No. 801,500. PATENTED OCT. 10, 1905.

F. E. YOUNG.

APPARATUS FOR MAKING STEEL.

APPLICATION FILED DEC. 20, 1902.

2 SHEETS—SHEET 1.

Fig. 2.

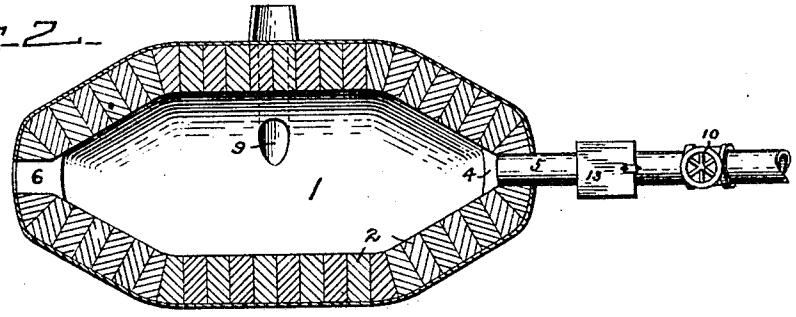


Fig. 1.

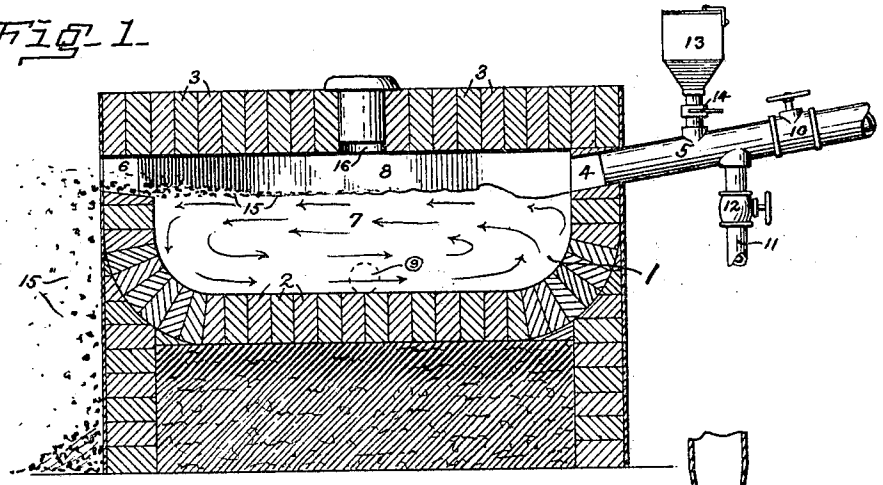
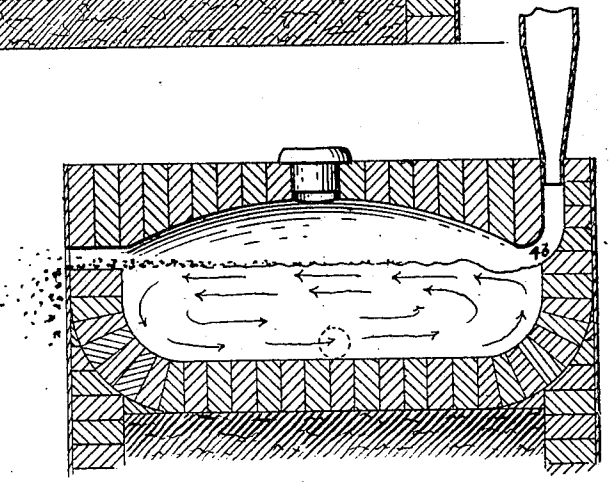


Fig. 3.



WITNESSES:

W. H. Stough

Elsie F. Mallory.

INVENTOR

Frank E. Young.

BY

Harry Grease.

ATTORNEY

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2 SHEETS—SHEET 2.

FIG. 5.

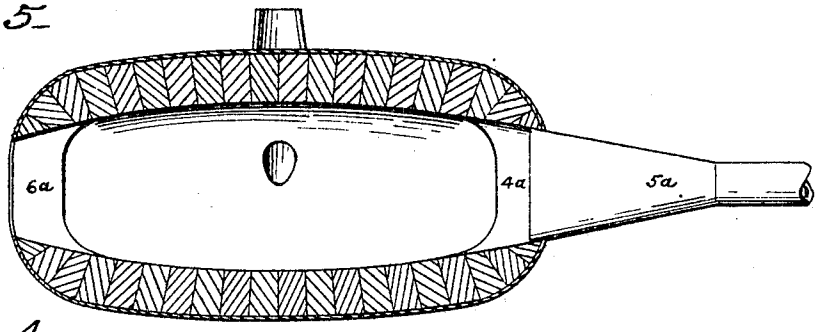


FIG. 4.

