

June 12, 1956

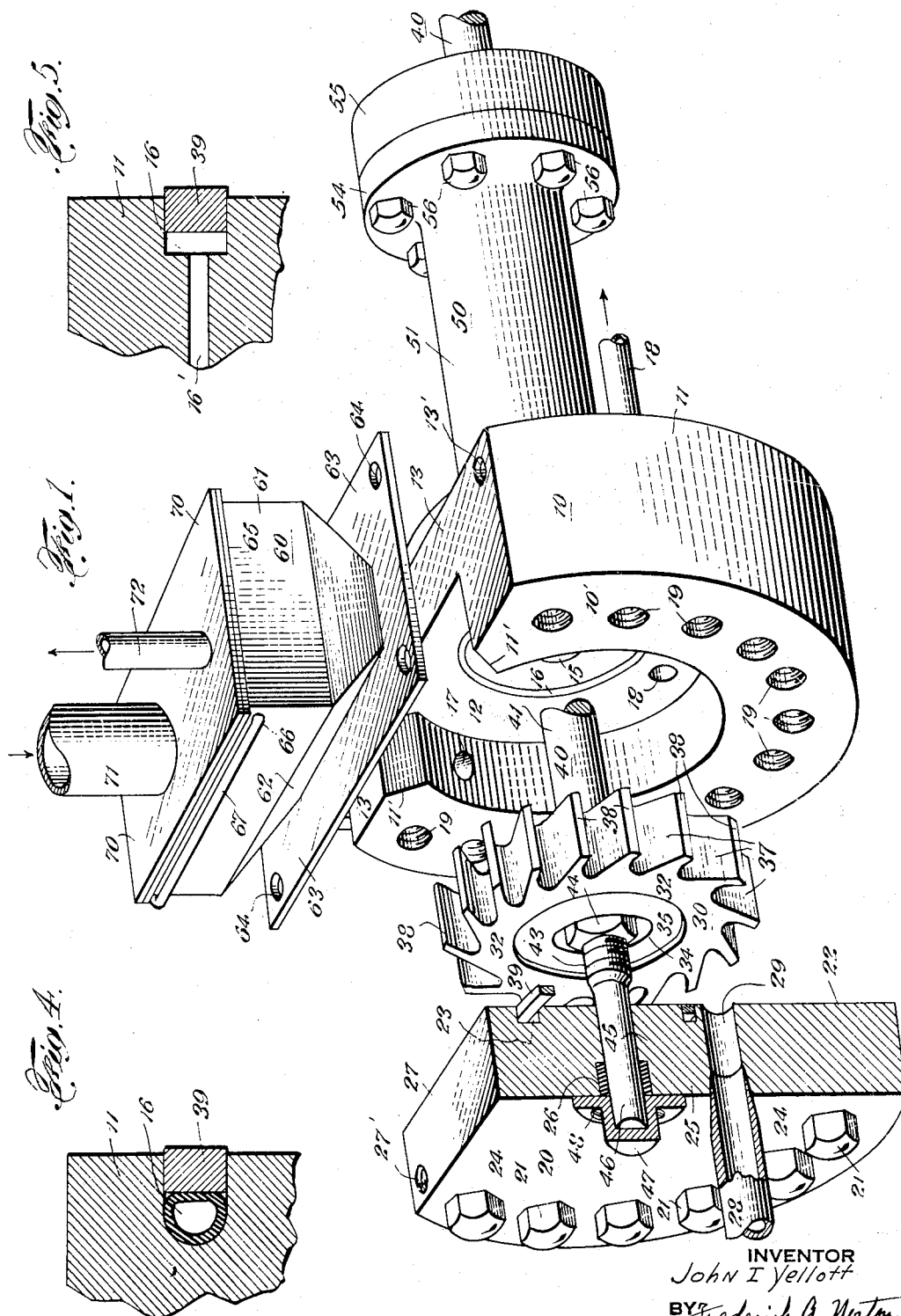
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2,750,233

ROTARY SOLIDS TRANSFER PUMP

Original Filed Nov. 30, 1949

3 Sheets-Sheet 1



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Fig. 3.

