

physical personality as a whole reacting on the outer world."

As to self-consciousness and the unity of the self, the psychologist answers that the feeling of self-consciousness is the general feeling that arises when the psychophysical personality reacts upon the outer world.

I am aware of the weaknesses of the "new" psychology. It is easily vulnerable at many points. There is no time here for a fair criticism, however, except to say that the last Psychological Congress showed that incorrigible tendency of the German minds to out-Hegel Hegel in their daring theories. In spite of the boasts of the present generation of Germans that the new psychology is scientific and not metaphysical, the words of their own Jean Paul point to one of the dangers to the new young science in the hands of a German—"The kingdom of the English is the sea; that of the French, the land; while the German owns the kingdom of the air." The new psychology claims only to be in its beginnings. Its future will be safe and its effect salutary if it be not overwhelmed by highly inventive theorizing.—The Outlook.

#### HISTORICAL AND TECHNICAL SKETCH OF THE ORIGIN OF THE BESSEMER PROCESS.\*

By SIR HENRY BESSEMER, London, England (Honorary Member of the American Society of Mechanical Engineers).

EVER mindful of the great honor spontaneously conferred on me by the president and council of the American Society of Mechanical Engineers in electing me an honorary member of that learned body, I have deemed it both a privilege and a duty on my part to lay before them a brief account of the early origin of the Bessemer process of steel manufacture, as developed at my bronze powder manufactory in London.

It is generally well known that this invention had its origin in certain experiments commenced in January, 1855, for the purpose of improving the quality of cast iron employed for founding heavy ordnance, by rendering the iron more tough, increasing its tensile strength and making it less subject to injury by abrasion. I was aware that Fairbairn and others had sought to improve cast iron by the fusion of some malleable scrap iron along with the pig iron in the cupola furnace: this fusion of scrap iron, intermixed with the mass of coke, was found to convert the malleable iron into white cast iron, which was at the same time much contaminated with sulphur, and thus, to a great extent, this method had failed in its object. In my experiments I avoided the difficulties inseparable from Fairbairn's plan, by employing a reverberatory furnace in which the pig iron was fused, forming a bath; into this bath I put broken up bars of blister steel, made from Swedish or other charcoal iron, its fusion taking place without being further carburized by contact with the solid fuel, or contaminated by the absorption of sulphur. The high temperature necessary for the fusion of a large proportion of steel in the bath was attained by constructing the firegrate much wider than the bath, by contracting the width of the furnace considerably at the bridge, and also by continuing to taper the furnace slightly all the way from the fire bridge to the downcast flue, which was connected with a tall chimney shaft. My English patent for this arrangement bears date January 10, 1855. Many alterations and modifications of this furnace were made from time to time; it was found that the large volume of flame sweeping over the open hearth of the furnace was mixed with a considerable quantity of combustible gas, to consume which a hollow fire bridge was employed, having numerous perforations made in the fireclay lumps of which it was composed, and so arranged as to allow jets of hot atmospheric air to mingle with these combustible gases, which had the effect of producing an intense heat close down on the surface of the bath; it was also found that the admission of hot air all along the back of the fire bridge produced a decarbonizing action on the bath, and hence the degree of carburization of the metal might be altered by regulating the admission of air. The flow of air through the hollow fire bridge served also to moderate its temperature and render it more durable.

Some of the samples of metal which I produced by this process were, when annealed, of an extremely fine grain and of great strength. At this stage of my experiments I determined on casting a small model gun, which in the lathe gave shavings slightly curled, and closely resembling the turnings from a steel ingot. The metal when polished also looked white and close grained like steel. I was so well pleased with this casting that I took it over to Paris, obtained an audience with, and showed it to, the emperor, who had, in fact, encouraged me to make an attempt to improve iron employed in founding heavy ordnance. His majesty, who had desired me to report progress, accepted this experimental gun, remarking that some day it might have an historical interest, and it was in recognition of this circumstance that his majesty, later on, intimated to me, through Col. Belleville, his desire to confer on me the grand cross of the Legion of Honor, provided I could obtain permission to wear it, a privilege which our ambassadors twice refused. His majesty also gave me permission to erect my furnace at the government cannon foundry at Ruelle, near Angouleme, to which place I went, with proper introductions, for the purpose of arranging all the necessary details. I also sent over from England several thousand special firebricks, etc., for the erection of the furnace.

But on resuming my further researches, after returning to London, an incident occurred which suddenly put a stop to the intended works at the Ruelle Gun Foundry, and, in fact, altered all my future plans and investigations.

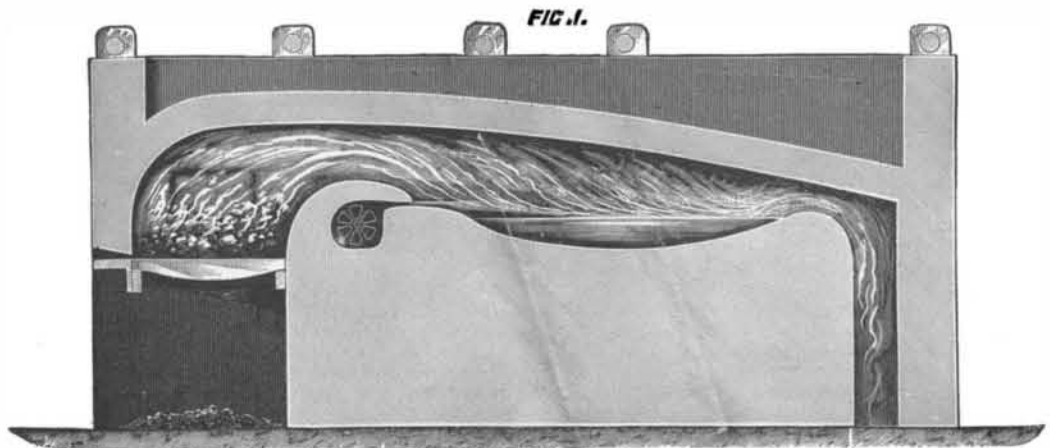
The furnace as it was then arranged is shown in vertical section by Fig. 1, and in horizontal section on a line passing through openings in the perforated hollow fire bridge by Fig. 2, where the narrowing of the body of the furnace is clearly shown, and the manner in which the jets of air were directed so as to produce an intense ignition of the combustible gases mingled with, and passing over, with the large volume of flame, from the overcharged firegrate.

