BESSEMER AND GUN-METAL.

[From "Once a Week."]

Many of the readers of this periodical may not be familiar with the more prominent principles of iron and steel manufacture, and as they are an important part of great-gun manufacture, I will therefore name them as briefly as possible.

Pure iron like pure gold is homogeneous, but unlike gold it is rarely pure. If gold be kept in a melted condition a sufficiently long time, all extraneous matters may be burnt away, but if iron be kept in a hot state too long it will be burnt away itself. Pure iron appears to be ductile, but pure iron will not melt. To form cast-iron, a quantity of carbon must be mixed with the pure iron, If the quantity of carbon be less in amount, steel is the result.

The ancient method of making steel was to cover up bars of iron with charcoal powder, and to keep them in a red-heated condition for a fortnight or so. When taken out the iron was found covered with blisters arising from gases constituting some of the impurities of the iron. Consequently, the purer the iron the less it would be blistered. To turn the blistered steel to use, it was shorn to pieces, and the pieces piled on each other, heated to a welding temperature—*i. e.*, surface melted—and forged under the hammer. When drawn out into bars it was called "single sheer steel." To improve it, it was cut up again and re-piled, welded, drawn into bars, and so called "double sheer steel." But these processes left the metal full of specks, flaws, and imperfect welds, with scaly particles, rendering it unfit for delicate cutting-tools.

In those days die-sinkers and others paid as much as three or four guineas per pound for a steel brought from India, called "wootz," which came in little half-round lumps, shaped as the bottom of a crucible, and weighing from two to three pounds. This was, in fact, the metal from which Indian sword-blades and other weapons were forged, and it was really natural steel cast by workmen sitting on their haunches and urging their fire by right and left-hand circular bellows.

In process of time it was discovered that, if instead of welding up the shorn blistered steel, it was put into a crucible, it could be melted into a homogeneous mass without flaw or speck, and then forged into a malleable bar. This was called "cast steel," but it was a long time before people would be persuaded that cast steel would be other than brittle, like cast-iron. But as time went on, die-sinkers found that what was called, "Huntsman's steel," sold at about four guineas a hundred weight, was quite as good as wootz at four guineas a pound, and wootz was thenceforward kept at home in India for the sword-blade making.

English steel was made from Swedish iron, simply because it was a purer iron than any other, and was manufactured by charcoal, and not by coke. But neither steel nor iron could be manufactuerd in large masses, save by the process of welding together small portions—ever an imperfect process at best in the modes used; and so the prices ranged from eighty pounds per tun, for the highest qualities, to thirty pounds per tun for the lowest—carriage springs—till the advent of railroads, when, with an enormously increased demand, the price went gradually down to twenty for manufactured springs, all specified to be of Swedish steel—all Sweden and Russia to boot not being competent to furnish the supply; English iron being in fact resorted to, to manufacture an inferior article.

One man finally solved for us the problem, how to produce both iron and steel in homogeneous masses of any required bulk. This man was Henry Bessemer, one of that not numerous inventive race by dint of whose brains England is not as China, but is ever progressive—a race ever seeking to develop the true meaning of what has been called the "primal curse," not "sweat of the brow," but rather sweat of the brain within the brow, wherein to seek redemption from all painful drudgery by converting it into healthy exercise. From sugar-refining to iron-making, yet with the bent of his mind—doubtless French Huguenot by derivation—ever leaning rather to chemistry than to mechanism, there are few things of the future that Henry Bessemer has not tried at, as witness the patent list, that record of pretended rewards for genius, wherein his name appears no less than sixty-seven times, beginning in March 1838, and ending in December 1858, ranging over many subjects, such as printing, railroad-brakes glass, bronze, powder, paints and colors, atmospheric propulsion, steam-vessels, locomotives, sugar, varnishes, kilns, furnaces, ornamenting surfaces, guns and projectiles, waterproof fabrics, screw propellers, iron and steel railway wheels, beams and girders, treating coal, &c. Twenty-one patents were taken previous to the alteration of the law, for England only, exclusive of Irish and Scottish, and probably three thousand pounds were extracted from the inventor's pockets for fees. The patents he has taken since the alteration of the law indicates the fact that the cost of patents is not less than before, but considerably greater; the restriction in title being so great that five patents for three years, at £30 each, are required instead of one at £100 for fourteen years; the five patents, if extended to fourteen years, costing about £160 eaeh, or £800 instead of £350, if English, Scotch, and Irish be included in both cases. Many of these latter patents probably did not go beyond "protection," being, in truth taken to prevent others from obtaining patents for every variety of article that could be made out of the improved iron and steel to the detriment of the real inventor.