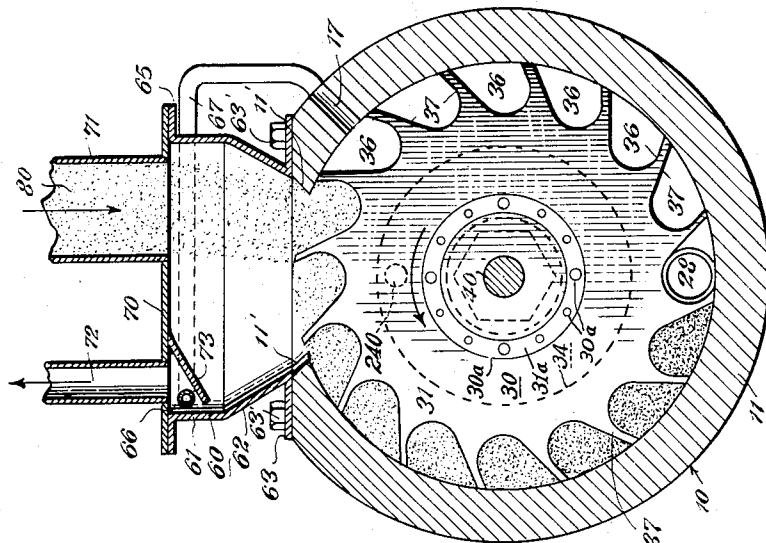


Fig. 6.

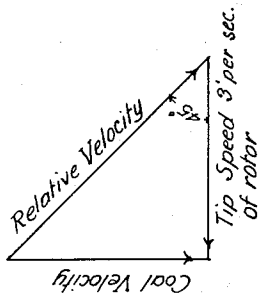
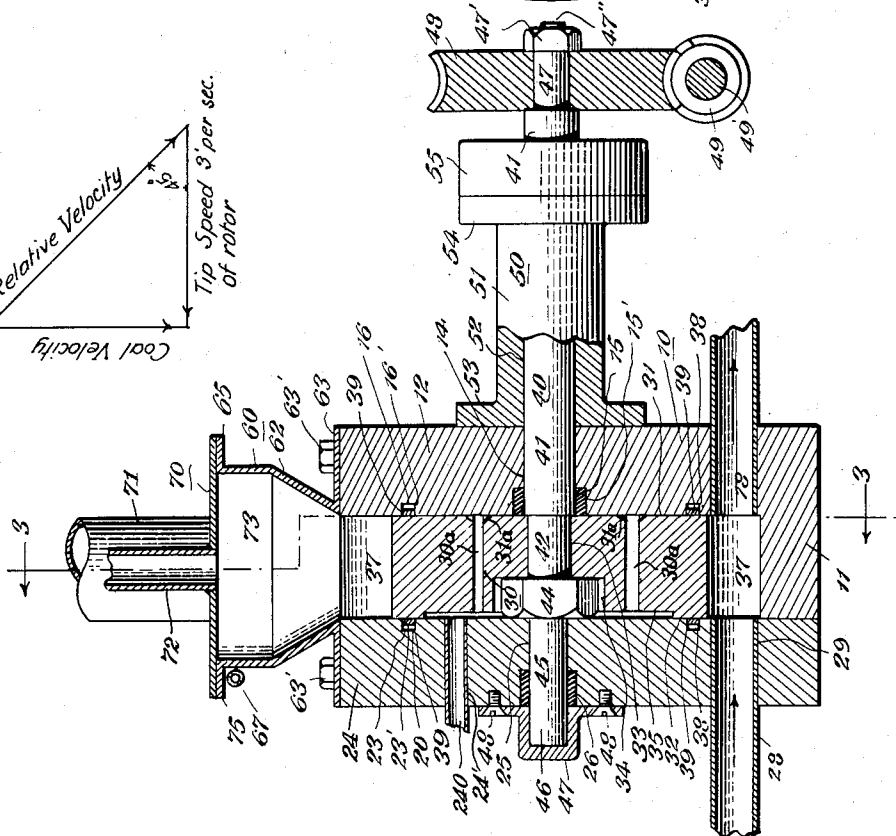


Fig. 2.