The small scale on which this experimental furnace

was built (viz., a capacity of three hundred weight only) was much against my obtaining the high temperature necessary to melt a large proportion of steel in the pig iron bath. I was of course fully aware that a furnace of sufficient capacity to cast a five or a ten ton gun would produce a much higher temperature than it

Before dismissing this subject it may be interesting even at this distant period to speculate on what would have been the natural outcome of the open-hearth furnace experiments, had I not been so suddenly diverted from their further pursuit.

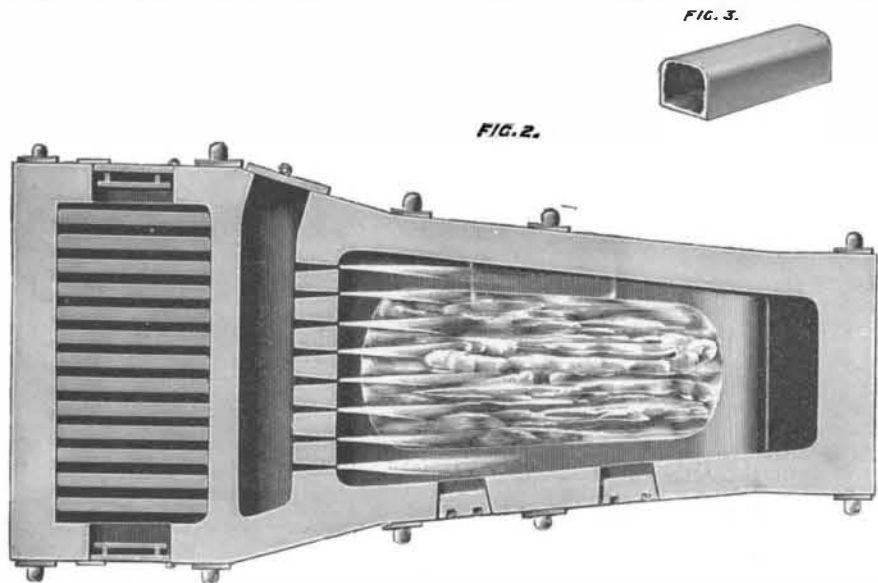
Such a furnace, with a forced draught and a capacity



REVERBERATORY FURNACE, 1855—VERTICAL SECTION.

was possible to attain in my small furnace, and also that a forced draught, obtained by closing in the ash-pit and forcing air into it, would also still further increase the temperature. That this forced draught was in my mind at the time, is shown by the fact that I took out a patent for the manufacture of cast steel dated October 17, 1855; that is, about two months after the casting of the model gun; in this patent I fully de-

scribed the forcing of air by a fan into the closed ash-pits of furnaces employed in the manufacture of cast steel; and it has often since occurred to me that, with the additional resources still untried, I did not act wisely in so suddenly abandoning these open-hearth experiments, in favor of an entirely different system, suggested to my mind by the incident before referred to. But with my impulsive nature and my intense de-



REVERBERATORY FURNACE, 1855—HORIZONTAL SECTION.

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This was about ten years prior to the first patent taken out by M. Emile Martin, and now generally known as the Siemens-Martin process. This patent was obtained in England in the name of Emile Martin only, and is dated August 18, 1865, or more than ten years after my patent of January 10, 1855. M. Emile Martin, in his patent, says: "The manufacture is effected upon the principle of fusion of iron or natural

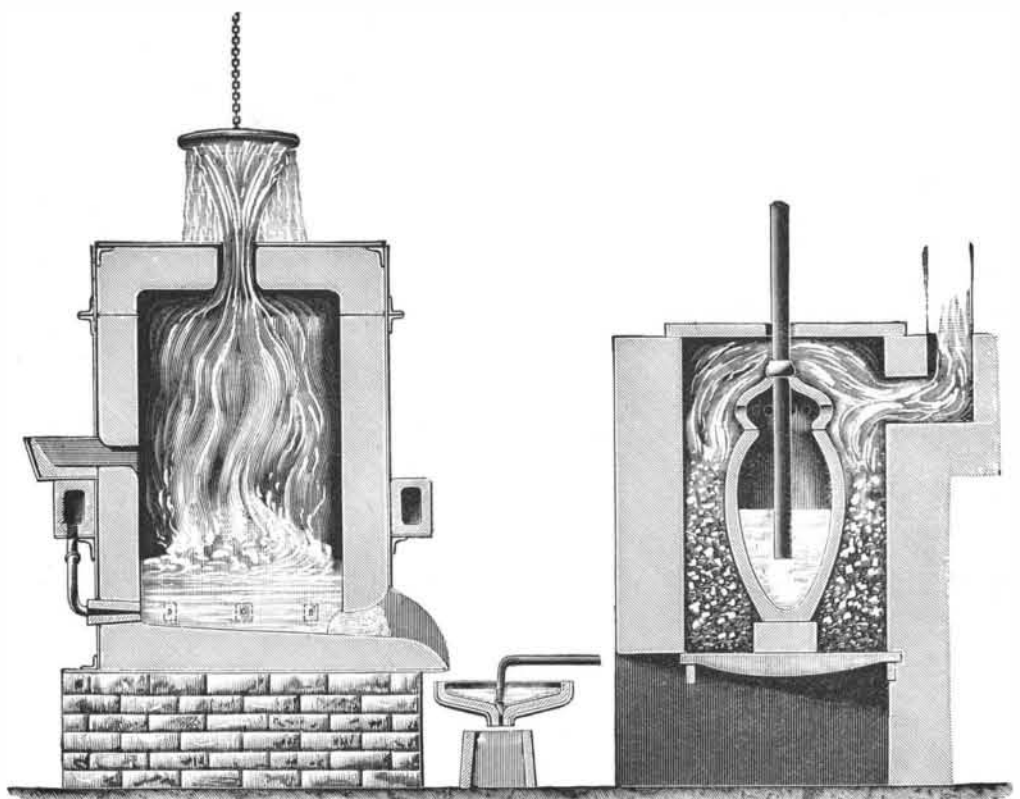


FIG. 5.—FIRST SEPARATE AIR-BLAST CONVERTER.

FIG. 4.—AIR FURNACE AND CRUCIBLE WITH INTERNAL BLOWPIPE.

sire to follow up every new problem which presented itself, I at once threw myself unreservedly into this new study, which seemed to open a way to the rapid production of bars, rails, and plates, of malleable metal direct from the blast furnace.

steel in a bath of cast iron, maintained at a white heat, in a reverberatory furnace such as a Siemens gas furnace."

