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W. J. MATTHYS ETAL

3,204,942

DISTRIBUTOR FOR PNEUMATICALLY TRANSPORTED PARTICLE-FORM MATERIAL

Filed Feb. 18, 1963

2 Sheets-Sheet 1

FIG. 1

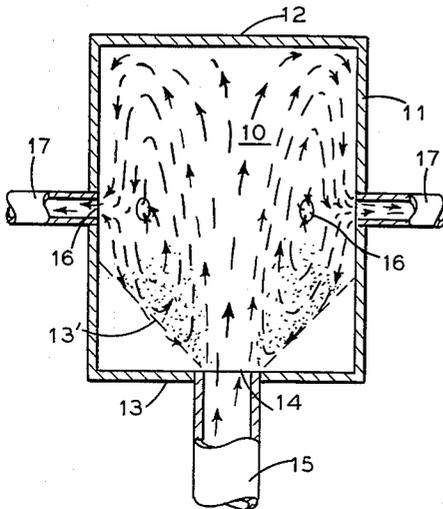


FIG. 2

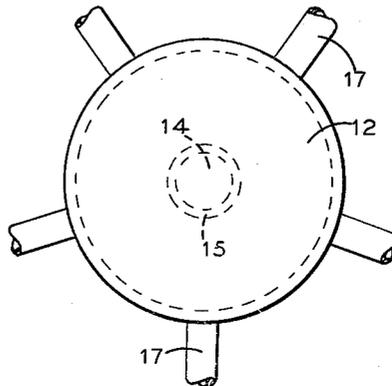
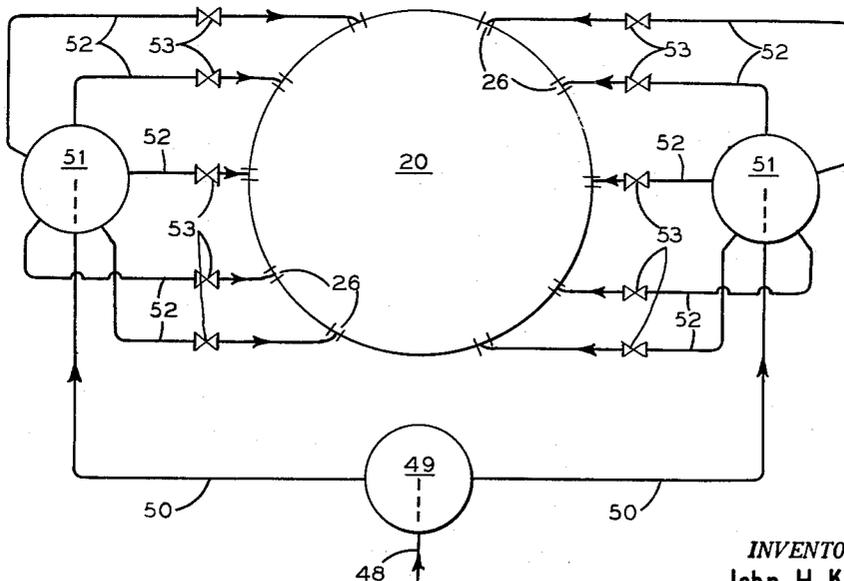


FIG. 4



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**DISTRIBUTOR FOR PNEUMATICALLY TRANSPORTED PARTICLE-FORM MATERIAL**

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7 Claims. (Cl. 266—28)

This invention relates to a distributor for pneumatically transported particle-form material and more particularly to a distributor wherein a mixture of carrier air and particle-form fuel is divided into a plurality of effluent streams of equal density and weight for introduction into and combustion in a blast furnace.

Recent activities in the steel industry have been directed toward the adaptation of supplementary pulverized coal firing systems for use in blast furnaces. Experimental work indicates that it may be possible to replace as much as 40% of the high cost coke used in blast furnaces with lower cost pulverized fuel, and to this end several schemes have been proposed for preparing the pulverized fuel for introduction into the blast furnace. One of these schemes, in which the present invention may be advantageously used, is shown and described in detail in U.S. Patent No. 3,150,962, issued September 29, 1964. The economic justification for the use of pulverized coal in blast furnaces, as well as the general prerequisites of such a system, are fully described in the aforementioned U.S. patent and thus will not be repeated herein.

