tion is difficult and expensive. The fusibility of iron depends upon the quantity of carbon present; and no commercially available method has till now been discovered by which iron, after parting with a very large proportion of carbon, can be brought to remain in a state more nearly approaching fusion than that of a pasty mass.

Steel is produced from iron from which the carbon and other impurities have been extracted, by a tedious and costly process, the object of which is the restoration of a portion of the carbon which previous processes have removed. Steel contains, according to the purposes for which it is wanted, from rather more than ½ per cent. to rather less than 2 per cent. of carbon.

Malleable iron—or iron comparatively free from carbon—is usually produced, in this country. in the following manner:

The melted iron, as extracted from the ore in the smelting or blast furnace, is run out into bars a few feet in length, technically termed 'pigs.' These pigs, when cold, are removed from the sand-molds into which they were run, and transferred to a second furnace, called the 'fining furnace,' where they are again reduced to a state of fusion; and finally, the mass thus produced is placed in a third furnace, where it undergoes the process of puddling.

Omitting all matters of detail, the essential part of this operation is the reduction of the iron to a pasty mass, which is stirred and rolled about by the workman until a large ball or 'bloom' of iron, weighing from 60 to 70 pounds, is conglomerated at the end of the rod with which he works, and is judged to be in a fit state for the final process.

It is then withdrawn from the fire, and taken to a 'tilting hammer' and a pair of squeezers, or to a Nasmyth's steam forge, where it is subjected to a very heavy pressure, and a quantity of melted slag and refuse, mixed with the puddled iron, squeezed out.

For the purpose of our present comparison we need follow the process no further. Other methods of producing malleable iron directly from the ore are in use in various parts of the continent: but they are extremely expensive, require a rich ore and a very pure fuel, are only applicable upon a small scale, and sacrifice a very large per centage—in some cases from 40 to 50 per cent—of the metal.

Of all our more important mechanical operations, perhaps puddling is the most imperfect and unsatisfactory. It is very expensive, both from the quantity of fuel consumed (which is about equal to the weight of metal treated) and the severe nature of the labor required. During the recent hot weather it was found necessary to stop nearly all the Staffordshire puddling furnaces—two men having fallen dead at their work.

The result is the production of an iron so far from being chemically pure that it is astonishing how much we have been able to effect with so imperfect a material. From the immense demand for iron which has prevailed for some years past, and the stimulus that has thus been given to the production of increased quantity, the quality has very seriously deteriorated.

The difficulty experienced by the government during the late war in procuring iron of a quality suitable for the purposes of warfare is too well known to need more than a passing reference.

Mr. Bessemer's experiments have been conducted upon the pig-iron. He proposes that, for the purposes of manufacture, the smelted iron, as it leaves the blast furnace, shall be run immediately into the converting vessel presently to be described; but, for the purposes of experiment, it has been more convenient to melt down pig iron, as the metal is much sooner reduced to a state of fusion. The experiment, therefore, takes up the process at the point at which the metal is ordinarily placed in the fining furnace.

It must be remembered, however, that one important end answered by his invention is to do away with the consumption of fuel required for this intermediate process.

The 'converting vessel,' where the change of the melted metal from ordinary cast iron to malleable iron or steel is to take place, consists, externally, of a cylinder of iron, surrounded, near the bottom, by a hollow ring—an annular pipe, in fact—of the same metal, communicating with five small 'tuyere' pipes, placed at equal distances round the cylinder. These pipes are carried through the outer and inner structure of the vessel, and each of them enters the chamber within, near the junction of the side with the floor, by an aperture about three-eighths of an inch in diameter, protected by a coating of the best fire clay.

The external cylinder is lined with a thick lining of fire brick, and the internal structure consists of two chambers, or stories, communicating by a small cylindrical opening in the center. The lower chamber, into which the melted iron is introduced, is a simple cylinder—the upper chamber has a floor inversely arched, so that any melted metal forced up through the opening from the lower chamber may trickle back again, and the roof is in the shape of a cupola or dome. Two apertures, a few inches square, placed opposite each other, between the floor and the top of this chamber, communicate with the external air.

A powerful blast, worked by a small engine, can be let into the hollow ring which girds the outer cylinder, and thence, of course, enters the lower chamber through the tuyere pipes. A hole at the bottom of the chamber, secured in the usual manner, furnishes the means of tapping the vessel and running off the produce into the molds prepared for it.

When everything is ready for the operations to commence, the blast is set on to blow into the converting vessel—the melting furnace is tapped— and the melted iron, of the usual deep orange tint, pours slowly down the channel into the lower chamber of the converting vessel, through an aperture which is then closed up and luted.

