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HEATED BLAST CUPOLA

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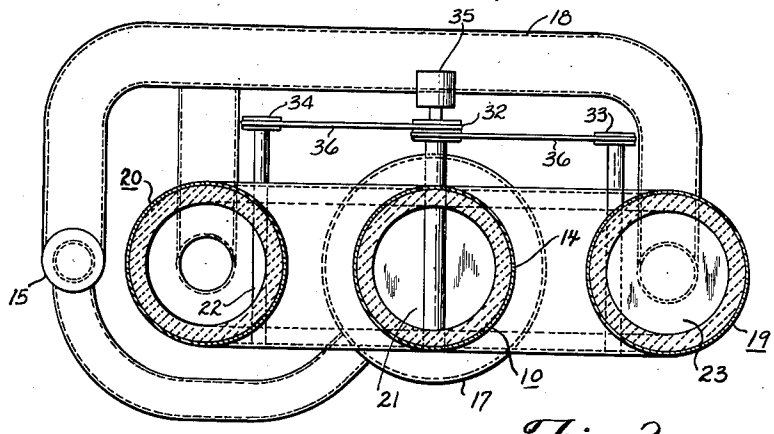


Fig. 2

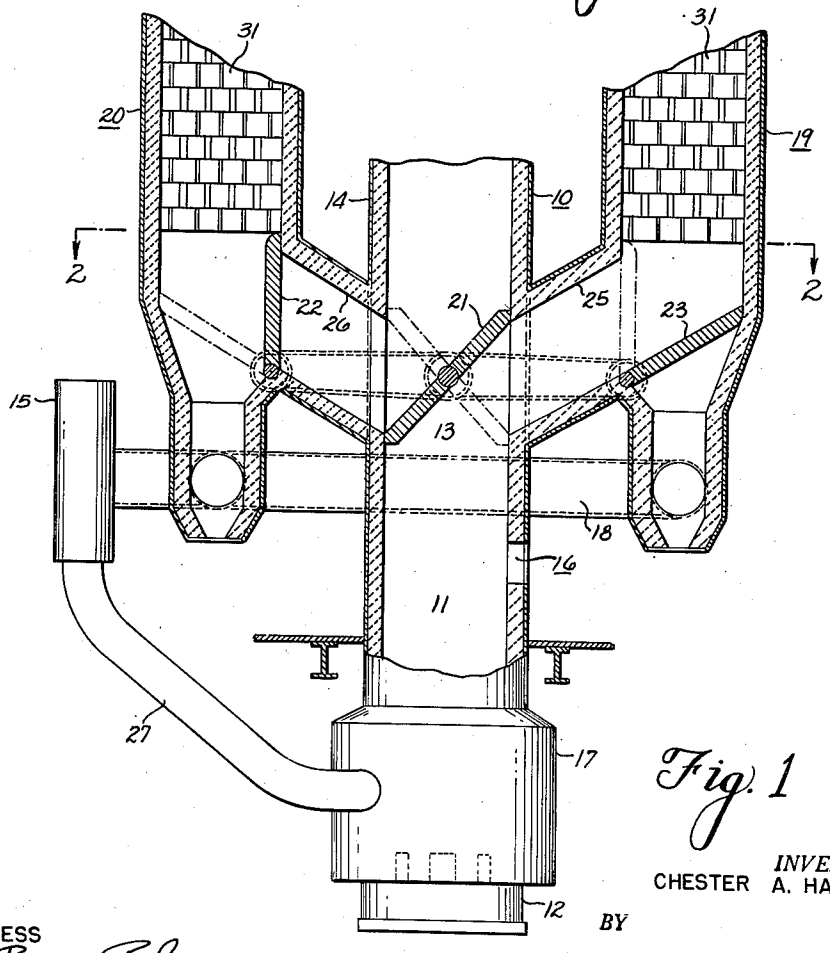


Fig. 1

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HEATED BLAST CUPOLA

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This invention relates to metallurgical processes in general, and relates more particularly to cupola practice and construction.