Modern high capacity blast furnaces are provided with 16 to 24 air ports or tuyeres through which high temperature blast air, at about 1800° F., is introduced into the furnace above the hearth. Recent developments in blast furnace operating techniques have shown that the high blast air temperatures result in improved conditions in the blast furnace hearth for producing the desired quality of pig iron, and that operation at these high temperatures will permit higher iron production rates than have heretofore been possible. To attain these high blast air temperatures, an extensive program has been carried out to develop the regenerative stoves in which the blast air is heated. The high furnace temperature associated with optimum furnace operation dictates that a minimum amount of relatively cool carrier air be introduced into the furnace along with pulverized fuel. To avoid coking or burning of coal in the transmission lines, the temperature of the carrier air and pulverized fuel is limited by the characteristic coking or ignition temperature of the fuel being used. Thus it is desirable to use a minimum amount of the relatively cool carrier air to preclude dilution of the high temperature blast air.

Another factor greatly affecting blast furnace operation is the uniformity of combustion throughout the cross-sectional area of the hearth and both sections of the furnace. Any local upset in combustion conditions can cause severe channeling of the gases up through the furnace stack or the formation of undesirable ash and slag ledges immediately above the combustion zone, either of which would seriously affect the overall operation of the blast furnace. This requirement of uniform combustion in the furnace dictates the necessity of using a large number of blast air tuyeres and also makes it necessary to distribute the auxiliary pulverized coal as uniformly as possible within the combustion zone. This distribution of supplementary fuel can best be accomplished by introducing equal amounts through all of the tuyeres.

From the above it can be seen that one of the primary problems in the adaptation of supplementary pulverized coal firing systems to blast furnaces is that of equally

distributing the pulverized fuel to all of the tuyeres while using a minimum amount of relatively cool carrier air.

As described above, equal distribution of the coal is necessary to maintain uniformity of reaction as it proceeds within the furnace, and the minimum amount of carrier air is essential to avoid undue reduction in the requisite high temperature associated with blast furnace operating conditions. During operation it may be necessary, because of adverse conditions within the combustion zone of the furnace, to cut the supply of supplementary fuel to one or more of the tuyeres. During such times, it is obviously necessary that the fuel delivered to each of those tuyeres remaining in operation must be maintained in substantially equal amounts so that a further unbalance in furnace conditions will not occur. Therefore, the distribution system must be capable of adjustment in order that equal amounts of fuel may be delivered to each and every tuyere which is kept in service to satisfy particular operating conditions. Advantageously, the distributor herein disclosed accomplishes this by a self-adjustment feature which is inherent in the design.

It is an object of this invention to provide a distributor for dividing an incoming stream of pneumatically transported pulverized fuel into a plurality of effluent streams having equal coal-air densities and coal quantities. It is a further object to accomplish this distribution and transport with a mixture of fuel and air having a low air/coal ratio, i.e. below 6 standard cubic feet of air per pound of fuel. A more specific object of this invention is to provide a distributor for use in conjunction with a supplementary pulverized fuel system for a blast furnace whereby the fuel may be equally distributed to a plurality of tuyeres and whereby equable distribution to a lesser number of tuyeres may be similarly accomplished without having to make any changes to the distributor.

To attain the above mentioned objects a distributor is provided which includes walls forming a vertically disposed, unobstructed chamber which is symmetrical about its vertical axis. The chamber is closed at its upper end or top, and a central inlet is provided in the bottom thereof, through which an air-fuel mixture to be distributed to multiple coal pipes is axially introduced into the chamber. A plurality of spaced outlets, each communicating with an associated coal pipe, are provided in the chamber walls for the discharge of the mixture from the distributor. These outlets are arranged in a common horizontal plane and are equi-distant from the vertical axis of the chamber. In such a distributor the density of the outgoing streams of air and coal will be equal, and if the outlets are of equal size, the quantity of fuel going to each outlet will also be equal. When the distributor is used in conjunction with a blast furnace, so that each outlet is connected to a tuyere by a conveying pipe or conduit, the flow from the distributor to each tuyere will be equal if the back pressure of each outlet (pressure drop through each conduit system and its corresponding tuyere) is equal.