The pressure of the blast is about 9 or 10 pounds to the square inch—strong enough to force the air completely through the superincumbent mass of fused iron, and out through the apertures near the top of the vessel.

As the action is continued, every particle of the melted metal is brought in turn into contact with a stream of air. To use the language of chemistry, an energetic combination takes places between the oxygen of the air pumped in and the carbon mixed with the iron. In popular language, fire, instead of being supplied externally round and about the mass of iron, is kindled and sustained throughout every particle of the liquid metal.

A heat is thus generated, vastly greater than that which can be supplied by mere external combustion. What is taking place is indicated by the tongues of flame which, in two or three minutes, begin to shoot forth from the apertures in the vessel, and which gradually increase in body and in intensity until the whole mass is in a state of agitation, almost like boiling water—the difference being, however, that the agitation is caused by the external force of the air blown rapidly and continuously through the liquid iron, not by the conversion of the substance itself into an expansible vapor, as in the case of genuine ebullition.

However, this state may very fairly be called 'the boil,' and it is indicated by the blowing out, through the apertures, of large quantities of melted slag—the refuse which is squeezed out of the puddler's 'bloom' under the action of immense pressure, but which is here driven off simply by the action of the blast, because, being much lighter than the iron, it rises to the top, like scum upon the surface of water, now that the metal is in a state of perfect fluidity.

It is supposed that at this period a very important change begins to take place, and that that part of the carbon which is in a state, not of mechanical mixture, but of chemical combination with the iron, is now compelled, by the agency of the increasing heat, to part from the metal, and yield itself a captive to the superior affinity of the oxygen.

This 'boil' takes place from fifteen to twenty or twenty-five minutes after the commencement of the process, and continues with more or less violence until all the carbon is burned out. The moment that this is effected, and that no more carbon, or only a very small quantity remains, the metal must be run out, otherwise the action of the air would cool the metal, and make it set hard with great rapidity. It may be run out into molds of any size or shape; but the most advantageous form is that of a deep and narrow mold, as then the slag which has not been already removed, and which comes last out of the hole at the bottom of the converting vessel, lies in a thin cake at the top of the casting, and is easily taken off by a pair of shears.

It will be obvious that one principal feature in the process is, that the operator deals with the metal in a state of perfect fluidity—a desideratum hitherto unattainable with iron containing only a small quantity of carbon. Hence it can not merely be procured in masses of any size (whereas the puddler can only produce 60 or 70 lbs. in a lump) but it will possess the distinguishing character of all fluids—it will be perfectly homogenous. The texture, composition and quality will be the same throughout every part of the mass. That the fluidity is really greatly increased, notwithstanding the subtraction of the carbon, is shown by the fact that it is found desirable to diminish the power of the blast from 9 or 10 pounds, to about 5 pounds during the latter part of the process, as well as by the rapidity with which the metal runs out of the furnace, and its brilliant whiteness.

It is impossible to overrate the advantage of having a really homogenous product. In large masses of malleable iron, procured in the ordinary way by welding together a number of the puddler's blooms, there often occur small knobs and fragments of metal much harder than the rest; and many manufacturers consider soft malleable iron quite as trying to their tools as hard steel, from the unexpected increase of resistance suddenly offered by particular parts of the mass, and the consequent unequal strain upon different portions of the machinery. The greater the mass required, the greater the difficulty of obtaining a metal upon all parts of which equal reliance can be placed; and hence, where a very heavy strain, in a direction different from that of the fiber, is expected, strength is often obliged to be sought in an enormous thickness of material. The prodigious weight of anchors is rendered necessary by the impossibility of calculating accurately the strength of the metal in any particular part, so that the size of the whole must be increased to meet the chance of a bad piece of metal occurring here and there.

One of Mr. Bessemer's numerous patents is for the application of his invention to the construction of anchors, in which he hopes to attain equal strength with a greatly diminished weight.

It is hardly necessary to point out the enormous saving in labor and fuel effected by the new process, especially in the manufacture of steel.—Mr. Bessemer believes that steel, such as is now worth from £50 to £60 a tun, may be produced at a cost to the manufacturer of less than £10 a tun. In the manufacture of malleable iron, also, the saving will be very great, tho' less than in the case of steel. Indeed, one of the results of the invention will be the curious anomaly that steel will be produced at a little less risk, and therefore at a little less cost, than malleable iron; for it is obvious that, by tapping the furnace before the complete combustion of the carbon has taken place, steel will be produced instead of iron.

