Aug. 12, 1952 J. M. AVERY 2,606,672

BLAST FURNACE

Filed July 10, 1947 2 SHEETS—SHEET 1

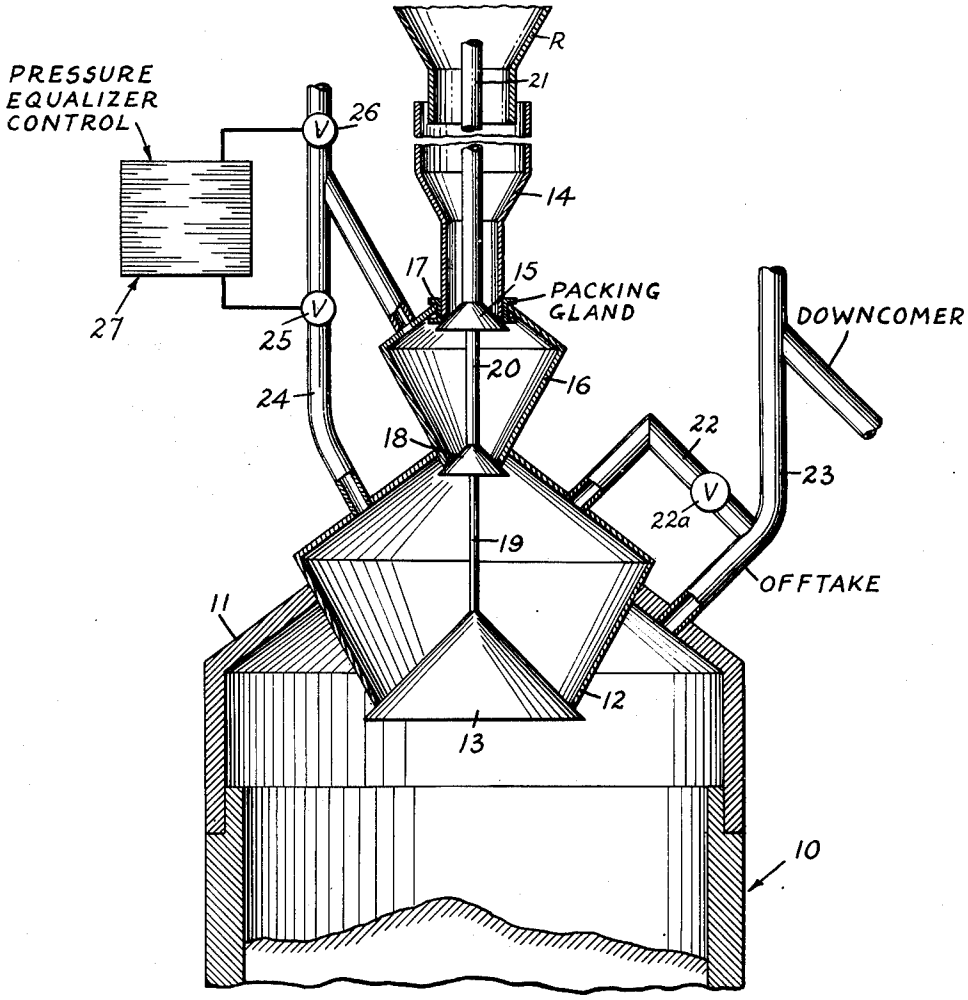


FIG.I.

