May 10, 1960 B. M. LARSEN 2,936,230

METHOD FOR MAKING STEEL

Filed July 26, 1955

FIG. 1.

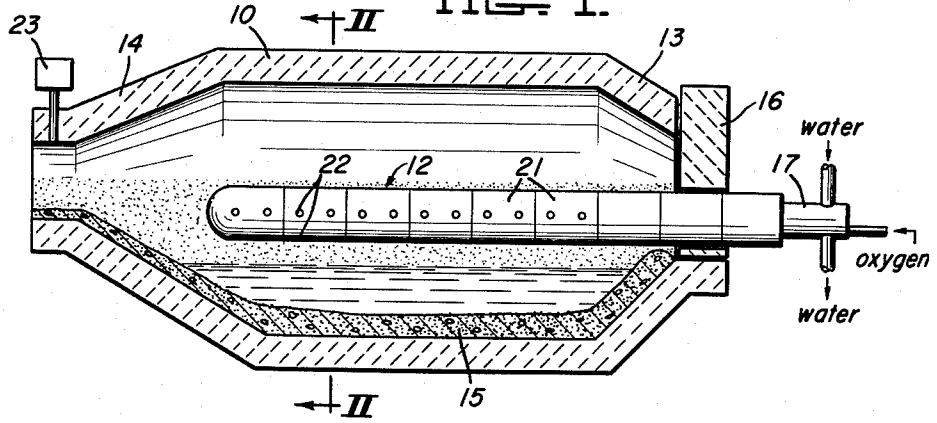


FIG. 2.

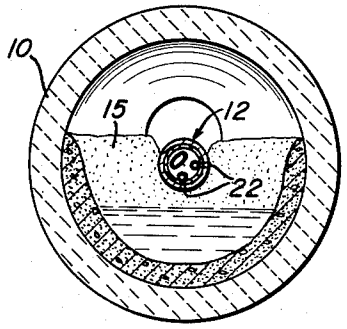


FIG. 3.

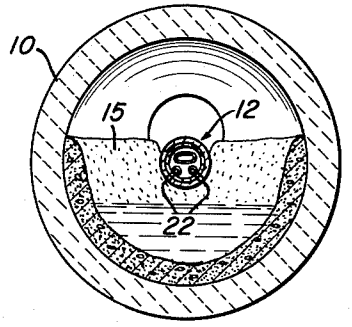


FIG. 4.

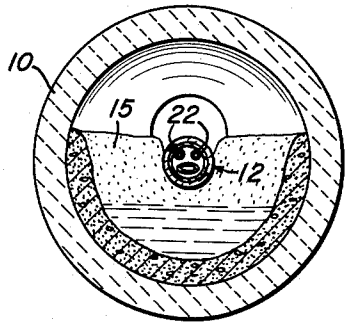
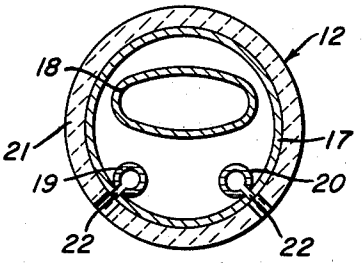


FIG. 5.



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METHOD FOR MAKING STEEL

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7 Claims. (Cl. 75—52)

This invention relates to an improved Bessemer-type apparatus and method for making steel.

The conventional Bessemer process for making steel involves blowing cold air into a bath of molten ferrous metal from the bottom and thereby oxidizing silicon and manganese and subsequently carbon from the iron. Modifications include the side-blown Bessemer or turbo-hearth process, in which air streams are directed at an angle against the upper surface of the bath, and the so-called "L-D" process in which a stream of commercially pure oxygen is directed vertically downward at the upper surface. A disadvantage common to all these processes is that they admit of little control of the composition of the final product. Another disadvantage is the large heat loss which results from oxidizing much of the carbon only to carbon monoxide within the vessel, and from heating large volumes of atmospheric nitrogen in the bottom and side-blown Bessemer processes. Consequently there is little excess heat available for melting scrap, and the charge must consist mostly of hot metal. Another disadvantage is excessive fuming and the resulting loss of iron. Acid Bessemer processes are notoriously ineffective for removal of phosphorous. Because of these limitations, most steel currently is made by the more expensive and time consuming open hearth process.

An object of the present invention is to provide an improved Bessemer-type apparatus and method which largely overcome the disadvantages of previous Bessemer processes.

