United States Patent [19]

Rote

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[54] **TUYERE CONSTRUCTION**

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[73] Assignee: **United States Steel Corporation,** Pittsburgh, Pa.

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[52] **U.S. Cl.** **266/41,** 266/35

[51] **Int. Cl.** **C21c 5/48**

[58] **Field of Search** .... 266/35, 36 P, 41; 75/60

[56] **References Cited**

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Primary Examiner—Gerald A. Dost
Attorney, Agent, or Firm—Ralph H. Dougherty

[57] **ABSTRACT**

A tuyere construction for a Q-BOP steelmaking vessel has an inner tube of a noncircular oblong cross-sectional shape and an outer tube of like shape, the inner and outer tubes being spaced apart to form an annular opening therebetween. The opening usually has a spacing substantially equal all around the inner tube.

9 Claims, 8 Drawing Figures

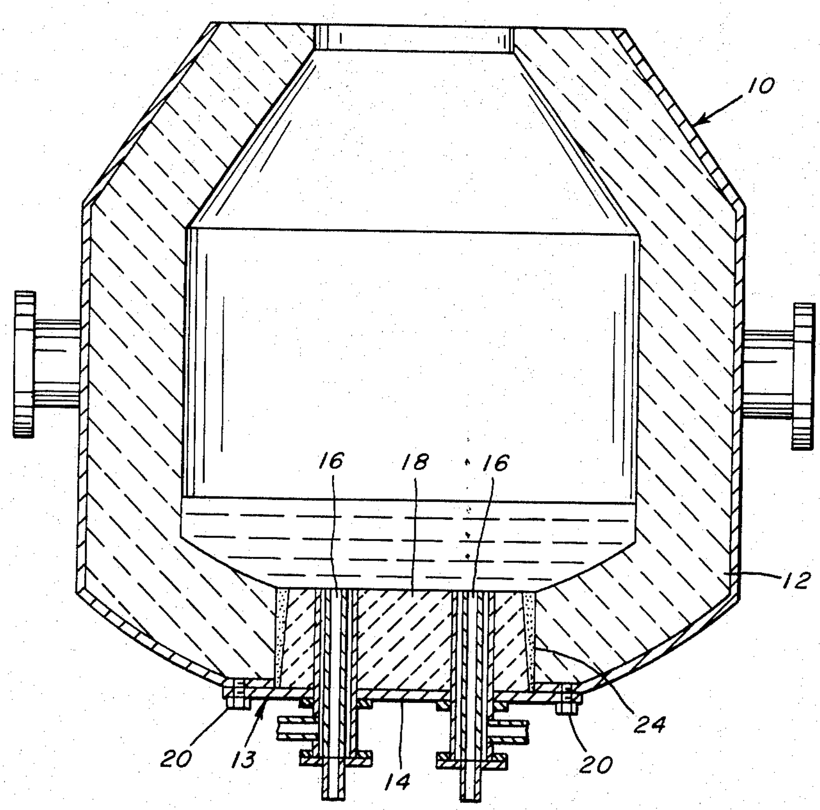

FIG. 1.