Practice and experience will, no doubt, in time enable the workman so to regulate the operation as to produce to a nicety any particular quality of iron or steel required; but until this practical knowledge has been gained, there will be some difficulty in calculating the exact length of time to be occupied in the conversion.

If, therefore, the process should be continued a little too long for steel, malleable iron will be obtained—if it be continued a little too long for malleable iron, the metal will be set in the furnace. 'The boil' appears to be the critical period. Whatever be the time occupied in arriving at 'the boil,' it is found that from twelve to fifteen minutes are requisite to produce malleable iron, and from seven to twelve minutes to produce the different qualities of steel.

How effectually the carbon can be removed is shown by an analysis of a chance specimen of Mr. Bessemer's malleable iron, made by Dr. Henry, who, we believe, was strongly inclined to doubt whether the process could really be so successful as it was stated to be. He found the quantity of carbon present to be less than 1-30th per cent—or less than 1-300th part of the metal. Of silica, a trace merely was found.

By the application of means already well understood, the sulphur and phosphorus will be as completely removed. A considerable portion of both is driven off without the use of any means for that special object; and by treating the melted metal with proper substances, these impurities will be withdrawn.

The difficulty which Mr. Bessemer has applied himself to solve, and which he has solved, is the complete separation of carbon and the earthy bases. Apart from the cheapness and facility of his process, he has been able successfully to grapple with the half per cent of carbon which puddling can never get rid of.

The process, as described above, is open to a serious objection. The blast must be kept up to the last, or the melted metal would run into the tuyeres, and spoil the blast apparatus. Hence the air is being driven through the metal up to the very moment that it ceases to run out of the vessel; and the ingots produced are consequently very porous and full of air bubbles. With malleable iron, this is of no importance, as it would always be rolled while in a state not far from fusion, and the air would be completely squeezed out, as the slag is squeezed out of the puddled ball.

But cast steel would be useless if porous—a difficulty which is met by an ingenious modification of the converting vessel. It is slung horizontally at the end of two cranks, which, by means of a counterbalancing weight, can easily be turned through any angle. The blast is admitted by a pipe passing through the axle of one of the cranks, and thus revolving with the converting vessel.

The tuyeres enter the converting vessel by a series of apertures forming a horizontal row.—The cylinder can thus be made to revolve round the axis of the crank without turning upon any axis of its own; and thus the apertures of the tuyeres may be raised till they are brought above the surface of the metal.

The blast can then be turned off and the agitation of the metal allowed to subside. Iron melted by existing processes sets in about three or four minutes; but Mr. Bessemer finds that he can allow it to stand for ten or twelve minutes—a period quite sufficient to allow all the air-bubbles to escape—and the cylinder may then be raised still further, and the metal poured off as gently as may be requisite, through a spout at the top or in the side of the vessel.

The quality of the steel produced admits of no doubt. A fragment broken off from an ingot cast when we saw the experiment, was compared with a fragment broken off from the end of a file. It was harder, and far finer in the grain.

The experiment in question was conducted with six or seven hundred weight of Yorkshire iron of a common quality. An ingot of six hundred weight was produced in one piece in about 25 minutes. There will be no difficulty in producing masses of any size or shape. The size of the converting vessel and the number of tuyeres may be increased to any requisite extent.

The blast need not be increased in strength, as it will only be necessary to enlarge the area of the floor of the vessel, so that the iron may not rise to a height of more than 8 or 9 inches. The loss was about 13 per cent; but of this a considerable quantity might be recovered, as the slag blown out during the boil contains about 50 per cent of iron, in the shape of little globules, like shot, set in the slag.

It is extremely porous, and crumbles to the touch, so that it might be broken up, and the iron separated by washing, with little difficulty and labor. In the ordinary puddling process, from 17 to 25 per cent. is lost, and in the Catalan and Corsican processes, not only is a weight of charcoal consmed from three to seven times that of the iron produced, but 5-13ths, or about 28 per cent. of the metal is sacrificed to secure the purity of the remainder.

Mr. Nasmyth tried some years ago to decarburize cast iron by blowing steam into the melted metal. This attempt failed, as the separation of the oxygen from the steam exhausted so much of the heat of the metal that the heat evolved in the combination of the oxygen with the carbon in the iron was insufficient to compensate the waste; and the iron was cooled instead of being heated.

With the freedom from jealousy which marks a truly great mind, Mr. Nasmyth paid, as we have said, at the late meeting at Cheltenham, a graceful tribute to the importance of the invention, and spoke in terms no less honorable to himself than to Mr. Bessemer, of the ingenuity of the process and the vastness of the results to which it would unquestionably lead.

