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83.2; 222/502, 503; 266/27

[56] **References Cited**
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3,511,390 5/1970 Pantke et al. 214/35 X
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[54] **APPARATUS FOR CHARGING SHAFT-TYPE FURNACES**
9 Claims, 4 Drawing Figs.
[52] U.S. Cl..... **214/35 R,**
222/503
[51] Int. Cl..... **F27b 1/20**

ABSTRACT: An apparatus for the charging and sealing of shaft-type furnaces in which a pair of sliding-plate gas locks are provided above and below a roof-shaped distributor in the charging housing. The distributor coacts with a pair of swingable flaps to prevent free flow of the charge, the flaps being simultaneously swung in opposite senses to open chutes for the charge into the furnace when the lower gate is open.

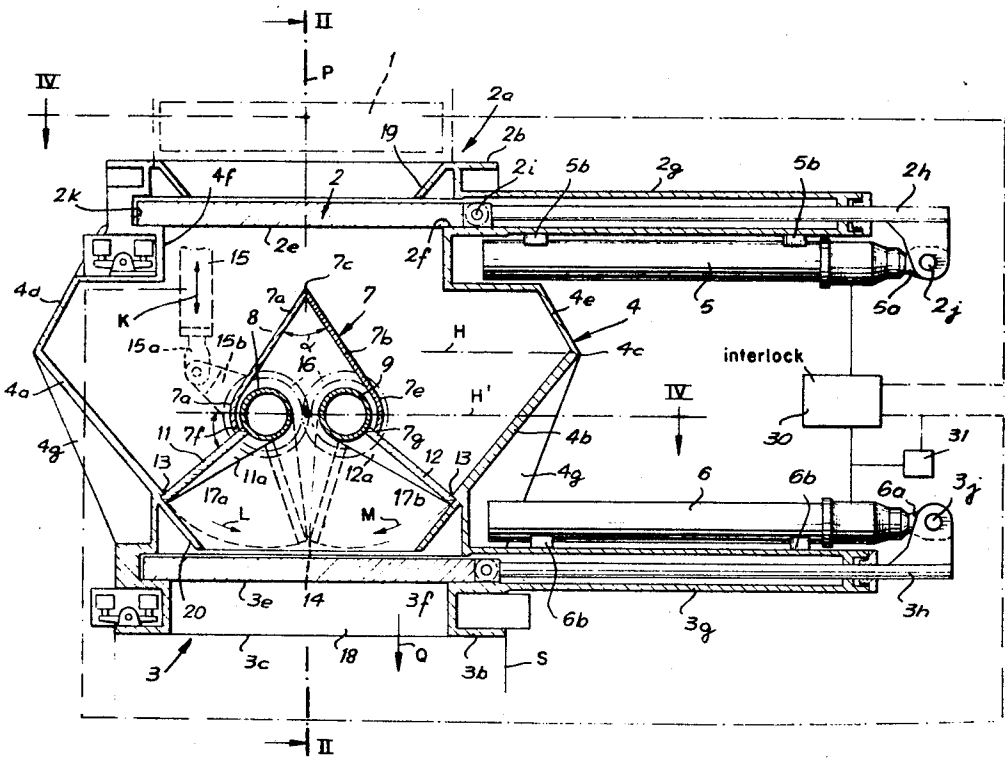
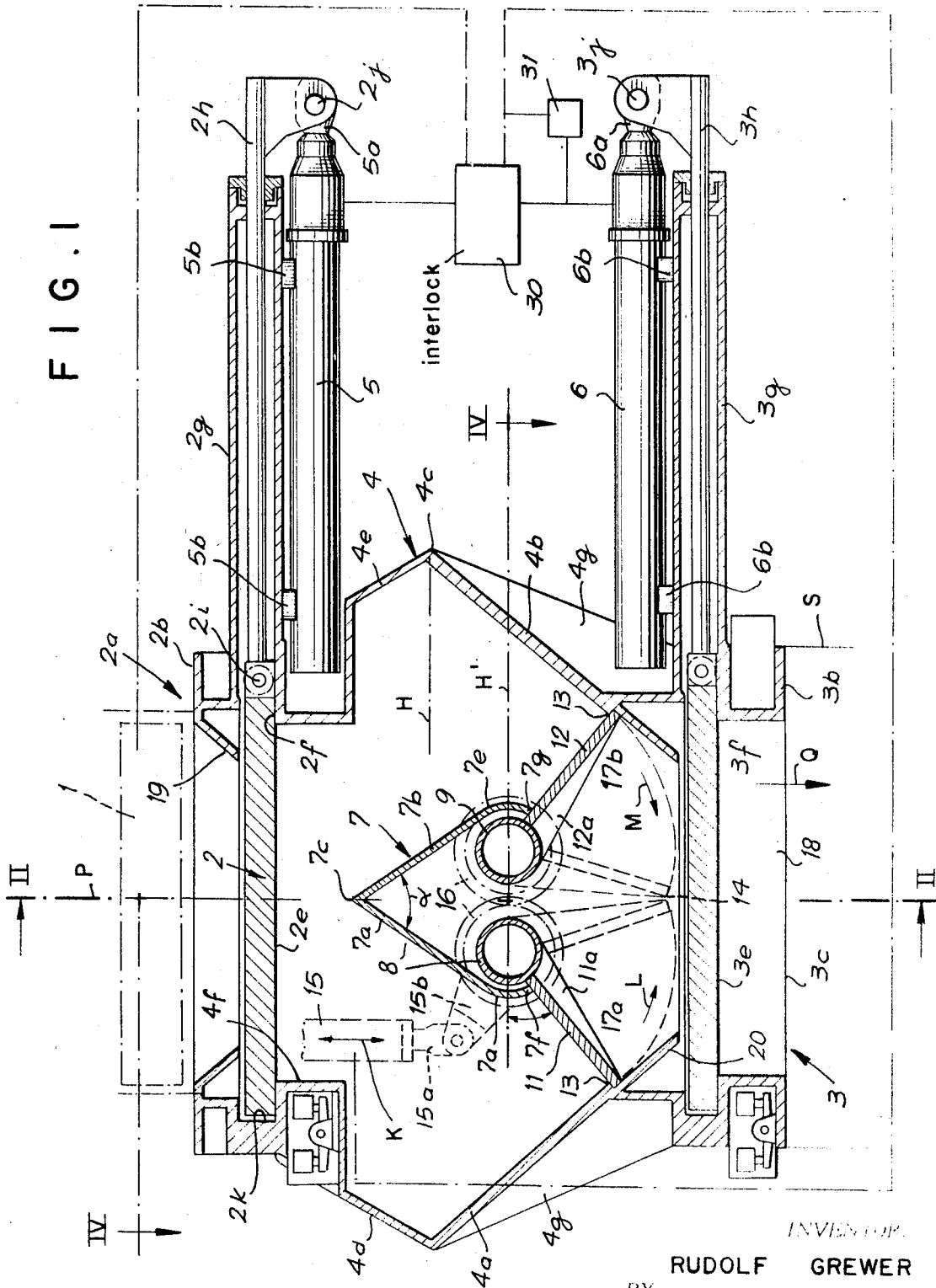