I desire to say that I make no claim whatever to the prior invention of the Martin-Siemens process, nor do I

\* Presented at the New York meeting (December, 1896) of the American Society of Mechanical Engineers. From advance proofs furnished by the society.

for one moment assume that my patent of 1855 furnished any information which either of these gentlemen availed themselves of; but I think I am justified in saying that the fusion of steel in a bath of pig iron on the open hearth of a reverberatory furnace, which I had patented and successfully effected, was, to use a

when the remarkable incident I have twice referred to occurred in this way: Some pieces of pig iron in one side of the bath attracted my attention by remaining unmelted despite the great heat of the furnace, and I turned on a little more air through the fire bridge with the intention of increasing the combustion; on again

at Fig. 3, thus showing that atmospheric air alone was capable of wholly decarburizing gray pig iron and converting it into malleable iron without puddling or any other manipulation. It was this which gave a new direction to my thoughts, and, after due consideration, I became convinced that if air could be brought in contact with a sufficiently extensive surface of molten crude iron, the latter would rapidly be converted into malleable iron.

This, like all new problems, had a special interest for me, and I became impatient to test it by more than a laboratory experiment; without loss of time I had some fire clay crucibles made with perforated covers and also some fire clay blowpipes, which I joined to a three feet length of one inch gas pipe, the opposite end of which was attached by a piece of rubber tubing to a fixed blast pipe. This elastic connection permitted the easy introduction and withdrawal of the blowpipe into and out of the crucible, as shown at Fig. 4, which represents a vertical section of an air furnace, containing a crucible, which in this case represented the "converter." About ten pounds of molten gray pig iron about half filled the crucible, and thirty minutes' blowing was found to convert ten pounds of this gray pig iron into soft malleable iron. Here at least one great fact was elicited, viz., the absolute decarburization of molten crude iron without any manipulation, but not without fuel; for had not a very high temperature been kept up in the air furnace all the time this quiet blowing for thirty minutes was going on, it would have resulted in the solidification of the metal in the crucible long before complete decarburization had been effected. Hence arose the all-important question: Can sufficient internal heat be produced by the introduction of atmospheric air to retain the fluidity of the metal until it is wholly decarburized in a vessel not externally heated?

This I determined to try without delay. I fitted up a larger blast cylinder in connection with a twenty horse power engine which I had daily at work, and I also erected an ordinary foundry cupola capable of melting half a ton of pig iron. Then came the question of the best form and size for the experimental "converter." I had very few data to guide me in this, as the crucible converter was hidden from view in the furnace during the blow. I, however, found that slag was produced during the blow and escaped through the holes in the lid; this fact guided me to the construction of a very simple form of cylindrical converter, about four feet in height in the interior, which was sufficiently tall and capacious, as I believed, to prevent anything but a few sparks and heated gases from escaping through a central hole made in the flat top of the vessel for that purpose, as shown in vertical section at Fig. 5. The converter had six horizontal tuyeres arranged around the lower part of it; these were connected by six adjustable branch pipes, deriving their supply of air from an annular rectangular chamber extending around the converter, as shown.

All being thus arranged, and a blast of ten or fifteen pounds pressure turned on, about seven hundredweight of molten pig iron was run into the hopper provided on one side of the converter for that purpose. All went on quietly for about ten minutes. Sparks such as are commonly seen when tapping a cupola, accompanied by hot gases, ascended through the opening in the top of the converter, just as I supposed would be the case, but soon after a rapid change took place. In fact, the silicon had been quietly consumed, and the oxygen next uniting with the carbon, sent up an ever-increasing stream of sparks and a voluminous white flame; then followed a succession of mild explosions, throwing molten slags and splashes of metal high up into the air, the apparatus becoming a miniature volcano in a state of active eruption. No one could approach the converter to turn off the blast, and some low flat since covered roofs close at hand were in danger of being set on fire by the shower of red hot matter falling on them. All this was a veritable revelation to me, as I had in no way anticipated such violent results. However, in ten minutes more the eruption had ceased, the flame died down, the process was complete, and on tapping the converter into a shallow pan or ladle, and forming it into an ingot, it was found to be wholly decarburized malleable iron.

Such were the conditions under which the first charge of pig iron was converted into malleable iron in a vessel neither internally nor externally heated by fire.

I, however, desired to convert a second charge of pig iron, which had been put into the cupola, and in order to prevent this dangerous projection upward of sparks and molten slags, a temporary expedient was resorted to, which, however, failed in its object. I procured one of those circular checkered cast iron plates so much used in the London pavements to allow coals to be put into the cellars below the pavement. This plate, which was about a foot in diameter, was suspended by a chain at a distance of eighteen inches above the central opening, in the top of the converter, as shown in Fig. 5.

This as a mere temporary device was deemed sufficient to allow the conversion of another seven hundredweight charge to be effected without any danger of setting fire to the premises. The converting operation went on quietly as before, but when the eruption commenced I saw the suspended plate get rapidly red hot, and in a few minutes more it melted and fell away, leaving the chain dangling over the opening, and allowing the slags and splashes of metal to shoot upward as before. Thus it happened that the first converter which I had constructed was at once condemned as commercially impracticable, owing to this vertical eruption of cinder, and for this reason only. All attempts to lessen the violence of the process by a reduction of the number of tuyeres, or by lessening the diameter of the tuyere pipe orifices, or by diminishing the pressure of the blast, only resulted in a reduction of the necessary temperature, and in preventing the conversion of the molten pig iron into malleable iron. In one case the trial of a diminished area of tuyere opening resulted in nearly the whole charge of metal, after more than an hour's blowing, being converted into a solid mass of brittle white iron similar to ordinary refiner's plate metal. Indeed, I may say that the results of all my early investigations proved to me, beyond the possibility of doubt, a fact which has since been confirmed in every Bessemer steel works throughout Europe and America, viz., that rapidity of action ending in a violent eruption are absolutely necessary conditions of success; and when we take into consideration the fact

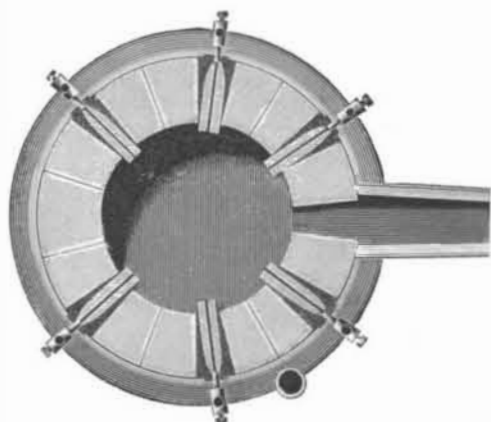


FIG. 8.—CONVERTER WITH UPPER CHAMBER—HORIZONTAL SECTION.

