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The editor is always glad to receive for examination illustrated articles on subjects of timely interest. If the photographs are *sharp*, the articles *short*, and the facts *authentic*, the contributions will receive special attention. Accepted articles will be paid for at regular space rates.

HISTORICAL.

Upon a certain summer's day in the year 1755, there might have been witnessed the advance of a small detachment of British and Colonial troops, not much over a thousand strong, through the dense forests that lined the banks of the Monongahela River a few miles above the point where it merges with the Allegheny. The objective point of the expedition was a small fort at the confluence of these rivers, which formed one of the most important links in that chain of military posts and trading stations, which the restless and far-seeing energy of the French colonial government had strung out between the mouths of the St. Lawrence and the Mississippi, by way of the Great Lakes, the Ohio, and the Mississippi Valley. In the van of this little army, bearing himself with a confidence born of much successful warfare in other lands under less difficult conditions, and heedless of the warnings of his young colonial aide-de-camp George Washington, who had command of the rear guard, was Gen. Braddock. Advancing in a close formation, which was better suited to the open spaces of Continental battlegrounds than to the all-but-impenetrable forests of the American frontier, the devoted band marched right into an ambush of the French regulars and their Indian allies, and was quickly cut to pieces. Braddock was killed, and Col. Washington, his military coat pierced more than once by the bullets of the French sharpshooters, barely succeeded in carrying the shattered remnants of the force back over the Alleghenies into Colonial territory. The political and military considerations that prompted that disastrous expedition were worthy of a better fate; and, indeed, subsequent history has proved that in endeavoring to capture Fort Du Quesne and break the bounds which the French were endeavoring to set to the westward development of the British colonies, our forefathers had taken a just view of the situation. To-day the objective point of the expedition forms the site of Pittsburg, one of the greatest centers of industrial activity in the world; while hidden among the back streets of the city, and rescued from destruction and preserved through the care and munificence of a local historical society, may still be found Fort Du Quesne, or rather its immediate successor Fort Pitt. A few miles up the river, at the town of Braddock and on the identical spot where the battle occurred, is to be found one of the greatest steel works in the world; while for many a mile along those very banks of the Monongahela where Braddock laboriously cut his way through the woods, is to be found the most wonderful aggregation of coking ovens, blast furnaces, and rolling mills in the world. Although just now we are concerned merely with the history of the development of these industries, we may be pardoned a reference to the fact that in St. Louis, five hundred miles to the westward of the Braddock battlefield, the great Republic which has sprung from that strip of colonies that fringed the Atlantic seaboard in 1755, is just now preparing to celebrate the one hundredth anniversary of its acquisition from France of the vast territories from which that country sought to bar the early colonials out.

In selecting a point of beginning for a brief survey of the rise and growth of the iron and steel industry in this country, we cannot do better than go to the records of Pennsylvania, from which we shall learn that in the year 1786 the Legislature lent a certain Mr. Humphries the sum of three hundred pounds for five years, to enable him to make steel "as good as in England." Progress must have been slow; for a quarter of a century later, or in the year 1810, the total production of pig iron in the United States was but 53,908 tons; and of this, less than one thousand tons was made into steel. In 1842 the total was only 215,000 tons; and in 1861, during the great civil war, it was still far below the million mark, being only 653,164 tons. In 1864 the total production had risen for the first time to a little over one million tons. Up to this time steel was looked upon as a very special product, the methods of production being costly and the total output relatively small. But in the year 1864 there was invented and demonstrated in the mother country what was, and will ever be, the greatest invention in the history of iron and steel—the Bessemer converter. By this device, it was made possible during an operation of an extremely simple and inexpensive character, and in a few minutes' time, to convert common cast iron into steel. Steel, from costing as high as six or seven cents a pound for the common grades, began steadily to decrease in cost, until in the closing year of the nineteenth century steel billets, in lots of a hundred thousand tons, came to be sold at the rate of "three pounds of steel for two cents." The entrance of the Bessemer converter marked the close of the Iron Age, and from this time on steel became the standard material of construction in all but a few limited classes of work. It was not long before the Bessemer process was introduced into this country, and this fact, coupled with the period of general commercial prosperity which followed upon the close of the civil war, stimulated the development of the iron and steel industry so greatly that by the year 1872 the total production of pig iron had increased to 2,548,713 tons. In 1880 the total had climbed to 3,835,191 tons, and in the following year it had risen to a little over 4,000,000 tons. By the close of this decade the production of pig iron had doubled, the total output in 1891 having reached the wonderful figure of 8,279,870 tons. During the last decade of the century there was another increase of about one hundred per cent, during which the total output of pig iron passed far beyond that of our nearest competitor, Great Britain, reaching in 1901 the enormous output of 15,878,354 tons; while for the following year the production climbed yet higher, reaching a total of 17,821,307 tons. Toward the close of the century there was introduced a method of steel manufacture which gave early promise of being a rival to the Bessemer converter, a promise which has been so far fulfilled, that it may be said without any exaggeration that the age of Bessemer steel is drawing to its close, and that open-hearth steel is destined ultimately to be the all-but-exclusive product of the industry. The open-hearth furnace has the advantage, especially in the United States, that whereas the Bessemer process requires for its successful working the use of ores that are comparatively free from phosphorus, ores that are high in phosphorus can be used successfully in the open-hearth furnace. Moreover, for reasons which are given later in the present issue, it is possible to produce a grade of steel in the open hearth that is so superior to Bessemer steel as to more than compensate for the additional cost of manufacture. The advantages of the process and product were quickly recognized by both ironmasters and engineers; and it is becoming increasingly common to see open-hearth steel called for in the specifications of the more important classes of construction.