FIG. 1



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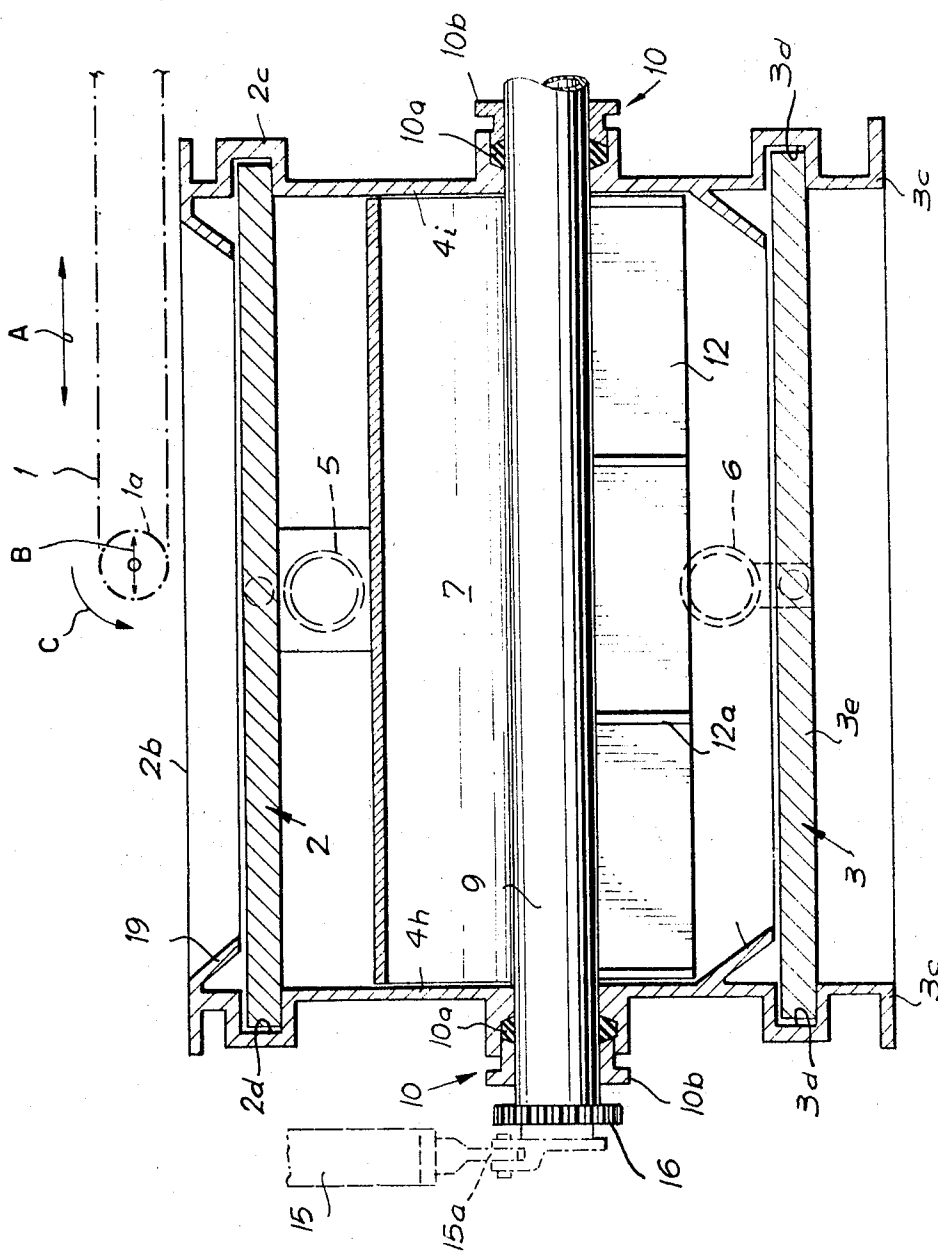


