of a tremendous giant. Immense chains hang from the top of queer things that look like a letter of the alphabet upside-down, so: ᒣ, only these inverted letters are as high as a house. Each link of the chains is half as long as your body, and the steel in each link is as thick as one's leg. These affairs supporting the chains are called cranes. No boy who has ever seen a live crane, would recognize these other cranes from the name. The iron ones are not graceful, nor anything but strong and fitted to their work; which is to lift huge bowls of melted metal or tremendous masses of steel. This they do as easily as you would pick up your lunch-basket. A steam-engine forms part of each of these cranes, and one man at this engine makes the big chain come slowly down, or rise, or move from place to place. The crane obeys the movement of the man's hand upon a lever as readily as the elephants obey every sign and word of their trainer.

Well,— now for the making of our cannon.

Stand here a moment and look over there where the brightness of a hundred electric lights and the fireworks of forty Fourths of July seem holding a meeting. What do you see there? Why, something shaped like a stumpy bottle, and as big as an ordinary bedroom in a hotel. Near it is another object like the first, but smaller. These are "converters." They are so called because in them iron is converted into steel — and in a few minutes, too. I can not in this article tell you how this is done, because I need all the space to describe the making of the cannon. But this much I can say, air being blown through molten iron purifies it and makes it into steel. If you have pitched quoits, you know that they are made of cast iron. If you have a good pocket-knife, you probably know that its blades are made of steel. Iron is fit enough for quoits or stoves, but would never do for knife-blades. It is not hard enough nor strong enough. So with our cannon. It could be made of iron, but an iron cannon could not withstand the expansive force of exploding gunpowder. So the iron is converted into steel, and the cannon is made of the harder, tougher, stronger metal.

If you shade your eyes with your hands and look into the mouth of the bottle-shaped affair I have mentioned, you will see a glowing lake of melted metal, that is now steel, but was iron a short time before. It is ready to pour into — what? Into a hole in the ground! A hole as deep and as wide as the well in your grandfather's yard in the country. You can not see this hole, though it is just at your feet; and nothing betrays its presence but a big funnel that opens its dark mouth to swallow the lake of melted steel in the converter. That funnel leads the metal into the hole, and the hole is made in fine black sand, so cunningly packed and arranged that the hole itself is just the shape of a cannon standing small end uppermost. This mold is nearly twenty feet deep.

Put one of your fingers in damp sand. Press the sand closely about your finger, then draw it carefully out, and you will leave a mold of the finger. Now, if you had some melted steel and poured it into that hole, you would make a finger of cast-steel. Just that sort of an operation is to take place in the building we have entered. The mold is ready. It was made by putting a wooden cannon in the sand, packing the latter around the wood, then carefully removing this wooden "pattern," so that a cannon mold remained. This is to be filled with steel, which, when cooled, will be a cannon "in the rough," that is, a cannon begun but not finished.

Do you hear that shout? It is the signal to the man in the crane, the man who runs the steam-engine. That rattling, thundering noise is made by the obedient crane which has begun its work. It lowers a monster ladle or bucket down to the mouth of the converter. The latter is tipped over on its side, and, when the ladle is low enough, there is another shout, and another crane goes to work. Its duty is to tilt the converter until a stream of white-hot steel pours into the ladle, exactly as water is poured from a bottle into a glass. And how the brilliant, dazzling sparks do fly! It is as if a fire-work, a "pin-wheel" as big as a steamer's paddle-box, had been set off. The great bucket is soon filled, and there is another shout. The crane begins to move, and the bucket (as big as the biggest hogshead), rises into the air and slowly swings toward the funnel already described.

How in the world is the metal to run from the ladle into the funnel? Glance at the picture on the preceding page and you shall see. The great crane lowers the bucket slowly and carefully until it hangs just over the mouth of the funnel. In the bottom of the bucket is a hole closed with a plug. Another order is shouted, and a brave man whose skin seems insensible to heat, and who cares no more for flying sparks than if they were snow-flakes, comes up close to the ladleful of molten steel and turns a little crank that lifts the plug. A dazzling stream of metal rushes straight down into the funnel and disappears from sight. The funnel leads that dazzling cataract into a pipe running below the hole in the sand, whence it makes a turn and rises into the mold itself. It would not do to let the heavy metal go tumbling twenty feet into the sand, for it would break down the sides of the mold, and so ruin the entire work. In about two minutes the mold is full and the great ladle is empty. The cannon has been "cast," and if we could look through the sand we would see — what? A red-hot cannon, the color of a ripe cherry, standing on its large end or breach.