Thus he went on, ever working through good report and ill report, falling often from a height where success seemed attained, not from false calculations, but from some adverse and before-undiscovered fact in nature, most valuable to us to know, but not tending at the time to replenish the inventor's purse.

At the British Association of 1857, Mr. Bessemer read a paper, wherein he described his process of iron-making. The ordinary process is, first, to run it from the ore into pigs by one heat. Secondly, to re-heat it and "puddle" it, *i. e.*, stir it about in a melted condition with iron rods moved by men's arms till it becomes stringy and tough, and gets rid of some extraneous matter. Thirdly, to beat it by hammer into a mass, called technically a "bloom." Fourthy, to rollt his bloom into a bar or bars, making the commonest iron. Fifthly, to cut the bar into short lengths, and pile them up. Sixthly, to re-heat this pile and forge it into another bloom; and, seventhly, to re-roll it into a bar or bars. If, during the process of heating, the oxygen of the atmosphere gets access to the surfaces, scale is formed, which prevents perfect adhesion under the hammer, and the metal is not homogeneous.

Mr. Bessemer simplifies all this. When the metal is melted in the great furnace is is run out into a huge clay crucible, practically a colander, by reason of several openings in the bottom, through which the metal would run were it not impeded by a strong blast of air under great pressure, which is forced through all the interstices of the iron, and instead of cooling it, raises the heat to a greatly increased intensity. This burns away the carbon, which constitutes the chief difference between cast iron and malleable iron, and also some other matters; and when the metal is poured out, it is pure iron, if the process is carried on long enough, or if stopped at an earlier period so as to leave some carbon in it, it is pure steel: in both cases malleable. Thus one heat serves to make a malleable ingot, which is only limited in size by the size of the crucible, which may contain two tuns; and, as many crucible may be used and poured out together, there is no reason why a homogeneous lump of fifty or more tuns should not be produced, either of iron or steel, which may be dealt with by the hammer, or by rolls, or both.

In rolling thin sheets of metal in the ordinary manner, the size is limited by the difficulty of retaining the heat. By another arrangement of Mr. Bessemer, this difficulty may be obviated. Hollow rolls are used, through which a stream of water pours, and on the surface of which jets of water play. Between these rolls, which are placed horizontally, and form a tank or channel when they approach each other, the molten metal is poured, and thus a sheet of any desired width or thickness may be formed, and only limited in length by the supply which the crucible are capable of keeping up. The ore goes into the furnace a crude stone, and comes out of the rolls a sheet of tough metal. Iron-making is thus rendered as simple as the paper-making processes, where the rags go in at one end of the train of apparatus, and come out at the other perfect paper.

At Baxter House, St. Pancras, this new process of melting was first exhibited to the public, and excited an equal amount of wonder and incredulity. On one occasion, a sort of Welsh St. Thomas, iron-doubting, sneered as he saw the metal poured, and asked: "Do you call that malleable iron?" The inventor went into a shed, brought out a carpenter's axe while the metal was still red, and cut three notches in the angle, just as might be done at the angle of a square foot of timber. The silent answer struck St. Thomas dumb.

Still the inventor had much to learn. The iron hissing, boiling, and bubbling in its clay colander, was poured out in its ebullient state like so much champagne; and as it cooled was filled with innumerable air-cells; and the apparent want of success filled the mouths of fools and scoffers with matter for exultation. Far and wide the whole affair was considered a failure; natheless that men of logical mind knew to the contrary. But the resolute inventor stuck to his work, he had sounded the depth of his invention, but he had not explored many of its ramifications. Two years behold him again before the world with the verification of his theories and of his earlier practice: the causes of failure unfolded. His next paper was read at the Institution of Civil Engineers; and those who know the critical acumen of that strong-brained body of men, and were present at the reception of Mr. Bessemer, and beheld the enthusiasm spontaneously kindled, as important truths were enunciated, and sample after sample was exhibited, opening new capabilities to those anti-Chinese sons of eternal progress, are not likely to forget it. No actor at a successful *debut*, no writer of a successful play, was ever more warmly greeted. A small cannon, a railway axle, a three-ply cable, twisted up of cold iron, one-and-a-half inch diameter, steel bars and rods of all shapes, a large circular saw, boiler-plates of perfect surface and great width, and, lastly, ribbons of iron as thin as paper, were exhibited. A small cylinder was shown of cast metal in a perfect condition, and another cylinder was shown which had been doubled up flat under the hammer, without exhibiting the smallest crack at the sharp bends, but the tensile strength was shown to be nearly twenty-four per cent greater than that of the most costly iron made in England.