FIG. 2

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FIG. 4

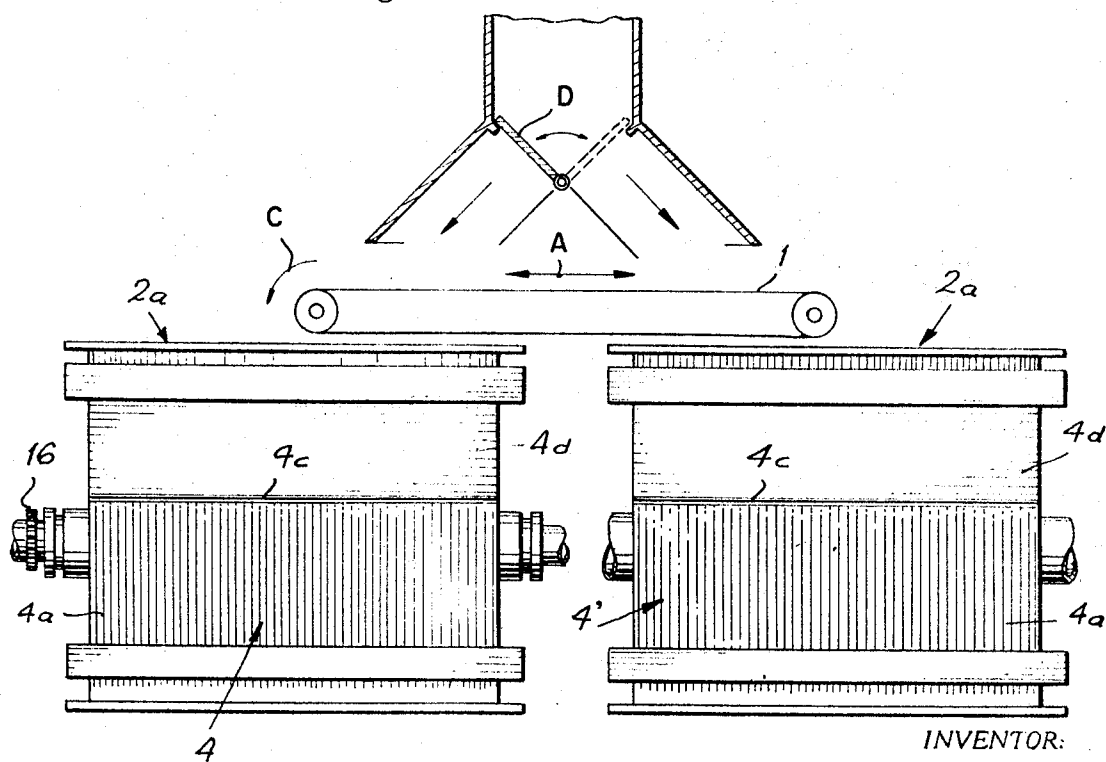
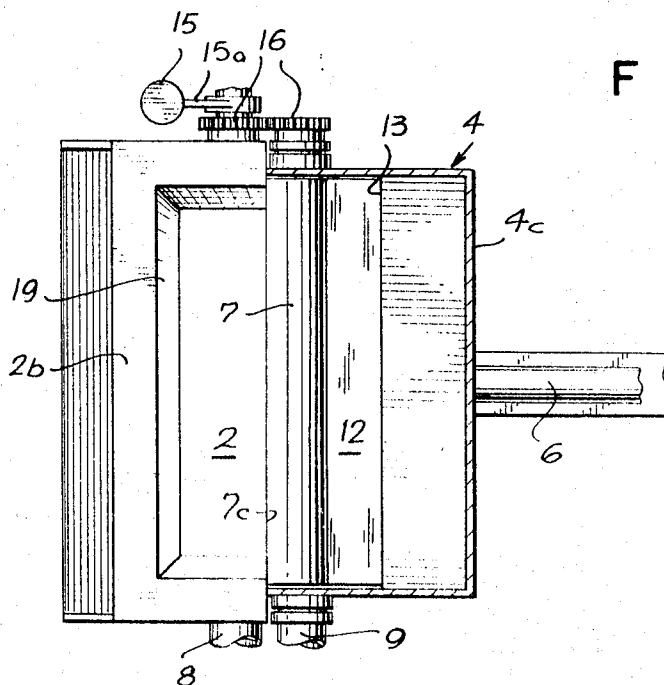