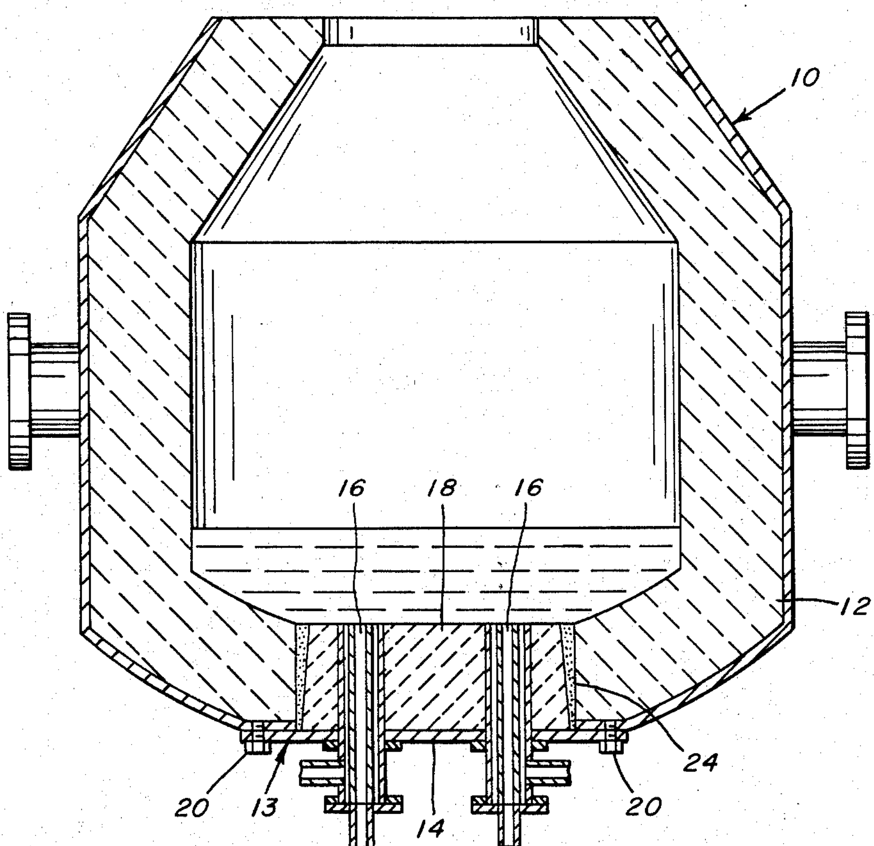

FIG. 4.

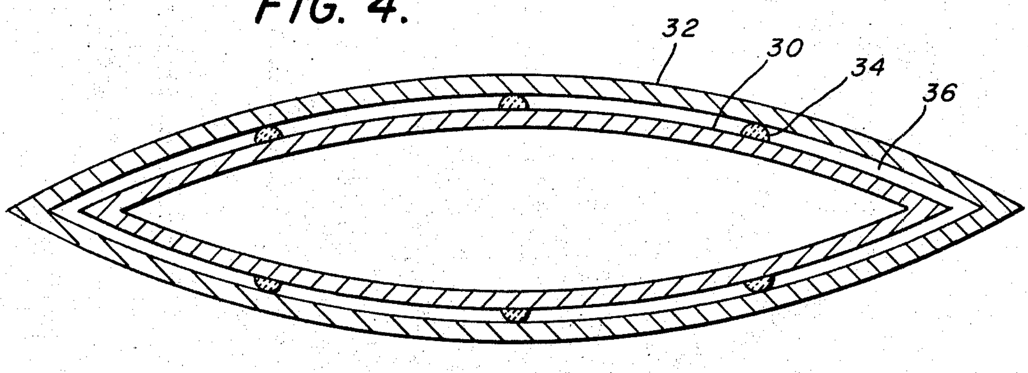

FIG. 2.

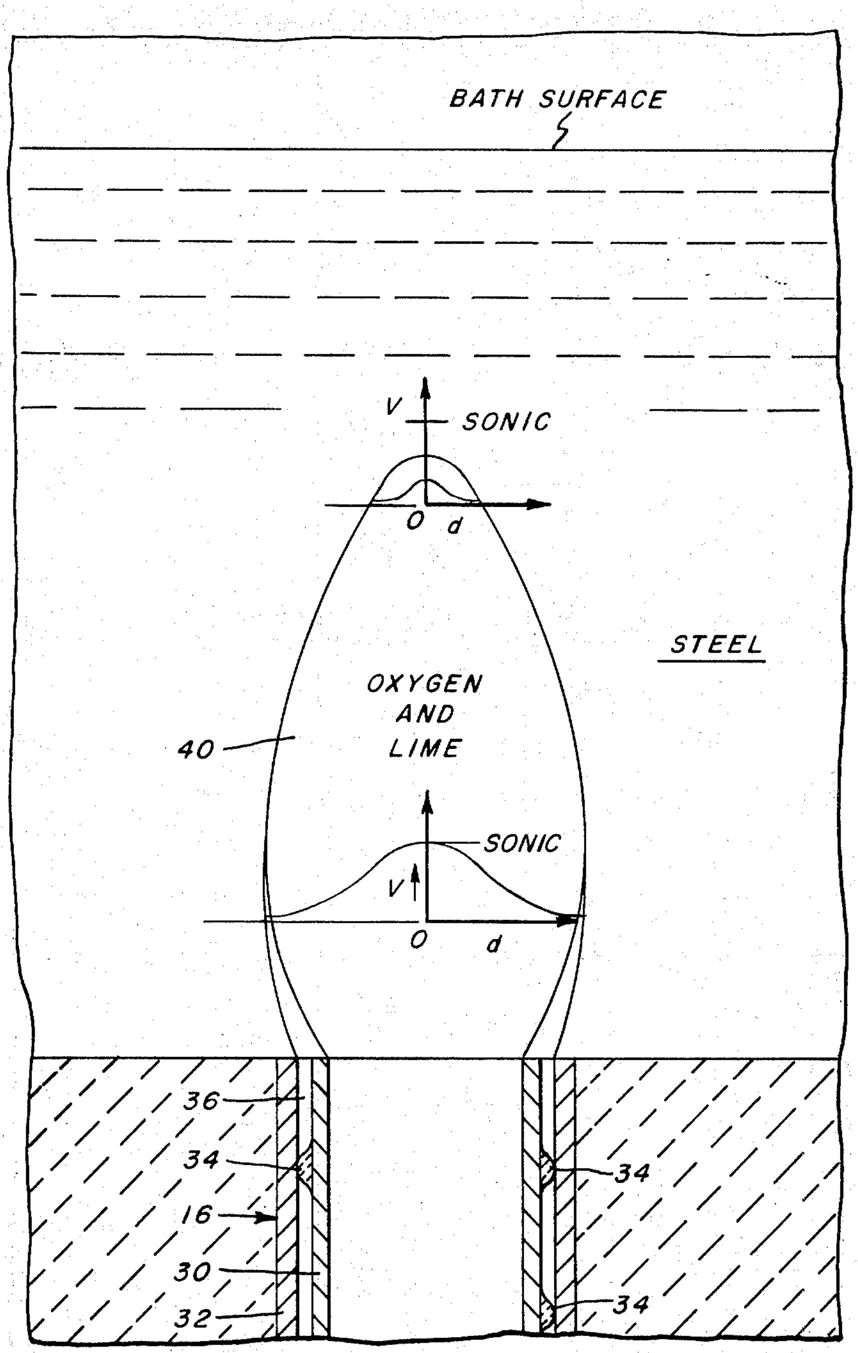
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FIG. 3.