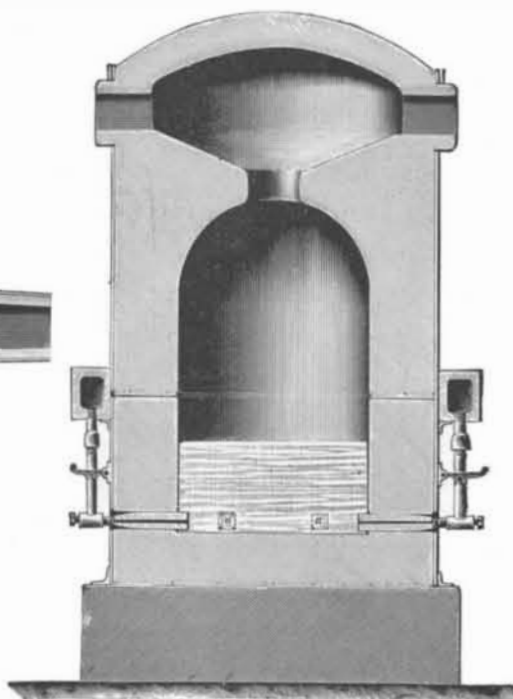


FIG. 7.—CONVERTER WITH UPPER CHAMBER—VERTICAL SECTION.

favorite expression of Mr. Gladstone, "approaching within measurable distance" of that now well-known and successful process.

On my return from the Ruelle gun foundry, I resumed my experiments with the open hearth furnace,

opening the furnace door after an interval of half an hour, these two pieces of pig still remained unfused. I then took an iron bar with the intention of pushing them into the bath, when I discovered that they were merely thin shells of decarburized iron, as represented

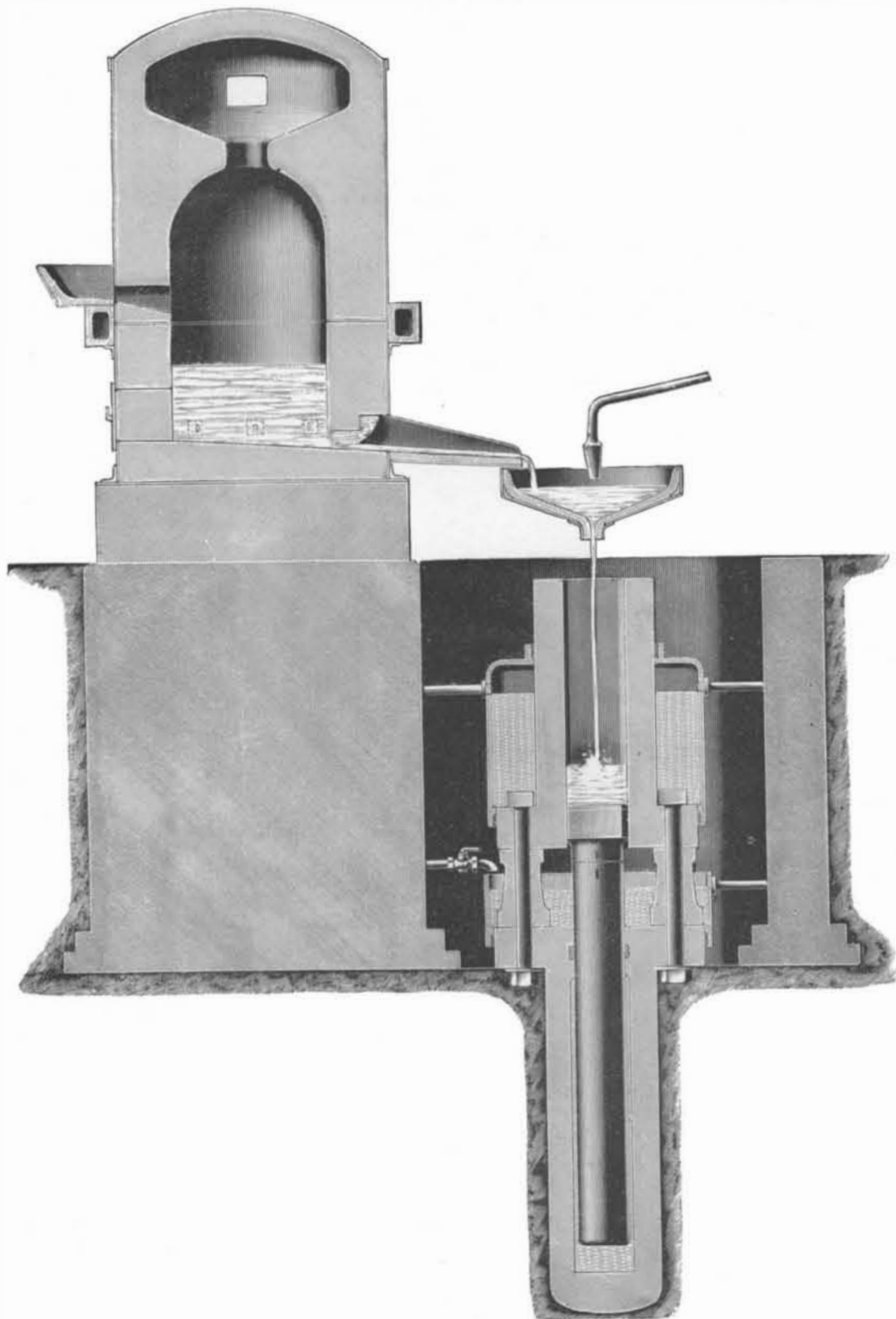


FIG. 9.—CONVERTER AND HYDRAULIC CASTING APPARATUS, 1856.