A thin sheet of iron, reticulated and pierced with holes, almost like a lady's veil, was produced, and stated to be a skin left on one of the crucibles after pouring out the metal. "Is that malleable iron?" asked one of the audience. The inventor simply folded it, and double-folded it, and laid it again on the table in answer.

Representative men of the iron-master mold were present, some of whom denied that there was anything novel in the process, and others asserted that it was too costly to be of any use. Others inquired why it was that Mr. Bessemer chanced to be successful now, having failed of commercial success at the outset.

"I expended £7,000," said one, "and lost forty per cent of iron in the process."

"I," replied Mr. Bessemer, "sometimes lost a hundred per cent, but I persevered. I found that experimenting with heavier charges of metal gave a decided improvement, and I found that all ores were not equally suited to my process. Blaenavon pig at £9. 10*s*., was not so good as Swedish pig, nor as the red hematite of Cumberland, of which class of ores nearly a million tuns are raised annually, yielding upwards of sixty per cent of metal."

"The process melted down the lining of our furnaces," said another.

"So it did mine," replied Bessemer, "till I established myself as a steel manufacturer at Sheffield, and got to use the Sheffield road-drift. In short when I began my experiments, I was an amateur iron-master, and two years of consecutive work have converted me into a practical man."

Most engineers present felt that they were in the presence of a benefactor, who had immeasurably enlarged the sphere of their operations, whether in bridges, rails, locomotives, or ships. It was the triumph of a simple-minded man, earnest of purpose, and frank of nature, with nothing to conceal, but with the instinct of unsealing every mystery of nature so far as he could, and giving it to man's uses. And, verily, that man had toiled and ranged through matter for twenty years, and at last gave to the world a process of which the results are incalculable—homogeneous iron and steel without limit as to size.

Upon projectiles and projectile weapons these results must have an enormous effect; the process of welding iron together for barrels of small arms and for great guns may now be dispensed with. A short, thick, hollow cylinder being cast, may be at once rolled out direct between rollers into a musket or rifle barrel of any desired form; and great guns may be cast hollow, and put under the operation of a tilt or steam hammer, if needed, to consolidate the metal. And these malleable iron guns can be procured at one-third the cost of the ordinary cast-iron guns; and what is very important, the malleable steel is even cheaper in cost than malleable iron. The class of guns described in the last number, to be borne on wheels without horses, might be produced with little labor and cost, ve y rapidly to any amount.

With regard to monster guns, they may be regarded as useful only for two purposes—to mount on forts for defense, and to place in vessels. They are not otherwise transportable weapons of offense. This question is yet in embryo; but if armored ships are to obtain, this question must obtain also. For shot that are to pierce armored vessels, it is quite clear that the Bessemer malleable steel will prove a most important material, as it can easily be tempered to any required hardness to act as a punch, and can be more easily manufactured than the wrought iron shot that have replaced fragile cast-iron.

Before constructing monster guns we have yet to settle the question of the form, proportion and weight of the shot we are to use for given distances with a given destructive power. This ascertained, there will be no difficulty in the construction of the gun itself. But it should be a gun so proportionably heavy as to be absolutely without recoil; so long as to expend expansively the minimum amount of powder required to obtain the longest possible range; so dense in the material as not to fracture; and so solid as not to spring and temporarily enlarge its diameter with the explosion. A maximum-sized gun of this kind would probably weigh 100 tuns, and if used for forts would require machinery to move it and aim it. If used on vessels it would be placed fore and aft with only a vertical movement, and the vessel itself would serve as a stock to it, lateral movement being given by the screw and rudder. Fitted to an armored vessel, with the bows thoroughly protected, such a gun would be able to batter down everything in the shape of a stone wall at such a distance as to render being hit from the fort almost an infinitesimal chance. It would be like shooting at the edge of the east wind.