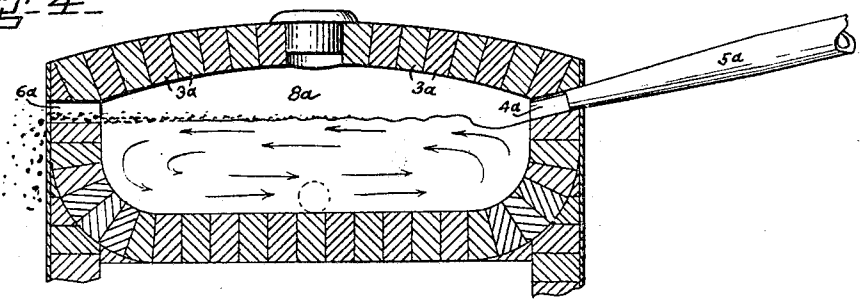


FIG. 7.

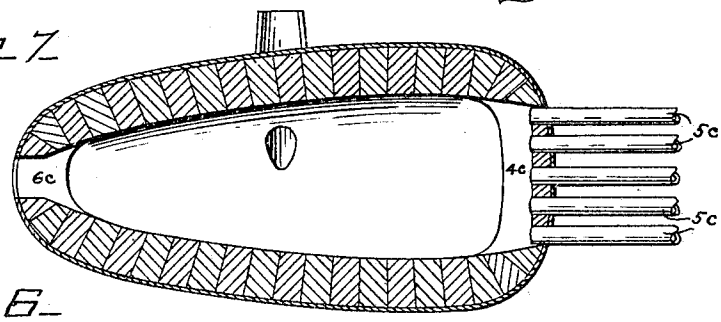
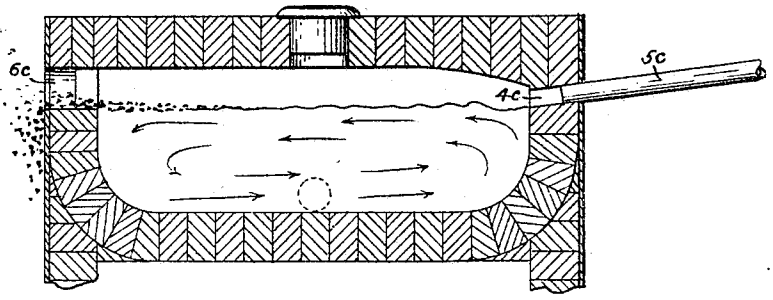


FIG. 6.



WITNESSES:

W. H. Stough.

Elsie T. Mallory.

INVENTOR

Frank E. Young,

BY

Harry Grease.

ATTORNEY

UNITED STATES PATENT OFFICE.

FRANK E. YOUNG, OF CANTON, OHIO.

APPARATUS FOR MAKING STEEL.

No. 801,500. Specification of Letters Patent. Patented Oct. 10, 1905.

Application filed December 20, 1902. Serial No. 135,961.

To all whom it may concern:

Be it known that I, FRANK E. YOUNG, a citizen of the United States, residing at Canton, in the county of Stark and State of Ohio, have invented a new and useful Apparatus for Making Steel, of which the following is a specification.

My invention relates to an apparatus for the pneumatic process of converting molten iron into malleable iron or steel; and the general objects of my invention are to oxidize the bath slowly, more perfectly, without agitation, and under complete control and at the same time to utilize the blast for removing the slag from the surface of the metal, with a resulting elimination of all the metalloids, including sulfur and phosphorus, which renders it possible to make steel out of scrap and low-grade irons.

By my apparatus I seek to combine all the distinctive features of the Bessemer process, the hand-puddling, and the open-hearth methods, which are, briefly, the rapid elimination of the metalloids in the Bessemer, the mechanical rolling in the hand-puddling, and the period of rest or still-melt in the open-hearth.