A further object is to provide an improved Bessemer-type apparatus and method which (*a*) minimize heat losses from the vessel and (*b*) utilize all of the potential heat of oxidation, and thus permit larger proportions of scrap in the charge.

A further object is to provide an improved apparatus and method of this type which afford most of the advantages of an open hearth in diversity of materials that can be handled and control over the composition of the steel produced.

In accomplishing these and other objects of the invention, I have provided improved details of structure, a preferred form of which is shown in the accompanying drawing, in which:

Figure 1 is a diagrammatic longitudinal section of my improved steel making apparatus;

Figure 2 is a cross section on line II—II of Figure 1 showing the parts in the positions they occupy at early stages of a heat;

Figure 3 is a view similar to Figure 2, but showing the parts at a later stage;

Figure 4 is another similar view, but showing the parts at a still later stage; and

Figure 5 is a cross section on a larger scale of the lance embodied in my apparatus.

As best shown in Figure 1, my apparatus comprises essentially a vessel **10** and a lance **12**. This vessel is generally cylindrical, but has tapered portions **13** and **14** at its charging and pouring ends respectively. Normally

the longitudinal axis of the vessel is horizontal, but it is mounted by any conventional means not shown to tilt in either direction. The mounting also includes means not shown to rock the vessel on its longitudinal axis through an arc up to about 45°. The bottom of the vessel has a lining **15** of a basic or neutral refractory. The charging end has a door **16**, while the pouring end is open. The lance **12** removably extends into the vessel approximately on its longitudinal axis. The lance includes a water cooled pipe **17**, a water inlet tube **18** within said pipe, and a pair of oxygen inlet tubes **19** and **20** also within said pipe. The exterior of the pipe **17** carries a series of refractory sleeves **21**. The oxygen inlet tubes **19** and **20** extend substantially the length of the pipe **17** and are fixed adjacent the inner circumference thereof on radii spaced about 90° apart, although the exact angle is not critical. The tubes and the pipe have a series of mating jet openings **22** along the length of the tubes spaced at intervals of about three to five inches. Preferably a recorder **23** is attached to the vessel **10** adjacent the pouring end to indicate the oxygen content of the off-gases.

According to my steel making method, the vessel **10** is first preheated to about 2500–2800° F. in any conventional way, such as by insertion of a fuel-oxygen burner in place of the lance **12**. The vessel is charged with ferrous material, which can include up to about 30 percent scrap and the remainder hot metal, plus a flux of burnt lime in an amount equivalent to about 60 to 80 pounds burnt lime per ton of steel produced. The silicon content of the initial charge is about 0.60 to 1.2 percent. The door **16** is installed and the lance **12** inserted in the position shown in Figure 2, that is, with one row of jet openings **22** directed vertically downward at the surface of the charge.

The oxygen inlet tube **19** or **20** whose jet openings are directed downwardly is connected to a source of commercially pure oxygen under relatively high pressure sufficient to deliver oxygen at a rate of about 15 to 18 pounds per hour per opening. At the same time the vessel **10** may be rocked on its longitudinal axis. Silicon and manganese in the charge oxidize and furnish heat for melting the solid constituents. The combined effect of the rocking motion and the subdivision of the oxygen into many small streams prevents over-concentration of oxygen at any one point. The lime combines with silica formed by selective oxidation of silicon and forms a liquid slag, which also contains some iron oxide and manganese oxide. At this stage there is very little oxidation of carbon, and little fuming. However, some carbon monoxide forms and may be burned with low pressure oxygen introduced via the other oxygen inlet tube **19** or **20** whose jet openings are directed toward the side. Preferably the oxygen introduced in this way is sufficient to leave a small amount of free oxygen (1 to 2 percent) in the off-gases from the vessel, as indicated by the recorder **23**.

After about 6 to 12 minutes the silicon content of the charge drops to about 0.05 to 0.20 percent, the volume and the fume content of the off-gases increase, and the rates of manganese and carbon oxidation increase. Typically a bath whose initial temperature is 2300–2400° F. reaches a temperature of 2500–2700° F. at this stage and the solid materials are mostly dissolved. As an example, the bath might have the following initial liquid composition:

C—4.0%, Mn—1.7%, S—0.025%, Si—0.88%

As the silicon concentration is blown down to 0.030 percent, the composition may become:

Metal: C—3.9%, Mn—1.1%, S—0.015%, Si—0.30%
Slag: SiO_2—20%, CaO—25%, MnO—13%, FeO—25%, MgO, Al_2O_3, Fe_2O_3—balance

As an additional step in the procedure (not essential, however), oxygen rate can now be decreased sharply or the oxygen cut off entirely for about 10 to 20 minutes to give a readjustment in the metal and slag, and the composition becomes in this case:

Metal: C—3.80%, Mn—1.4%, S—0.014%, Si—0.15%
Slag: SiO_2—31%, CaO—36%, MnO—10%, FeO—10%, MgO, Al_2O_3, Fe_2O_3—balance

With the vessel stationary, the lance 12 is withdrawn, whereupon the vessel may be tilted toward the charging end to pour off most of the slag. Additional lime may also be charged.