Long-range rifles, it may be remembered, were more than a match for the fort-mounted artillery at Bomarsund and in the Crimea, killing off the artillerymen. This will become more and more the rule as guns are improved. Monster guns are not calculated to pick off skirmishers, and it therefore becomes needful to protect their gunners. With the large embrasures of the ordinary kind which would be required for monster guns, the risk to the gunners would be much increased. It therefore is well to inquire whether there is any reason why the gun should not be closely covered in. With the ordinary mode of mounting on trunnions this seems scarcely practicable. But it would be very practicable to mount the gun on a sphere or ball working in a socket and capable of radiating in any direction. If the radius of the gun were only required to be small, as in a moving vessel, the ball might be placed at the muzzle, and in such case little sound or vibration, and *no smoke whatever should come into the vessel*, and no damage could be done to the gun save by shot striking exactly in the muzzle. This is so perfectly practical an arrangement, that nothing but the fact of a ship's sides being too weak to sustain the recoil of guns so attached ought to keep it out of use. Our sailors are too precious a commodity to have them wasted in working muzzle-loading guns at open ports. The steam ram now constructing is perfectly adapted to this arrangment, and a properly-constructed gun should be free from recoil. Even in our present state of knowledge, muzzle-loading guns must be regarded as things of the past, matching with "Brown Bess," and other tower antiquities. Into the details of construction it is not desirable to enter; and although the improvements indicated give these advantages chiefly to nations with manufacturers widely spread and of a high order, still the State should ever have in reserve a stock of improvements to meet emergencies; not making them common till required by the presence of adverse circumstances. The State should "keep a hold of the actual, knit the new securely to it, and give to them both conjointly a fresh direction." The astonishment created by the results of the Armstrong gun is simply a proof how much the progressive actual is overlooked by the many, while the special individual by time and thought turns it to account; and then it is assumed we can go no further, not heeding the words of the philosopher poet—

Men my brothers! Men the workers! ever making something new;
That which they have done but earnest, of the things that they shall do."

W. B. ADAMS.

NEW YORK WATER.

A few years ago the water with which Boston is supplied became quite fœtid, acquired a fishy taste, and formed a subject for much anxiety to the people of that city. In the subsequent year, the water in the city of Albany, N. Y., was affected in a similar manner; and now the "Croton," of this city, seems to have caught the infection. It has not yet acquired the exact fishy taste of the Cochituate fountains; but as it has been growing gradually worse for the past two weeks, it may yet arrive at that stage of deterioration if something is not immediately done to discover and arrest the evil. The reports of the scientific committees which were appointed to investigate the water evils in Boston and Albany attributed them to minute animalculæ and the decay of vegetable matter, brought about by a deficient supply of water in dry seasons, whereby the ponds be came, in a measure, stagnant by the very limited quantity that was permitted to flow into the distributing reservoirs. The impure water in New York this season cannot be ascribed to such causes, because there has been no drouth; the supply of water has been abundant, and the season has not been unfavorable. The taste of the water is similar to that retained in a "moss-covered bucket" for several days, and the odor is very like that of marsh gas, thus affording some evidence that there has been an overflow of marsh lands into Croton Lake.

It has been stated that Dr. Chilton and some others have analyzed the Croton, without finding anything of a deleterious character in it. This may be true. The waters of the Dismal Swamp, although of a berry-brown color, are stated to be very healthy and very pleasant. The first quality may belong to the Croton, but not the last. That's certain.

ON HARDENING STEEL.

There are few things of which it is more difficult to understand the *rationale* than hardening steel; or why the same operation of heating red-hot and plunging into a cold fluid, which hardens steel, should soften copper.

Some persons will explain everything whether they understand it or not, and for this also have they found, in their own imagination, perfectly satisfactory answer, and cut the difficulty by saying steel is condensed by the operation; but, unfortunately for their theory, the reverse is the fact, and instead of being condensed, it is expanded by hardening, as any one may soon satisfy himself by taking a piece of steel as it leaves the forge or anvil, and fitting it exactly into a gage, or between two fixed points, and then hardening it; it will then be found that the steel will not now go into the gage or between the fixed points. Or let him rivet together a piece of steel to a piece of iron, filing the ends of both even, so that they may be exactly the same length, then heat them to a proper heat to harden the steel, and plunge them into water; he will find the expansive force of the steel has nearly torn the rivets out, and that it extends beyond the iron at both ends, any article may be taken with steel on one surface and iron on the other—such as a joiner's plane iron in the forged state—flat on both surfaces, and hardened; and the expansion of the steel will cause that side to be convex, and the iron side concave; how this is to be got flat again will be explained afterwards.

