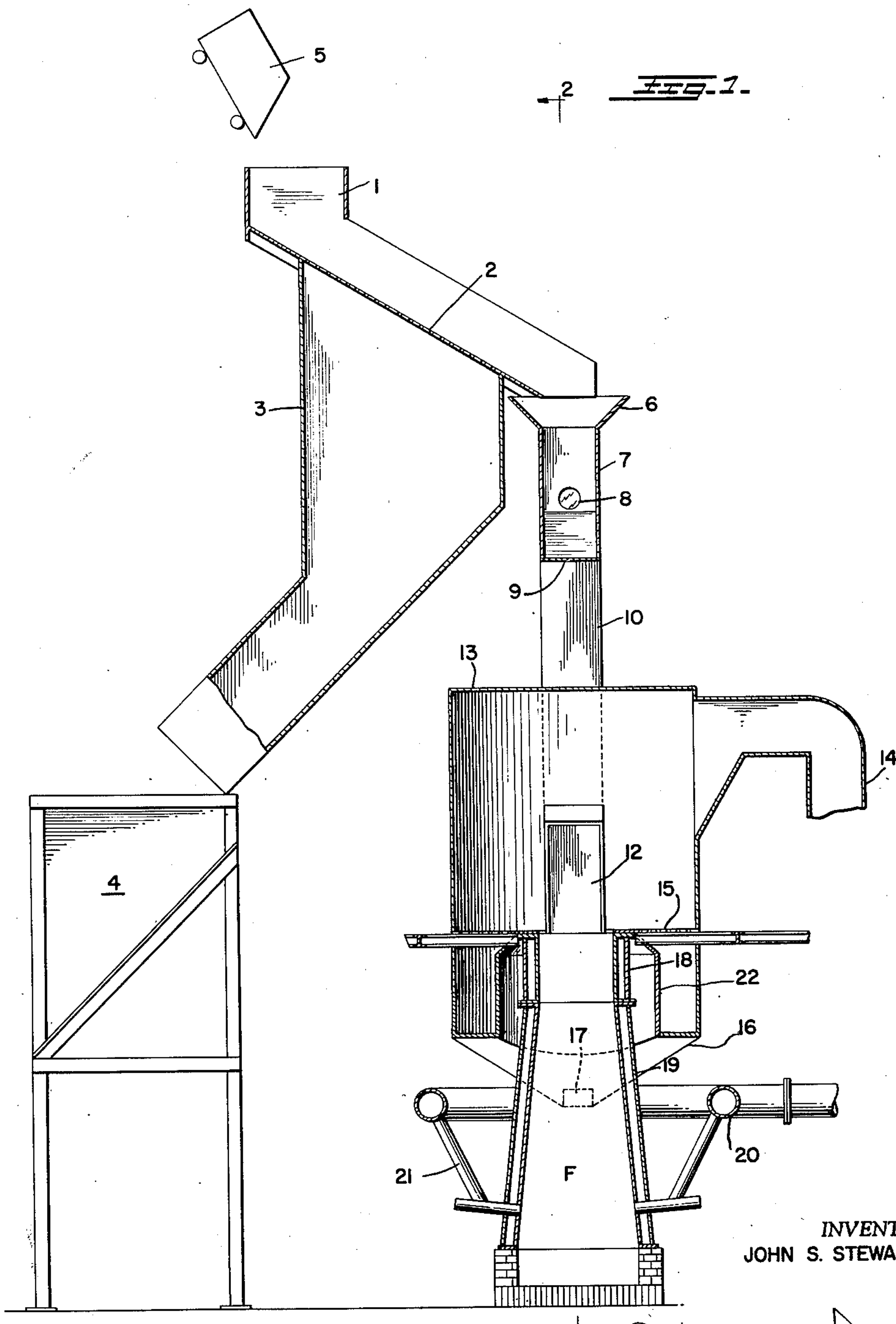
May 14, 1957 J. S. STEWART 2,792,213

TOP STRUCTURE FOR BLAST FURNACES

Filed Sept. 13, 1954 2 Sheets-Sheet 1

FIG. 1.