Now, they must leave that cannon in its sand-bed for five days, where it shall gradually cool and harden so that it can be handled.

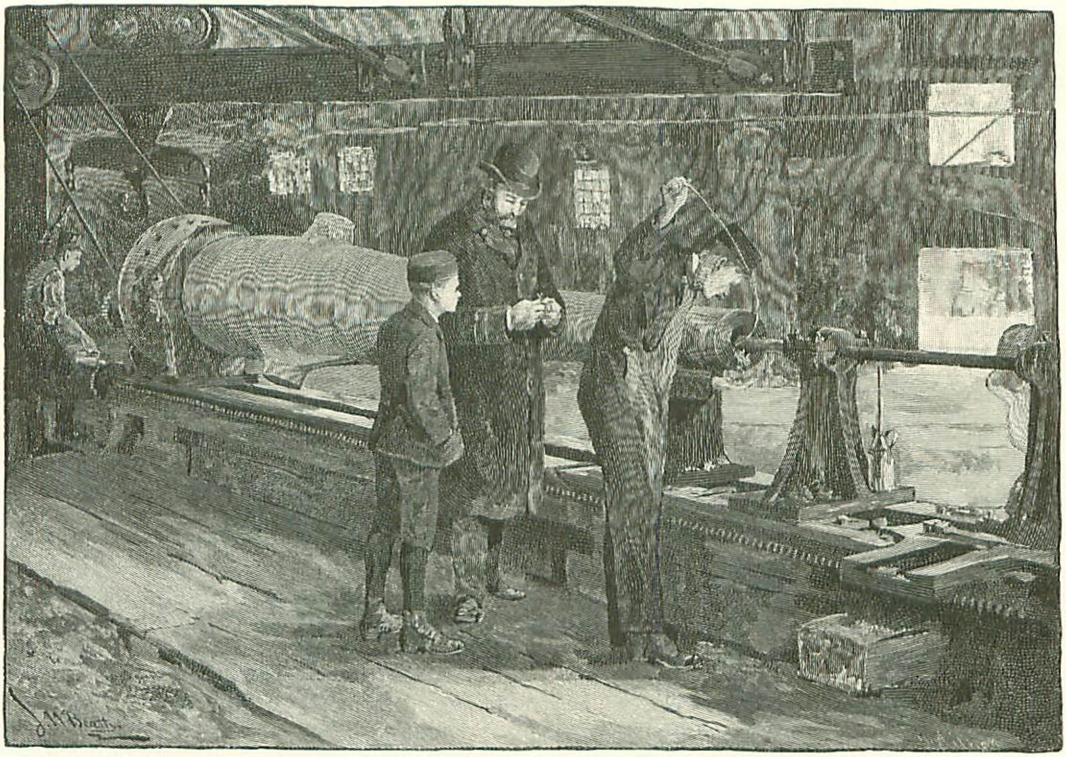
Let us, however, suppose these five days to be over, and that we are again in the big building. Where is our cannon? It has been lifted from the sand and is lying in a tremendous turning-lathe. Most of you have seen a wood-turner at work, and some of you may have a lathe of your own. This cannon is "in the rough," and must be turned smooth. More than that, it is a *solid* cannon. There is no bore in it — no place to put the powder or the shot into. It must be turned on the outside and bored on the inside, clear from one end to the other, until it looks like a pipe with very thick walls. To do this requires an enormous lathe, one as long as a large room and as strong as it can possibly be made.

Up among the dusky rafters of the roof, right above this big lathe, is a wheel, or, as it is called in shop language, a "pulley"— perhaps because it "pulls" a belt. From this pulley a belt runs down to another pulley at one end of the lathe. The second pulley turns a cog-wheel very fast, and that turns a larger cog-wheel somewhat slower, and the second wheel, in turn, gives a yet slower motion to a third wheel. But what these wheels lose in speed they gain in power, and by the time the rapid motion of the pulley reaches the big geared wheel that turns the cannon the latter makes but six turns in a minute or even revolves more slowly yet, if desired. This slow motion, however, is an extremely powerful one, as will be shown.