In addition, the present invention encompasses the method of operating a semi-direct pulverized fuel system in combination with a pressurized blast furnace whereby high pressure conveying and drying air is continuously cycled through a pulverizer and separator, and pulverized coal is entrained in the air in the former and separated from the air in the latter. A minor portion of the conveying air is withdrawn from the cycle to be used for carrying the coal to the blast furnace, and an equal amount of heated makeup air is introduced into the cycle. The carrier air is combined with a regulated quantity of pulverized coal from the separator to form a mixture having an air/fuel ratio of less than 6 standard cubic feet per pound of coal, and this mixture is divided into a

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plurality of substantially equal density streams for delivery to each of the tuyeres of the blast furnace.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawing and descriptive matter in which there is illustrated and described a preferred embodiment of the invention.

Of the drawings:

FIG. 1 is a sectional side view of a preferred embodiment of the distributor;

FIG. 2 is a top view of the distributor shown in FIG. 1;

FIG. 3 is a schematic diagram of a blast furnace pulverized fuel preparation and conveying system embodying distributors of the type shown in FIGS. 1 and 2;

FIG. 4 is a schematic diagram showing in more detail that portion of FIG. 3 which relates to the pulverized fuel distribution system and a blast furnace.

A preferred embodiment of the distributor is shown in FIGS. 1 and 2. The main portion of the distributor is a vertically disposed right cylindrical chamber 10 formed by a tubular side wall 11, a top plate 12 and a bottom plate 13. An inlet pipe 15 is fitted into the central inlet opening 14 in the bottom plate 13, and extends axially downward with respect to the chamber 10. A plurality (five as shown in FIG. 2) of equally sized outlet openings 16 are formed in spaced relation in a common horizontal plane in the side wall 11. The outlet pipes or conduits 17 are fitted into these openings 16 and extend radially outward from the chamber 10.

In operation, a mixture of air and pulverized material is introduced axially into the chamber 10 through the inlet pipe 15. The mixture is subsequently discharged through the openings 16 in equal quantities and with uniform densities in each of the pipes 17. As shown diagrammatically in FIG. 1, the jet effect of the incoming stream penetrates the full length of the chamber 10 and impinges on the top plate 12. The jet then "mushrooms" and a downward uniform recirculation of the mixture takes place with some of the mixture passing out of the chamber 10 through the openings 16. The portion of the mixture which does not leave the chamber 10 continues downwardly to the bottom of the chamber 10, and forms, in an equilibrium condition, a reservoir of material that is re-entrained in the incoming stream.

Of particular significance is the fact that actual testing has shown that this distributor is capable of equally distributing air and pulverized solids mixtures having an extremely wide range of air/material ratios, i.e., from above 12 to as low as 0.22 standard cubic feet of air per pound of pulverized material. Operation in the lower portion of this range would seem to suggest that the distributor operation is somewhat akin to a fluidized bed; however, the principle of operation is not analogous to fluidized bed principles. In a fluidized bed, the fluidized medium is introduced at low velocity over a wide area such that the entire body of material in a given zone is aerated. However, in this distributor, the confined inlet stream is introduced at a relatively high velocity into the enlarged chamber 10 to produce the jet effect described above. To further distinguish the principle involved from a fluidized bed, it should be noted that the distributor also functions efficiently at higher air/material ratios, i.e., above 12 standard cubic feet of air per pound of pulverized material.

As a practical matter, a frusto-conical bottom (shown in phantom as 13' in FIG. 1) may be provided in the chamber 10 to avoid any accumulation in the bottom recesses of the chamber. As can be seen from the figure, this bottom has a downwardly diminishing diameter. Otherwise, there would be a tendency for material to accumulate on the bottom plate 13 adjacent the sidewall 11 which could result in intermittent "slugging" of the

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material through the outlets 16, or could produce a fire hazard.