The lance 12 is reinserted in the vessel 10, but in the position shown in Figure 3 with the jet openings of both tubes 19 and 20 directed obliquely downward. Both tubes are connected to a source of commercially pure oxygen under low pressure sufficient to deliver oxygen at a rate of about 5 to 10 pounds per hour per jet opening. The actual oxygen input is adjusted to yield 1 to 4 percent free oxygen in the off-gases from the vessel. The vessel may be stationary or may be rocked as before. As the slag absorbs oxygen and the silicon in the metal drops to a few hundreds of one percent, a carbon boil slowly begins. The boil increases the rate of oxygen absorption, and rocking of the vessel can be stopped. The jets blow oxygen gently over the slag surface, and little or no oxygen contacts the metal directly. Instead oxygen reaches the metal exclusively by absorption and diffusion plus convection through the slag layer. The rate of boil increases, and oxidation of phosphorous, manganese and carbon proceeds, the carbon dropping at a rate as high as 300 points (3.00%) per hour. Oxygen above the bath effectively oxidizes the carbon monoxide evolved from the metal to carbon dioxide.

After 40 to 80 minutes the lance is rotated 180° to the position shown in Figure 4. The oxygen rate is diminished to leave only a fraction of one percent free oxygen in the off-gases. As the boil dies down, the oxygen is cut off and the lance removed. The bath is now checked for temperature, carbon content, and slag basicity. More cold scrap or pig or lime can be charged. If further carbon drop is needed (usual case), the lance is restored to the position shown in Figure 3 and low pressure oxygen introduced for a short time. Finally the lance is returned to the position shown in Figure 4 or removed to allow a slow approach to final slag composition and carbon level in the refined bath. The vessel is tilted toward its pouring end to remove the charge.

The total heat time is about two to two and a half hours, somewhat longer than for the usual Bessemer processes and its modifications previously discussed. However, the composition of the final product can be controlled as closely as in an open hearth process. The amount of cold material that can be melted is larger than in the bottom or side blown processes, and at least as large as in other oxygen Bessemer processes. The amount of fine dust carried from the vessel is but a small fraction of that from other Bessemer processes, and there is less erosion of refractory surfaces.

While I have shown and described only a single embodiment of my invention, it is apparent that modifications may arise. Therefore, I do not wish to be limited to the disclosure set forth but only by the scope of the appended claims.

I claim:

1. A top-blowing method of making steel comprising charging a vessel with ferrous metal which is at least partially molten and a lime flux, introducing commercially pure oxygen to the vessel in high pressure streams directed substantially vertically downwardly from above the charge to oxidize silicon from the metal, melting solids in the charge and forming a slag layer thereon exclusively by heat obtained through oxidation of constituents of the charge, thereafter introducing commercially pure oxygen to the vessel above the charge in streams directed obliquely at the surface of the charge under a pressure insufficient to penetrate the slag layer mechanically, the number of said second named streams being greater than the number of said first named streams, and transferring oxygen to the metal for oxidizing carbon exclusively by absorption and diffusion plus convection through said slag layer.

2. A top-blowing method of making steel comprising charging a vessel with ferrous metal consisting of cold solids up to about 30 percent and the remainder hot metal and a lime flux, introducing commercially pure oxygen to the vessel in high pressure streams directed substantially vertically downwardly from above the charge to oxidize silicon from the metal, melting solids in the charge and forming a slag layer thereon exclusively by heat obtained through oxidation of constituents of the charge, thereafter introducing commercially pure oxygen to the vessel above the charge in streams directed obliquely at the surface of charge under a pressure insufficient to penetrate the slag layer mechanically, the number of said second named streams being greater than the number of said first named streams, and transferring oxygen to the metal for oxidizing carbon exclusively by absorption and diffusion plus convection through said slag layer.