FIG. 3

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APPARATUS FOR CHARGING SHAFT-TYPE FURNACES

The present invention relates to an apparatus for charging shaft-type furnaces and, more particularly, to a long-wearing charging apparatus of this character which is substantially unaffected by erosive action of the closure members sealing the apparatus against the throughflow of gases from the furnace.

Metallurgical reduction furnaces of the shaft or cupola type are increasingly employed at the present time for the reduction of metallurgical ores and especially for the conversion of iron ore into sponge iron or an iron melt.

Such furnaces generally make use of a rising stream of a metallurgical reduction of gas, consisting predominantly of hydrogen and carbon monoxide, which is introduced at a lower portion of the furnace through blast pipes, tuyeres and the like. The gas passes upwardly through the substantially porous charge while reacting with the metallurgical ore to reduce the latter and form water vapor and carbon dioxide. The invention is particularly appropriate with so-called "high-pressure" reduction furnaces of this character, i.e. furnaces in which the blast is supplied at high velocity and a pressure differential exists between the interior of the furnace and ambient pressure. As a consequence, the apparatus for charging such a furnace must simultaneously preclude the escape of gases at elevated pressure from the shaft furnace, such gases being toxic, noxious and corrosive with respect to sealing charges of the furnace and the charging apparatus.

Consequently, it has been the common practice in metallurgical reduction furnaces of this type, especially blast furnaces, high-pressure shaft furnaces and cupolas, to provide a double-closure arrangement at the upper or charging end of the furnace, i.e. in the form of so-called "closure bells" arranged one above another and of conical configuration for engagement with respective seats to preclude the escape of gases. These vertically spaced alternately displaceable members are operated sequentially so that, when the lower member is opened to connect the seal housing above the furnace with its interior, the other closure member is shut, thereby blocking communication between ambient atmosphere and the housing. In the other half-cycle of the operation of these systems, the upper closure bell is opened while the lower bell is closed thereby permitting the introduction of a charge into the furnace through the housing while blocking communication between the housing and the furnace.

In most prior art systems of this general type, the closure bells perform a double function, namely, the sealing of the furnace, and the distribution of the freshly added charge over the cross section of the furnace and the previous charge bed formed therein. Conveyor means, ducts or the like, e.g. skip loaders and similar arrangements, can be used to carry the charge to the mouth of the housing for emptying into the furnace with the aid of the double-closure lock formed by the bells. It must be noted that, in the operation of this lock, closure members are provided in two vertically spaced horizontal planes and at least one of them is always closed to prevent a sudden drop in pressure within the furnace or an instantaneous flow of high-velocity gas therefrom.

A disadvantage of conventional systems of this type for sealing and charging a shaft-type furnace of the general character described, is that relatively long free fall paths are provided for the charge, thereby permitting deterioration thereof, while conventional systems also are characterized by a tendency toward segregation or stratification of the charge into localized concentrations of coarse and fine particles. The conical closure members tend to deposit the charge in a generally conical pile which leads to a concentration of the fines along the upper part of the cone while the coarse particles concentrate elsewhere, the pile being in the form of a ridge somewhere between the center of the furnace and the furnace wall. As the charge is increased and becomes compacted, a uniform penetration of the charge by the gas cannot occur.

In face, in the design considerations of such furnaces, it is important to note that efficient operation requires a high throughflow of the gaseous phase and thus relatively high charge porosity and yet sufficient charge density that the elemental metal will be produced at high rates and with economy. Since there is a tendency in conventional systems, as noted earlier, toward segregation and concentration of fine and coarse particles in the porous columnar mass, there is a tendency for the gases to pass through channels formed in the less dense regions to the exclusion of the remainder of the body. Portions of the charge then remain unreacted while other portions are brought into intimate contact with excessive quantities of the reducing gas with no increased output from these portions of the gas.

Thus while it is recognized that proper distribution of the charge within the furnace and addition of increments of the charge with a minimum of segregation or separation of the charge into coarse and fine particles is essential, it has been difficult, if not impossible, to minimize such segregation effects and yet maintain effective sealing of the furnace. As the tendency towards separation increases, the uniformity of the gas flow through the charge increases and the poorer is the product and furnace efficiency. In general, it has been found that swinging flap closures which may form the gas lock of such furnace, conveyor systems cooperating therewith to introduce the charge and like prior art arrangements are also unsatisfactory for the foregoing reasons and also because of the tendency to the high-velocity gases transversing the sealing edges of the closure members and entraining fine particles of the charge therewith, perform an abrasive action and cause early deterioration of the edges of the closure members and of the arrangements for introducing the charge.