Mr. Bessemer, on the other hand, derives from the experience of Mr. Nasmyth the important knowledge that, by the joint use of jets of steam and blasts of air, he will be able to regulate with the utmost nicety the amount of heat generated, and the rapidity of the process.

The history of this invention is curious. Some two years ago, Mr. Bessemer's attention was attracted to a subject happily now of less pressing interest than it then was—namely, the manufacture of rifled cannon.

The object of rifling muskets and cannon is to secure a control over the direction of that rotation which is part of the motion of every projectile, and to insure that it shall take place round an axis coincident with the direction of the missile.

For this purpose, with the Minie musket and the Lancaster gun, an elongated ball is used, and the interior of the projecting tube is cut with a curved groove or grooves.

When a leaden ball is shot, no appreciable injury is caused to the barrel of the gun, but when an iron ball is used, as in the case of cannon, the wear and tear is very great indeed. The Lancaster guns are seriously injured, if not rendered unservicable, after a very few hundred rounds.

It occurred to Mr. Bessemer that the object might be attained, without rifling the cannon, by using an elongated ball, with a hole drilled half-way down its longer axis, and prolonged into two channels opening by a curved arm upon each side of the ball.

The effect of the air passing through these bent pipes and out at the back of the ball, as it flew through the air, would be to create a motion of rotation round the longer axis of the ball, just as, in an emission steam-engine, a rotation is created by the backward pressure of steam issuing from a bent pipe.

Finding difficulties in the way of testing the invention in England, and availing himself of certain circumstances into which it is not necessary to enter, he applied to the Emperor of the French, who instantly placed the resources of the arsenal at Vincennes at his disposal, and afforded him every facility for his experiments.

The balls were found to rotate as expected—a fact which was proved by causing a small projection to spring out of the side of the ball the moment it left the mouth of the cannon, and observing the position in which this cut targets of thin board placed at intervals in the flight of the ball; but it was also found that the cannon could not safely carry the increased weight of metal rendered necessary by the elongation of the ball. Hence, Mr. Bessemer was led to make experiments on the production of a tougher metal for cannon.

He tried numerous mixtures of various kinds of fusible metal, until at last he began to consider whether it might not be practicable to produce malleable iron in a state in which it would be easier to mold it to the required form than by the expensive process of forging. The result of his experiments has been the discovery of a process applicable to the arts of peace no less than to those of war.

It is difficult to assign any limits to the importance of an invention whose influence will be felt throughout the civilized world in an improved quality and diminished cost of one of the great staples of modern industry.

The first axiom of the iron trade is demonstrated to be a fallacy; and, to a mind familiar with the subject, the magnitude of the change cannot be more emphatically expressed than in the simple proposition that the ancient and fundamental antagonism between the terms cast iron and malleable iron has ceased to exist; for malleable iron will now always be cast.

It is impossible to doubt the truth of the opinion modestly expressed by Mr. Bessemer, that others will improve on his invention, and that his process will not receive its full development for many years to come.

There is no country in which its influence will be as extended as our own, in which so large a portion of the community is engaged, directly or indirectly, in arts connected with the manufacture of iron and steel; but there are others where its effects within a narrow sphere will be yet more striking, and yet more welcome. In some countries, where malleable iron is produced direct from the ore, the consumption of charcoal has become matter for serious alarm.

In Sardinia it has long been, to many reflecting minds, a subject of grave doubt whether the benefits to be derived from the development of this branch of industry were not more than outweighed by the wholesale destruction of the forests for fuel.

We are glad to learn that Mr. Bessemer has not only secured the legitimate reward of his industry and ingenuity by the grant of patent rights in almost every part of Europe, but that, alive to the greatness of his invention, he has resolved to adopt a wise and liberal policy in the grant of licenses, and to place the use of his process within the reach of all persons who may be desirous of its important advantages.

[From The Wolverhampton Chronicle.]

Mr. Bessemer's discovery of a method of making malleable iron and 'semi-steel' without subjecting pig iron to the process of refining and puddling, by which a large saving in fuel and labor and machinery will be effected, continues to excite great attention in this neighborhood.

It our last publication we gave Mr. Bessemer's account of his invention, as detailed at the meeting of the British Association for Advancing Art and Science at Cheltenham; and in our present paper we furnish a further account of an experimental trial which took place in London on Friday last. The operation was witnessed by a numerous company of gentlemen connected with the iron trade, and pronounced successful.

Two conditions, however, were wanting to that thorough fulfillment of the promises which Mr. Bessemer's invention holds out, which may seem to require some explanation; and this explanation it is now our purpose to afford. The experiment, for several good reasons, took place in London;