All steel expands in hardening, but that expands most which is most highly converted, and in direct proportion to the amount of carbon it received in that process. No other general rule can be given for the treating of steel for hardening than this, and it should in all cases be heated as regularly as possible to the lowest temperature at which that particular kind of steel will harden, and as little as possible beyond it, remembering that the more highly converted the steel is, the lower the temperature at which it will harden; and that a small article, such as a penknife-blade, will harden at a lower temperature than a more bulky one made of the same steel, because the small article is more suddenly cooled. The hardening of the very bulky articles, such as the face of an anvil, cannot be affected in the same way as smaller articles, by plunging them into water; for the length of time required in cooling will be almost certain to leave the middle of the face soft, where it is of the most consequence that it should be hard. Where the anvil-forge is worked by water-power, they possess the best means in hardening them, which is this:—The anvil, properly heated, should be placed in a water-tank face upwards, under a chute connected with the mill-dam; the chute drawn, and a heavy and continuous stream of water let fall from a height of ten or twelve feet upon the anvil-face, which effectually hardens the surface.

A red-hot anvil plunged into water would for a time, be surrounded by an atmosphere of steam, which would prevent its direct contact with the cold water, whereby its cooling would be retarded too much to harden the face; and hence the advantage of a continuous stream of cold water. Hence, also, the necessity of moving about in the water even articles of a pound or two in weight, to remove them away from the stream as it is generated upon their surfaces and thus promote more rapid cooling.

It is a good plan to harden hammer-faces, where there is a tub and water tap conveniently near, by plunging the red-hot hammer, held with the face upwards, into the water, so that a stream from the tap may fall upon its face. The face of hammers and anvils is ground after being hardened, but should never be tempered.—*Orr's Industrial Arts.*

DURATION OF LIFE AMONG THE JEWS.

According to the observations of M. Gatters, the duration of life among the Jews is considerably longer than with Christians; even in infancy, the mortality of the former is relatively less than among the latter. From his calculations, it results that the average length of life is, for Israelites, 46·5 years; for Germans, 26·7; for the Croats, 20·2; for the Austrians, 27·5. Gatters attributes the superiority on the part of the Jews, in different climates, entirely to the influence of race, and suggests the advantage of paying attention to the ethnographic element in the etiology of diseases. It is very probable that the cause of the greater longevity of Jews over Christians does not depend wholly on race, as Gatters thinks, but especially, if not entirely, on the fact that the Jews are more wealthy than Christians, and that their hygiene is superior to that of the latter.

EXPERIMENTS ON THE OLD ATLANTIC CABLE.—The Buffalo *Republic* says three pieces of the Atlantic cable, which were purchased by Messrs. Tiffany & Co., of New York, have been laid across the Mississippi, at St. Louis, in order to put that office in connection with the eastern lines. The first cable worked very well for about three weeks, the second about thirteen hours, and the third, which was laid on Saturday evening, gave out on Sunday night. On Thursday the second cable was under-run by experienced electricians, but no flaw was discovered—nothing perceptible to account for the cessation of the working capacity of the cable. The last cable was put to a good test, having been entirely submerged for over two hours before being laid. The first cable was examined from St. Louis to near the Illinois shore, where the cable having been imbedded in the sand gave way. Up to the place of parting there was nothing perceptible that could lead to the discoverery of the existing trouble. The third cable also furnishes no evidence whereby the cause of the difficulty can be detected.

IRON RAILROAD CAR.—An iron car, built according to the patent of Dr. La Mothe, was exhibited for a few days last week at the New York and Erie Railroad station, Jersey City. It is one of the handsomest cars we have ever examined, and we have no doubt but the proprietors of the road for which it was built (Boston and Lowell) will feel highly pleased with its appearance. Its sides are of double plates, with a space between, and the seams are branded with narrow strips, riveted on in such a manner as to form panels. It is fire-proof, and lighter than a wooden car of the same size.

C. A. Schultz has a new and economical steam-engine on exhibition at the Neptune Iron-works, foot of Eighth-street, East river, in this city. The novelty of this engine is so great that we shall shortly give an illustration and description of it in the SCIENTIFIC AMERICAN