It may be noted, in this connection, that pressure differentials are generally created across each of the closure members so that, as they are opened, the narrow gap formed between their respective seats and their sealing edges sustains a high-velocity flow of gas-entrained particles through this gap and across these edges, thereby multiplying the abrasive action and deterioration of the sealing arrangement.

Aside from the foregoing consideration, it may be noted that it is possible to maintain the porosity of the charged column within the furnace, as proposed in the last few years, by the use of pellets of the metallurgical ore as also also to finely divided powders or irregular agglomerates or clumps. More recently, it has been discovered that greater economy in terms of equipment, manpower and processing time can be realized when nonhardened or so-called "green" pellets are used in the charge of the shaft-type furnace of the character described. However, such pellets are incapable of sustaining severe compression forces, tend to break up when subjected to shock, and are prone to deterioration by abrasive contact with surfaces and neighboring particles. When breakdown of the "green" pellets, which otherwise allow substantial improvement in the production rate and efficiency of the shaft-type furnaces does occur, the fine particles from which the pellets were formed are found to distribute themselves irregularly within the furnace to obstruct the uniform distribution of interstitial passages which must be maintained or formed therein to distribute the reducing gas uniformly over the charge.

It is, therefore, the principal object of the present invention to provide an apparatus for the sealing and charging of shaft-type furnaces, especially blast furnaces or high-pressure cupola furnaces, which will avoid the aforementioned disadvantages and operate more efficiently than earlier furnaces of the same general character.

Another object of this invention is to provide a sealing and charging apparatus for a shaft-type furnace which eliminates or reduces the escape of gas from the furnace and yet permits an improved distribution of charge increments in the furnace and upon any bed of previous charge which may be present therein.

Yet another object of this invention is to provide a system for charging shaft-type furnaces while sealing the latter which is less prone to deterioration of the sealing edges of the closure members, provides greater security against the escape of gases and permits charging of the furnace with a more delicate charges, e.g. so-called "green" pellets, without difficulty.

It is a further object of the instant invention to provide a shaft-furnace sealing and charging arrangement which reduces segregation of the charge into fine and coarse fractions.

Still further, it is an object of this invention to provide a charging system for the shaft-type furnaces which extends the principles originally set forth in the commonly owned application Ser. No. 711,102 filed 6 March 1968 and entitled "Apparatus For Charging Shaft-type Furnaces," now U.S. Pat. No. 3,511,390.

In that application, there is described an apparatus for charging an upstanding shaft-type furnace which comprises a conveyor means for advancing the comminuted material or charge to the apparatus and a pair of upper and lower closure members adapted to bar the escape of gas and gas-entrained particles from the furnace. That system was based on the discovery that, when the dispensing device, which receives the comminuted material from the conveyor and is located between the closure members, is a tiltable tray whose swinging axis extends parallel to the direction of movement of the conveyor so that the latter is displaceable in the direction of this horizontal axis, a uniform layer of comminuted material is deposited in the furnace without formation of a piling cone and with a substantially uniform thickness. The conveyor means is a band-type conveyor which may be discontinuously operable in the cadence of the swinging movement of the tiltable distributing tray, while the closure members are horizontally shiftable gates lying in planes perpendicular to the axis of the furnace above and below the tiltable tray. These linearly slidable horizontal gates, which are displaceable between a chamber receiving each gate in the open condition thereof, and a position in which the gates spans the mouth of the furnace is capable of overcoming some of the substantial disadvantages of earlier systems whereby particle-entraining gases at high velocity form ridges, grooves and the like by mechanical erosion of the sealing edges of the closure members. In fact, with the linear horizontal displacement of the platelike gates, which are slidably guided along their opposite longitudinal edges in recesses of a support frame surmounting the furnace and with the forward edge of the gate being lodged in a similar recess at the far side of the frame, there appears to be no deterioration of the sealing parts.

The gates may, as described earlier, be operated alternately in the cadence of displacement of the distributing tray. Advantageously, a hydraulically pneumatic system is provided in which the slidable gates are shifted by piston and cylinder arrangements, while a further cylinder serves to displace the tiltable tray via a bellcrank lever. It has been found that this type of control system is particularly satisfactory for use when a number of tiltable trays are used in tandem with reversible conveyors or duct systems for delivering the charge to the apparatus.

