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F. E. YOUNG.

ART OF MAKING STEEL.

APPLICATION FILED MAY 31, 1902.

NO MODEL.

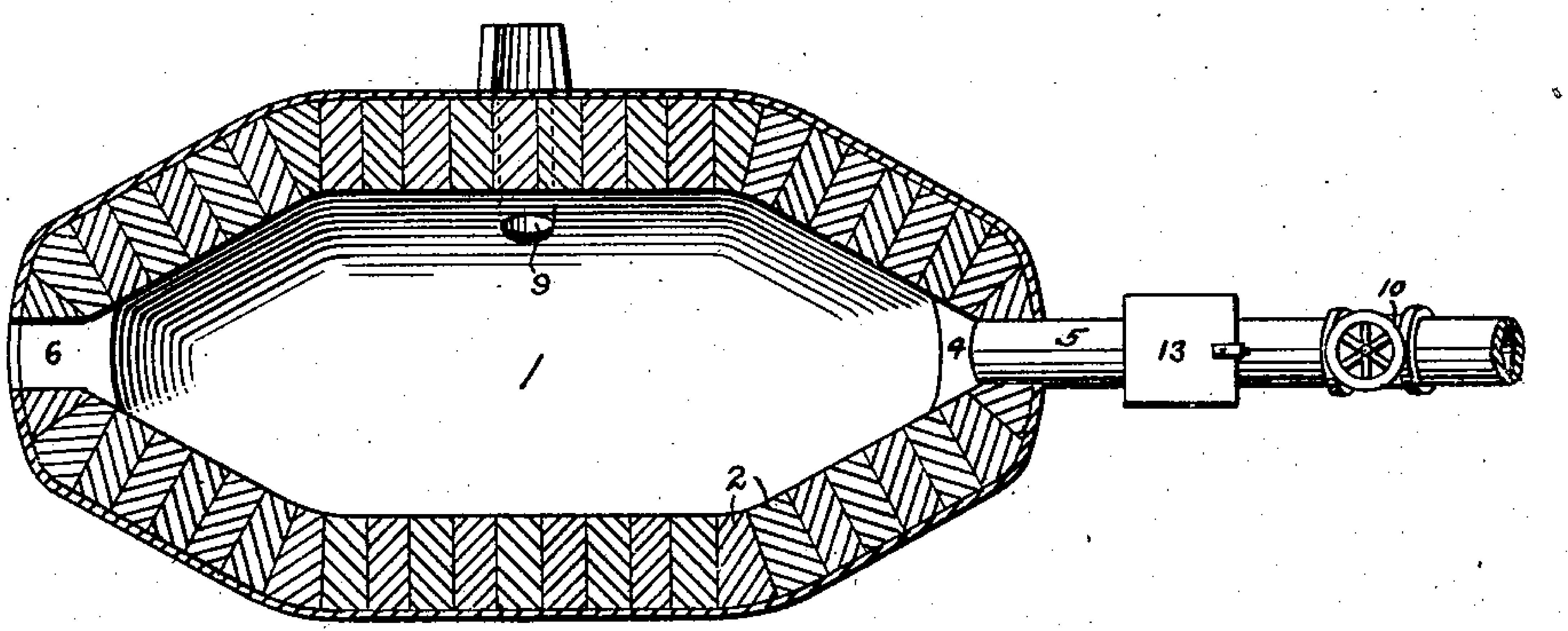

Fig. 2.