In converting crude iron into malleable iron or steel by the use of air or other aeriform oxidizing agents for the purpose of oxidizing the combustible elements held in combination with the iron several essential fundamental conditions underlie a perfection of the process and must be properly coördinated in one general action to produce the best results. First, it is essential that the oxidizing agent shall be brought into contact with all portions of the molten metal in a gradual, even, and continuous manner to secure a perfect oxidation of all parts without an overoxidation of any portion; second, it is important that all slag or scoria should be immediately removed from the molten metal as soon as it rises to the surface to prevent its mechanical admixture with the iron, as well as to prevent the sulfur, and especially the phosphorus, from recombining therewith, and, third, it is very important that the air should be as completely deoxidized as possible, so that no more air need be used than is necessary to thoroughly oxidize the combustible materials contained in the iron.

In the pneumatic processes heretofore used, whether practiced in a movable or stationary converter, the blast is injected either from the bottom, as in the Bessemer, or from the side below the surface of the metal, as in the Roberts, or just above the metal, as in the Tropenas; but in all these methods it is projected upward from the surface of the metal to an exit at or near the top of the converter, and the slag or scoria rises to the surface, where it accumulates and shields the iron from the air above or becomes more or less mixed or combined with the iron; but by my apparatus I project the blast under constant pressure directly across the entire surface of the molten metal, immediately removing therefrom all the slag or scoria as soon as it rises, setting the metal into a rolling motion by the mechanical action of the blast on its surface and holding the air in close contact with the metal in proportion to the pressure of the blast. This prevents any excessive agitation, and a perfect union of the oxygen of the air with the metalloids of the iron takes place with a less volume of blast.

In carrying out my process, which has been made the subject of another application for Letters Patent filed May 31, 1902, Serial No. 109,816, I make use of the converting apparatus illustrated in the accompanying drawings, in which—

Figure 1 is a vertical longitudinal section of one form of the converter; Fig. 2, a horizontal section of the same through the inlet and outlet apertures; Fig. 3, a vertical longitudinal section of another form of the converter; Fig. 4, a vertical longitudinal section of another form of the converter; Fig. 5, a horizontal section of the same through the inlet and outlet apertures; Fig. 6, a vertical longitudinal section of another form of the converter, and Fig. 7 a horizontal section of the same through the inlet and outlet apertures.

Similar numerals refer to similar parts throughout the drawings.

The converter is preferably made as an elongated vessel 1, reduced in width at the ends and having all the angles rounded. It is lined with a refractory material, as with the fire-brick 2, and the top is completely closed over, as by the fire-brick slabs 3, placed on edge. At one end is the inlet-aperture 4, in which is inserted the blast-pipe 5, and at the opposite end is the outlet-aperture 6, preferably of about the same size as the inlet-aperture.

The inlet and outlet apertures are located at or near above the surface of the molten metal 7, and the covering-slabs are only a short distance thereabove, so that the air-space 8 is as long and as wide as the surface

of the metal, but is not very deep. At a convenient place in the bottom of the vessel is the tap-hole 9, which is kept closed excepting when a charge is being tapped out.

The blast-pipe may be inclined slightly downward at its entrance into the converter, if desired, and the air-blast is derived from a positive blower, preferably of the Root type, (not shown,) and is preferably regulated by the valve 10. A gas or steam pipe 11 is connected with the blast-pipe at a convenient point and is provided with the regulating-valve 12, and there may be also one or more hoppers, as 13, provided with gates 14, for introducing powdered carbon, silicon, or other chemicals into the blast.

The details of the converter can be varied, as shown in Figs. 4 and 5, in which the inlet-aperture 4^a and the outlet-aperture 6^a are horizontally elongated and vertically contracted to be narrow slits extending substantially the full width of the converter just above the surface of the molten metal. In this form of converter the mouth of the blast-pipe 5^a is flared and flattened to fit the inlet-aperture and the width of the converter is made substantially the same throughout its length; but in order to retard the blast within the converter the close cover formed by the slabs 3^a is longitudinally arched from end to end, so that the cross-section of the air-space 8^a is increased in area in the middle part of the converter. This same general form of the converter can be varied by bringing in the blast from above at the end, as shown at 4^b in Fig. 3, and the details of the converter can be further varied, as shown in Figs. 6 and 7, in which the inlet-aperture 4^c is a narrow horizontal slit and the outlet-aperture 6^c is more nearly round, in which case the converter is formed of full width, with an arched cover at the inlet end, and is gradually contracted in width, with a flat cover at the outlet end. In this form of converter a number of small blast-pipes 5^c, located side by side in the inlet-aperture, can be used; but they must terminate a sufficient distance away from the edge of the molten metal so that the blast will have merged to completely cover the entire surface of the metal; but in all forms of the converter it is necessary that the outlet-aperture shall have an unobstructed mouth to permit a free exit of the slag and other impurities which are removed therethrough by action of the blast.