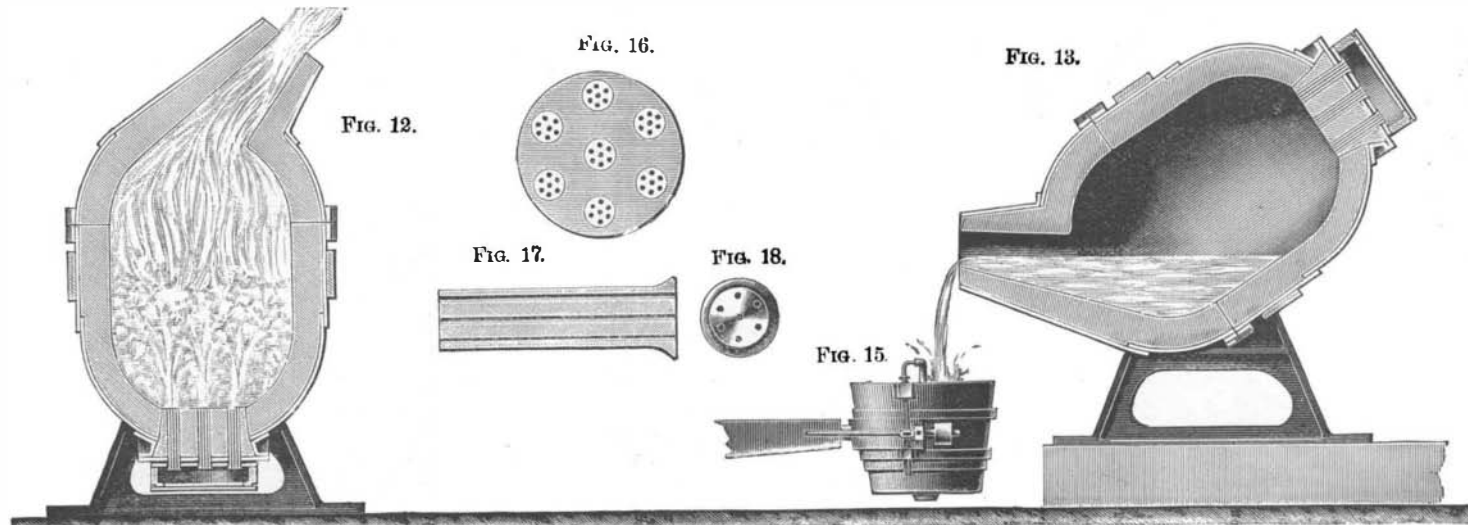


that the converted metal must be made to acquire an enormously high temperature, so that it may not be chilled in tapping, or pouring it out of the incandescent converter into a cold open ladle; that it be not chilled by the addition of a large quantity of much cooler metal employed to deoxidize it; that it does not chill and form a skull in the casting ladle during the comparatively long time required to form it into ingots: it is obvious that to carry out the Bessemer process successfully a temperature must be obtained very considerably above the mere melting temperature of malleable iron. In order to obtain this temperature it is necessary to drive powerful streams of air into the metal, so as to divide it into innumerable fiery globules diffused throughout the whole body of metal under operation, which for the time being may be likened to a fluid sponge, with the active combustion of carbon with

to Fig. 7, is represented in Fig. 9, showing in one side the hopper by which the molten iron is run in by a movable spout direct from the cupola. This view also shows the tapping hole open, and the spout which conducts the converted metal into a movable shallow pan or receiver supported by a long handle (not shown). A fire-brick plug, attached to a long handle, is fitted to a fire-brick ring or opening in the bottom of the pan, and prevents any debris from the tapping hole being carried into the mould.

As this apparatus was intended to exhibit the process, it was essential that an easy way should be provided for getting away the ingots and quickly repeating the process. This casting apparatus, constructed precisely as represented in Fig. 9, was erected at my bronze manufactory in London, about two months prior to my reading the "Cheltenham Paper." It is

my use of that, or any other pig iron, to recarburize the converted metal after the blow. There was also another absolute bar to Mr. Mushet's claims to the exclusive use of manganese in my process besides its public use in all countries by cast steel manufacturers, for in another patent of mine, dated May 31, 1856—that is, sixteen weeks prior to either of Mr. Mushet's three manganese patents—I gave the right to the public to alloy steel in my process with any metals previously used to alloy cast steel, by showing various ways in which these alloys might be made in my process, either by fluid or solid metals, or by metallic oxides. After this description I entered a disclaimer to their exclusive use, by means of which disclaimer and publication all alloys of steel might be made in my converting process which had hitherto been made by other cast steel manufacturers; so that the three patents of Mr. Mushet, em-



DETAILS OF MODERN BESSEMER CONVERTER, SHOWING POSITION DURING THE BLOW AND DURING DISCHARGE.

oxygen going on in every one of its myriads of ever-changing cavities.

It has been found that the union of carbon and oxygen takes place so rapidly at this high temperature as to produce a series of mild explosions which are scarcely noticed in the large converters in common use which have a space for the violent expansions, of some eight or ten feet in height above the normal level of the metal; in this space the violent action expends itself unseen, and is only partially recognized by a small additional quantity of slags leaping out of the mouth of the converter.

I had no sooner condemned my first cylindrical converter than I commenced to remedy its defects. The most obvious and ready way of doing this would have been simply to make an opening near the top, on one side of it, and thus allow the escape of the ejected matter to take place horizontally, and direct the discharge against a wall, or allow it to fall into a pit, etc., but I desired to prevent the discharge of metal splashes as far as possible, so that I determined on constructing the new converter with an upper chamber having an arched roof and a conical sloping floor. This converter is represented at Fig. 7 in vertical section, and at Fig. 8 in horizontal cross section, taken through the tuyeres. When a converter is so constructed the fluid matters which would otherwise pass vertically upward into the air are thrown against the arched roof, and any fluid

represented in vertical section in Fig. 9. The interior of the mould was 10 in. square and about 3 ft. in length, and was made in two pieces planed quite parallel and then permanently bolted together. The mould had a massive square lower flange resting on four dwarf columns, which stood on the square upper flange of a hydraulic cylinder. Massive bolts passed through these dwarf columns and through the square flanges, and thus united the ingot mould and hydraulic cylinder, in which a ram or plunger was placed, having a movable square head which accurately fitted the mould and formed a closely fitting movable bottom to it. Both the ram and the external surface of the mould were kept cool by a water jacket provided with supply and waste pipes. Matters being thus arranged, the converted metal was allowed to fall in a vertical stream from the receiver on to the head of the ram. The receiver was then removed, and water under pressure was turned on to the hydraulic cylinder as soon as the steel was solidified, when a beautifully square ingot, 10 in. square and weighing about 7 cwt., steadily rose and stood on end ready for removal, the head of the ram rising 1 or 2 in. above the top of the mould. There are, no doubt, many persons still living who witnessed this combined converting and casting apparatus in successful operation at my bronze works in London.

Two 10 in. square ingots made with this apparatus

bracing, as they did, every known means of employing manganese, and which were intended to corner me and control my patent, utterly broke down simply by having been anticipated in my two former patents. In consequence of this, Mr. Mushet did not think it worth while even to give me notice that in using spiegeleisen for recarburizing I was infringing his patents, nor did he make any attempt legally or otherwise to prevent me and all my English licensees from the free use of manganese; and I could never understand why American steel manufacturers paid a royalty for the use of these invalid patents.