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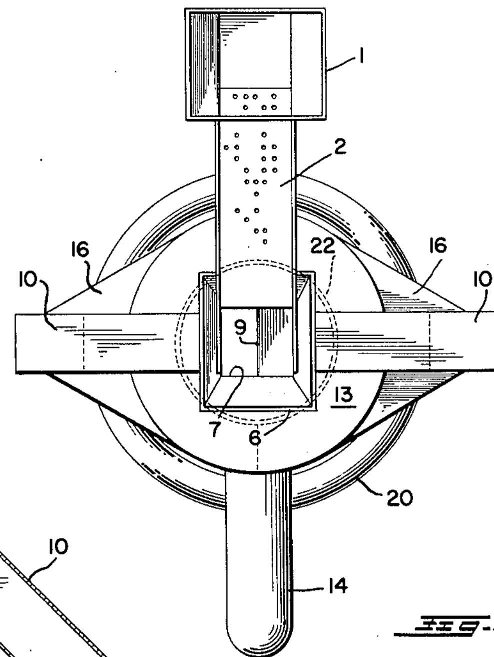

FIG. 3.

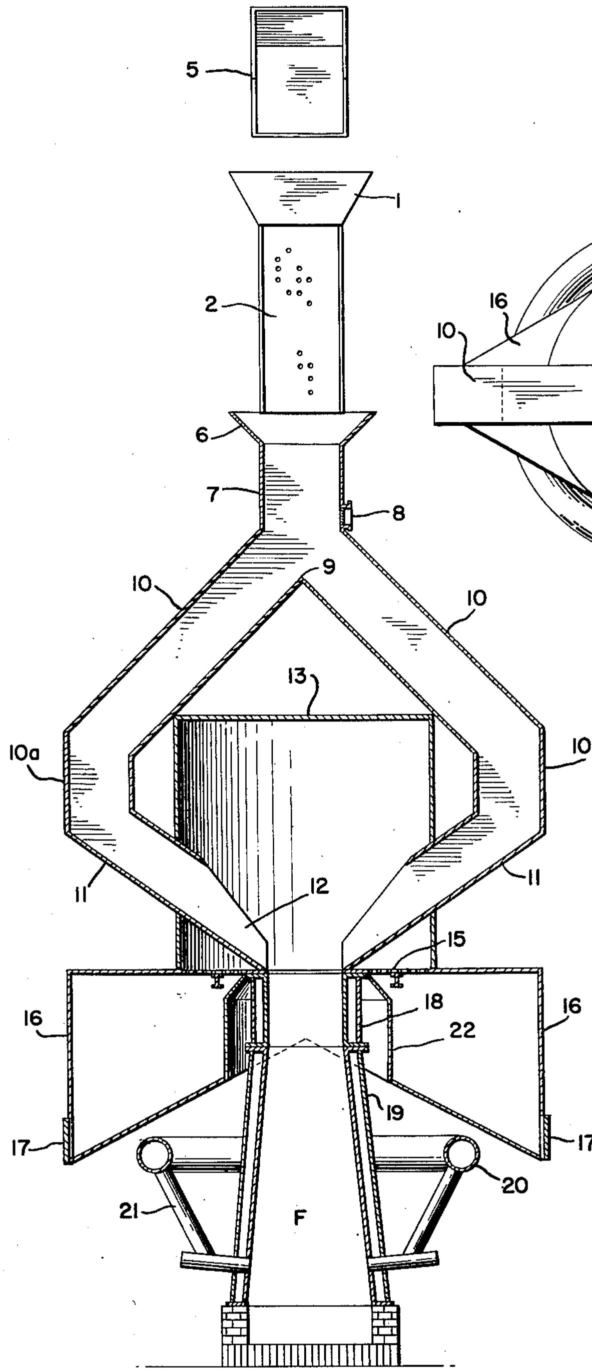

FIG. 2.

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TOP STRUCTURE FOR BLAST FURNACES

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12 Claims. (Cl. 266—27)

This invention relates to improvements in blast furnaces, and more particularly pertains to a top structure for blast furnaces for the feeding of charge material to the furnace and for the recovery of fines therefrom, as well as from the furnace gases.

It has heretofore been recognized that the presence of fines in furnace charges exerts harmful effects upon blast furnace operation, and that this is true of the smelting of both ferrous and non-ferrous ores. For example, in blast furnaces for smelting iron ore where the column of ore may be 100 feet or more in height necessary to accomplish the reduction of the iron oxide to its metallic state before it reaches the smelting zone in the lower part of the furnace, the ideal condition for iron smelting would be to have a charge consisting of coke, limestone, sized iron ore and sinter which has even porosity at every point in each cross-section as it descends in the furnace against the ascending reduction gas. If this condition were to prevail throughout the height of the shaft, there would be even gas flow which would result in even reduction, gas composition, temperature, velocity, pressure and heat transfer throughout each cross-section.