Although the outlet openings 16 are shown in FIG. 2 as being evenly spaced circumferentially about the side wall 11, it has been shown in the tests to be hereinafter described that this uniform disposition of outlets 16 is not essential to satisfactory operation.

A distributor of the type shown in FIGS. 1 and 2 was tested using mixtures of air and pulverized coal to determine its "efficiency" as a distributor when operating under pressure. In these tests, air/coal mixtures of known proportions were introduced into the distributor during a measured period of time, and the quantity of material issuing from each of the outlet pipes 16 was collected, weighed and compared to determine the degree of flow unbalance to the several pipes. From these results, the degree of unbalance (a measure of distribution efficiency) was determined as the difference between the highest and lowest percentage of pulverized coal collected from the individual pipes.

The following are representative results obtained in tests on a distributor having a 4 inch pipe for the inlet 15, five 1½ inch outlet pipes 17, and having a right cylindrical chamber 10 with an inside diameter of 15¼ inches and a height of 24 inches.

Table number one

Test.....	A	B	C	D	E	F
Distributor Press, p.s.i.g.....	36.5	37.5	37.0	36.0	35.3	35.5
Total Coal, lb.....	289.0	532.5	759.5	856.0	782.0	909.0
Air/coal, s.c.f./lb.....	12.6	7.04	1.38	0.905	0.400	0.217
Percent collected						
Outlet:						
#1.....	21.1	21.5	19.0	20.5	20.5	18.9
#2.....	19.1	19.9	19.4	20.2	20.2	20.1
#3.....	18.7	18.6	20.2	19.2	19.5	18.7
#4.....	20.1	19.0	20.9	19.7	19.1	21.5
#5.....	21.0	21.0	20.5	20.4	20.7	20.8
Degree of Unbalance, Percent.....	2.4	2.9	1.9	1.40	1.6	2.8

Further tests, using the same distributor, were conducted with one, two or three of the outlet conduits 17 closed off, and the resulting distribution through the remaining conduits was equally as good as with all of them open and in use. Another series of tests showed that the quantity of coal flowing through each conduit 17 was directly proportional to the air flow therethrough. This means that the distributor provides a mixture of uniform density at the outlets 16, and thus it follows that when the resistance to flow through each outlet conduit 17 is equal, the quantity of coal flowing therethrough will also be equal.

In a series of tests, using a plastic model of the distributor described above, the diameter of the chamber 10 was varied to ascertain whether any size limitations could be found. As a result of these tests, it was determined that for satisfactory solids distribution the ratio of the chamber diameter to the diameter of the inlet 14 had to be maintained between 3.5 and 8.0, and that optimum performance was obtained when this ratio was between 4.0 and 6.0. In the model tests, the flow pattern of the material within the distributor could be observed as bearing out the principles of operation discussed above.

In transporting coal at low air/coal ratio such as have been described (below 6 standard cubic feet of air per pound of coal), further testing has shown that the characteristic flow pattern is a fluctuating flow or a form of two-phase flow commonly referred to as "slugging," i.e., separation of the two constituents into entities known as "slugs." If this condition exists at the distributor inlet, it will be substantially eliminated when the mixture passes through the distributor because of internal recirculation within the distributor chamber.

In the course of conducting the above tests and observations several limitations in the design of the dis-

tributor became apparent. To effect optimum performance, the distributor must be vertically disposed, the outlets 16 must be in a common horizontal plane and the inlet pipe 15 must be centrally positioned in the bottom of chamber 10. Also the single inlet line 15 must be arranged to introduce the incoming stream axially into the chamber 10 to assure uniform flow entering the distributor to produce the symmetrical recirculation pattern described above. For best results, the inlet 15 should have a straight vertical portion of about ten times its internal diameter.