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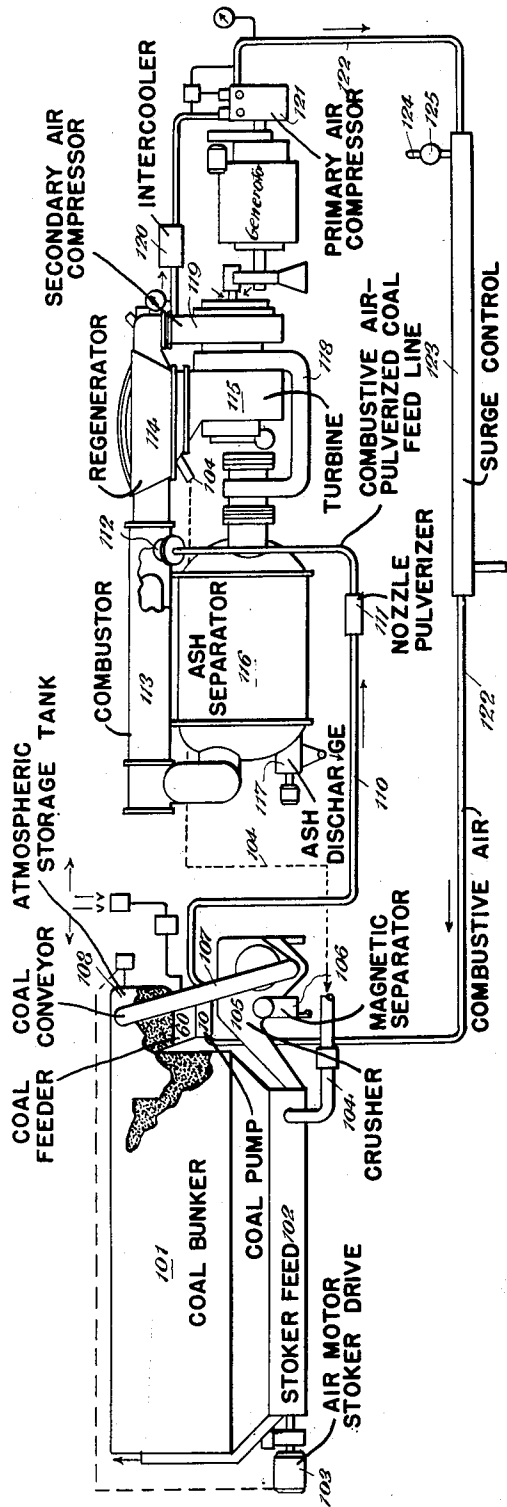
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Fig. 1.



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ROTARY SOLIDS TRANSFER PUMP

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Original application November 30, 1949, Serial No. 130,215, now Patent No. 2,652,687, dated September 22, 1953. Divided and this application June 23, 1953, Serial No. 363,524

10 Claims. (Cl. 302—49)

This invention relates to improvements in rotary solids transfer pumps used as feeders for introducing particulate solids into pneumatic conveyors used for conveying such particulate solids as a streaming entrainment of fluidized solid particles in a pressurized pneumatic fluid carrier. More particularly, the invention relates to a rotary feeder or solids transfer pump adapted to deliver a uniform, predetermined flow of particulate solids from one pressure level to another without loss of pressure during the transfer operation. This application is a division of my application for Gas Turbine Power Plant, Serial No. 130,215, filed November 30, 1949, now Patent No. 2,652,687, issued September 22, 1953.

In the transfer of particulate solids, such as crushed coal, from a hopper maintained at atmospheric pressure, into a pressurized air stream for delivery through a nozzle pulverizer into a pressurized combustor, as disclosed in my application Ser. No. 691,307, filed August 17, 1946, for Coal Fired Gas Turbine Power Plant, now U. S. Patent No. 2,651,176 of September 8, 1953, it has been found necessary to use multiple hoppers with air locks, and to connect the air locks with the pressure delivery line to balance the pressure in the hoppers and prevent blow back of the pressurized fluid into the hoppers. It has also been found necessary to provide special equipment for controlling the quantity of crushed coal introduced into the pressurized combustor feed line, as well as other equipment for selectively withdrawing or "stripping" desired quantities of the fluidized solid particles from the feed line, at will, in order to vary the ratio of solids to carrier fluid and thereby vary the volume of gases generated in the combustor.