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Aug. 12, 1952 J. M. AVERY 2,606,672

BLAST FURNACE

Filed July 10, 1947 2 SHEETS—SHEET 2

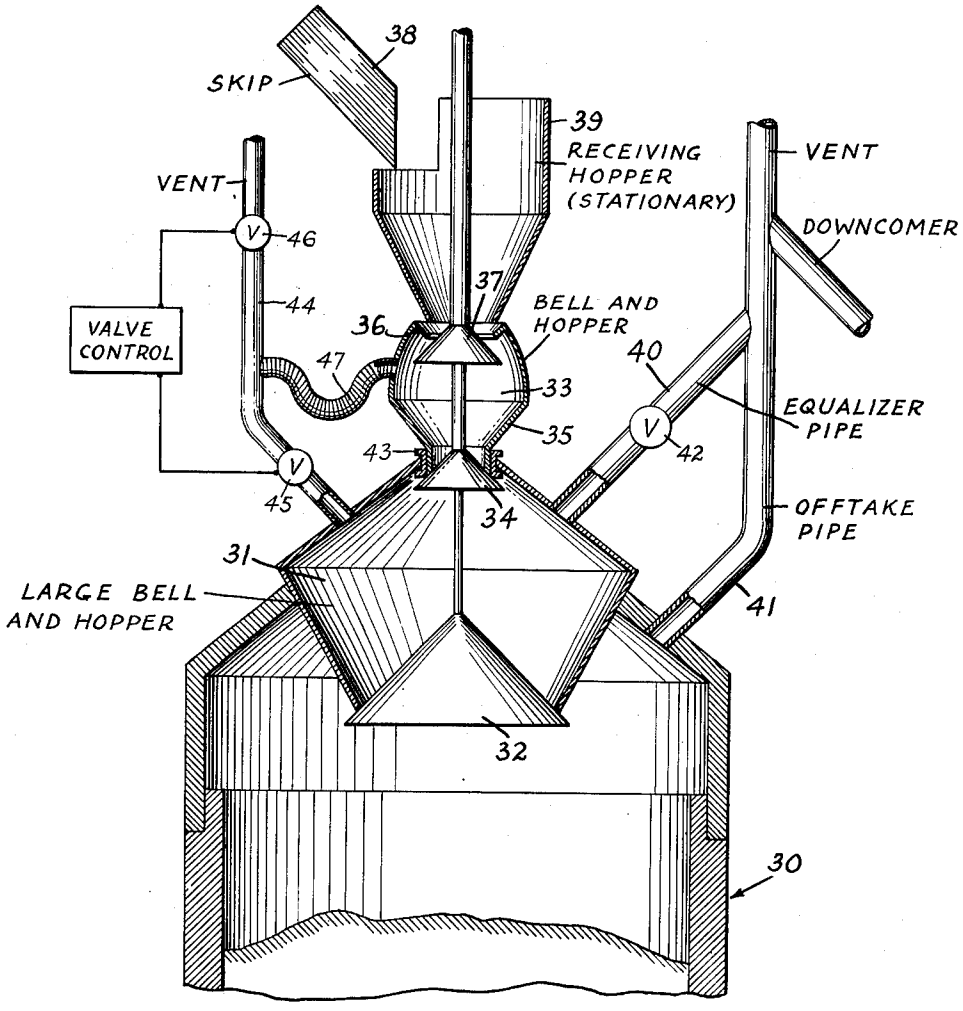


FIG. 2.

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UNITED STATES PATENT OFFICE

2,606,672

BLAST FURNACE

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2 Claims. (Cl. 214—37)

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This invention relates to improvements in devices for smelting pig iron such as, for example, blast furnaces and the like, and it relates particularly to an improved form of charging hopper construction for use in such devices at pressures substantially above atmospheric pressure.

My United States Patent No. 2,131,031, dated September 27, 1938, discloses a method for operating blast furnaces under top pressures that are very substantially higher than are used in normal operation in order to increase production and/or improve fuel economy.

This method has been difficult to practise commercially for the reason that furnaces of the type heretofore are in certain respects not entirely satisfactory for use at such high pressures. It has been found that the usual double bell and hopper arrangement for charging blast furnaces does not provide a satisfactory seal when the furnace is operated under the pressure conditions called for in my patent. This double bell construction customarily includes a small revolving bell and cylindrical hopper which is superimposed upon a larger bell and hopper fixed in the top of the furnace. The small hopper receives single skip charges of ore, coke, limestone, and the like which are dumped at frequent intervals into the large hopper by lowering the small bell after revolving the hopper through a predetermined angle. At less frequent intervals, the large bell is lowered to discharge the several skip loads of raw material into the furnace; that procedure serving to provide proper distribution of the charging stock within the furnace.