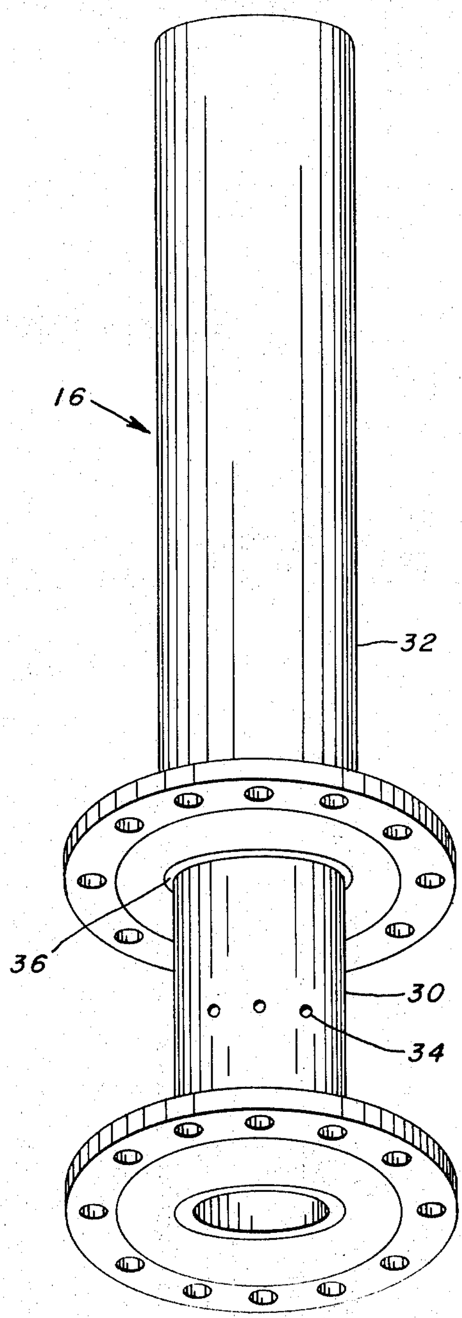


FIG. 5.

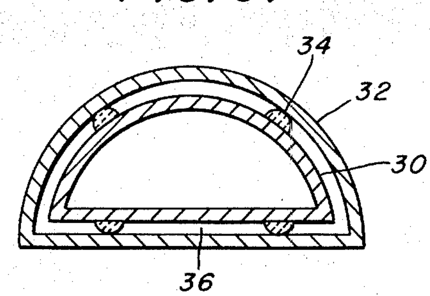


FIG. 6.