However, as pointed out by Prof. T. L. Joseph in a paper entitled "The Blast Furnace Process and Means of Control" presented February 1946, before the American Institute of Mining and Metallurgical Engineers, with present raw material, uniform gas flow is impossible due to the packing of the fines along the in-wall of the shaft. Irregularities in the furnace are always present when fine ore is used. When the size of the particles falls below ⅜ inch, the resistance to gas flow increases rapidly. By the elimination of fine sizes of ore and by agglomerating or sintering the fines, there will be an increase in the percentage of voids and the permeability of the ore layers which will result in much higher tonnages smelted. Sized material, be it large or small, contains the maximum number of voids; minimum voids occur when very large and very small particles are mixed, such as coke and fines. The ability of a furnace to take blast and burn coke is fixed by conditions in the shaft that govern how much gas can be handled; and fines in the ore affect the ability of the shaft to handle gas. With the raw material used in iron blast furnaces at the present time, only 10 to 15 percent of the total cross-section is effective for gas flow due to packing of fines along the in-wall.

It is therefore apparent that for the best operation of both non-ferrous and ferrous blast-furnaces it is necessary to eliminate ore fines from the blast-furnace charge.

In order to reduce the presence of fines in the furnace it is advisable that the material constituting the furnace charge should be screened before its delivery to the furnace. However, it is not usually practicable to screen the material as it is delivered to the smelter in boat- or train-load lots, since the prime object at that time is to get the ore unloaded and bedded as quickly and cheaply as possible. An intermediate screening plant would have a high capital cost and upkeep. The same applies to brass scrap smelters.

In order to provide the simplest and cheapest method of screening out the fines in the blast-furnace charge, this invention proposes a screening device, such as a vibrating screen or a slotted-metal screen chute at an angle of 30 to 45 degrees, installed at the top of the blast-furnace skip dump. In this way, the charge is screened in small batches, with one loading, just prior to being charged into the blast furnace. Another advantage is that the coarse charge, when screened at this location on its way to the furnace is not subject to weathering.

The gases from the iron blast-furnace are rich in CO gas, and, after being cleansed of dust, they pass to stoves and are burned to provide heat to preheat the air that goes into the blast-furnace tuyeres. Gas-tight blast-furnace charging, which eliminates the infiltration of air to the furnace hood, is necessary to accomplish this purpose. Iron blast-furnaces are ordinarily provided with a double bell. These bells are of large size and weight and extend high in the blast-furnace structure. Because of their height, it is necessary to have very high gas off-takes; as a net result, the conventional top-structure of the iron blast-furnace is quite costly.

Many of the conventional iron blast-furnaces of the present day have a stock-line diameter of 20 feet. The vertical distance of the big bell to the stock line is 4 to 6 feet. When the charge is dumped from the 50 degree large bell, the charge hits the in-wall of the furnace, the fines in the charge drop vertically and are deposited along the in-wall, while the coarser pieces and coarse coke roll on the angle of repose of the charge to the center of the furnace. With a 30 to 35 degree angle of repose, on a 20 foot diameter stock-line, this forms a hollow in the center of the furnace 6 to 7 feet deeper than at the in-wall. As the top of the charge column is much lower and more porous, due to large numbers of voids at the center, and packed with fines with a small percentage of voids at the in-wall, there is bound to be a segregation of the gas flow toward the center, thereby robbing the gas flow at the sides, as gas will flow along the lines of least resistance. Further, in order to provide space for the next charge, the charge must subside in the furnace to a level sufficient to contain the next bell charge. This varying of stockline level causes variable pressure readings from charge to charge.

The invention therefore has as another object to provide a top structure for blast furnaces which obviates the double bell construction and in place thereof provides a chute into the top of which the charge material is fed from a distributing hopper, the material being split into a plurality of separate streams which flow through branch chutes into the top of the furnace, whereby the material is automatically delivered into the furnace in response to the subsidence of the level of the furnace charge and which seals off and prevents the escape of gases via the chutes.

The advantages of this construction are:

(*a*) No heavy double bells with complicated operating mechanism are necessary, hence the feed mechanism of the invention is of cheaper and simpler construction.

(*b*) As the stock in the furnace goes down, the charge is self-fed, being replenished by the gravity flow of the charge in the chutes.

(*c*) The furnace is kept full at all times, maintaining constant pressure in the blast furnace.

(*d*) The top of the furnace column is maintained practically level, with no deep depression in the center. The charge is deposited evenly around the periphery at the top of the shaft with no segregation of the coarse and fine pieces, thus giving even gas flow throughout the entire cross-section.

(*e*) The chutes are always maintained full of charge, serving as reserve bins.

(f) With the chutes full of charge, the chutes are rendered gas-tight.