During the intervals when the large bell is lowered, the small bell is required to hold or maintain the pressure within the furnace. During the more frequent intervals when the small bell is lowered, the large bell is called upon to maintain the pressure within the furnace.

Under ordinary conditions, when only a small differential exists between the pressure of top gas within the furnace and the outside atmosphere, the large bell provides a reasonably tight and satisfactory seal. But when the furnace is operated under substantial superatmospheric top gas pressure it has been found that serious trouble is likely to develop. In such case the increased pressure differential across the sealing surfaces forces an increased volume of gas through small cracks and crevices in the sealing surfaces. The resultant loss of gas might not in itself be a serious matter, were it not for the fact that the trouble is cumulative in effect. The leaking gases, passing at rather high velocity through

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cracks and crevices, carry with them a considerable quantity of highly abrasive dust particles, which exert an abrasive or scouring action on the sealing surfaces. The result is a constant enlargement of leaks to such an extent that serious gas losses result, and the furnace has to be shut down for repairs.

It has been proposed to provide the large hopper and bell with hardened sealing surfaces in order to minimize the abrasive effect of the escaping gas and dust. This expedient is helpful in overcoming the difficulty, but does not completely overcome it. This is particularly true because of another source of trouble, namely, that the large bell or hopper, or both, sometimes warp or become distorted because of occasional exposure to unusually hot top gases, so that cracks or gaps of comparatively large size develop between the sealing surfaces. Because of this warping of the large bell or hopper, it has been suggested that a resilient seal, which is designed to maintain a pressuretight seal in spite of warping or distortion of the bell or hopper, be provided between these closure elements. This expedient is not entirely satisfactory for the reason that the resilient seal is sometimes exposed to very high temperatures, as for example when a "slip" occurs within the furnace. These temperatures, on occasion, are so high as to destroy any known material which has the necessary resiliency for use as a flexible seal.

It has also been proposed that a third bell be installed in the bottom of the receiving hopper, and that this hopper be made the revolving element and the present revolving hopper fixed in position. But this is difficult or even impractical because in general the receiving hopper usually is designed to accommodate the discharge of two skips operating on parallel tracks, and therefore cannot be made to revolve without a major redesigning of the superstructure. In general, therefore, this arrangement requires that the whole superstructure be raised in order to provide room for an additional hopper between the receiving hopper and the intermediate hopper, the said additional hopper being designed to revolve and being fitted with the third bell as a bottom closure. Obviously this also involves shifting, and in most cases rebuilding, the sealing ring and driving device of the rotating element. Such major changes in the top structure are even more expensive and undesirable than appears at first glance, for the elevation of the receiving hopper also requires that the skip hoist tracks be raised in order to discharge the skips at the higher

level. This involves a major and very expensive alteration.

It has further been proposed, in connection with the use of a third bell system as described to provide as a necessary means for equalizing pressure between the bells, to compress furnace gas, after it has passed through the cleaning system, to a pressure higher than that of the top gas and use it for pressure equalization. This requires passage of the substantial volume of gas used for equalization through the cleaning system, compressing it in compressors supplied for that purpose, and providing mains, control valves and the like for leading said gas back to the top of the furnace. All of this involves considerable expense. Moreover, since the gas is compressed to a pressure greater than that of the top gas, the hazard arises that if the control devices and valves fail to function properly, the gas supplied for equalization may develop either too much or too little pressure and thereby create serious operating troubles.

An object of the present invention is to provide a hopper and bell construction which overcomes the disadvantages of the hopper and bell constructions referred to above and which does not require a resilient sealing means or any special treatment of the sealing surfaces of the bell or hopper.