It has now been found that the feeding of crushed coal, or other frangible solids, into a pressurized pneumatic feed line, can be carried out more accurately, expeditiously, and economically, by the utilization of the improved rotary solids transfer pump or pressurizer of the present invention, in which the features of novelty and advantage include the introduction of the particulate material, in a free falling stream, into peripheral pockets of a toothed, rotary feeder wheel, which pockets are configured to present an axis which is determined as the hypotenuse of a right triangle whose side is the vector of particle velocity of the free falling particles, and whose base is the vector of the tip velocity of the pockets.

The fundamental principle of operation of this pump is as follows:

The rotor, which is shaped like a large gear wheel or milling cutter, and is provided with teeth on its periphery, runs within a rigid casing, but without actual contact between the rotor and the casing. I have found that, if the clearances between the rotor and the casing are made very small, less than $\frac{1}{1000}$ of an inch, the leakage of air and coal through such clearances is reduced to a feasible amount, and the abrasion of the moving part of the pump is kept to a minimum, because no rubbing seals are required to reduce the leakage below the value which is obtained by virtue of the small clearances.

In the operation of the preferred form of the pump as incorporated in a pressurized combustion system, to be described more fully hereinafter, the crushed coal is dropped into the top of the pump from a height sufficient to give the coal particles a velocity of about 3 feet per

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second, and the tip speed of the rotor is about 3 feet per second. The relative velocity of the coal to the rotor is thus about 4 feet per second, and is inclined at an angle of approximately 45° to the peripheral surface of the rotor. The teeth of the rotor are preferably spaced at this angle, to enable the coal to fall smoothly into the pockets. No side plates are provided on the pockets, because the coal is removed from the pockets, after they have rotated from the filling zone to the discharge point, by blowing air transversely across the face of the rotor, parallel to the shaft. This air stream not only picks up the coal from the rotor pockets, but also carries the coal on to the pulverizer and the combustion system.

There has thus been provided a simple means for filling the pockets, despite the fact that the rotor is turning at a speed of approximately 60 R. P. M., and for discharging the coal from the rotor into a flowing air stream. In actual tests, the pressure in this air stream was as much as 145 p. s. i. a., and there seemed to be no reason why the pressure could not be at least doubled.

Leakage across the face of the rotor is prevented by means of annular seals which are set in the casing and are caused to press against the two faces of the rotor. A vent is preferably provided on the sides of the casing, to allow the escape of the air which leaks under these seals. A vent is also provided to discharge the air which is carried around by the rotor pockets from the coal pick-up line. It is important that this leakage be discharged before the pockets enter the filling zone. A vent is provided in the filling region, in order to allow the escape of the air which will leak through the narrow clearances between the rotor and the casing.

The rotor of the pump is driven by any appropriate means, with its rotation rapid enough to minimize pulsations in the coal flow.

In the operation of the pump, an outboard bearing is used to prevent the rotor from being displaced because of the air pressure under the rotor.

In summary, the present invention is directed to a device which will take a powdered material from atmospheric pressure, carry it into a casing provided with clearances less than $\frac{1}{1000}$ inch and deliver it to a pressurized flowing air stream. The fundamental principle in the maintaining of small clearances without rubbing seals in the pocket area. In actual test, with an air pressure of 100 p. s. i. a., and an air flow through the delivery pipe of 1600 lbs. per hour, the leakage of air through the vent system was approximately 60 lbs. per hour, and the leakage of coal was negligible.

It is, therefore, among the features of novelty and advantage of the present invention to provide a rotary solids transfer pump in which the discharge of material from the pockets is accomplished by blowing out with a transverse stream of high pressure fluid; the minimizing of leakage by maintaining close clearances, without actual rubbing contact, between the rotor and stator elements; the prevention of leakage across the faces of the rotor by non-seizing ring packing pneumatically biased in self-aligning bearing engagement with the faces of the rotor; and the venting of the discharged, pressurized pockets to allow trapped, high-pressure air to escape. Other features of novelty and advantage include the incorporation of the novel rotary solids transfer pump in the pressurized pneumatic feed line of a pneumatic conveyor or combustor feed line of a generating electric power plant having a gas turbine prime mover.