In this same patent of May 31, 1856, I anticipated the invention of Sir Joseph Whitworth for casting steel under great pressure in order to render the ingots or castings more sound.

I stated that "I have observed that the cellular condition of cast steel, and more especially malleable iron castings, is more or less owing to the spontaneous disengagement of gaseous matter in the interior of the fluid mass. Now, it is well known that substances capable of vaporizing, or of evolving gaseous matters, do so with greater difficulty if surrounded by a dense atmosphere. I therefore make use of this peculiar property of matter in order to increase the soundness of ingots or other articles formed by casting in fluid malleable iron or steel." Then follow details of apparatus both for casting under gaseous pressure and also by the

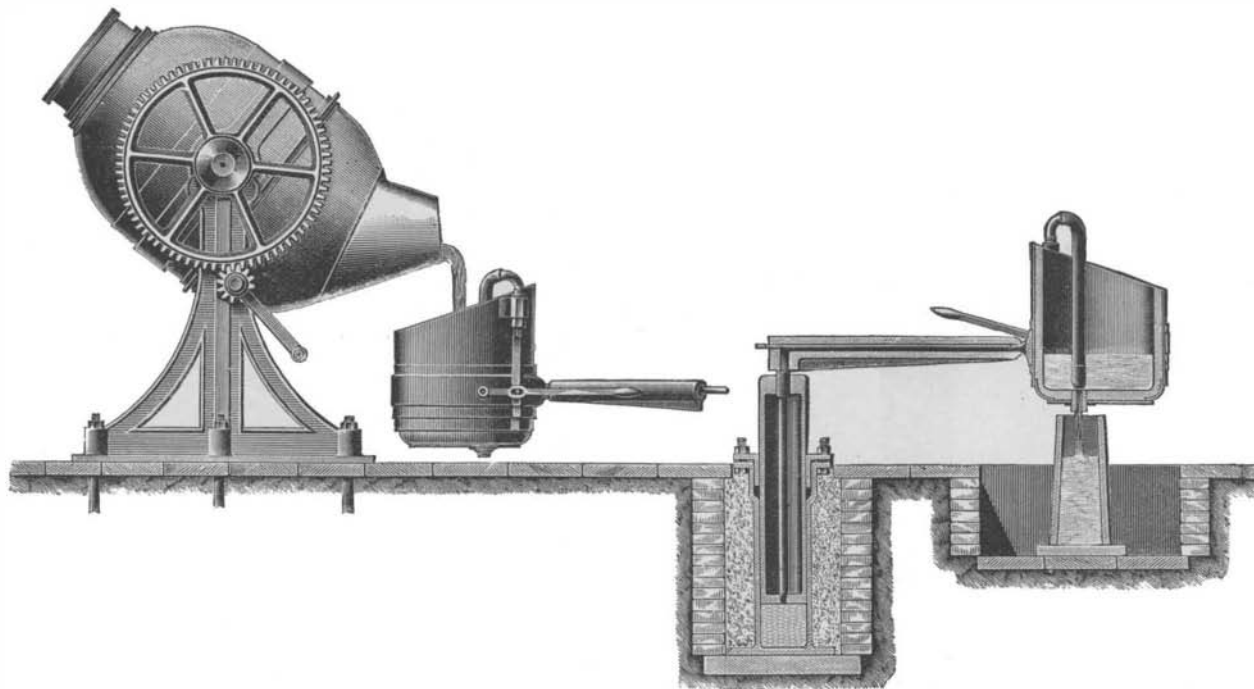


FIG. 19.—THE FIRST MOVABLE CONVERTER ERECTED AT THE BESSEMER STEEL WORKS, SHEFFIELD.

metal which may be thrown up falls upon the sloping floor of the upper chamber, and again returns to the lower one, while the flame and a portion of the slags find their way out of the two square lateral openings provided for that purpose. This upper chamber serves also as a receptacle for heating up any metal intended to recarburize or alloy with the steel in course of being converted. The section, Fig. 8, shows six well burned fireclay or plumbago tuyere pipes, fitted to openings left in the lining for that purpose. Their outer ends are made conical to facilitate the ramming in of loam around them, and which effectually holds them in position, and at the same time admits of their easy removal when worn out; a jointed piece of iron tube, with a catch to hold it in place, communicates the blast to each tuyere.

Another view of this converter, taken at right angles

were sent to the Dowlais Iron Works, in Wales, and, without hammering, were rolled into two flat-footed rails, on August 26, 1856—that is, thirteen days after the reading of the "Cheltenham Paper." They were rolled under the personal superintendence of Mr. Edward Williams, past president of the Iron and Steel Institute, where two pieces of these rails are still kept as examples of the early working of my process in London.

I may here call attention to the fact that in my patent, dated October 17, 1855, I described how the state of carburization of the converted metal might be regulated by the addition of molten pig iron after the blow had taken place; and as this patent was dated eleven months prior to Mr. Mushet's patent, claiming to recarburize the converted metal with the German pig iron known as spiegeleisen, Mr. Mushet could not prevent

direct action of a hydraulic plunger acting on the fluid steel during its solidification. I have no doubt whatever but that when Sir Joseph Whitworth applied for his patent for casting steel under the pressure of a hydraulic plunger, he was wholly unaware of what I had patented nine years previously, and it is only due to Sir Joseph to say that immediately on his patent agent pointing out this fact to him, he came to me and took a license under my patent, paying me a royalty on all the compressed steel made at his works up to the date at which my patent ceased to exist. That his special mechanical arrangements were an original invention I have never had any doubt whatever, and he had the additional merit of successfully carrying them out.

Before concluding this brief sketch of the moresalient points connected with the many forms of apparatus de-

signed by me to facilitate or improve my process, I must revert to the difficulties inseparable from a fixed converter, for in this form of apparatus much heat is dissipated by the necessity of blowing before running in the metal, and, what is still worse, the necessity of continuing the blast after the metal is converted and during the whole time of its discharge. Then there is the uncertainty as to the time employed in tapping, during which time the blowing must be continued, and there is also the difficulty of stopping the process, if anything goes wrong with the blast engine, or if a tuyere gives way.