Another object of the present invention is to provide a bell and hopper construction whereby loss of gases from the system is reduced to a minimum during the charging operations.

Another object of the invention is to achieve such results without requiring expensive or impractical changes in the top structure, superstructure or skip hoist bridge of the furnace.

Another object of the invention is to provide a means of supplying, as a means for equalizing pressure between the hoppers, a source of relatively clean gas which automatically develops the desired amount of pressure without any need for special equipment or long and expensive piping or conduits, and without passing the gas through the gas cleaning system.

Other objects of the invention will become apparent from the following description of a typical hopper and bell construction embodying the present invention.

In accordance with the present invention, I have provided a structure including an additional bell and sealing construction and including suitable connections whereby the pressures within the hoppers may be adjusted in order to facilitate the operation of the charging structure and reduce the loss of gases therefrom. More particularly, the added bell and the hopper are arranged to provide a seal that relieves the bell of the large hopper of its sealing function and thereby makes unnecessary the provision of a tight seal between the large bell and hopper.

Suitable by-pass connections are provided between the hoppers whereby the pressures therein may be equalized to permit easy displacement of the bells. One of the by-passes may be provided with suitable valves for connecting and disconnecting the hoppers and for venting the upper hopper to atmosphere so that it may be charged without the escape of gases therethrough.

The above-described system has many advantages, for example, the large bell and hopper which are directly associated with the furnace are no longer required to have a gas-sealing relationship with each other and, therefore, any leakage or warpage between the large bell and hopper does not adversely affect the operation of the furnace. The new sealing hopper provides sealing action to prevent escape of gases and its elements are shielded from direct contact with excessively hot gases in the furnace by the large bell and hopper so that there is much less danger of warping and distortion of the sealing surfaces. Moreover, these elements being smaller, there is less likelihood of leakage developing around their contacting sealing surfaces. In addition, the large hopper acts effectively as a dust settler, and the gases used to equalize pressure in the sealing hopper are comparatively clean. Consequently, any gas leakage past the bells of the sealing hopper does not result in substantial erosion of the sealing surfaces. Thus, these effective sealing elements need not be provided with hardened surfaces or with a flexible sealing means although such sealing means can be used since the sealing hopper and its bell or bells are not exposed directly to the high temperature conditions that result from a "slip" in the furnace.

As has been mentioned, a further advantage of the invention is a substantial saving in the volume of top gas vented to the atmosphere by operation of the charging mechanism. With the conventional revolving hopper arrangement, the small bell is lowered after each skip is dumped, venting the large hopper to atmosphere. Since the large hopper has a capacity of at least six skip loads, and is vented every few minutes, the loss of gas may be considerable, especially under pressure operation. When using the sealing hopper of the invention, the gas vented each time a skip is dumped is that contained in the small sealing hopper, and is therefore only a fraction of that lost under the present method. The volume of gas saved in this manner may amount to several hundred thousands of cubic feet per day.

The small volume of the sealing hopper also decreases the volume of gas and shortens the time required to equalize pressure in order that the small bell may be lowered.

The apparatus of the invention also overcomes another problem, that of maintaining properly operating valves in the pressure equalizing pipes. It has been found that when this equalizing is done by means of dirty top gas as in the prior systems, these valves tend to stick or plug. In the system of the invention, dirty top gas is led directly from the offtake pipe into the large hopper. Here because of the relatively large volume and cross section, and the comparative stagnation of the gas, a large proportion of the dust, and especially the largest and most troublesome particles, settle out. It follows that the gas withdrawn periodically from the large hopper to equalize pressure in the sealing hopper is comparatively clean and can be passed through valves without trouble. No valve is needed in the line between the gas offtake and the large hopper, though one may be provided for occasional use in order to cut off pressure in the large hopper to permit easy access to the lower small bell and sealing ring.