There, then, is the cannon, as big as a log in a saw-mill, lying in this lathe and turning slowly, steadily, and irresistibly by the power of steam, acting through the belt, pulleys, and cogs I have described. The cannon must be bored from end to end through the heart of the cold hard steel. It must, also, be turned smooth on the outside. As taken from the sand it was no smoother than the sand itself, that is, about as smooth as the surface of a pressed brick, or of a school slate. The surface of the cannon must be made as smooth and nearly as bright as that of a tin bucket. To do this the cannon is turned just as a wood-turner turns a bedpost, except that in this case the chisel is firmly bolted to the lathe, and the gun turns very slowly instead of rapidly. The trimmings, or shavings, do not fly about the shop as they do in a wood-turning establishment. No, the cannon revolves with a certain leisurely dignity—about as slowly as the cylinder of a large musical-box — as if it had weeks for its completion. The chisel turns off spiral curls of steel parings as gracefully and much more slowly than a cook pares apples. Gradually the outside of the cannon loses its dull, dead-black appearance and begins to shine. The long parings are bright as new augers, or "twist-drills," and quite as stiff as ramrods.

At last the cannon is turned down, and is ready to be bored inside. In this operation it must be bored so straight and true that the boring tool, entering at the exact center of the small end of the cannon, will come out precisely at the center of the large end, seventeen feet away. Those of you who have tried to bore a straight hole lengthwise through even a short bit of wood will know that this work requires not a little skill and care.

When any of you boys have a job of boring to do at your work-bench, you make fast the article to be bored and turn the boring tool. It is just the other way in boring a cannon. The boring tool, or "bit," is held firm and motionless, while the great mass of steel to be bored turns around. This plan is found to insure steadiness of the "bit." It would be almost impossible to make this bit firm and solid enough to do its difficult work, and yet free to turn around in the cannon. So if you had been at the side of this gun-lathe when the work was begun you would have seen that the bit was motionless — except for a slow advance into the gun.



THE CANNON IN THE BORING LATHE.

The bit attends strictly to business, and steadily bores its way through the steel. Most of you have been to the country and have seen a pig "rooting" in the ground. Imagine, then, the pig to be standing still and the ground to be slowly passing under the pig's snout and being "rooted," and you will have a case much like that of the bit and the cannon. In fact, the boring tool is called a "hog-nosed" bit, and it roots up that cannon as if it enjoyed the operation. No long, graceful curls come from this boring, but small, crisp shavings that are removed as fast as they accumulate in order that the boring tool's work shall not be interfered with. The bit is going into the steel at the rate of three-eighths of an inch for every turn of the cannon, and it is making a round hole almost large enough for a boy to put his head in — five and three-quarters inches in diameter. As the round hole grows deeper, the heavy bar, on which the bit is fastened, advances into the cannon steadily, moved by a number of wheels and screws that form part of the lathe.

I must not lose sight of the shavings, the little ones that come from the inside, and the long, spirally twisted ones that are turned from the outside of the cannon. A military-looking man, standing near the lathe, does not lose sight of these shavings or trimmings, either. You can see him in the picture. This man's business is to carefully inspect the borings and trimmings. That is what he is paid to do. Uncle Sam pays him, and expects him to earn his salary. The cannon is being made for Uncle Sam, and he intends to find out all its qualities, whether good or bad. So the man eyes the borings carefully. Now, if with a plane, or your knife-blade, you will cut a thin shaving from a bit of wood, it will show any little flaw existing in the wood from which it was sliced. The tiniest knot-hole or crack will show in the shaving much more plainly than in the wood itself. So it is with a cannon's shaving. It is a dreadful tell-tale, and the fault-finding man beside the gun knows this perfectly well. He examines the spiral turning, or the little piece of boring, and finds no evidence of a flaw or crack. The long spiral strip is as smooth as glass and as glossy as your sister's curls.

Into the solid steel the hog-nosed bit roots its way, until it is in so far that a little electric light must bear it company, to show the workmen how matters are progressing in the heart of the cannon. After eighteen days of steady boring, the bit lets daylight into the bore of the cannon by emerging at the other (or larger) end, seventeen feet away. If you should look through the cannon now, you would be sure it was made of glass, not steel. It shines like a polished mirror, and the electric light at the farther end makes a pathway of reflection like a little sunset in a small ocean.