An object of this invention is to provide preheated air for the air blast of a cupola furnace.

The primary object of this invention, however, is to provide a preheated air blast from the beginning of the cupola melt.

Another object of this invention is to conserve natural resources and personal expense by reducing the fuel requirements of a cupola furnace for a particular melt.

A further object of this invention is to provide improved combustion conditions within a cupola furnace.

Yet another object of this invention is to eliminate slag bridges within the cupola furnace.

A still further object of this invention is to eliminate tuyère stoppage by frozen slag within the cupola furnace.

And another object of this invention is to prevent uneven resistance to air blast travel through the melt and the resulting hot spots and cold spots within the cupola furnace.

Other objects and a fuller understanding of the invention may be had by referring to the following description and claims, taken in conjunction with the accompanying drawing in which:

Figure 1 is an elevational sectional view of a cupola furnace embodying the principles of this invention, the view being somewhat diagrammatical for the purpose of illustrating the principles of the invention and not proporting to set forth engineering details of the cupola; and

Figure 2 is a sectional view along the line 2—2 of Figure 1.

Referring now more in detail to the drawing, an apparatus selected to disclose the present invention is shown as comprising a re-melting iron cupola 10 of usual construction in regard to the charging and melting features. This cupola is supported upon base 12 and comprises essentially a refractory tubular body 14 having a charging door 16. A wind box 17 is arranged about the lower portion of the cupola and communicates with tuyères which direct air under compression into the lower combustion zone 11 of the cupola. Ordinarily, the cupola is charged with alternate layers of coke and iron upon a prepared bed of coals within the combustion zone 11, and the products of combustion and other gases resulting from the operation of the cupola move upwardly into a gas header zone 13 of the tubular body 14. The

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present day practice, with the possible exception of a few extremely complicated special installations, allows the gases or products of combustion to pass upwardly through the tubular body 14 and exhaust into the atmosphere. This practice is extremely wasteful because, as those skilled in the art are aware, the gases leaving the combusion zone contain a large proportion of carbon monoxide and other inflammable gases which represent an extreme heat loss inasmuch as these gases are incompletely oxidized and capable of further oxidation. Of course, oxidation of these gases is an exothermic reaction and will produce a large output of heat energy which is all wasted in the atmosphere as the gases burn in the upper portion of the tubular body 14 and at the top opening of the tubular body 14.

In foundry practices employing a cupola of the type illustrated, a fire bed is prepared in the lower portion of the combustion zone 11 and is fed with a considerable amount of solid fuel for a period of about two hours before the charge of coke, iron and slagging materials are entered through the charging door 16. Even though this bed preparation period is comparatively efficient as compared to the later melting period, the heat produced is entirely wasted except for warming the combusion zone 11 and the preparation of a hot bed to start melting operation after the air blast is commenced. Furthermore, the common practice is to blow atmospheric air into the wind box 17 after the charge is placed upon the prepared bed, and this cold air results in a slow heating of the charge before the melting temperature is finally obtained. As previously stated, there has been some attempt to employ preheaters to recover some of the unburned gases from the gas header zone 13 and pass these gases through a heat exchanger in order to preheat the air blast, but none of these arrangements previously heated air from the first moment, or for that matter for the first hour, that the air blast is employed. These prior art devices require a considerable amount of heat to be developed in the charge before the preheat begins to operate. Another device has been proposed wherein air blast is blown crosswise through the combusion zone 11 and some of the products of combustion forced out through a side pipe on the opposite side of the blast and passed through a checker work of fire brick to store up thermal energy. The air blast is then reversed and thereby provides a preheat for the air blast. This method has never been practiced commercially because of the obvious prac-

tical difficulty of forcing air in a sufficiently concentrated path through a bed of coal and melting iron into a collecting pipe on the side of the furnace. Many other practical difficulties make this type of preheating inoperative.