We may look with pardonable pride upon the growth of an industry for which there is no parallel in the history of the world; and the more so as this growth is a true index of the general material prosperity of the country at large. For it must be remembered that, great as is the total production of iron and steel, it has proved, during the last year or two, so far short of the home demand, that we have been obliged to call upon foreign manufacturers to supply the deficit.

SECRETS OF OUR SUPREMACY IN IRON AND STEEL.

In looking for the causes which underlie the supremacy of the United States in the steel and iron trade, honesty and gratitude alike demand that first place be given to the marvelous natural resources of the country, for which there is no parallel anywhere in the world. Not only has nature provided stores of iron ore, coal, and limestone in lavish abundance, but the supply itself is easy of recovery from its native beds, and advantageously placed for the transporting of its various elements to a common center; while the materials are of a quality that could scarcely be surpassed for economy of handling and treatment in mine, furnace, and mill. But although the fundamental secrets of our success are to be found in natural conditions, too much cannot be said in praise of the intelligence and skill with which the American ironmaster has risen to his opportunities. It is to the remarkable ingenuity shown in the production of labor-saving machinery that much of the cheapening of the cost of production is due; to say nothing of the broad administrative ability shown by the management of the great steel and iron works, in laying out the component parts of their establishments in such a way that the heavy tonnage which passes through these plants day by day shall proceed from the crude material to the finished product with the least possible amount of handling and trans-shipment. Lastly our iron and steel men, early in the history of the development of the industry, perceived and acted upon the fundamental economic fact that, for the cheap production of iron and steel, magnitude of operations and combinations of capital are essential.

First then, we must recognize the lavish hand with which Nature prepared the way for our industrial triumphs, by accumulating along the southern and western shores of Lake Superior those vast beds of iron ore, which are not only the most extensive in the world, but are so placed that the labor of excavating and loading for shipment is practically nothing. The ore, which is extremely rich, sixty per cent of it being iron, lies practically at the surface of the ground; and it is so loose and friable that all that is necessary for its recovery is to run in a train of cars, set a steam shovel at work, and load the material directly onto the cars. This work has actually been done at the rate of 5,800 tons in ten hours, and this with the labor of but eight men at a cost of five cents only per ton for labor. The supply is enormous, a single corporation having recently estimated its holdings at 500,000,000 tons, valued at as many million dollars. These vast and easily-recovered supplies, however, would have a limited value, were there not available a proportionate supply of coking coal; and this has been provided with an equally lavish hand in the famous Connellsville district, where a single coke company on entering into one of the great industrial combinations of the past few years, stated that it owned 40,000 acres of coal lands in this region, and 11,000 coke ovens. Within easy reach of the coal district there are also large quarries of limestone, the third of the three constituents in the charge of a blast furnace.

But the mere existence of these natural supplies of the raw materials of manufacture would not in itself be sufficient to account for the marvelous growth of the iron and steel industry in America. The raw materials must be brought together to some common center, and the transportation of this enormous tonnage, the frequent handling and trans-shipment that is necessary, must be done with the least possible amount of expense, if the American ironmaster is to start with anything like an even chance in competition with European manufacturers; for these are not under the necessity of transporting their materials over a thousand miles of distance, before they can smelt them in the blast furnace. Now, here it is that man has so ably co-operated with Nature. Acting on the well-established industrial principle that the greater the magnitude of the scale of operations, the less is the cost per ton of the finished product, the machinery and general plant for excavating, handling, and transporting the ore have been built on a colossal scale. At the mines, steam shovels capable of lifting five tons of ore at each stroke will load a 25-ton car in two and a half minutes, or at the rate of 600 tons an hour, and in accordance with the same policy cars have grown to 50 tons in capacity and locomotives to 130 tons in weight. When the ore trains reach Lake Superior special automatic, quick-acting machinery unloads the ore direct into special ore steamers built for this particular work. At the eastern terminal ports similar machinery unloads the ore from steamer to railroad, where again 50-ton cars and 130-ton engines haul the precious mineral in trains of 1,000 tons or more total weight, into the heart of the coal and coke region, where it is finally unloaded by special machinery, at the foot of the blast furnaces.