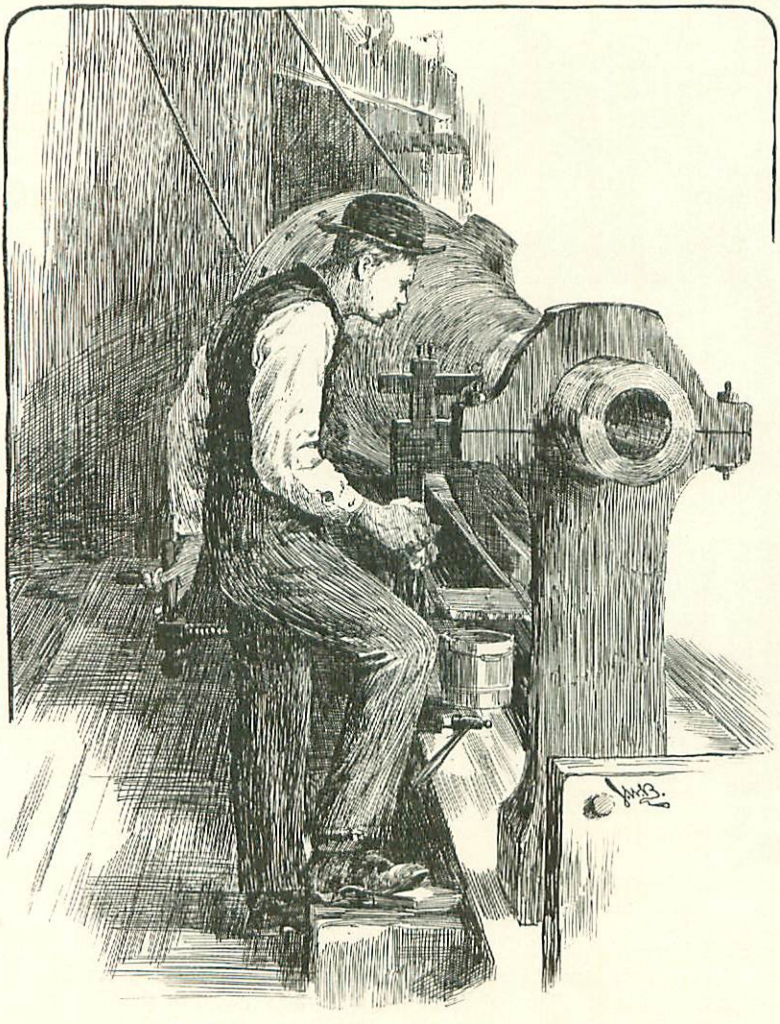
So the most difficult part of the work is done. To trim down and polish the outside of the cannon is comparatively easy. During this operation the gun revolves more rapidly. The polishing is done with emery, until the surface shines like the nickel-work on a brand-new bicycle.

Some of you will say, about this time, "We have seen plenty of big cannon, but were never able to look through them from end to end, because the hole did not go clear through." Well, this is not that kind of a cannon. Those you saw were "muzzle-loaders." This is a "breech-loader." Like a breech-loading shotgun, this cannon is charged from the rear, not from the muzzle.

In order that this may be possible, the bore at the big end of the cannon is closed with a breech plug, or pin, so arranged that it can be rapidly removed to admit the powder and the shell or shot. About three feet of the bore nearest the breech is made a trifle larger than the rest, in order to hold the proper amount of powder to send a tremendous shell out of the cannon at the rate of two thousand feet in a second of time.

The cannon now looks like a huge nine-pin with a hole bored through it, or like a very thick base-ball bat. It has been "rough bored," and is ready for a quite different process. It must be put in a pit. Not such a pit as received Joseph when his wicked brothers persecuted him, long, long ago, but in a very different sort of a pit. One in which the thermometer — if it did not melt — would stand at fourteen hundred degrees. You all know how sultry the weather is at ninety or ninety-five degrees, so it is not hard to imagine how hot is the place where this gun must go. It is the "annealing pit"; merely a brick-lined well dug in the ground, but deep enough and wide enough to hold the cannon, which is shut in the pit, muzzle down, and sealed as tightly as if it was a mummy in the hands of an ancient Egyptian undertaker. Then the heat is turned on, little by little, until a gas-flame surrounds the gun from end to end, and it gradually assumes a dull cherry redness once more. It takes three days and three nights to bring the pit and gun up to this heat, and then the well and its contents are allowed to cool slowly for seven days.