For a better understanding of the present invention, reference may be had to the accompanying drawings in which:

Figure 1 is a view in vertical section disclosing a portion of a blast furnace having a hopper structure embodying the pressure-equalizing features of the present invention; and

Figure 2 is a view in vertical section of the

preferred form of hopper structure of the invention.

As disclosed in Figure 1, the hopper structure embodying the present invention may be applied to a conventional blast furnace 10 having the usual frusto-conical top portion 11 in which is mounted the usual large charging hopper 12 having a conical bell 13 closing its lower end. The above-described structure is conventional in blast furnaces and may take many different forms.

The device also, as in conventional furnace construction, includes a revolving charging hopper 14 having a bell 15 for closing its lower end. This hopper is adapted to receive skip charges at frequent intervals from a third receiving hopper R into which the skip or skips are dumped and to retain them until the bell 15 is lowered to permit the discharge of the material from the hopper 14.

In order to obtain the results described above, I have placed between the hopper 15 and the hopper 12 an intermediate hopper 16 having its lower end communicating with the hopper 12 and its upper end receiving rotatably the hopper 14. A suitable packing gland 17 is interposed between the hopper 14 and the hopper 16 to permit relative rotation of these parts without substantial escape of gas. The hopper 16 is also provided with a bell 18 which may be lowered to permit the discharge of any material therein into the hopper 12. All of the bells, 13, 15 and 18 may be lowered selectively by means of suitable concentric shafts 19, 20 and 21 which are connected to the bells 13, 18 and 15 respectively. The shafts 19 may be of solid construction and the shafts 20 and 21 are tubular and all these shafts are in telescopic relationship.

The pressure within the hopper 12 is equalized with the pressure in the furnace shaft 10 by means of a by-pass connection 22 having inclined legs to render it self-cleaning. The by-pass 22 may be either connected directly to the furnace and to the hopper 12 or to the offtake pipe 23 of the furnace. A valve 22a may be placed in the by-pass 22, if desired, to permit the hopper 12 to be disconnected from the offtake pipe when repairs are being made to the bell 18 or the hopper 16.

The hopper 12 and the hopper 16 are also connected by means of a by-pass conduit 24 which has a valve 25 therein by means of which communication between the hoppers 12 and 16 may be shut off.

A second valve 26 is also provided in the conduit 24 for venting the hopper 16 to atmosphere or shutting off communication between the hopper 16 and the atmosphere. The valves 25 and 26 may be controlled from a remote point by any suitable electrical or mechanical control device 27 that acts to close the valve 26 and open the valve 25, and close the valve 25 and open the valve 26.

In operation, the hopper 14 may be charged with a skip load of material for discharge into the hopper 16. When the contents of the hopper 14 are to be discharged into the hopper 16, the valve 26 is opened and the valve 25 is closed, thereby placing the hopper 16 under atmospheric pressure. The bell 15 is then opened and the charge is dumped into the hopper 16. Several skip loads of material may be dumped into the hopper 16 before it is opened for discharge into the hopper 12.

When the contents of the hopper 16 are to be discharged into the hopper 12, the valve 26 is closed and the valve 25 is opened, thereby placing the interior of the hopper 16 under the same pressure as the hopper 12 and the furnace 10. The bell 18 is then lowered and the contents of the hopper 16 are discharged into the hopper 12. If desired, several charges from the hopper 16 may be dumped into the hopper 12 before the latter is ready for discharge into the furnace 10. When the hopper 12 is dumped and during intervals between the charging of the furnace, the valve 25 is closed and the valve 26 is opened, thereby venting any gas under pressure in the hopper 16 to atmosphere. This relieves the hopper 16 and the bell 15 of the pressure but the bell 18 prevents escape of gases into the hopper 16. The bell 13 then may be lowered and the contents of the hopper 12 discharged into the furnace with the bell 18 maintaining a pressure seal during this operation. When the bell 13 is raised the bell 18 is shielded against direct contact with gases or radiant heat in the furnace.