The distributor shown in FIGS. 1 and 2 is the preferred embodiment because of its simplicity of construction; however, it may be concluded that variations in the design of the distributor could be made without affecting its performance or departing from the expounded principle of operation. For example, the outlet conduits 17 need not necessarily extend radially outward from the chamber 10. Also, the chamber 10 does not have to be circular in cross-section but could, for example, be hexagonal or octagonal; however, in these instances it is suggested that the outlets 16 should be evenly displaced about the periphery of the chamber. It is also contemplated that the flat top plate 12 could be replaced by one having a different shape. For example, a hemispherical or conical top could be used so long as the characteristic flow pattern within the chamber is maintained. Generally speaking, the chamber 10 should at least be symmetrical about the vertical axis of the distributor, and the outlets 16 should be equi-distant from this vertical axis.

An auxiliary pulverized coal firing system for use in conjunction with a blast furnace and incorporating distributors of the type described above is shown in FIG. 3. The blast furnace 20 is of the usual type wherein provisions are made for the delivery of iron ore, flux, and coke through the upper end and for removal of slag and pig iron through appropriate openings (not shown) in the bottom. Since blast furnaces and their method of operation are well known in the art, only pertinent details directly associated with the supplementary pulverized fuel system will be herein described.

Blast air for the furnace 20 is supplied by a compressor 21, and is heated to about 1800° F. by a battery of regenerative stoves 22. The hot blast air is delivered through duct 23 to a torus shaped bustle pipe 24 which encircles the blast furnace 20 at about the level of the bosh. The blast air is then introduced into the furnace 20 through goosenecks 25 which extend through the air ports or tuyeres 26. In this description, it will be assumed, for the sake of simplicity, that there are 10 tuyeres 26 evenly spaced about the circumference of the blast furnace 20; however, it should be recognized that the present invention may also be used in conjunction with a blast furnace having a smaller or greater number of tuyeres.

The raw coal to be fired in the blast furnace 20 is supplied to an atmospheric hopper 30, thence through a series of pressurized lock hoppers 31 having appropriate pressure-tight coal valves 32, and into the pulverizer 33. Conveying air for the prepared fuel is supplied to the pulverizer 33 from the recirculating fan 34 through line 27. The pulverized fuel, in suspension in the conveying air, is carried by line 35 to the separator 36 where the coal/air mixture is separated, the pulverized coal dropping into the lower hopper 37 while the air is removed at the top of the separator 36 through air line 38. The majority of the separated air is returned to the recirculating fan 34 through line 40, the remainder being used as carrier air for conveying pulverized coal from the lower hopper 37 to the blast furnace 20 as will be hereinafter described. Make-up air for the conveying air circuit is supplied from the compressor 21 through lines 41 and the separately fired air heater 42. The make-up air for the conveying cycle is preheated to the desired temperature (about 400° F.) in the heater 42 and is introduced into the cycle

through the mixing T 43. Thus the conveying air is continuously circulated by the fan 34 through a cycle including the pulverizer 33 and the separator 36, and the minor portion of the conveying air that is withdrawn from the cycle downstream of the separator 36 for purposes of conveying the pulverized coal to the blast furnace 20 is replaced by heated air entering the cycle through the mixing T 43.

The carrier air to be used for conveying the pulverized coal from the lower hopper 37 to the blast furnace 20, is obtained from air line 38 and passed through carrier air line 44 to the mixing T 45 which is immediately below the lower hopper 37. The carrier air flow is regulated to a desired rate by valve 46 and the amount of pulverized coal flowing to the mixing T 45 is regulated by control of the feeder 47 so that an air/coal mixture of the desired density is continuously formed in the mixing T 45. This air/coal mixture passes through the primary distributor supply line 48 and thence into the primary distributor 49, which is of the general type described earlier. The primary distributor 49 in this instance is constructed with only two outlet conduits 50, which serve as the secondary distributor supply lines. Each of the secondary distributors 51 are also of the general type already described and are constructed with five outlet conduits 52 each. Thus the air/coal mixture is first divided into two streams in the primary distributor 49, and each of these streams is further subdivided into five streams each in the two secondary distributors 51. Each of the outlet conduits 52 is arranged to supply its air/fuel stream to a specific tuyere 26 of the blast furnace 20. In the drawing (FIG. 3), for the sake of simplicity, only one outlet conduit 52 is shown as being connected to its corresponding tuyere. From the above, it can be seen that distributors of the type herein described could be arranged to divide a mixture of air and pulverized coal into practically any desired number of streams.