These difficulties and many others caused me to search diligently for a remedy for these grave defects, which at that time appeared impossible to overcome, until the happy idea occurred to me of moving the converter on axes, so as to be able to keep the tuyeres above the metal until a charge of molten iron was run in, and which permitted the whole charge to be commenced at one and the same time, and admitted also of the cessation of blowing during its discharge. This movement of the converter also permitted a stoppage of the process to take place at any time for the removal of a worn out tuyere if necessary, and afforded great facilities for working the process. The peculiar form of the movable converter was a matter of great importance as there were several necessary requirements to provide for. First, in order to make the heavy lining secure when turned upside down, a more or less arched shape in all directions was necessary, and a long oval form seemed best adapted to the purpose, as it allowed some eight or nine feet in height for the metal to throw itself about in, without leaving the converter. Then the large mouth or outlet pointing to one side was necessary to direct the sparks to be all discharged in a direction away from the casting pit. After much study the precise form arrived at is shown at Figs. 12 and 13, of which Fig. 12 shows the position it occupies during the blow, and Fig. 13 shows the position it assumes during the discharge of the converted metal into a loamed-up casting ladle provided with a discharge valve at the bottom; the ladle can be moved from mould to mould by closing the valve during such movement, and on opening it a vertical stream descends into the mould, perfectly free from any admixture of slags. The advantage of this mode of filling the moulds will be understood when it is borne in mind that the latter are necessarily narrow, upright iron vessels. Now, it is well known that a stream of molten metal, poured from the lip of a ladle, will describe a parabolic curve in its descent, and tends to strike the further side of the mould before reaching the bottom. The surface of the cast iron mould so struck is instantly melted by the incandescent stream of steel, and the ingot and the mould thus become united, causing great inconvenience and destruction to the mould; nor is it easy in pouring the steel from a ladle to prevent some of the fluid slag floating on its surface from flowing over with the steel and spoiling the ingot. All of these difficulties are avoided by the valvular ladle discharging a vertical stream down the center of the mould, the quantity and flow being regulated with great facility by the hand lever on the side of the ladle.

Many other mechanical contrivances were necessary to perfect the process: such, for instance, as a patent blast engine with noiseless self-acting valves; the hydraulic casting crane carrying the casting ladle over every mould in the semicircular casting pit, and capable of rising and falling to correspond to the descent of the mouth of the converter when filling the ladle for casting. Then there are the direct-acting ingot cranes which clear the pit and refill it with another set of moulds rapidly and with little manual labor; then we have the elevated "valve stand," called in America "the pulpit," from which safe position a single workman can overlook the whole converting apparatus, controlling all their movements, governing the blast, working the hydraulic cranes, etc.

The mode of transmitting semirotary motion to the converter was another important question which I had to solve. I was of opinion that ordinary shafting and straps were out of the question in dealing with this fiery monster; five or ten tons of fluid metal had to be lifted in one direction, the load diminishing until the fluid running to the opposite end of the converter tended to drive the lifting gear in the reverse direction, so that if anything went wrong or slipped, the converter might swing itself round and discharge these five or ten tons of incandescent steel on to the floor or among the workpeople. This determined me to adopt the hydraulic apparatus now universally employed for governing the motions of the converter, for with this simple and reliable apparatus, a lad at safe distance can start it in motion or stop it instantly, can alter its speed of motion, and control the pouring out of ten tons of incandescent steel as easily as a lady pours out a cup of tea.

The first movable converter was erected at my steel works in Sheffield, and was moved by hand gearing, because at that early date I had not invented the hydraulic apparatus just described. This early converting apparatus did good work at Sheffield, and was constructed precisely as represented in Fig. 19, which shows also the first modification of the hydraulic casting crane, afterward elaborated and rendered suitable for casting heavy charges of steel.

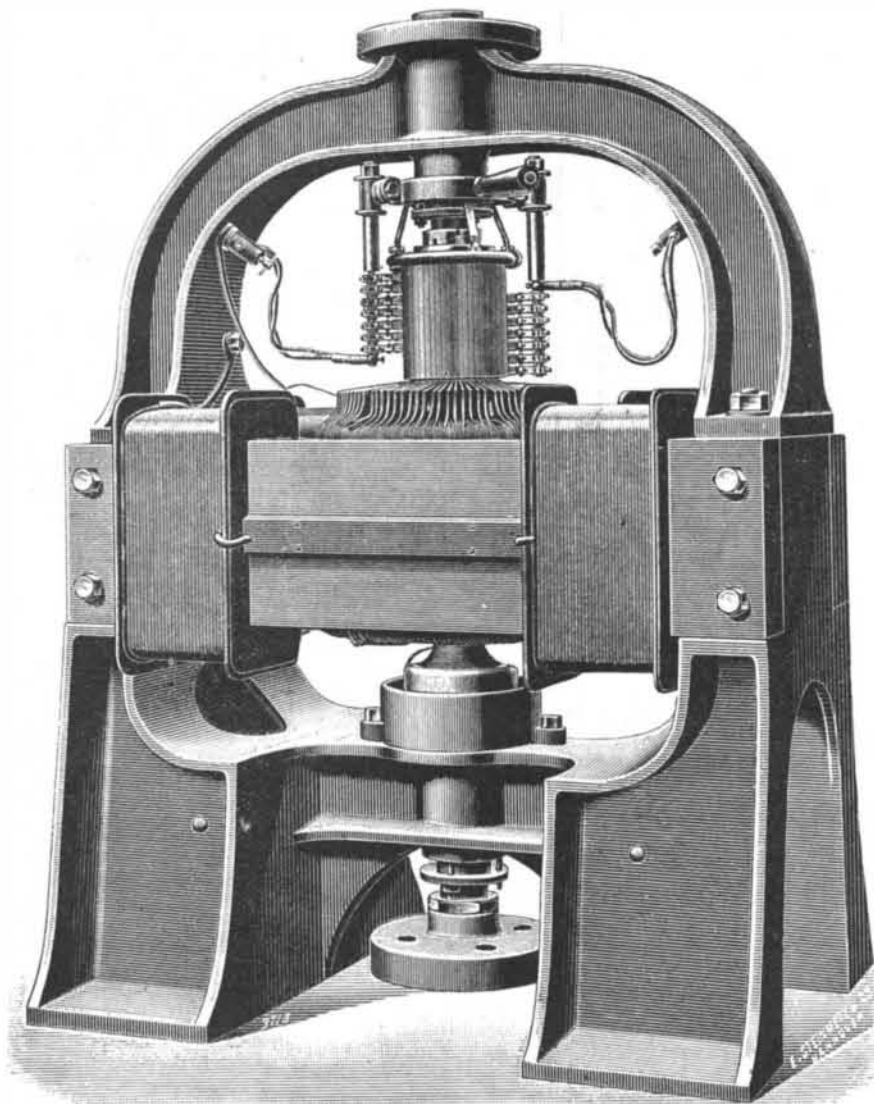
In conclusion, permit me to say that I have great pleasure in bringing before the many eminent engineers of which this society is composed a brief sketch of the early days of this invention, and although many interesting details are necessarily omitted, I trust that I have said enough to show how the Bessemer process originated, and how, by constant study and practical research, it was developed from a mere abstract theory, nearer and nearer to a degree of practical development at my bronze works in London till I was justified in erecting the Bessemer Steel Works in Sheffield, which still remain in active operation under the style of Henry Bessemer & Company, Limited. These works were established for commercial purposes and also to serve as a pioneer works or school, where the process was for several years exhibited to any iron or steel manufacturers who desired to take a license to manufacture under my patents; during that time all who desired to do so were allowed to bring their own pig iron, and personally, or by their managers, see it converted prior to taking a license.