3. A top-blowing method of making steel comprising charging a vessel with ferrous metal consisting of cold solids up to about 30 percent and the remainder hot metal and a lime flux in an amount equivalent to about 60 to 80 pounds burnt lime per tone of steel produced, simultaneously rocking the vessel and introducing commercially pure oxygen thereto in a multiplicity of high pressure streams directed substantially vertically downwardly from above the charge to oxidize silicon from the metal, melting solids in the charge and forming a slag layer thereon exclusively by heat obtained through oxidation of constituents of the charge, thereafter introducing commercially pure oxygen to the vessel above the charge in streams directed obliquely at the surface of charge under a pressure insufficient to penetrate the slag layer mechanically, the number of said second named streams being greater than the number of said first named streams, and transferring oxygen to the metal for oxidizing carbon exclusively by absorption and diffusion plus convection through said slag layer.

4. A top blowing method of making steel comprising charging a vessel with ferrous metal consisting of cold solids up to about 30 percent and the remainder hot metal and a lime flux in an amount equivalent to about 60 to 80 pounds burnt lime per ton of steel produced, introducing commercially pure oxygen to the vessel in a multiplicity of high pressure streams directed substantially vertically downwardly from above the charge to oxidize silicon from the metal, melting solids in the charge and forming a slag layer thereon exclusively by heat obtained through oxidation of constituents of the charge, pouring off most of said slag layer, thereafter introducing commercially pure oxygen to the vessel above the charge in streams directed obliquely at the surface of charge under a pressure insufficient to penetrate the slag layer mechanically, the number of said second named streams being greater than the number of said first named streams, and transferring oxygen to the metal for oxidizing carbon exclusively by absorption and diffusion plus convection through said slag layer.

5. A top-blowing method of making steel comprising preheating a vessel to about 2500–2800° F., charging the vessel with ferrous metal consisting of cold solids up to about 30 percent and the remainder hot metal and a lime flux in an amount equivalent to about 60 to 80 pounds burnt lime per ton of steel produced, introducing commercially pure oxygen to the vessel in a multiplicity of high pressure streams directed substantially vertically downwardly from above the charge to oxidize silicon

from the metal, melting solids in the charge and forming a lime-silicate slag layer thereon containing some iron and manganese oxides exclusively by heat obtained through oxidation of constituents of the charge, pouring off most of said slag layer, thereafter introducing commercially pure oxygen to the vessel above the charge in streams directed obliquely at the surface of charge under a pressure insufficient to penetrate the slag layer mechanically, the number of said second named streams being greater than the number of said first named streams, and transferring oxygen to the metal for oxidizing carbon exclusively by absorption and diffusion plus convection through said slag layer.

6. A top-blowing method of making steel comprising charging a vessel with ferrous metal which is at least partially molten and has a silicon content of at least 0.60 percent and a lime flux, introducing commercially pure oxygen to the vessel in a multiplicity of high pressure streams directed substantially vertically downwardly from above the charge to oxidize silicon from the metal, melting solids in the charge and forming a slag layer thereon exclusively by heat obtained through oxidation of constituents of the charge, discontinuing the high pressure oxygen introduction when the silicon content of the metal falls below 0.20 percent, thereafter introducing commercially pure oxygen to the vessel above the charge in streams directed obliquely at the surface of charge under a pressure insufficient to penetrate the slag layer mechanically, the number of said second named streams being greater than the number of said first named streams, and transferring oxygen to the metal for oxidizing carbon exclusively by absorption and diffusion plus convection through said slag layer.

7. A top-blowing method of making steel comprising preheating a vessel to about 2500–2800° F., charging the

vessel with ferrous metal consisting of cold solids up to about 30 percent and the remainder hot metal and lime flux in an amount equivalent to about 60 to 80 pounds burnt lime per ton of steel produced, the metal of the charge having a silicon content of at least 0.60 percent, introducing commercially pure oxygen to the vessel in a multiplicity of high pressure streams directed substantially vertically downwardly from above the charge to oxidize silicon from the metal, melting solids in the charge and forming a lime-silicate slag layer thereon containing some iron and manganese oxides exclusively by heat obtained through oxidation of constituents of the charge, discontinuing the high pressure oxygen introduction and pouring off most of said slag layer when the silicon content of the metal falls below 0.20 percent, thereafter introducing commercially pure oxygen to the vessel above the charge in streams directed obliquely at the surface of charge under a pressure insufficient to penetrate the slag layer mechanically, the number of said second named streams being greater than the number of said first named streams, and transferring oxygen to the metal for oxidizing carbon exclusively by absorption and diffusion plus convection through said slag layer.

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