It has now been found further that the above-described system can be improved by providing between the upper and lower sliding-plate gates of the charging apparatus, a central hoodlike or roof-shaped distributing arrangement for the charge. The hooklike member, which is upwardly converging and lies along a vertical median plane of the furnace, is disposed below the upper closure member and above the lower closure member while being provided with a swinging flap arrangement adapted to subdivide the interior of the housing of the charging apparatus into upper and lower compartments sealed from one another when the flaps are shifted into their "closed" position. The flaps according to the present invention, cooperate with downwardly converging walls of the housing, which thereby constitutes a hopper structure, terminating in a mouth of reduced cross section closed

by the lower sliding plate. Above the distributing and deflecting hood, which overlies and protect the shaft of the swinging flaps, the housing may also diverge toward a mouth closed by the upper sliding plate. The location of the charged distributor and flap seal arrangement intermediate the two gas lock gates, according to the present invention, has been found to significantly reduce the free fall height of the charge and in fact to substitute a free fall of the charge through the gas lock, a sliding and rolling feed of the charge into the furnace with a corresponding reduction in deterioration of "green" pellets and segregation of the particles of the charge into coarse and fine fractions. In fact, this action mixes the charge thoroughly so that instead of segregation or separation, there is a tendency toward a more homogeneous distribution of particles sizes in the layer of charge deposited in the furnace.

According to an essential feature of this invention, the distributing hood in the housing between the gates is of roof or coping shape, i.e. as a pair of downwardly diverging surfaces extending in the major dimension of the housing which may be rectangular in horizontal cross section, and meeting at an acute angle junction at the peak of this distributor. The flaps, which extend along the sides of the roof-shaped distributor, are journaled, in accordance with a particular feature of this invention, on respective shafts lying in a common horizontal plane and symmetrically on opposite sides of a vertical median plane of the furnace and charging apparatus. Preferably, the housing is elongated, as noted above and both the horizontal shafts which lie wholly within the outlines of the roof-shaped distributor and a downward projection of the outlines thereof so as to be protected from the charge introduced into the housing from above, span the housing in the longitudinal direction and are coupled for joint rotation by, for example, meshing gears externally of the housing. When the flaps are swung symmetrically inwardly, i.e. toward one another, they abut in the aforementioned median plane of symmetry to unblock communication between the upper part of the housing and the lower housing portion, while simultaneously releasing the charge previously deposited on these flaps into the furnace. In their outer or spread positions, the flaps abut upwardly against stops formed on the housing walls to constitute a seal and a support for the charge increment which is introduced into the housing.

According to an important feature of this invention, the housing is formed with downwardly converging frustoconical longitudinal walls and at least a pair of vertical end walls, the converging walls defining chutes with the respective flaps, along which the green pellets roll and slide as they pass into the interior of the furnace. In their spread positions, the flaps or wings preferably lie at about right angles to the converging walls of the housing above the distributor, the housing converges toward the inlet opening or mouth which is blocked by the upper gate. It has been found that the symmetrical arrangement described above prevents separation of the charge into large and small particles fractions and in addition limits free fall of the particles.

According to yet another feature of this invention, the charge is fed to the housing by a conveyor means, e.g. an endless band conveyor which is shiftable in the direction of elongation of the roof-shaped distributor. Preferably, the conveyor alternates between housings each of which has a roof-shaped distributor and cooperating flaps or wings of the type described.

The above and other objects, features and advantages of the present invention will become more readily apparent from the following description, reference being made to the accompanying drawing in which:

FIG. 1 is a vertical cross-sectional view transverse to the longitudinal dimensions of an apparatus for charging a shaft furnace in accordance with the present invention;

FIG. 2 is a cross section taken along the vertical median plane of the apparatus perpendicular to the plane of FIG. 1,

FIG. 3 is a view of a convertible conveyor arrangement for use with the system of FIGS. 1 and 2; and

FIG. 4 is a cross section taken along the line IV-IV of FIG. 1.

In FIGS. 1 and 2 of the drawing, there is shown a sealing and charging apparatus for a shaft furnace S which comprises a conveyor belt arrangement 1 which is reversible as shown by the arrow A and has a discharge-side roll 1a shiftable in the direction of arrow B on suitable guides or the like as described in application Ser. No. 711,102 so that the conveyor may discharge green pellets of iron oxide or the like into the charging apparatus as represented by arrow C. Since the discharge end of the conveyor moves in the longitudinal direction across the entire mouth of the charging apparatus, the pellets are distributed uniformly in the charging apparatus. An upper gate 2 closes the hopperlike housing 4 which, as can be seen from FIG. 1, has a pair of downwardly and inwardly sloping chute-like walls 4a and 4b reaching to the widest portion 4c of the housing. The horizontal plane H of this portion of the housing intersects of roof-shaped distributor 7, the function of which will be described in greater detail hereinafter. Above the plane H, longitudinal walls 4d and 4e converge upwardly and define the mouth 4f of the charging housing 4. Reinforcing webs 4g are provided along the walls 4a, 4b and extend transversely thereto while the housing end walls 4h and 4i as seen in FIG. 2.