Another important object of the present invention is to provide a top structure for blast furnaces adapted to recover the fines blown out of the furnace by the furnace gases. More particularly this object is accomplished by providing an enlarged metal hood surrounding the top of the furnace so that the gases emerging from the furnace and carrying the fines entrained therein enter the expansion chamber defined by the hood where the fines, or "dust," settle out and are collected in a dust bin which encircles the top of the shaft, just below the hood, while the gases are cooled by contact with the large radiating surface of the hood.

Other objects and advantages will be apparent from the following detailed description of a preferred embodiment of the invention, reference being made to the accompanying drawings, in which:

Figure 1 is a view in vertical cross-section of a blast furnace equipped with a top structure embodying the invention;

Figure 2 is a view in vertical cross-section taken on the line 2—2 of Fig. 1;

Figure 3 is a plan view of the blast furnace.

In the blast furnace illustrated in the drawings, charge material for the furnace F is delivered into the upper end of a chute **1** disposed at an inclination such as to gravitationally feed the material therealong. In the bottom of this chute throughout a portion of its length is an opening covered by a perforated plate **2** for screening the fines from the material while it is in transit down the chute. The fines passing through the screen fall into a closed hopper **3** from the lower end of which the fines are led off into a storage bin **4**.

The charge material is unloaded into the chute **1** from a skip **5** (indicated diagrammatically in Figs. 1 and 2) and the material issuing from the lower end of the chute is received in a charging hopper **6**, which I term a distributing hopper. The distributing hopper is located at and communicates with the upper end of a hollow, vertically-disposed main chute **7**, which latter chute is shaped so as to expand downwardly and outwardly as will be apparent from Fig. 2. A charge-level indicator **8** provided near the bottom of the main chute signals when the level of the material filling this chute approaches the bottom of the chute so that the supply of material may be replenished.

The main chute **7** at its lower end divides into two hollow branch chutes, the bottom walls of which intersect at their elevated ends at an angle of 45 degrees to form a splitter **9** located centrally below the outlet of the main chute and each of the branch chutes is constituted of a downwardly and outwardly inclined section **10**, a short vertical section **10a** and a downwardly and inwardly inclined section **11** ending in an open-top chute section **12**, which latter terminates adjacent the top of the shaft of the furnace F. The two sections **12** are arranged to feed into the shaft in opposed directions at circumferentially spaced locations about the open top of the shaft, and the inclination of these sections is greater than the angle of repose of the material.

Enclosing the upper end of the shaft is a cylindrical, metal, hood **13** of relatively large diameter closed at its top and forming an expansion chamber for the gases issuing from the shaft. An offtake duct **14** opens through the wall of the hood and may lead to a dust collector (not shown). The bottom of the hood is provided with a grating **15** through which the fines given up by the gases are free to fall into a dust bin **16**. The bottom of the dust bin is inclined downwardly and outwardly and doors **17** are suitably provided for the removal of the collected fines from the bin.

The blast furnace to which the above-described top structure is applied may be of any conventional type, or the inverted-bosh construction described in my Patent No. 2,373,514. Such a furnace comprises top jackets **18**, bottom jackets **19** and a bustle pipe **20** encircling the furnace and connected to a source of air supply by a duct **20a**. Air under pressure is delivered into the furnace in the usual manner by means of tuyeres connected to the bustle pipe by pipes **21**. Within the dust-bin **16** and surrounding the upper end of the shaft, but radially spaced a short distance therefrom, is the inner wall of the dust-bin, or shroud **22**, to separate and protect the jackets from the accumulating dust in the bin and to afford convenient replacement of the jackets which becomes necessary from time to time.

In the operation of the blast furnace the charge material is delivered into the upper end of chute **1** by the skip conveyor **5** and slides down the chute by gravity passing over the perforated plate **2**. The fines pass through the perforations of the plate into the hopper **3** and subsequently into the bin **4**, and are thus removed from the charge. The fines collected in the bin **4** may later be sintered or agglomerated for subsequent use as a part of the furnace charge.

The charge material flowing off the chute **2** into the charging hopper **6** passes into the vertically-disposed main chute **7** which latter is always maintained filled or partially filled with material, as evidenced by the level indicator **8**. As the level of the charge in the furnace subsides, additional charge material is automatically fed into the furnace to replenish the supply via the branch chutes **10**, **10a**, **11** and **12**. The splitter **9** serves to divide the charge filling the lower end of the main chute **7** into two separate streams which are self-feeding through the branch chutes into the upper end of the shaft in a direction inwardly of and at equidistantly spaced locations about its circumference. The charge filling the main chute **7** and the branch chutes **10**, **10a** and **11** prevents the escape of furnace gases therethrough.