From the preceding description, it will be clear that the only time the bell 15 is subjected to the pressure in the furnace, is when the bell 18 is lowered. This is at relatively infrequent intervals as compared with the lowering of the bell 15. During the discharge of material from the hopper 12 into the furnace and discharge of the hopper 14 into the hopper 16, the bell 18 prevents discharge of gases and thus effectively seals the furnaces.

The above-described hopper construction is especially useful for installation with new blast furnaces and it may also be useful for replacing or modifying the hopper and bell constructions of existing blast furnaces. However, in many instances, it is impractical to place the above-described hopper and bell construction in existing blast furnaces for the reason that it would require major changes in the buildings, skip hoist and other structural elements for the reason that the addition of the intermediate hopper 16 increases the overall height of the furnace in an amount almost equal to the height of the hopper 16.

A modified type of hopper and bell construction attaining the same results as that described above, but which can be used in existing types of furnaces without increasing the overall height of the furnace, is disclosed in Figure 2. In this form of the invention, the furnace 30 is provided with the conventional large hopper 31, having the movable bell 32 closing its lower end. Mounted in the upper end of the hopper 31 is a smaller hopper 33, also having a bell 34, closing its lower end. The hopper 33 replaces the conventional cylindrical revolving hopper and is of substantially different shape and dimensions for a purpose to be explained hereinafter. The hopper 33, as shown in Figure 2, has an outwardly bowed or inclined circumferential wall 35 and has at its upper end an inwardly directed flange 36 forming a seat in sealing relation to the bell 37, which is adapted to move up and down in the hopper 33 into and out of engagement with the edge of the flange 36.

The hopper 35 is enlarged transversely for the reason that sufficient space must be provided in it in order to accommodate the material fed into the hopper by the skip 38 when the bell 37 is lowered. Ordinarily, the skip or skips 38 discharge into a stationary hopper 39 disposed above the revolving hopper so that the skip charges are directed into the revolving hopper one at a

time. The hopper 33 is adapted to receive one skip load and is so arranged that when the bell 37 is lowered, space is provided around it for passage of the material supplied by the skips. If the conventional cylindrical type of revolving hopper were used, the bell 37 could not move downwardly into the hopper 33 because of the presence of the material therein.

The above-described construction is provided with pressure equalizing connections including an equalizing pipe 40 connecting the offtake pipe 41 with the interior of the hopper 31. A valve is not required in this pipe inasmuch as it is used to equalize the pressures on opposite sides of the bell 32, although a valve 42 may be provided to shut off the offtake pipe from the hopper 31, where repairs are to be made to the bell 34 and hopper 33.

Preferably, the hopper 33 is mounted in the usual rotary packing 43 to permit its rotation or oscillation. As illustrated, the hopper is arranged to oscillate rather than rotate, inasmuch as this simplifies the pressure equalizing structure and reduces the possibility of gas leaks. As shown in Figure 2, pressure equalization between the hoppers 31 and 33 and the hopper 33 and the atmosphere may be accomplished by means of a conduit 44 forming a vent and having spaced valves 45 and 46 like the valves 25 and 26. To permit oscillation of the hopper 33, a flexible pipe 47 is connected to the hopper 33 and to the conduit 44 between the valves 45 and 46. The flexible conduit is of sufficient length to permit 180° oscillation of the hopper 33.

A rotary mount for the hopper 33 may not be required for the reason that the bell 37 tends to distribute material uniformly through the hopper 33.

As indicated in the description of the device shown in Figure 1, the hopper 31 acts as a settling chamber for the dust, and therefore the gases flowing through the pipes 44 and 47 and the valves 45 and 46 are substantially clean.