The above and other features of novelty and advantage of the present invention will be described with reference to one form of the novel rotary feeder as illustrated in the drawings, and in which

Fig. 1 is an exploded view of the feeder with the outboard bearing-plate in section;

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Fig. 2 is a vertical axial section of the feeder;

Fig. 3 is a view taken on line 3—3 of Fig. 2 showing the inboard side of the feeder wheel and the mode of filling and discharging the pockets;

Figs. 4 and 5 are sectional details of the bearing rings and mountings;

Fig. 6 is a vector diagram illustrating the coincidence of the angle of fall into the feeder pockets with the pocket angle, and

Fig. 7 is schematic showing of a coal burning gas turbine power plant incorporating the novel feeder herein.

Referring now to the drawings, and more particularly to the showings of Figs. 1—3, the novel rotary solids pump and pressurizer will be seen to comprise the following sections or parts: a body or housing 10; an outboard face and bearing plate 20; a feeder wheel 30; shaft 40; shaft housing 50, and feed hopper 60.

The housing 10 is a cup shaped member having a generally cylindrical body or wall 11, and an integral, inboard face and bearing plate, 12. The housing is provided with a flat upper surface 13, and at right angles thereto, a flat outer surface 10 normal to the axis. The interior surface of section 11 forms a chamber with the inner surface of inboard face plate 12, which is axially apertured at 14 to receive the shaft 40, and countersunk at 15, to receive the shaft packing 15'. While the inboard face plate 12 of the pump is shown as integral with the housing wall or body 11, it is to be understood that the parts may be separate members, secured in any suitable manner. The face plate 12 is provided further with a ring groove 16, concentric with the shaft, and connected through duct 16' to a pressure fluid source, not shown. The upper edges of the inner surface of pump body 11 are chamfered, as indicated at 11', with at least one vent 17 formed directly below one such chamfered section. A discharge opening 18 is formed in plate 12 in the vertical plane of, and below the axial aperture 14. The outboard face 10' of the pump housing is tapped and threaded, as indicated generally at 19, to receive machine screws 21 which serve to secure detachable outboard face plate 20 in position against the housing. The upper face 13, of the pump housing is also tapped and threaded as shown at 13'.

The detachable outboard face plate 20 is conformed to housing 10, and is secured thereto by machine screws 21. Its inner face 22 is flat, and is provided with a ring groove 23 connected, through duct 23', to a common fluid source with duct 16'. The outer face 24 of plate 20 is countersunk about axial shaft hole or bearing 25 to receive packing 26. The upper, flat surface 27 of the plate 20, is coplanar with face 13 of the pump housing 10, and is tapped and threaded, as indicated at 27'. Upstream air inlet 29 is in axial alignment with discharge outlet 18, and in vertical alignment with shaft bearing 25.

The feeder wheel 30, as shown, is a toothed rotor having parallel flat faces 31, 32, respectively perpendicular to the axis of central shaft aperture 33. Face 32 is countersunk to provide a coaxial socket 34, and a surface depression 35. A series of peripheral pockets 36 are separated by vanes or teeth 37 having peripheral faces 38. The teeth or vanes 37, as shown, are inclined at an angle of approximately 45° to the diameters passing through diametrically opposite vane tips. The identical ring grooves 16, 23, seat identical ring gaskets or sealing members 39 which are biased in self-seating, non-galling, bearing engagement against the faces of the rotor 30, and inwardly of the pockets, all as will be described more in detail hereinafter. The pockets 36, in the preferred form of the invention herein shown, are 16 in number, and it is found desirable to have a large number of small pockets, rather than a few large pockets. With a constant speed of the toothed rotor, the number of pockets should be great enough to eliminate pulsation in delivery of fluidized solid particles, or, in the case of coal fed to a pressurized

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combustor, to eliminate pulsation of flame. With a moderate speed pump (ca. 60 R. P. M.), 16 pockets will deliver 1080 unit charges per minute, which in practical operation, insures an essentially non-pulsating flow of fluidized particles.

The toothed rotor 30 is mounted for rotation on shaft 40. This shaft has a main body portion 41 having bearing engagement in the inboard face plate 12 and inboard bearing 50, secured to the face plate or formed integral therewith. The outboard section of the shaft is stepped down, as indicated at 42, to provide a rotor engaging section, the outboard portion of the section 42 being threaded, as indicated at 43, to receive lock nut 44, which is turned up on the thread to have locking bearing engagement against the base of socket 34. The outboard end of the shaft is further reduced in diameter, as indicated at 45, and has rotatable bearing support in the axis 25 of outboard face plate 20. The shaft is suitably packed in the packing 26 and its tip end extends beyond face 24 of the face plate. The tip end 46 is covered by a cap 47, which is secured to the face plate in any suitable manner, as by screws 48.