It should be noted that the pressure within the conveying air cycle including the pulverizer 33 and the separator 36 is sufficiently high to overcome the cumulative static pressure within the blast furnace 20 and the pressure drop through the line 42, mixing T 45, distributor inlet line 48, distributor 49, outlet lines 50, distributors 51 and conduits 52. Thus, the pressure in the conveying air cycle is sufficiently high to pass the pulverized fuel from the mixing T 45 through the entire distribution system and into the blast furnace 20 without the aid of any booster.

Although the distributor has been described herein in conjunction with the preparation and conveying of air borne pulverized coal to a blast furnace, it should be recognized that the disclosed distributor may also be used in conjunction with other systems for the distribution of any pneumatically transported particle-form material.

In FIG. 4, the arrangement of the distribution system is shown schematically in relation to the blast furnace 20, and the same reference numerals correspond to like parts in both FIG. 3 and FIG. 4. As described before, the air/coal mixture enters via the primary distributor supply line 48 into the primary distributor 49, and is therein divided into two streams which pass by way of the two secondary distributor supply lines 50, one supply line serving each secondary distributor 51. Each of the secondary distributors 51 is constructed with five outlet conduits 52 which conduct their respective streams of air/coal mixture to a corresponding tuyere 26. Valves 53 are also provided so that any of the conduits 52 can be removed from service for maintenance as well as to compensate for upsets in conditions within the blast furnace 20.

It should be noted that to obtain equal distribution through all of the conduits 52, the pressure drop through all of the conduit flow paths should be equal; therefore, the conduits 52 should be arranged and constructed so that equal back pressures are obtained at all of the outlets

of the secondary distributors 51 when there is equal flow through the outlets. If necessary, flow restrictors may be placed in the lines 52 to effect equality of pressure drop therethrough.

Preferably each secondary distributor 51 supplies fuel to its nearest tuyere 26, rather than having the outlet conduits or pipes 52, from the several secondary distributors 51, in a complicated, staggered arrangement about the blast furnace. The arrangement shown allows the fuel distribution system to be designed and installed using a minimum amount of piping (conduits 52), and is possible only because of the unique operating characteristics of the distributors 49 and 51.

As previously mentioned, the quantity of fuel leaving each outlet of a distributor is directly proportional to the air flow through that outlet. To illustrate the operation of this distribution system, let us assume that the total coal flow to the primary distributor 49 is 9000 pounds of coal per hour. With all ten of the cut-off valves 53 open, this will result in a flow to each tuyere 26 of 900 pounds of coal per hour. Let us now assume that one of the valves 53 is closed because of a local operational upset within the blast furnace 20, and that it is desired to maintain the total coal input rate of 9000 pounds per hour. The air flow to the secondary distributor 51 will now be reapportioned to equalize the pressure at the outlets of the primary distributor 49 so that the air flow to the secondary distributor 51 having all of its associated valves 53 open, will receive a larger portion of the air than will the other secondary distributor 51 which is now serving only four tuyeres. Since the primary distributor 49 distributes the coal on a density basis, a correspondingly larger portion of coal will also be delivered to the secondary distributor having all valves 53 open. Thus the quantities of coal flowing through all of the conduits 52 that remain open will still be substantially equal, i.e., now about 1000 pounds of coal per hour. From this description, it can be seen that the unique operating characteristics of the distributor provide equal quantities of coal to the tuyeres 26 that are retained in service even when one or several of them are not being used. Thus the distribution system affords a large degree of flexibility to the supplementary coal firing system so that it may be effectively utilized without interruption even during periods when conditions within the blast furnace 20 are upset.

While in accordance with the provisions of the statutes there is illustrated and described herein a specific embodiment of the invention, those skilled in the art will understand that changes may be made in the form of the invention covered by the claims, and that certain features of the invention may sometimes be used to advantage without a corresponding use of the other features.