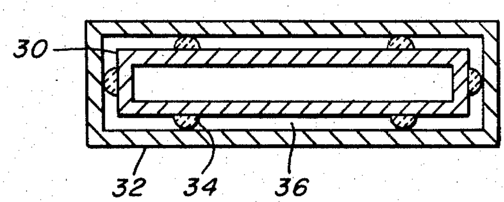


FIG. 7.

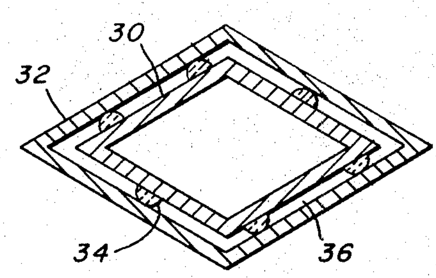
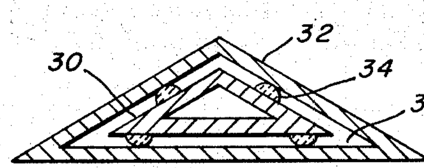


FIG. 8.



TUYERE CONSTRUCTION

In the bottom blown oxygen steelmaking process, which is known as the Q-BOP process, a vessel has a removable bottom or plug which contains one or more tuyeres through which oxygen and other gases or particulate matter such as lime or other flux are blown into the vessel. Each tuyere comprises an oxygen inlet tube surrounded by a larger concentric inlet tube for the simultaneous injection of a jacket gas. This jacket gas acts as a coolant, reducing the rate of reaction between the molten metal and the oxygen adjacent the tuyere preventing rapid erosion of the tuyere. Thus the furnace lining and the tuyere wear at the same rate. Heretofore, tuyeres have been of symmetrical cross-section, generally cylindrically shaped, the outer tube being spaced from the inner tube by a number of small beads welded to one of the tubes, or by a spiral of wire welded to one of the tubes, or by any other convenient means for maintaining concentricity.

In the bottom blown steelmaking process, "spitting" is quite common. Spitting is the propulsion of bath and slag material onto the upper walls and nose of the vessel. Severe spitting can result in actually blocking the mouth of the vessel. This requires that the solidified material in the mouth of the vessel be removed mechanically, which, of course, necessitates shutting down the operation of the vessel. Removal of solidified material also damages the refractory lining of the vessel necessitating repair and long vessel shutdown periods.

I have determined that spitting is dependent upon three factors: (1) the depth of the bath, (2) the oxygen flow rate, and (3) the tuyere size. I have observed that heats made with bottoms having small tuyere openings have less spitting than heats made with bottoms having large tuyere openings, provided the gas pressures at the tuyere inlets are equal.

The bath depth depends upon the amount of wear of the lining of the vessel, especially around the sides and thus cannot be well controlled. Further, if it were desirable to add more metal to the bath to increase the bath depth, this would increase the heat size, and it is probable that the tapping equipment would be required to be modified to accommodate such larger heat size. In order to reduce spitting by reducing the oxygen flow rate, one would necessarily increase the blowing time of the heat which is extremely undesirable as it increases the tap-to-tap time and correspondingly reduces production. Therefore, the only variable which can readily be controlled is the tuyere size.

I have invented a tuyere construction that reduces spitting, yet allows the same amount of gas flow as a large tuyere because it has the same cross-sectional area.

My tuyere can have any elongated shape wherein its length to width ratio is 2 to 1 or greater, which has the same cross-sectional area as a circular tuyere for the required oxygen flow rate. This tuyere will reduce spitting in the vessel markedly in comparison to a round tuyere of the same cross-sectional area, having the same oxygen flow rate in a vessel with the same bath depth.

It is the principal object of this invention to provide a tuyere construction for a bottom blown oxygen steelmaking vessel which will reduce spitting in the vessel.

It is another object to provide a tuyere construction which will deliver oxygen to the vessel at the optimum flow rate.

These and other objects will become more apparent by referring to the following specification and the appended drawings in which:

FIG. **1** is a cross-sectional view of a bottom blown oxygen steelmaking vessel;

FIG. **2** is an enlarged vertical cross-sectional view taken through a conventional tuyere and the bath above the tuyere having velocity curves superimposed on the gas jet;

FIG. **3** is an isometric view of one embodiment of my tuyere construction;

FIG. **4** is a horizontal cross-section view of the embodiment of FIG. **3**;

FIG. **5** is a cross-sectional view of an additional embodiment of my tuyere construction having a semicircular cross-section;

FIG. **6** is a cross-sectional view of a rectangular tuyere construction;

FIG. **7** is a cross-sectional view of a rhombic tuyere construction; and

FIG. **8** is a cross-sectional view of a triangular tuyere construction.