The upper gate 2 comprises a frame 2a overlying the mouth 4f of the housing 4 and having a rectangular configuration with longitudinal walls 2b and transverse walls 2c. The latter are provided with inwardly open guide grooves 2d for the horizontally shiftable closure plate 2e which extends through a slot 2f in one of the walls 2b and is receivable in a closed housing 2g designed to protect the plate against exposure to the elements and contamination. A connecting rod 2h is hinged to the plate 2e at 2i and is articulated at 2j to the piston 5a of a fluid-responsive cylinder 5 connected to the underside of chamber 2g by brackets 5b.

The lower gate or closure arrangement is represented generally at 3 and includes a lower frame 3a made up of walls 3b and 3c, the former having a slot 3f through which the closure plate 3e can be withdrawn into a chamber 3g by a fluid-responsive cylinder 6 mounted by brackets 6b on the housing 3g. The piston 6a is articulated at 3j to the connecting rod 3h which extends through the housing 3g and is pivotally connected at 3i to the plate 3e. Guide channels 3d, confronting one another in the walls 3c of the frame, slidably receive the plate 3e. In each frame the free end of the plate 2e, 3e is receivable in a further groove 2k, 3k to ensure total sealing of the apparatus.

As noted earlier, below the center of the mouth 4f, there is provided a roof or copinglike charge-distributing element 7 in the form of a hood which lies in the vertical median plane P of the apparatus and extends the full length thereof horizontally between the end walls 4h and 4i to which this hood 7 is secured. The hood comprises a pair of downwardly diverging flanks 7a and 7b united in a peak 7c and including with one another an acute angle of about 70° as represented by α . The flanks 7a and 7b are plates which curve inwardly into the aprons 7d and 7e closely flanking a pair of tubular shafts 8 and 9 journaled in bearing assemblies 10 in the end walls 4h and 4i through which these shafts extend, the bearing assemblies having seals 10a held in place by packing nuts 10b to prevent leakage of gas from the housing 4.

The distributor 7 has the function of uniformly distributing the charge within the housing 4 onto a pair of wings or flaps 11, 12 extending radially from the shafts 8 and 9, respectively and reinforced by ribs 11a and 12a of triangular configuration. The distributor serves to reduce the free fall height of the charge and allows the charge to tumble along the outer surfaces of the flanks 7a and 7b in a sliding and rolling action which has been found to be less detrimental to green pellets, in spite of the low compressive strength and wear resistance thereof. The bottom edges 7f and 8g of the aprons 7d, 7e abut the flaps 11 and 12 when the latter are in their upper, outwardly swung positions represented in solid lines in their upper, outwardly swung positions represented in solid lines in

FIG. 1. The aprons 7d and 7e protect the shaft 8 and 9, which they flank, from contact with the charge. The shafts 8 and 9, define pivotal axes for the flaps 11 and 12 which lie in a horizontal plane H' and enable the flaps to be swung in opposite senses about these axes. To this end, externally of the housing 4, the shafts are provided with intermeshing gears 16, best seen in FIG. 2. In their upper positions, the flaps 11 and 12 abut, at their free ends, stops 13, formed in the walls 4a and 4b of the housing while in their lower or "open" position, the flaps abut one another at 14 in the plane P as represented in broken lines in FIG. 1. To actuate the flaps 11 and 12, there is provided a fluid-responsive cylinder arrangement 15, the piston 15a of which is vertically shiftable (arrow K) and is articulated to a bellcrank lever 15b affixed to shaft 8.

When the flaps 11 and 12 are swung inwardly into abutment at 14, they define with the walls 4a and 4b respective chutes 17a and 17b through which the charge flows in the direction of arrows L and M in two streams to ensure a thorough mixing and further prevent separation of the charge. When the gate 3 is opened, the charge cascades downwardly through the window 18 in the direction of arrow Q into the charging duct of the shaft furnace as represented in S. In this system, the flaps 11 and 12 need not be hermetically sealing to accomplish the objects of the invention. The cylinder 15 and the cylinders 5, 6 are connected to a programmer 30 which is provided with an interlock 31 between the lower gate 3 and the flaps 11 so that the latter cannot be swung inwardly as long as the gate 3 is open.

The sequence of operations, as determined by the programmer 30, initially opens the upper gate 2 while maintaining the lower gate 3 closed and the flaps 11 and 12 in the spread positions shown in solid lines in FIG. 1. Only when the gate 2 has been fully withdrawn, does the programmer operate the conveyor 1 to deposit the charge uniformly in the housing 4.