The gases vented from the open end of the shaft which are rich in carbon monoxide enter the enlarged expansion chamber defined by the hood **13** where their velocity is slowed down and the fines entrained therein settle out and pass through the grating **15** into the bin **16** which seals the bottom of the hood against the atmosphere. The gases, cooled both by expansion and by contact with the surface of the hood, are withdrawn through the duct **14** and after being cleaned of dust may be used as fuel to preheat the air that is delivered into the furnace from the tuyeres.

The fines collecting in the bin **16** are removed through the doors **17** for subsequent use as part of the furnace charge since they are ideal for sintering, containing as they do the right amount of fine coke dust for sintering.

As will be apparent from the foregoing description there is provided a top structure for blast furnaces in which the charge material is self-feeding into the furnace via gas-tight chutes during which it undergoes a screening to remove the fines, and in which the hood encircling the top of the shaft forms an expansion chamber for the furnace gases and provides a bin for the recovery of the fines carried off in such gases.

For shafts of narrow diameter, as in non-ferrous blast furnaces, two gas-tight, self-feeding charge chutes are ordinarily sufficient; but for shafts of larger diameter, such as iron blast furnaces, four or even more gas-tight, self-feeding charge chutes may be necessary to distribute the charge around the complete circumference of the shaft.

While I have described what I deem to be a practical and efficient embodiment of my invention, it is to be understood that I do not wish to be limited strictly thereto since changes in arrangement, disposition and form of the parts may be made without departing from the principle of my invention as comprehended within the scope of the following claims.

I claim:

1. In a blast furnace having a vertical shaft for re-

ceiving and confining a column of material to be smelted and having tuyeres for injecting air into the bottom of the combustion zone of the furnace for supporting combustion therein, a top structure comprising a hopper located at an elevation above the shaft, a main chute extending downwardly from the hopper for delivering material into said shaft, an inclined chute for gravitationally feeding material into said hopper, and a screen provided along the bottom of said inclined chute for removing fines from the material during its passage down said inclined chute.

2. A top structure as set forth in claim 1 including a storage bin located below the screen for receiving the fines.

3. A top structure as set forth in claim 1 wherein the main chute at its lower end is in gas-tight communication with the upper end of the shaft.

4. In a blast furnace having a vertical shaft for receiving and confining a column of material to be smelted and having tuyeres for injecting air into the bottom of the combustion zone of the furnace for supporting combustion therein, a top structure comprising an enlarged hood enclosing and extending above the upper end of the shaft and defining an expansion chamber for the gases issuing from the shaft, offtake means for the removal of gases from said hood, and means sealing the bottom of said hood and providing a collector for fines settling out of said gases.

5. A top structure as set forth in claim 4 in which the collector comprises a bin mounted at the lower end of said hood having a downwardly and outwardly sloping bottom for directing the collected fines radially outward of the shaft.

6. In a blast furnace having a vertical shaft for receiving and confining a column of material to be smelted and having tuyeres for injecting air into the bottom of the combustion zone of the furnace for supporting combustion therein, a top structure comprising an enlarged hood enclosing and extending above the upper end of the shaft and defining an expansion chamber for the gases issuing from the shaft, offtake means for the removal of gases from said hood, means sealing the bottom of the hood and providing a collector for fines

settling out of said gases, a hopper located at an elevation above the hood, a main chute extending downwardly from the hopper, and a plurality of branch chutes angularly leading off from said main chute, said branch chutes extending through said hood and having their lower ends terminating adjacent the top of the shaft and sloping downwardly at an angle greater than the angle of repose of the material.

7. A top structure for blast furnaces as set forth in claim 6 in which the lower ends of the branch chutes are located in circumferentially-spaced relation with respect to the top of the shaft.

8. A top structure for blast furnaces as set forth in claim 6 wherein the branch chutes comprise at their upper ends two divergent sections extending downwardly and outwardly of the main chute and at their lower ends two convergent sections extending downwardly and inwardly of the main chute.

9. A top structure for blast furnaces as set forth in claim 6 including an inclined chute for gravitationally delivering material into the hopper and means for the removal of fines from the material during its travel along said inclined chute.

10. A top structure for blast furnaces as set forth in claim 6 including an indicator for showing the level of the material filling the main chute.

11. A top structure for blast furnaces as set forth by claim 6 including means for conveying charge material into said hopper and a screen located along said conveying means for removing fines from the material.

12. A top structure for blast furnaces as set forth in claim 6 including means for conveying charge material into said hopper and a vibrating screen located along said conveying means for removing fines from the material.

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