This invention embodies the concept of providing a full preheat for the air blast immediately upon operation of the air blast to start the melting cycle after the charge has been placed upon the prepared bed, and also embodies the apparatus to accomplish the preheating from the start. As set forth in the drawing, this invention may be carried out by the provision of thermal storage chambers 19 and 20. The chambers 19 and 20 are preferably filled with a checker work 31 of fire brick or similar refractory material capable of absorbing a considerable amount of thermal energy. The storage chambers 19 and 20 are preferably of a cross-sectional area, sufficiently large to provide ample passage ways through the checker work 31 in order that back pressure of gases within the tubular body 14 will not build up to an excessive extent. A gas duct 25 interconnects the chamber 19 with the gas header zone 13, and a gas duct 26 interconnects the chamber 20 with the gas header zone 13. A gate valve 21 pivotally mounted in the tubular body 14, substantially as illustrated in the Figure 1, is adapted to act as a directional valve to direct gases into the chambers 19 and 20. That is, the gate valve 21 has a first position, substantially as illustrated in the Figure 1, and will thereby direct gases from the gas header zone 13 through the storage chamber 19. The phantom position of the gate valve 21 illustrates a second position for the valve to direct gases from the zone 13 through the storage chamber 20.

The operation of melting the charge in the cupola illustrated in the drawing results in a large percentage of incompletely burned gases, just as any other cupola will do regardless of whether or not a preheated air blast is employed. As a matter of fact, it is necesary to maintain the passage of gases through the melting charge in an incompletely oxidized state in order that the melting charge will not be unduly oxidized by excess oxygen. Therefore, in the operation of this invention, an oil pot may be placed just inside the charging door 16 in order to assure the ignition of the gases in the zone 13. The charging door 16 is always open and the rush of gases through the tubular body 14 will draw air through the door 16 and the air will mix with the incompletely burned gases and supply the necessary oxygen to complete the oxidation of the gases. Therefore, combustion of the gases will take place in the apparatus illustrated in the drawing from the area just above the charging door 16 and will continue to burn as the gases pass upwardly through the storage chambers 19 or 20, whichever is chosen by the position of the gate valve 21. Thus, the heat energy which ordinarily would be wasted into the atmosphere is used to heat the checker work 31.

A bustle pipe 18 provides an air duct to interconnect the storage chambers 19 and 20 with the intake of a blower 15. The blower 15 is adapted to direct air under compression through air duct 27 to the wind box 17. Therefore, the air blast which enters the combustion zone 11 is drawn through the bustle pipe 18 from the storage chambers 19 and 20. However, one of the storage chambers 19 and 20 must be heated while the other is supplying preheated air to the bustle pipe 18 for the air blast. Therefore, gate valves 22 and 23 are provided to alternately close the bottom of each chamber while simultaneously opening the gas duct entering the chamber, or closing the gas duct entering the chamber and opening the bottom of the chamber to communicate with the bustle pipe 18. In other words, the gate valves 22 and 23 also have two operating positions similar to those described in connection with the gate valve 21. The gate valve 22 in Figure 1 is illustrated as being in a position to close the gas duct 26 and open the bottom of the chamber 20 to place the chamber 20 in unrestricted communication with the bustle pipe 18. The phantom position of gate valve 22 illustrates the second position to close the bottom of the chamber 20 and open the gas duct 26. Also in the Figure 1, the gate valve 23 is illustrated closing the bottom of the storage chamber 19 to prevent communication between the storage chamber 19 and the bustle pipe 18, but allowing the gas duct 25 to remain open and provide communication between the gas header zone 13 and the storage chamber 19. The phantom illustration of gate valve 23 illustrates the second position of the valve 23 wherein the gas duct 25 is closed and the bottom of the chamber 19 is open and in communication with the bustle pipe 18.