The inboard bearing member 50 is of generally cylindrical construction, and is provided with a body portion 51 centrally apertured at 52 to receive main section 41 of shaft 40. The member 50 is flanged at its outboard end, as indicated at 53, and is secured to the face plate 12 in any suitable manner. The inboard end of the shaft bearing 50 also is flanged, as indicated at 54, and provides a bearing for hollow cap 55, which is suitably packed to provide lubrication for the inboard end of section 41 of the shaft. The cap 55 is secured to flange 54 by machine screws 56, as shown in Fig. 1, and serves as a thrust bearing for the shaft. The inboard end of the shaft is reduced, as shown at 47 (Fig. 3), to receive gear wheel 48 in a drive or keyed fit. The gear is locked in position by nut 47' which engages the threaded end 47'' of the shaft. A pinion gear 49, mounted on shaft 49', meshes with and serves to drive the gear wheel 48.

The feed hopper 60 comprises a generally rectangular, box-like body portion 61 with converging bottom portions 62 integral with bottom flange plate 63. The plate 63 is apertured at the corners, as indicated at 64. The apertures 64 are severally aligned with the tapped holes 13', 27' in the inboard and outboard face plates respectively. The flange plate 63 is secured on and over the flat top surface of the assembled pump by machine screw 63'. The top of the rectangular body section 61 of the hopper is flanged, as shown at 65, to provide a bearing surface for cover plate 70 of the feed mechanism. At one side, the body section 61 of the hopper is apertured, as shown at 66, and this aperture is connected through conduit 67 to the vent 17 of the pump body. Variable delivery of crushed coal is effected by incorporating a variable feeder in or in place of feed hopper 60, a suitable type being known as the "Omega" feeder, which is manufactured by the Builders Iron Foundry Company, of Providence, Rhode Island, and one of which has been successfully used in the power plant of the invention herein.

The cover plate 70 mounts a material feed pipe 71 and a vent pipe 72. On the under surface of the plate 70 and below the inlet to pipe 72 is mounted a baffle plate 73, desirably welded or otherwise secured to the plate. The feed line 71 is preferably arranged at one end of plate 70 so that its axis is in substantial alignment with the opening of a pocket 36 of the feed wheel 30, with the trailing edge of the pocket opening coinciding with the bottom edge of the rear chamfer 11' of the pump casing.

In operation, and as shown in detail in Fig. 3, the particulate solids 80 are dropped through feed line 71 into the hopper 60. Because of the arrangement of the parts the solids fall freely into the first empty pocket 36 of rotor 30 which is clearing the pump casing 11 in its rotation. As the rotor turns, the pockets, severally charged with uniform charges of loose material, travel around

the inside of the pump casing until they are severally and consecutively brought into alignment with the opening of the air feed pipe 28. At this point the charge of solid particles in each pocket is blown out of the pocket into the solids discharge line 18 as a streaming entrainment of solid particles in a pressurized gaseous fluid. As the rotor continues to rotate the empty pockets successively move into alignment with vent aperture 17 of the pump casing, and the pressure air contained in each pocket is vented through conduit 67, and opening 66 into the feed hopper 60, thence to the atmosphere through vent line 72.

In the operation of the improved solids transfer pump herein, best results are obtained when the rotor of the pump is operated at a uniform speed, and the quantity of solids transferred is varied by varying the rate of feed or quantity of solids introduced into the pump in the solids stream 80. By calibrating the pocket size or capacity of the pockets 36 to receive a maximum unit quantity, it is possible to vary the amount of solids transferred by the pump solely by varying the rate of feed of the solids contained in solids stream 80. Thus the pump may be operated with the amount of solids transported, per pocket, per rotation of the wheel, varying from zero to a maximum. Because of the number of pockets, the successive pulsating discharges of solids from pockets 36 into the line 18 will be so rapid that the pulsations will overlap, and an essentially uniformly dispersed stream of solids will be transported and delivered by the pressure line 18. This, particularly in view of the fact that it is found that, even with pulsating charges of solids introduced into a pressure stream of constant velocity and uniform pressure, there is substantially immediate and uniform dispersion of the solids immediately beyond the point of introduction into the pipe 18.