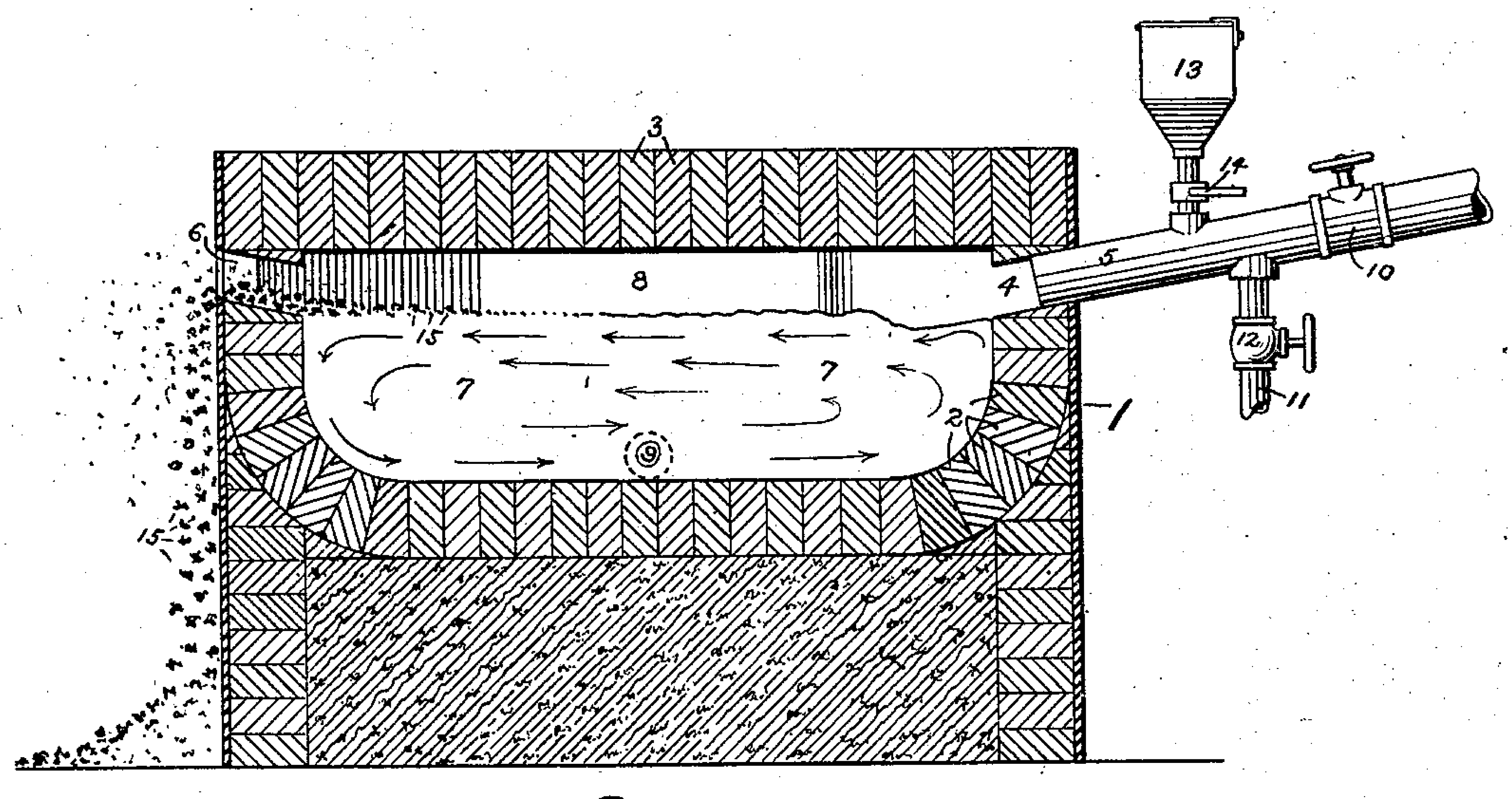

Fig. 1.

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UNITED STATES PATENT OFFICE.

FRANK E. YOUNG, OF CANTON, OHIO.

ART OF MAKING STEEL.

SPECIFICATION forming part of Letters Patent No. 724,770, dated April 7, 1903.

Application filed May 31, 1902. Serial No. 109,816. (No specimens.)

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 Improvement in the Art of Making Steel, of which the following is a specification.

My invention relates to an improvement in the pneumatic process of converting molten iron into malleable iron or steel; and the general objects of my improvement 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.

In my process 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 the 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 in my process 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 I make use of a converting apparatus, which apparatus will be made the subject of another application for patent and may be of the construction shown in the accompanying drawings, in which—

Figure 1 is a longitudinal vertical section of the converter, and Fig. 2 is a horizontal section through the inlet and outlet apertures.

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 also be one or more hoppers, as 13, provided with gates 14 for introducing powdered carbon, silicon, or other chemicals into 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 give 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 spluttering or an undue agitation of the metal.

For charging the converter several of the slabs 3 are removed from the mouth end 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 and the removed slabs are replaced. 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 oxidizing-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 (centigrade) and forms silica, which is immediately removed by the blast and does not unite with the ferrous and manganous oxids to form an acid slag, as in the other pneumatic processes. It is this silicious or acid slag that prevents the oxidation of the phosphorus in the other processes. 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 in my process, 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 afterblow 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, (centigrade,) which generation of heat cannot be produced in the other processes, as explained above, and constitutes one of the very important advantages of my method. The combustion of carbon generates eight thousand heat units, (centigrade.) 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 process 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 processes, 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 processes the iron has the characteristics of burned 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 process, the action being so violent, the blow must be finished in from fifteen to twenty minutes, while in my process, 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 processes heretofore practiced, so no impurities have been removed excepting such as can be oxidized out, and sulfur and phosphorus have always remained, while in my process fluxes can be added and their products removed by the blast. Additions, such as graphite, spiegeleisen, ferromanganese, or ferrosilicon, can also be introduced in a powdered or granulated 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 top at the end or 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 variety 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 of large volume and high pressure, as of twenty to twenty-five pounds, which is necessary in the Bessemer process and wherein only a minor portion of the oxygen is consumed.