As shown in FIG. **1**, a bottom blown oxygen steelmaking vessel **10** has a refractory lining **12** and a removable bottom **13**, comprising a bottom plate **14**, and one or more generally upstanding tuyeres **16**, which are surrounded by a refractory material **18**. The bottom plate **14** is fastened to the furnace by bolts **20**. The sides of the refractory portion of the removable bottom do not contact the refractory lining **12** of the vessel, but sufficient clearance is provided around the bottom for inserting a gunning mixture **24** to provide a metal and slag-tight seal.

As can be seen in FIG. **2**, dual concentric tuyere **16**, comprising inner tube **30** and outer tube **32** is located in the bottom of a vessel. Tube **30** is spaced from tube **32** by spacers **34** which may be weld beads as shown in FIGS. **3** and **4**, spiral wound wire or any other suitable means for maintaining concentricity. The central tube **30** delivers oxygen and lime to the molten metal bath. A jacketing gas, which is, in this case, natural gas, is delivered to the bath through the annular space **36** between the central tube **30** and the outer tube **32**. Upon emergence of the gases into the bath, they expand as shown in FIG. **2**. The gases diffuse into the bath or mix with the bath as bubbles, leaving a gas pocket **40** generally as indicated on the drawing which is roughly in the shape of a candle flame. The oxygen pressure should be equal to or greater than that of the jacket gas. The velocity of the gases is sonic at their entrance into the bath, however, the velocity curves superimposed upon the gas pocket in FIG. **2** show that the velocities are low at the edge of the pocket due to interaction with the bath and higher at the center until the gas is totally dissipated. Should this gas pocket or jet become so elongated as to penetrate the surface of the bath, an extremely great amount of spitting would occur. The x-axis of the velocity curve represents the distance (d) from the central vertical axis of the gas jet. The y-axis represents the velocity (v) of the gas as it varies from zero to sonic velocity.

I have found that any noncircular oblong shape will have the effect of reducing the height of the jet of gas in the bath and thus will reduce the tendency of spitting to occur in such bath. Any elongated shape will accomplish this. Some suitable shapes are a triangle, rectangle, half circle, diamond or rhombus, ellipse or pointed ellipse. The length to width ratio of the cross-section of the shape would be 2 to 1 or more. Although it usually would be, it need not be symmetrical about a center line.

A second advantage is present for these oblong tuyeres. The larger interface which is provided by the elongated jet stream gives a more rapid and better dephosphorization of the bath. Dephosphorization occurs at the interface between the gas jet and this molten metal bath. This is an important difference between Q-BOP and BOP steelmaking. In the BOP dephosphorization occurs by metal reaction with the surface slag layer. In the Q-BOP dephosphorization primarily occurs at the surface of the jet within the bath where FeO, phosphorus and CaO are present. The CaO is derived from the powdered lime blown with the oxygen. The FeO is formed through reaction of blown-in oxygen and Fe in the bath. The phosphorus is a normal contaminant of the charged blast furnace hot metal.

It is readily apparent from the foregoing that I have invented a tuyere construction for a Q-BOP steelmaking vessel which will reduce spitting in the vessel yet will deliver oxygen to the bath at the optimum flow rate.

I claim:

1. In a bottom blown oxygen steelmaking vessel, an improved large tuyere construction for minimizing spitting in the vessel but delivering oxygen to the vessel at an optimum flow rate, said tuyere construction comprising a plurality of substantially vertical tuyeres, each of which includes:

an inner tube of a noncircular oblong cross-sectional shape, which shape has a length to width ratio of at least 2 to 1;

an outer tube of like shape; and

spacers interposed between said tubes to form an annular space between the inner and outer tubes.

2. A tuyere construction according to claim **1** in which the annular space is substantially equidistant all around the inner tube.

3. A tuyere construction according to claim **1** in which said shape is symmetrical about a center line.

4. A tuyere construction according to claim **2** in which said shape is elliptical.

5. A tuyere construction according to claim **2** in which said shape is semicircular.

6. A tuyere construction according to claim **2** in which said shape is rectangular.

7. A tuyere construction according to claim **2** in which said shape is rhombic.

8. A tuyere construction according to claim **1** in which said shape is triangular.

9. A tuyere construction according to claim **2** in which said shape is a pointed ellipse.

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