Thereafter, the supply of the charge through the mouth 4f of the housing 4 is terminated and the gate 2 fully closed and the gate 3 fully opened before the programmer 30 swings the flaps 11 and 12 inwardly to empty the charge into the furnace. Since high-velocity gases do not flow past the sealing edges of the gates 2 and 3 at any time during this operational sequence and never are forced through narrow gaps between sealing members in the housing, deterioration of these members is reduced. Funnellike aprons 19 and 20 above the gates 2 and 3 are provided inwardly of the frame members to prevent movement of the charge in the register of the sealing edges. As the charge is formed in the furnace, it constitutes a cushion bed for subsequent layers and thereby reduces the free fall height. As described in Ser. No. 711,102, sensing means for the quantity of charge fed into the housing 4 to terminate operation of the conveyor 1 when the charge reached its desired level within the housing. After discharge of the housing by inward swinging of the flaps, gate 3 is closed, flaps 11 and 12 are returned to their solid lines positions as shown in FIG. 1, and the process repeated in a periodic manner.

In FIG. 3 there is shown an arrangement in which the conveyor 1 is reversible (arrow R) to deliver the charge to two charging devices 4 and 4', each of which is identical to the charging apparatus illustrated in FIGS. 1 and 2. In place of the conveyor 1, a reversible duct arrangement D may be provided to alternately supply the housings, while the previously filled housing is empty. A reversible conveyor and duct arrangement of this type is fully described in application Ser. No. 711,102 mentioned earlier.

The improvement described and illustrated is believed to admit of many modifications within the ability of persons skilled in the art, all such modifications being considered within the spirit and scope of the invention except as limited by the appended claims.

I claim:

1. An apparatus for charging a shaft-type furnace, comprising:
a horizontally elongated housing surmounting said furnace;

an upper and lower gate along upper and lower portions of said housing and alternatively operable to permit communication between said housing and said furnace and between the exterior of said housing;

an upwardly converging roof-type distributor disposed in said housing in the path of a charge introduced into said upper portion of said housing, said distributor spanning said housing in the longitudinal direction along a vertical median plane through said housing; and

a pair of swingable flaps mounted in said housing below said distributor and extending parallel to said distributor for temporarily retaining the charge in said housing, but swingable into an open position in which said flaps are downwardly convergent to permit passage of the charge into said furnace through said lower portion of said housing, said lower gate including a horizontal frame surrounding an opening immediately below the path of said flaps, and a plate horizontally shiftable in said frame across said opening, said housing having a pair of downwardly convergent walls reaching beneath the path of the flaps and terminating slightly above said plate.

2. The apparatus defined in claim 1, further comprising a pair of mutually parallel shafts extending in the longitudinal direction in said housing and journaled thereon within the outlines of said distributor and rigidly carrying said flaps, means for coupling said shafts for joint rotation in opposite senses and actuating means for rotating at least one of said shafts relative to said housing.

3. The apparatus defined in claim 2 wherein said flaps extend outwardly beyond said distributor in a "closed" position thereof, said housing having symmetrically downwardly converging walls cooperating with said flaps for retaining the charge temporarily thereon in the closed position of the said flaps.

4. An apparatus for charging a shaft-type furnace, comprising:

a horizontally elongated housing surmounting said furnace; an upper and a lower gate along upper and lower portions of said housing and alternatively operable to permit communication between said housing and said furnace and between the exterior and said housing;

an upwardly converging roof-type distributor disposed in said housing in the path of a charge introduced into said upper portion of said housing, said distributor spanning said housing in the longitudinal direction along a vertical median plane through said housing;

a pair of swingable flaps mounted in said housing below said

distributor and extending parallel to said distributor for temporarily retaining the charge in said housing but swingable into an open position to permit passage of the charge into said furnace through said lower portion of said housing,

a pair of mutually parallel shafts extending in the longitudinal direction in said housing and journaled thereon within the outlines of said distributor and rigidly carrying said flaps;

means for coupling said shafts for joint rotation in opposite senses; and

actuating means for rotating at least one of said shafts relative to said housing, said flaps extending outwardly beyond said distributor in a "closed" position thereof, said housing having symmetrically downwardly converging walls cooperating with said flaps for retaining the charge temporarily thereon in the closed position of said flaps, said distributor comprising a pair of downwardly diverging generally flat flanks joined in a peak lying along said median plane, and a pair of aprons integral with said flanks and surrounding said shafts, said aprons substantially abutting said flaps in said closed position.

5. The apparatus defined in claim 4, further comprising charge feed means above said upper portion of said housing and said upper gate and shiftable in the longitudinal direction parallel to said distributor, for depositing said charge in said housing.

6. The apparatus defined in claim 4, further comprising abutment means along said walls engageable with free ends of said flaps in said closed position, said flaps abutting one another in said open position, said flaps extending generally radially from said shafts.

7. The apparatus as defined in claim 6 wherein said upper and lower gates each include a frame aligned with the respective opening of said housing and formed with a pair of confronting guides channels, a closure plate slidably received in said frame and guided in said channels, and alternatively operable fluid-responsive cylinders connected with said plates for actuating same.

8. The apparatus defined in claim 7 wherein each of said frames is formed with a chamber receiving the respective plate in a retracted position thereof.

9. The apparatus defined in claim 8, further comprising conveyor means above said upper gate for delivering metallurgical pellets to said bucket through said upper gate in a retracted position of the corresponding plate.

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