Why is this done? Because it has been found that metal, and glass, too, is the better for being so treated. Slow heating followed by slow cooling, makes the steel gun homogeneous. That 's a very long word, and it means that, after the annealing process, the steel in the cannon is more uniform in texture. It is *alike* from end to end, and from the outside to the center. It has no soft places here, and hard places there. Like a perfectly sound apple, it is free from soft places, or hard places. When our cannon's ten days' baking and cooling are over, it is hoisted out of its fervid quarters and placed once more in the lathe for its final boring inside and polishing outside. A thin shaving is bored out from the inside, making the bore five and three-quarter inches in diameter. After this last boring the interior of the cannon shines still more brightly, and if you look into it, at the electric light, seventeen feet away at the other end, you see a dazzling sight. The steel seems a mass of crystal, full of all manner of beautiful colors, like a sea-shell. The outside is now polished until it shines like a new silk hat.



TRIMMING AND POLISHING THE OUTSIDE OF THE GUN.

It is a month since the steel cannon was begun. Under the eyes of the workmen in the big shops it has grown into shape, and now that it is ready to leave its birthplace the men grow devoted to the shining monster. They linger about the lathe, and are glad to have some work to do which will add to the beauty of the big weapon. It is going out into the world to be severely tried, and its godfathers feel a certain amount of anxiety for their pet.

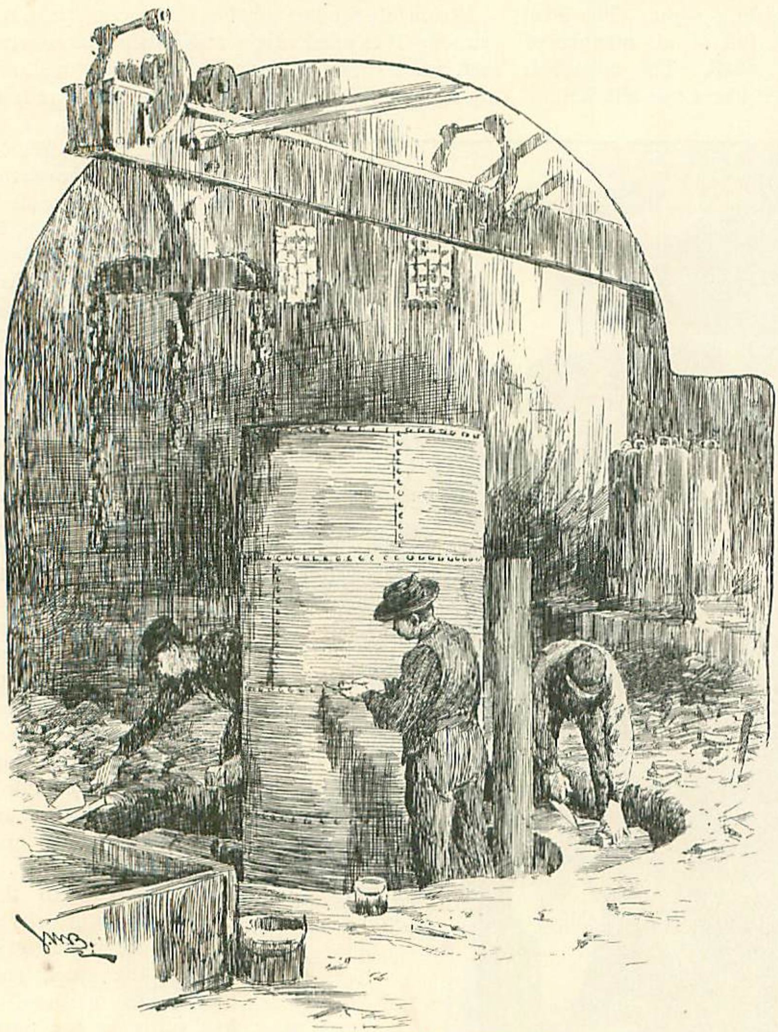
It is the first gun of its kind made in the City of Iron, and on its success or failure much depends.

Meanwhile the last touches have been put to the cannon. It is oiled inside and outside, to prevent rust, and is carefully placed on a "flat" car, standing on a track alongside the foundry. The rails of this track stretch in an unbroken line to Washington City, and over the rails the gun is trundled, behind a locomotive, to the Washington Navy Yard. Here another boring takes place, making the interior diameter six inches. Here, also, the breech-pin or plug is fitted into the breech.

Still another operation that the cannon must undergo is "rifling." A ball that is thrown with a twirl will go more speedily and truly to the mark than one that "wabbles about, every way." When you throw a base-ball, and wish it to twirl, you give your fingers a certain twist just as the ball leaves your hand. Our cannon's twisting fingers are fourteen in number, and they stretch inside from near one end to the other. They are slight grooves cut in the surface of the steel, and they make one and a half turns in the fourteen feet of their length.