To illustrate the preferred operation of the gate valves 21, 22 and 23 wherein the gate valves are co-ordinated to operate as a unit, the Figure 2 shows a reversible electric motor 35 having a pulley 32 thereon. Belts 36 operate from the pulley 32 to a pulley 33 on the gate valve 23 and to a pulley 34 on the gate valve 22. Therefore, the motor 35 may be operated in first direction to place the gate valves 21, 22 and 23 in the position illustrated in Figure 1, or may be operated in a second direction to position the gate valves as illustrated by the phantom views in Figure 1.

At the beginning of the melting cycle, a bed is prepared in the combustion zone 11. Bed preparation in the ordinary cupola requires from one to two hours. Prior to this invention, even with devices which have attempted to preheat the air blast, all of the heat produced by the bed preparation went out the stack and was lost into the atmosphere. In the operation of the cupola prepared in accordance with this invention, the products of combustion may be passed through either the storage chamber 19 or the storage chamber 20. In the Figure 1, the zone 13 is in communication with the chamber 19 because the gate valves 21, 22 and 23 are in their first position, and therefore, the heat produced by the bed preparation will be passed through the storage chamber 19 and will heat the checker work 31 therein.

After the bed has been adequately prepared, the cold charge of iron, coke and slagging materials is placed on top of the bed through the charging door 16. This charge is at atmospheric temperature and is, therefore, quite cold as compared with melting temperature. A considerable amount of heat is required to bring the fuel to a combustion temperature and the iron to melting temperature. However, by actuating the motor 35 to shift the valves illustrated in phantom in the Figure 1, the blower 15 may be operated to draw very hot air from the storage chamber 19 through the bustle pipe 18 and blow this air into the combustion zone 11. By this practice, this invention will recover about 50 per cent or more of the thermal energy given by the bed preparation and will place that thermal energy back into the combustion zone to quickly

ieat the charge up to melting temperature. Of course, when the valves are shifted as described, all products of combustion and heated gases will be passed through the chamber 20 and will begin to heat the checker work 31 within the chamber 20. After a period of time has elapsed and the energy is substantially withdrawn from the chamber 19, the gate valves may be returned to the position illustrated in the Figure 1 and heated air drawn from the storage chamber 20 to supply the combustion zone 11 with preheated air blast.

In cupola practice, somewhere in the neighborhood of one ton of atmospheric air is required to produce one ton of melted iron. This air, of course, contains about 80 per cent of nitrogen. The nitrogen does not support combustion, but does absorb a vast amount of heat energy as it passes through the combustion zone 11. If this nitrogen is passed back into the atmosphere along with the carbon monoxide produced in the combustion zone 11 as is presently done, about 62 per cent of the heat energy obtainable from the fuel is wasted and about 38 per cent is actually used in melting the iron and the slagging materials. By the use of the present invention, it has been found that substantially better than 50 per cent of the heat energy may be extracted from the gases and re-introduced into the combustion zone 11. The saving and efficiency of the fuel is, therefore, readily apparent. However, it has been found that preheating of air blast from the beginning not only saves fuel and produces a quicker melting heat, but also provides a uniform combustion within the zone 11 heretofore never considered possible. With cold air blast practice the first metal which comes from the cupola is generally so cold it is considered better to pig the first metal rather than attempt to use it in expensive molds. Furthermore, cold blast is known to produce slag bridges within the combustion zone which divert all of the air blast through a very small channel. This diversion of the blast usually takes place along one side wall of the tubular body and results in extremely high temperatures known as a hot spot, in the area of the reduced stream which oxidize the molten metal and burns out the sides of the cupola. Furthermore, chilled slag very often closes off one or more of the tuyères and materially restricts the air blast into the cupola.