And now, when I contemplate the great steel trade of Europe and America, with an annual production of

10,000,000 tons of Bessemer steel, I may be pardoned if I express some pride and satisfaction when I find that, notwithstanding the keen competition of rival manufacturers and the ceaseless activity and inventive talents of mechanical engineers, my original invention has not been swept away, but still exists in active operation in every steelmaking country in the world, intact in all its main features and in almost every detail as it left my hands forty years ago.

#### MOTOR FOR DRIVING CENTRIFUGAL PUMP.

WE illustrate one of a set of eight electric motors constructed by Messrs. Ernest Scott & Mountain, Limited, of the Close Works, Newcastle-on-Tyne, for driving the centrifugal pumps used for clearing the water from a large floating dock. As will be seen, the armature axis is placed vertically, being fitted with a coupling below to bolt on to another flange on the pump spindle. The field magnets are bolted to a heavy cast iron standard which also supports the bearings of the armature spindle. The commutator is located on the upper portion of the machine, being therefore easily accessible. The motors are designed



ELECTRIC MOTOR FOR CENTRIFUGAL PUMPS.

to run at 350 revolutions per minute, at which they develop 60 effective horse power.—Engineering.

#### THE REMOVAL OF IRON FROM DRINKING WATER.

AT Aurich, in East Friesland, a tube well 36 mm. in diameter was put down to a depth of 84 meters in alluvial ground for the purpose of supplying the barracks; but the water, although free from organic matter, was unfit for use on account of the large amount of iron in solution, amounting to 19.2 mgrms. per liter, and, when exposed to the air, became brown and turbid from the formation of ferric hydrate when the carbon dioxide which kept the iron in solution had escaped. As no other supply could be got, it was decided to purify it by the method adopted by C. Pieffe, the separation of the iron being facilitated by breaking up the mass of water into numerous fine streams so as to obtain the largest possible contact with the atmosphere. The apparatus consists of a rectangular iron scrubber 3 meters high, 2 meters long and 1 meter broad, filled with lumps of coke. The water is distributed by a series of perforated plates uniformly over the top of the coke column and passes downward into a collecting chamber below, and from thence through a sand filter bed 640 mm. thick, with about 11 square meters area, that of the scrubber being 2 square meters. The proportion of iron was diminished from 19.2 to 7.21 mgrms. per liter in the scrubber, and to 1.08 mgrms. after passing the filter. The apparatus was intended to treat  $3\frac{1}{2}$  cubic meters per hour, under which condition the rate of delivery per square meter was 1,750 liters in the scrubber and 380 liters in the filter.

The removal of the ochre deposit on the coke is effected from time to time by stopping the communication with the filter and allowing the water from the pump to flow for a short time in a single stream through each of the distributing plates in succession. The strong current thus obtained detaches the deposit. A similar coating accumulates on the top of the filter, rendering it nearly, if not quite, impermeable to water, so that about two meters of the upper part must be re-

newed at intervals of three or four weeks.—H. Schuster, Zeits. des Ing. und Arch. Ver. zu Hannover, 1894, 297; Proc. Inst. Civil Eng., 1894, 118, 34, 35.

#### FREEZING POINTS OF ORGANIC COMPOUNDS AND OF ALCOHOL.

THE peculiar regularity with which the boiling points of homologous organic compounds rise with the introduction of certain groups naturally led to the conclusion that a similar regularity ought to prevail with regard to the freezing points. In many cases, however, those compounds remained liquid at the low temperatures which can be produced in an ordinary laboratory. The Pietet Institute, at Berlin, has taken up these researches, of which Dr. Altschul gives a preliminary account in the Zeitschrift für die Gesamte Kälte-Industrie.

In the aromatic series, the methyl group produces a lowering of the freezing point; thus benzene freezes at  $+7^{\circ}$  Centigrade, toluene at  $-100^{\circ}$ , aniline at  $-8^{\circ}$ , methyl aniline was still liquid at  $-80^{\circ}$ . The substitution of hydrogen by chlorine raises the freezing point by a decreasing amount. In homologous acids like acetic acid (freezing point  $+16.5^{\circ}$ ), propionic acid ( $-24^{\circ}$ ), normal

butyric acid ( $-19^{\circ}$ ), the freezing points rise and fall, those with an odd number of carbon atoms having the lower freezing point. This was already established by Beyer.

Of several isomers the most symmetrical is most difficult to crystallize; isobutyric acid would not congeal at  $-80^{\circ}$ . The investigation of the behavior of mixtures induced Dr. Altschul first to inquire into the mixtures of various alcohols with water. The research was conducted in two ways, starting from absolute alcohol and adding water, and vice versa. The first series of experiments gave a hyperbola, the second, when more and more alcohol was admixed to the water, a series of straight lines joined by more or less regular curves. This would indicate that certain concentrations simply represent solutions of alcohol in water, like solutions of salts, while there are also certain hydrates; but the investigations are not concluded yet.—Trades Journal Review.

In the Havemeyer Building, New York City, they have recently put an Ingersoll air compressor in the engine room, and supply air to all the floors of the building. Any of the tenants who want air can have it. The Ingersoll-Sergeant people themselves will probably be the largest users, as they use air to run all their tools for exhibition purposes in their show room. The doors are opened by air, call bells are operated by air, letter presses are operated by air, and the furniture is dusted and carpets cleaned by compressed air. This is a new feature in office buildings, and may become a very popular one. Anybody that knows anything about compressed air knows that when air is compressed it is heated and when it is expanded it is cooled. Perhaps the time may come when a jet of air in the office, in the heat of summer, will be used as the most convenient and effective way of cooling.

The German miners are, in the opinion of the Berlin Reichsanzeiger, among the best paid in the world, their income ranging from \$225 to \$300 per year, with gifts of land and life insurance added.