By my process 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 the 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—

1. The process of simultaneously skimming, puddling, and converting molten iron into malleable iron or steel, consisting in projecting a blast along and across the entire surface of the molten metal.

2. The process of simultaneously skimming, puddling, and converting molten iron into malleable iron or steel, consisting in projecting a blast under pressure along and across the entire surface of the molten metal.

3. The process of simultaneously skimming, puddling, and converting molten iron into malleable iron or steel, consisting in projecting a blast and retarding the same along and across the entire surface of the molten metal.

4. The process of simultaneously skimming, puddling and converting molten iron into malleable iron or steel, consisting in projecting a blast and retarding the same at the first side and accelerating it at the farther

side along and across the entire surface of the molten metal.

5. The process of simultaneously skimming, puddling, and converting molten iron into malleable iron or steel, consisting in projecting a blast under pressure and retarding the same along and across the entire surface of the molten metal.

6. The process of simultaneously skimming, puddling and converting molten iron into malleable iron or steel, consisting in projecting a blast under pressure and retarding the same at the first side and accelerating it at the farther side along and across the entire surface of the molten metal.

7. The process of converting molten iron into malleable iron or steel, consisting in projecting alternate oxidizing and carbonizing blasts along and across the entire surface of the molten metal.

8. The process of converting molten iron into malleable iron or steel, consisting in projecting alternate oxidizing and carbonizing blasts under pressure along and across the entire surface of the molten metal.

9. The process of converting molten iron into malleable iron or steel, consisting in projecting alternate oxidizing and carbonizing blasts and retarding the same along and across the entire surface of the molten metal.

10. The process of converting molten iron into malleable iron or steel, consisting in projecting alternate oxidizing and carbonizing blasts under pressure and retarding the same along and across the entire surface of the molten metal.

11. The process of converting molten iron into malleable iron or steel, consisting in projecting alternate oxidizing, carbonizing and neutral blasts along and across the entire surface of the molten metal.

12. The process of converting molten iron into malleable iron or steel, consisting in projecting alternate oxidizing, carbonizing and neutral blasts under pressure along and across the entire surface of the molten metal.

13. The process of converting molten iron into malleable iron or steel, consisting in projecting alternate oxidizing, carbonizing and neutral blasts and retarding the same along and across the entire surface of the molten metal.

14. The process of converting molten iron into malleable iron or steel, consisting in projecting alternate oxidizing, carbonizing and neutral blasts under pressure and retarding the same along and across the entire surface of the molten metal.

15. The process of making malleable iron or steel, consisting in mixing heated scrap, iron oxid and molten iron and then projecting a blast along and across the entire surface of the metal.

16. The process of making malleable iron or steel, consisting in mixing heated scrap, iron oxid and molten iron and then projecting a blast under pressure along and across the entire surface of the metal.

17. The process of making malleable iron or steel, consisting in mixing heated scrap, iron oxid and molten iron and then projecting a blast and retarding the same along and across the entire surface of the metal.

18. The process of making malleable iron or steel, consisting in mixing heated scrap, iron oxid and molten iron and then projecting a blast under pressure and retarding the same along and across the entire surface of the metal.

19. In converting molten iron into malleable iron or steel, the process of adding fluxes by projecting them and skimming the molten metal, with a blast along and across the entire surface of the molten metal.

20. In converting molten iron into malleable iron or steel, the process of adding fluxes by projecting them and skimming the molten metal, with a blast under pressure along and across the entire surface of the molten metal.

21. In converting molten iron into malleable iron or steel, the process of adding fluxes by projecting them and skimming the molten metal, with a blast and retarding the same along and across the entire surface of the metal.

22. In converting molten iron into malleable iron or steel, the process of adding fluxes by projecting them and skimming the molten metal, with a blast under pressure and retarding the same along and across the entire surface of the molten metal.

23. In converting molten iron into malleable iron or steel, the process of making additions by projecting them with a blast along and across the entire surface of the molten metal.

24. In converting molten iron into malleable iron or steel, the process of making additions by projecting them with a blast under pressure along and across the entire surface of the molten metal.

25. In converting molten iron into malleable iron or steel, the process of making additions by projecting them with a blast and retarding the same along and across the entire surface of the molten metal.

26. In converting molten iron into malleable iron or steel, the process of making additions by projecting them with a blast under pressure and retarding the same along and across the entire surface of the molten metal.

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

FRANK E. YOUNG.

Witnesses:
HARRY FREASE,
JOSEPH FREASE.