What is claimed is:

1. Apparatus for distributing pneumatically transported particle-form material comprising walls defining an unobstructed chamber formed symmetrically about its vertically disposed axis and having its upper end closed, a bottom closure for said chamber including means forming a centrally disposed unobstructed inlet for the axial introduction into said chamber of a mixture of gas and particle-form material, said inlet having a cross-sectional area substantially less than the horizontal cross-sectional area of said chamber, and means forming a plurality of spaced outlets opening into said chamber, said outlets being arranged equi-distant from said axis in a common horizontal plane displaced a substantial distance from said upper end so that at least a substantial portion of the mixture entering said chamber impinges on said upper end and recirculates downwardly prior to exiting said chamber through said outlets.

2. Apparatus for distributing pneumatically transported pulverized fuel in a plurality of streams having substantially equal densities comprising walls defining an unobstructed chamber of circular horizontal cross section formed symmetrically about its vertical axis, said cham-

chamber including a substantially cylindrical portion closed at its upper end, a bottom closure of downwardly diminishing diameter being formed with a centrally disposed unobstructed inlet for the axial introduction into said chamber of a mixture of air and pulverized fuel, and means forming a plurality of circumferentially spaced outlets opening into said chamber, said outlets being arranged equi-distant from said axis in a common horizontal plane displaced a substantial distance from said upper end so that at least a substantial portion of the mixture entering said chamber impinges on said upper end and recirculates downwardly prior to exiting said chamber through said outlets.

3. In combination, a pressurized blast furnace of generally circular cross section and having a plurality of circumferentially spaced tuyeres positioned in a common plane in the lower portion thereof, said blast furnace being of the type wherein it is desirable to introduce pulverized fuel with a minimum amount of carrier air to all of said tuyeres, and a semi-direct pulverized fuel system including independent sources of pulverized fuel and carrier air, means for continuously combining regulated quantities of said pulverized fuel and said carrier air to form a mixture for introduction into said blast furnace, a distribution system for dividing said mixture into a plurality of streams having substantially equal densities and being equal in number to the number of said tuyeres, and a plurality of conduits extending from said distribution system to said tuyeres for passing each of said streams to a corresponding one of said tuyeres, the quantity of pulverized fuel flowing in each of said streams being proportional to the combined pressure drop through its corresponding conduit and tuyere, said distribution system including at least one distributor comprising walls defining an unobstructed chamber formed symmetrically about its vertically disposed axis and having its upper end closed, a bottom closure for said chamber including means forming a centrally disposed inlet for the introduction of a mixture of air and pulverized fuel into said chamber, said inlet having a cross-sectional area substantially less than the horizontal cross-sectional area of said chamber, and means forming a plurality of spaced outlets opening into said chamber, said outlets being arranged in a common horizontal plane and being equi-distant from said axis.

4. In combination, a pressurized blast furnace of generally circular cross section and having a plurality of circumferentially spaced tuyeres positioned in a common plane in the lower portion thereof, said blast furnace being of the type wherein it is desirable to introduce pulverized fuel with a minimum amount of carrier air to all of said tuyeres, and a semi-direct pulverized fuel system including independent sources of pulverized fuel and carrier air, means for continuously combining regulated quantities of said pulverized fuel and said carrier air to form a mixture for introduction into said blast furnace, a distribution system for dividing said mixture into a plurality of streams having substantially equal quantities of said pulverized fuel and being equal in number to the number of said tuyeres, and a plurality of conduits having substantially equal pressure drops and extending from said distribution system to said tuyeres for passing each of said streams to a corresponding one of said tuyeres, said distribution system including at least one distributor comprising walls defining an unobstructed chamber formed symmetrically about its vertically disposed axis and having its upper end closed, a bottom closure for said chamber including means forming a centrally disposed inlet for the introduction of a mixture of air and pulverized fuel into said chamber, said inlet having a cross-sectional area substantially less than the horizontal cross-sectional area of said chamber, and means forming a plurality of spaced outlets opening into said chamber, said outlets being equal in size and arranged in a common horizontal plane and equi-distant from said axis.