The ingenuity and resourcefulness shown in the matter of handling and transporting the huge tonnage necessary for the manufacture of over 17,000,000 tons of iron a year, was ably seconded when it came to the matter of recovering the iron in the blast furnaces, and fabricating it into the thousand and one forms in which the finished product is put upon the market. In no single branch of industry has more thought been given to labor saving than in the manufacture of iron and steel. In the first place, to reduce handling and transshipment to a minimum the processes are made as far as possible continuous. The erection of a typical modern steel works will call for a plot of ground which is rather a parallelogram than a square, and there are in the country to-day works that on a width of a quarter of a mile will extend for a mile and a quarter in length. At the upper end will be the stockyard, with its artificial mountains of ore and coke; next the blast furnaces; then the Bessemer converters, or the open-hearth furnaces, as the case may be. Then will come the soaking pits or furnaces for heating the cast ingots. Beyond them, in some cases, will stretch one vast building a thousand feet or more in length, with its blooming rolls and shears, roughing rolls, finishing rolls, and steel saws succeeding each other in orderly succession, until at the end of the building one can see the finished product being loaded onto the cars almost before the last trace of the furnace heat has gone out of it. Moreover, in its long journey through the mills, the material has been rolled and heated and rolled again, positively with no manual labor whatever; and in many of the mills that are notable for the great tonnage that they turn out in a single day, the continuous processes are carried on with such rapidity that the journey of a thousand feet or more through the mills is made on one single heat.

In any summary of the causes of our success in steel manufacture, great stress must be laid upon the early and multiplied adaptation of electricity as a motive power in the thousand and one uses to which it has lent itself so admirably. Among other applications that come to mind, there are: the overhead traveling electric crane; the electric charging machine that picks up a box containing a ton of mixture, thrusts it into the furnace, empties and withdraws it; the electric conveyer; the electric elevator for loading the blast furnaces; the electric buggies that receive the heated ingot after it has been lifted from the soaking pits and runs it down to the mill; electric machines for pushing the blooms in at one end of the furnace, and electric tongs for gripping them and pulling them out at the other end. These are a few of the uses of electricity, to say nothing of pneumatic and hydraulic power, that, conjointly with similar exhibitions of ingenuity, forethought, and administrative skill in mine, ship, and railroad, have enabled our manufacturers to sell "three pounds of steel for two cents," while paying the highest wages in the world to labor and returning the princeliest of fortunes to capital.

RECENT DEVELOPMENTS IN GUNS AND ARMOR.

BY JOHN F. MEIGS.

A most striking recent development in guns—and in speaking of guns we usually include the gun-carriage or gun-mount—is the effort now universal to throw the accurate and quick control of the gun into the hands of the people firing it. It may well be wondered that this has not always been a controlling idea in laying out guns and their mounts, but at the present time it is in this direction that the greatest effort is being made. The proof of this is to be seen by a comparison of the guns and mounts made ten or fifteen years ago with those now being made. The latter are arranged much more conveniently, and consequently their rate of fire is much faster. Modern 6-inch guns are being fired from ships eight or ten times in a minute at targets about the size of a ship and a mile distant, and hitting the target at each shot. Of course, doing this from a stable platform on shore would be comparatively easy. The projectile of these guns weighs 100 pounds, the powder charge about 40 to 50 pounds, and the weight of the gun, including all the turning parts, is about 25,000 pounds. This weight must be moved, to keep the sights on the target, by one man, and it will be seen that it is of the greatest importance to lay out all the shafting and gearing with a minimum of friction and lost motion.