The invention set forth herein has been found to be extremely practical and beneficial primarily because it provides preheated air from the first moment that the air blast is introduced, and it requires no additional fuel to heat the air blast. Industrial operators have been unwilling to expend considerable extra fuel to heat the air blast because their costs of operation are extremely high due to the large amount of fuel required per ton of melted iron. This invention not only reduces the actual amount of fuel required for the operation of a cupola, but assures usable iron at the first tap and prevents undesirable bridging and hot spots. Furthermore, this invention operates with an extremely small expenditure for extra equipment over that which is ordinarily required in cupola practice today, the entire addition being the chambers 19 and 20 and the gate valves used to direct the gas and air streams.

Although the invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

What is claimed is:

1. A shaft furnace comprising, a substantially vertical furnace having a combustion section, a gas header section above said combustion section, a first and second thermal energy storage chamber positioned above said gas header section, a first gas duct interconnecting said gas header section and said first storage chamber, a second gas duct interconnecting said gas header section and said second storage chamber, air blast means directing heated air under pressure in one direction of flow into said combustion section, first air duct means interconnecting said first storage chamber and said air blast means, second air duct means interconnecting said second storage chamber and said air blast means, and valve means having a first position to open said first gas duct and close said second gas duct and simultaneously open said second air duct and close said first air duct, said valve means having a second position to open said second gas duct and close said first gas duct and simultaneously open said first air duct and close said second air duct, whereby a selected one of said thermal energy storage chambers will be heated by gases from the furnace chamber and the other will heat air entering the air blast means.

2. A shaft furnace comprising, a substantially vertical furnace having a charging door, a combustion section below said door, a gas header section above said door, a first and second thermal energy storage chamber positioned above said gas header section, a first gas duct interconnecting said gas header section and said first storage chamber, a second gas duct interconnecting said gas header section and said second storage chamber, air blast means directing heated air under pressure in one direction of flow into said combustion section, first air duct means interconnecting said first storage chamber and said air blast means, second air duct means interconnecting said second storage chamber and said air blast means, and valve means having a first position to open said first gas duct and close said second gas duct and simultaneously open said second air duct and close said first air duct, said valve means having a second position to open said second gas duct and close said first gas duct and simultaneously open said first air duct and close said second air duct, whereby a selected one of said thermal energy storage chambers will be heated by gases from the furnace chamber and the other will heat air entering the air blast means.

3. A shaft furnace comprising, a substantially vertical furnace having an open top, a charging door, a combustion section below said door, a gas header section above said door, a first and a second thermal energy storage chamber positioned above said gas header section, a first gas duct having an entrance end leading from the gas header section and a delivery end entering the first storage chamber, a second gas duct having an entrance end leading from the gas header section and a delivery end entering the second storage chamber, air blast means directing heated air under pressure in one direction of flow into said combustion section, first air duct means interconnecting said first storage chamber and said air blast means, second air duct means interconnecting said second storage chamber and said

air blast means, a gas directing butterfly valve in said gas header section having a first operating position closing said first gas duct from said open top and opening the entrance end of the first gas duct into said gas header section, said first position of the gas directing valve interconnecting the entrance end of the second gas duct with the open top section of the furnace above said valve and closing the said second gas duct from the gas header section, said gas directing valve having a second position closing said second gas duct from said open top and opening the entrance end thereof into said gas header section, said second position of the gas directing valve interconnecting the entrance end of the first gas duct with the open top section of the furnace above said valve and closing the said first gas duct from the gas header section, intermediate positions of said gas directing butterfly valve between said first and second positions opening the gas header section to exhaust through said open top, a first air valve in said first storage chamber, said first air valve having an air directing position closing the delivery end of said first gas duct and opening the first air duct means, said first air valve having a gas directing position opening the delivery end of said first gas duct and closing the first air duct means, a second air valve in said second storage chamber, said second air valve having an

air directing position closing the delivery end of said second gas duct and opening the second air duct means, said second air valve having a gas directing position opening the delivery end of said second gas duct and closing the second air duct means, and valve operating control means to adjust all said valves to heat one storage chamber with gases from the furnace while air passes through the other to be heated as it passes to the furnace.

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