5. In combination, a pressurized blast furnace of generally circular cross section and having a plurality of circumferentially spaced tuyeres positioned in a common plane in the lower portion thereof, said blast furnace being of the type wherein it is desirable to introduce pulverized fuel with a minimum amount of carrier air to all of said tuyeres, and a semi-direct pulverized fuel system including independent sources of pulverized fuel and carrier air, means for continuously combining regulated quantities of said pulverized fuel and said carrier air to form a mixture for introduction into said blast furnace, a distribution system for dividing and mixture into a plurality of streams having substantially equal densities and quantities of said pulverized fuel, said streams being equal in number to the number of said tuyeres, and a plurality of conduits having equal pressure drops and extending from said distribution system to said tuyeres for passing each of said streams to a corresponding one of said tuyeres, said distribution system including at least one distributor comprising walls defining an unobstructed chamber formed symmetrically about its vertically disposed axis and having its upper end closed, a bottom closure for said chamber including means forming a centrally disposed inlet for the introduction of a mixture of air and pulverized fuel into said chamber, said inlet having a cross-sectional area substantially less than the horizontal cross-sectional area of said chamber, and means forming a plurality of spaced outlets opening into said chamber, said outlets being equal in size and arranged in a common horizontal plane and equi-distant from said axis.

6. In combination, a pressurized blast furnace having a plurality of spaced tuyeres circumferentially arranged in the lower portion thereof, and a fuel feeding system for delivering pneumatically transported particle-form carbonaceous fuel to a plurality of said tuyeres, said fuel feeding system comprising means for combining regulated quantities of said fuel and carrier gas to form a mixture for introduction into said blast furnace, a distribution system for dividing said mixture into a plurality of streams having substantially equal densities, and a plurality of conduits extending from said distribution system to said tuyeres for passing each of said streams to a corresponding one of said tuyeres, said distribution system including at least one distributor comprising walls defining an unobstructed chamber formed symmetrically about its vertically disposed axis and having its upper end closed, a bottom closure for said chamber including means forming a centrally disposed inlet for the introduction of said mixture axially into said chamber, said inlet having a cross-sectional area substantially less than the horizontal cross-sectional area of said chamber, and means forming

a plurality of spaced outlets opening into said chamber, said outlets being arranged in a common horizontal plane and being equi-distant from said axis.

7. In combination, a pressurized blast furnace having a plurality of spaced tuyeres circumferentially arranged in the lower portion thereof, said blast furnace being of the type wherein it is desirable to introduce carbonaceous solid fuel with a minimum amount of carrier air, and a fuel feeding system for delivering pneumatically transported particle-form carbonaceous fuel to a plurality of said tuyeres, said fuel feeding system comprising means for combining regulated quantities of said fuel and carrier air to form a mixture for introduction into said blast furnace, a distribution system for dividing said mixture into a plurality of streams having substantially equal densities, and a plurality of conduits extending from said distribution system to said tuyeres for passing each of said streams to a corresponding one of said tuyeres, the quantity of solid fuel flowing in each of said streams being proportional to the combined pressure drop through its respective conduit and tuyere, said distribution system including at least one distributor comprising walls defining an unobstructed chamber formed symmetrically about its vertically disposed axis and having its upper end closed, a bottom closure for said chamber including means forming a centrally disposed inlet for the introduction of at least a portion of said mixture axially into said chamber, said inlet having a cross-sectional area substantially less than the horizontal cross-sectional area of said chamber, and means forming a plurality of spaced outlets opening into said chamber, said outlets being arranged in a common horizontal plane and being equi-distant from said axis.

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50 MORRIS O. WOLK, *Primary Examiner.*

JAMES H. TAYMAN, JR., *Examiner.*

UNITED STATES PATENT OFFICE  
CERTIFICATE OF CORRECTION

Patent No. 3,204,942

September 7, 1965

William J. Matthys et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 55, for "both" read -- bosh --; column 4, in the table, under column "A", line 2 thereof, for "289.0" read -- 298.0 --; column 7, line 75, strike out "cham-"; column 9, line 12, for "and mixture" read -- said mixture --.

Signed and sealed this 28th day of June 1966.

(SEAL)

Attest:

ERNEST W. SWIDER

Attesting Officer

EDWARD J. BRENNER

Commissioner of Patents