With this advance in the convenient layout of the gun and its mount is going on at the present time a steady increase in the weight and length of guns. Six-inch guns, which used to weigh 11,000 pounds, now weigh 18,000 to 20,000 pounds. The weight of the projectile of these guns has not increased, and has remained always 100 pounds, but the velocity at which the projectile leaves the gun has increased from about 2,000 feet per second to from 3,000 to 3,500 feet per second, in consequence of a three or fourfold increase in the charge of powder. It may be argued that this change—that is, the constantly increasing weight of guns of a given caliber—is not a wise one. The great care and attention bestowed upon the convenient and accurate moving of the gun, however, can be nothing but an improvement. The growth and progress of change in artillery construction sometimes seems arbitrary—seems sometimes to be as arbitrary as the fashion in clothes. Old guns made three hundred years ago, which may be seen in the arsenals in this country and in Europe, had about the same shape and were in many respects similar to the guns of to-day. In the intermediate period, say about one hundred years ago, the guns had shrunken up, and become shorter and larger in diameter, with larger bores. We are now returning, or perhaps, more correctly, it should be said we have returned, to the fashions in artillery of three hundred years ago.

There are, of course, many respects in which the modern weapon has a great advantage over the earlier one. It is made of stronger steel, and concentric hoops are shrunken together, whereby the power of the gun to resist internal pressure is materially increased. But perhaps in no place is the advantage more marked than in the better mount or carriage of the present time. These are far better arranged than they used to be, and the consequence is that the guns may be much more rapidly and safely fired.

There is going on at the present time a steady advance in the strength of the metal used in guns. The elastic strength of metal now commonly used in larger guns is about 50,000 pounds per square inch, and in the smaller guns it runs as high as 75,000 pounds per square inch. This, however, is used only as an additional margin of safety, largely because the recoil of guns when fired is so great now, and the reaction thereby set up in the carriage is so severe that nothing would be gained by lightening the gun. Lightening the gun would only mean putting additional weight, and perhaps a weight greater than that saved, in the gun-carriage and foundation. Many are of the opinion that the advance in the strength of gun steel should be pushed further, but it would be hard to do this without lowering to some extent the elongation asked for in the metal at rupture. This now runs in the neighborhood of 18 to 25 per cent, and it could wisely be lowered for the sake of gaining a harder and stronger metal, because the entire operation of the gun is within its elastic limit. When it moves outside of this and becomes permanently enlarged, a comparatively slight enlargement would give warning, and the gun would be laid aside and not used any more.

The subject of the powder—or, as it has been called, the Spirit of Artillery—cannot be overlooked in the examination of guns. In the last few years the use of so-called smokeless powders has become universal. These are all nitro substitution products, and their principal characteristic, from an artillery point of view, is the fact that the entire weight, or very nearly the entire weight, turns into gas. In the older powders only about 60 per cent of the weight was gasified, and the remaining 40 per cent was projected from the gun in the form of dust, and constituted a considerable waste of energy. The point not entirely satisfactory in modern powders is their constancy in pressure and velocity, and stability in storage. It is a question whether under the same conditions of storage they are as stable and safe as the old-fashioned powder. Indeed, there is every reason to believe that they are not as safe or as stable, and they are watched with great care at stated times when stored. Incidentally, this powder gives little or no smoke, which is usually, but not always, an advantage.

This brings us naturally to other articles of great consequence in artillery—namely, projectiles and shell charges. We have now armor-piercing projectiles, deck-piercing projectiles, semi-armor-piercing projectiles, common forged and cast-steel projectiles, cast-iron projectiles, shrapnel, and so on, in endless variety. As the work the gun, whether ashore or afloat, will have to do can be pretty clearly predicted, it would appear as though one, or at most two, kinds of projectiles were enough. These two would naturally have, the one a high penetrative power, and the other a large capacity for internal charge, giving great destructive power when the shell is burst. No one who has not examined carefully the effect of bursting a shell in a closed space can have an idea of its destructiveness. A small 6-pounder shell, of about 2¼-inch diameter, containing 3 or 4 ounces of powder, burst in an ordinary room and breaking into 20 or 30 fragments, would probably destroy everything in the room.

We now come to the matter of protection—or armor. It is a mistake to suppose that protection was first used in either land or naval warfare in modern times. On land, as is well known, earthworks and masonry works of great thickness were used, but it is not so well known that the sides of ships of war of one hundred years ago were in many ways better protected relatively than our present ironclads. The frigate "Constitution," of the war of 1812, was protected against perforation at the waterline, whereby the ship may be destroyed, or perforation of her battery space, by which her gun crews could be destroyed, better than the ships of to-day, taking into account the guns of her time. At present the 12-inch guns, using 850 or 1,000 pound projectiles, are mounted in turrets clothed with 12-inch armor. These turrets can be penetrated by 12-inch guns with anything but a very oblique impact at any distance at which a gun is likely to hit. Similarly, too, the 6-inch guns of ships, or their 7-inch guns, which constitute the next step in the scale, are protected by 6-inch or 7-inch armor, and this armor can be penetrated by a 6-inch gun at as great ranges as it is likely to hit it. This armor is all face-hardened. The front or outside of the armor is glass-hard, while its back is comparatively soft and tough.