Upon entering the converter the blast spreads out and covers the whole surface of the molten metal, decreasing in speed as the air-space increases in cross area. At the other end it converges and leaves the converter at about the same speed with which it entered. The blast thus described causes a rolling motion of the molten iron, as indicated by the arrows, which could well be called a "pneumatic puddling," and removes the slag 15 and other impurities which rise to the surface, which could well be called a "pneumatic skimming." The consequent exposure of the entire surface of the metal and the retardation of the blast gives a free and prolonged opportunity for the chemical reactions of the oxygen of the blast with the metalloids of the iron, and the constant pressure of the air on the metal facilitates these reactions and also prevents somewhat a splashing or sputtering or an undue agitation of the metal.

For charging the converter several of the slabs 3 may be temporarily removed, and gates or other scrap from previous melting, or other steel or wrought-iron scrap, are placed in the vessel 1. Gas is then turned on with a light blast until the converter and contents are well heated, when the gas and air are turned off. Then some oxid of iron—as hammer, scale, or iron-rust—is thrown in, and the molten iron from a blast or other melting-furnace (not shown) is run in through ordinarily closed charging-holes, as 16. The heat of the molten iron melts the scrap and liberates the oxygen of the iron oxids, which combines with the silicon to form silica and reduces their iron to metallic condition. The silica rises to the surface and is immediately removed by the blast through the outlet-aperture instead of forming an acid slag by combining with the iron and manganese oxids. A light blast of air is then used until the first reaction subsides, which takes from two to four minutes, and the blast is then increased and continued as long as flame appears. As soon as the flame begins to disappear gas is turned on with the air-blast, and the gas and air are used in varying proportions, according to the product desired. More gas and less air produces a carbonizing or reducing flame, less gas and more air an oxiding-flame, while a neutral flame is produced by the two being mixed in such proportions as to produce perfect combustion.

The metal can be held almost indefinitely by using the neutral flame or carbonized by the reducing-flame or the carbon removed by the oxidizing-flame. The smelter can soon tell the proper proportions to use, and they are easily regulated by the respective valves. When the metal has been refined, I can add a proper amount of granulated ferromanganese, as from the hopper 13, and in a few minutes it is ready to pour.

The ferromanganese, as is well known, is added for the purpose of eliminating the occluded gases and for reducing the oxid of iron. I prefer, however, to use gas at this period of the blow, giving the bath a dead-melt and recarburizing to the point desired, as described above. In case I do not have gas then I use steam and oil or steam and carbon in a divided or powdered condition along

with the air. Silicon can also be added in this way at the end of the blow to render the metal more liquid, as for casting into molds.

In the process as described the oxygen of the oxids is set free by the heat of the molten iron and the iron of the oxids is reduced to metallic iron. The oxygen uniting with the metalloids of the molten iron generates an intense heat. The silicon first becomes oxidized and generates seven thousand eight hundred and thirty heat units (cent.) and forms silica, which is immediately removed by the blast and does not unite with the ferrous and manganese oxids to form an acid slag, as in the other pneumatic converters. It is this silicious or acid slag that prevents the oxidation of the phosphorus in the other converters. That the acid slag on the iron prevents the removal of the phosphorus in the acid-lined converters is well known by steel men, and by removing the silica as soon as it is formed, as is done by my converter, the phosphorus is left free to be oxidized. If, however, any of the phosphorus does combine with the iron oxids, it is removed in the after blow by reason of the hydrogen of the gas combining with the oxygen to form H_2O. Phosphorus by its combustion to phosphoric anhydrid generates five thousand seven hundred and forty-seven heat units, (cent.,) which generation of heat cannot be produced in the other converters, as explained above, and constitutes one of the very important advantages of my apparatus. The combustion of the carbon generates eight thousand heat units, (cent.) In the other processes it passes off as carbonic oxid and is imperfectly consumed, and, furthermore, the carbonic oxid, as is well known, carries away a great amount of heat; but in my converter the carbon is reduced to carbonic acid by reason of the pressure of the gases against the entire surface of the metal and their more tardy exit.