As the shell passes out, a copper ring which surrounds it is forced into these grooves, and the slight twist in them gives a twirl to the shell, that makes it turn faster than a buzz-saw, as it leaves the muzzle of the gun. It goes out in a hurry, as a matter of course, when fifty pounds of powder are exploded close behind it. So, in the time in which a boy would leisurely step two feet,— say one second,—

the steel shell sent from this cannon goes two thousand feet, and it keeps on going for six miles, or as far as you could walk, very briskly, in an hour and a half. The shell is as long as your arm, and it weighs nearly one hundred pounds. Inside, it is packed with powder. When that shell hits anything, it strikes point first, for the shell travels straight through the air like an arrow from a bow. The point contains a kind of powder that explodes when struck. When, therefore, that shell hits a wall of stone, iron, steel, or wood, it bursts as soon as it goes in, and any living thing near that place dies suddenly.



SEALING THE GUN IN THE ANNEALING PIT.

To do this deadly work is the cannon's — and the shell's — business. That is what they were made for. A great man once said: "In time of peace, prepare for war." This advice is followed by all nations. Uncle Sam is at peace with all his neighbors, and the world in general. But he finds it best to buy cannon and ships, for the destruction of forts and of other ships, so he said to the gun-makers in the City of Iron, "Make me a steel cannon, and if it does what I desire it to do, I will order more." Thus it came about that the doings here illustrated and described came to pass. If any of you bright boys, whose eyes follow these lines, will come to the City of Iron, I will take you to the place where these men-killers and fort-smashers and ship-sinkers are made.

There is a sequel to the true story of the making of a great steel gun. As the faithful historian of our cannon's career, I must tell you also of its end.

"If" is about as small a word as letters can make, but it means everything in the career of a cannon,— that is, an "experimental" one. You will find an "if" in a paragraph not far above this one. That little word was a sort of loophole for Uncle Samuel. *If* the steel cannon did what the Government desired it to do, *if* it bravely stood the trial test, then wise Uncle Sam would buy more guns like it. *If* the gun burst while being tried, or *if* it could not throw the shell as far, or as accurately, as the Government officers considered necessary, all the patient labor on that particular gun went for nothing,— the experiment would be regarded as a failure. Yet, not altogether a failure, as I shall show.

Well, our big cannon did not pass the test. In fact, it burst unexpectedly before it was quite a year old,— burst as its strength was for the second time being tested. Its fragments showed the mistakes of its makers, and so prepared the way for the coming of another steel cannon, in which these errors will not be repeated. After all, our cannon did better than to kill men. It instructed them. When it burst its fragments gave valuable information to its makers that could be obtained in no other way. So they will profit by the knowledge, and go to work on another steel cannon, which will be made in about the way which I have described; but the steel will be of a different texture. Thus, our great cannon was not made in vain, even if it did fail in the desired strength.

But about the bursting of this bright steel cannon. Gunpowder did it, one day, months ago, before 1888 was quite spent,—gunpowder of a kind few of you have ever seen. Each grain of this powder is as big as a walnut, and a round hole passes through every one. There are only ten of these grains to a pound of the powder.

When the cannon was ready for the test it was taken to Annapolis, Maryland, and after being mounted on a low car, or carriage, in a small shed, it was pointed at a hill of earth several hundred feet away. Then the army officers in charge of the test put in the powder and the 100-pound shell.

All was ready, the firing-officer and the spectators got behind heavy timber "bomb-proofs," and the "lanyard," or firing-string, was pulled. The first shot was a success, and if the little hill had been a fort it would have been blown to pieces. Nothing, apparently, went wrong. But, if the human eye could look into steel as readily as into clear glass, the evidences of weakness and of the near approach of death could have been seen deep in the heart of the steel cannon. The only way to find out what the gun could do, and would stand, was to keep on firing, and by means of ingenious instruments learn the amount of pressure exerted by the exploding gunpowder. Once more the cannon was loaded, this time with fifty pounds of powder, besides the big shell. Once more everybody got into the bomb-proofs, and the lanyard was pulled. Then the man-killer gave a great leap — and died. It burst into many pieces, great and small. It wrecked the little shed, tore great timbers to splinters, and sent its big end over a hundred feet away. Its "Finis" was spoken, and the men who made our great steel gun went home wiser than before, to do what all of us must do if we fail in any undertaking,—"Try, try again."