The plate in the course of manufacture is supercarbonized, that is, its face is impregnated with an additional amount of carbon, in a way similar to the well-known case-hardening process, whereby the outside face of the plate, when tempered in water, becomes intensely hard. The projectiles used against this armor are hardened at the point, their rear bodies being, as is the rear body of the armor, comparatively soft, and the contest between the plate and the projectile constitutes very largely the modern science of artillery. The velocity of the projectiles is pushed to the utmost by increasing the weight of the charge of powder used to propel them, and in the manufacture of the projectiles it is endeavored to make the point of the projectile very hard and the back soft, but yet not too soft. If the projectiles are hard all over, or similarly if an armor plate is hard all through, they will go to pieces on impact. The tough, comparatively soft, back part of both plate and projectile tends to hold the hard part together. In the last few years the practice of putting soft metal caps on the hard points of projectiles intended to pierce armor has become universal. There are many theories as to why these soft metal caps aid the projectiles in getting through the hard armor, but none of them seems entirely satisfactory. Of the fact, however, that they do increase the penetration of projectiles, there can be no doubt.

In the matter of protection or armor, in the land or coast defenses of this country, the principle of the disappearing gun has been utilized in very large degree. The gun, mounted behind a very thick parapet, rises only for a very short space of time when it is to be fired, and disappears on rocking levers behind the parapet immediately upon firing, and is loaded in the lower position. It will be seen that the protection of such guns is very good, but their rate of fire is lessened. Possibly it is true that the rate of fire of large guns is not materially less on disappearing mountings than on others; but as guns grow smaller, the time occupied in their rising and falling and in aiming them has a greater influence, and their rate of fire is seriously diminished. For such smaller classes of guns in our coast defenses it is planned to use gun shields, which are substantially armor plates covering the gun and its detachment of gunners against hostile fire.

There have grown up in all the countries of Europe, and are growing up in this country, private manufactories that will aid the government in the solution of the various ordnance problems brought forward. In many respects a private organization is more likely to bring forward improvements than is the government service. Not the least of these is the fact that it must continually be bringing things forward. It can live in no other way; and if its staff are well equipped and its measures are wise, it should bring forward many good things—things that are likely to last, and that are in the nature of sound progress, and not merely changes. Only great steel works, having large capital and controlled by directors willing to encourage the development of ordnance in their works, can succeed at this task. It is needless to point out the part the government may play in this development. If the government officers, both those who control lawmaking and those in the executive branches, do not do what they can to aid such a movement, it is likely that it may fail, and that what might have become a valuable public servant may be destroyed. The history of all countries shows in comparatively modern times—in the last thirty or forty years—the upbuilding of such private ordnance factories. There is no feature of the development of modern ordnance in this country more interesting and important than the evolution and equipment of great manufactories capable of supplying the material necessary for the national defense. We now have many establishments more or less well equipped in various lines, and it is to be earnestly hoped that the public at large, and governmental officers having power directly in the premises, will interest themselves actively in the growth of these. Manufactories producing ordnance and armor, having in hand an extremely specialized branch, and looking only to the government for work of this character, are especially interesting in this connection.

THE FUTURE OF OUR STEEL INDUSTRY.

In the course of a conversation with the late Abram S. Hewitt, who was one of the first to foresee the great proportions which the iron and steel industry in this country was destined to assume, the writer asked him to indicate the one fact which above all others assured the supremacy of the United States. To this he replied, that while other nations might in time equal us in the development of labor-saving machinery, we should always hold a commanding position because of the vast extent of the Lake Superior iron mines, and the extraordinary richness of the deposits. The correctness of this view of the situation can never be disputed. So long as we can shovel up ore, sixty per cent of which is iron, from the surface of the ground and load it onto the cars at the cost of only five cents a ton for labor, we are starting with an economic handicap in our favor which, in the present development of the art of steel making, it certainly seems impossible that our competitors should overcome. Moreover, social and political conditions in foreign countries are such that it is practically impossible for them to organize such combinations of properties as place the largest of our steel corporations at enormous economic advantage in the matter of operation and manufacture. Thus an estimate of the cost to the United States Steel Corporation of turning this iron ore into steel does not include any profits of the railroad in carrying it from mine to dock, or profits on docking facilities, or profits on steamship transportation through the lakes, or profits again of any railroad company in the haul from the Lakes to the Pittsburg furnaces. The possession by this corporation of everything in the way of rich and abundant supplies of raw material, transportation facilities, and up-to-date plant, that is necessary for the production of steel, should be sufficient to render permanent our present supremacy.