Owing to the more perfect combustion, there is not so much escape of flame as in the other converters, where the carbon monoxid escapes into the air to form carbon dioxid, so that while some of the silicon is removed without being oxidized and some of the graphitic carbon escapes in the form of "kish," yet owing to the use of less volume of blast and the lower pressure of the same I get a more perfect oxidation of the metalloids, and especially of the carbon and phosphorus. In this way I accomplish in an acid-lined converter that which has heretofore been possible only by the basic process.

At the end of the blow in all pneumatic converters the iron has the characteristics of burnt iron, being spongy or porous and brittle. This is owing to the large amount of occluded gases and the oxids of iron it contains. To remedy this, additions of spiegeleisen or ferromanganese are usually made in order to eliminate the oxygen and add carbon. I accomplish this in a cheaper, easier, and more perfect way by the gas-reducing flame, as described above. The hydrogen of the gas unites with the oxygen to form water, and the carbon unites with the iron. The carbonizing of the iron depends upon the length of time the reducing-flame is used. In case a test-piece shows it too high in carbon, the oxidizing-flame is used to reduce it. In this way steel of any degree of hardness can be made without additions.

In the Bessemer converter the action being so violent the blow must be finished in from fifteen to twenty minutes, while in my converter, the action being controlled and moderated by the limited blast, it can be extended for thirty or more minutes, and by reason of the extended period and the constant pressure of the gases on the metal the reactions are accomplished more perfectly and a better steel is made, especially for casting into molds, and at a less cost.

It has not been found practicable to use fluxes or chemicals with advantage in the pneumatic converters heretofore used, so no impurities have been removed excepting such as can be oxidized out, and sulfur and phosphorus have always remained, while in my converter fluxes can be added and their products removed by the blast. Additions—such as graphite, spiegeleisen, ferromanganese, or ferrosilicon—can be introduced in a powdered or granulated also form by way of the blast toward the latter part of the blow.

I am aware that gas, steam, graphite, silicon, &c., have been introduced into the converter by others; but they blow them into the molten iron at the bottom or side and into a converter open at the top, while in my process the fluxes and additions are introduced on the surface of the metal by the blast and into a converter open at the end near above the surface of the metal. After tapping out one charge the converter, being covered and having a thick lining, remains well heated and is ready for receiving another charge without any preliminary heating.

I have illustrated and described a converter having the inlet-aperture in the end just above the surface of the metal; but the nature of the process would not be affected if the inlet-aperture were in the end below the surface of the metal, excepting that in the latter case the blast would have to be strong enough to keep the iron out of the aperture.

Converters have generally been constructed on the pedestal and trunnion plan in order to charge and empty them quickly. This of course greatly increases the cost of construction and maintenance, as well as that of operating. As I have no accumulation of slag to empty and can readily tap out the finished steel I prefer to make the converter for my process stationary and of about two tons capacity; but it can be made of the tilting va-

riety and also varied in form and capacity to suit the exigencies of the case.

The converter necessary to practice my process is cheaper to construct, cheaper to operate, and requires less repair, as there are no submerged twyers to burn out and no movable parts to become deranged. There is, furthermore, a great saving in the use of a blast of small volume and low pressure, usually from two to four pounds per inch, instead of one large volume and high pressure, as of twenty to twenty-five pounds, which is necessary in the Bessemer converter and wherein only a minor portion of the oxygen is consumed.

By my converter I combine the three chief advantages of each of the three principal methods of making steel—viz., the Bessemer, the open-hearth, and the puddling methods. The three chief advantages of the Bessemer are great capacity, great uniformity, and great economy of labor and expense. The three chief advantages of the open-hearth are the use of steel-scrap, perfect control, and dead-melt, and the three chief advantages of hand-puddling are the use of inferior pig-iron and scrap, the removal of the sulfur and phosphorus, and the superior quality of the steel produced. Furthermore, I can make steel of uniform quality of molten iron taken directly from the blast-furnace.

What I claim as my invention, and desire to secure by Letters Patent, is—

An apparatus for converting iron into malleable iron or steel comprising a closed vessel, the cross area of the space above the metal being expanded from the ends toward the middle, a blast-inlet aperture at one end arranged to project a blast directly on the surface of the metal, a blast-outlet aperture at the other end, and means for producing a blast the current of which will expand at substantially the same rate as said cross area whereby the entire surface of the metal may be subjected to the action of the blast.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

FRANK E. YOUNG.

Witnesses:
CRYSTLE SUESS,
HARRY FREASE.