In operation, the skip loads of material may be dumped into the hopper 39 with the bell 37 lowered. The material passes the bell 37 and enters the hopper 33, which has its lower bell 34 closed and is vented to atmosphere by opening the valve 46 and closing the valve 45. When the contents of the hopper 33 are to be discharged into the hopper 31, the valve 46 is closed and the valve 45 is open. The bell 37 is also in a closed position preventing escape of gas from the hopper 33. With the pressure in the hoppers 31 and 33 thus equalized, the bell 34 may be lowered discharging the material in the hopper 33 into the hopper 31.

When the hopper 31 is to be unloaded the bells 34 and 37 are raised and the bell 32 is lowered thereby discharging the contents of the hopper 31 into the furnace. Gas cannot escape through the upper end of the hopper 33 for the reason that its ends are closed by the bells 37 and 34, respectively.

The above-described construction does not increase the overall height of the furnace for the reason that the hopper 33 is substituted for the conventional rotating hopper. Therefore, the top structure of existing furnaces, the skip hoist, or other structural elements cooperating with the furnace do not have to be rearranged or altered to accommodate the new hopper construction.

The above-described arrangements are more effective in preventing leakage of the gases from the furnace than the conventional bell and hopper constructions used heretofore and are less susceptible to damage for the reason that the effective sealing surfaces and elements are shielded from the direct exposure to hot gases in the furnace and from the direct action of abrasive dust particles which would tend to increase the size of leaks in the system and damage the valves therein. Moreover, the sealing action is retained over prolonged periods of time for the reason that the smaller areas for sealing the furnace are less susceptible to warping and distortion than the large sealing areas heretofore required.

It will be understood that the above-described embodiment of the invention is susceptible to considerable modification in the shape and design of the hopper and bells, in the arrangement of the sealing surfaces thereof, and therefore, the form of the invention described should be considered as illustrative only and not as limiting the scope of the following claims.

I claim:

1. A charging apparatus for pressurized blast furnaces and the like comprising a first stationary hopper for receiving charging material and having a bottom opening for discharging material therefrom, a second hopper to receive said material from said first hopper, said second hopper having outwardly bowed walls and top and bottom bell seats fixed to said second hopper at its top and bottom, separate bells engageable with said seats to seal the open top and bottom of said second hopper, said bells being movable selectively out of engagement with said seats to admit material into the top of said second hopper and discharge it from the bottom of said hopper, a stationary third hopper mounted in the top of said furnace and having a top opening to receive material discharged from said second hopper, and a bottom opening to discharge said material into said furnace, another movable bell for opening and closing the said bottom opening of the third hopper, means supporting said second hopper for rotation relative to said first and third hoppers and in sealed relation to said third hopper, a conduit directly connecting said third hopper to said furnace to maintain the pressures equal therein when the bell at the bottom of said third hopper is closed and means for equalizing the pressures selectively on opposite sides of said separate bells.

2. A charging apparatus for pressurized blast furnaces and the like comprising a first stationary hopper for receiving charging material and having a bottom opening adapted to discharge material, a second hopper for receiving said material from said first hopper and having top and bottom openings; pressure-tight sealing bells for opening and closing the top and bottom openings of said second hopper, means supporting said second hopper for oscillation through an arc of about 180° to provide proper distribution of the charge; a furnace; a third stationary hopper mounted in the top structure of said furnace for receiving material from said second hopper, a bottom bell-closure for said third hopper controlling the discharge of material into the furnace; a gas-tight sealing ring between said second and third hoppers; a first gas conduit connecting the interior of said third hopper with the interior of the furnace to equalize the pressures therein at all times; a second gas conduit connected to the interior of said third hopper and to atmosphere, said second gas conduit being located at a point removed from said first gas conduit to provide for the settling of dust, and a flexible pressure-

tight conduit joined to said second conduit and to said second hopper to permit oscillation of said second hopper; and valves in said second gas conduit on opposite sides of the junction of said flexible conduit with said second conduit for controlling in desired sequence the flow of gas for pressure equalization between adjacent hoppers.

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