The determination of the proper pocket size and angle of inclination of the pocket walls 37, as noted hereinabove, is relatively simple and can be determined using the vector diagram of forces shown in Fig. 6. Thus, with the vector of the coal velocity serving as a vertical component, and the vector of the tip speed of the walls of the pockets at right angles to the coal velocity vector, the relative velocity of the free-falling coal particles is determined as the hypotenuse of the vector triangle formed. With the angular relation between the coal velocity and the relative velocity established, the axis of the pockets will bear the same relation to the tips of the walls 37 as the hypotenuse of the vector triangle does to the base of the triangle.

As indicated above, the improved performance of the solids transfer pump in transferring solids from one pressure level to another, and without blow-back or appreciable leakage from the high pressure side to the low pressure side, is made possible by the special structural features of the device. Of these features, of prime importance is the fabrication and assemblage of the parts in such a manner that the gap or clearance between the tips of the pocket walls, or the periphery of the rotor, and the inner surface of the pump chamber should be not more than one-half the diameter of the average size of the particles it is proposed to handle. Secondly, the provision of self adjusting and self seating, non-seizing, self-lubricating, annular sealing members in the inner faces of the pump casing, biased into positive, constant sealing engagement against the faces of the rotor wheel, and immediately below the roots of the pocket walls, insures that the solid particles will be prevented from being driven inwardly of the feeder wheel to the shaft section and into the shaft bearings. This condition is insured by applying a positive pneumatic fluid pressure to the shaft housings with discharge radially to the pump chamber from the axis of the rotor across its faces to the sealing members 39. As shown in Figs. 1, 2, and 3, this desirable result was readily attained in the following manner: A hole 24' was drilled in outboard face plate 24, and a pressure air line 24a was tapped therein. This

pressure air line was coupled to a pressure air source, not shown, delivering air at a higher pressure than that obtaining in the combustible air feed line 28. The hole 24' discharges into the annular gap formed by and between the inboard face of member 24, the socket 34 and depression 35 of rotor or feed wheel 30. An annular groove 31a was formed on the inboard face 31 of the rotor, and was placed in free fluid communication with the outboard face 32 through a plurality of concentric, axial holes drilled through the rotor and designated generally by the numeral 30a. In this manner a positive outward pressure is applied to the pump chamber radially of the rotor shaft and any tendency for particulate material to flow back into the shaft section under the influence of the pneumatic pressure in the pump chamber will be essentially overcome.

Desirably the non-seizing, self-seating, sealing rings or gaskets 39, are made of self-lubricating bearing metals, or like compositions, such as copper-lead or copper-graphite material. By supplying air, under pressure, to the ducts 16', the groove 16 in which the sealing rings 39 are seated, the rings can be caused to have any desired sealing engagement against the rotor faces. With the air fed into the grooves 16, 23, at a pressure above that obtaining in the line 28, any leakage of air past the sealing rings will have to flow radially outward, to the outside or periphery of the rotor.

As disclosed hereinabove, the rotary coal pump or solids transfer pump of the present invention is especially suited for controlling the feed of solids into pneumatic feed lines wherein the ratio of solids to carrier fluid must be susceptible of instant and positive variation and control. Systems which require this type of control are shown in my copending patent applications directed to the pulverization of particulate coal in a pneumatic line to form a fluidized solid stream of combustible particles which are fed to a combustor and burned, under pressure, to provide motive fluid for gas turbines.

In Fig. 7 I have illustrated a power plant of the turbine-driven, generating electric type, in which bunker coal is preliminarily coarse ground and fed to an atmospheric storage tank, from which it is discharged, through a solids feeder or pump, to a pressurized air stream in which it is reduced to flour fineness and burned in a combustor to supply motive gases for a gas turbine.

In the system there shown, bunker coal is stored in a coal bunker 101 having a stoker feed 102 driven by a stoker driver or air motor 103. Desirably, drying air is taken from the turbine exhaust through line 104 and delivered into the discharge end of the stoker. After traversing the length of the stoker and drying the coal, it may be vented to the atmosphere as illustrated. Dry coal is fed into a crusher 105, incorporating a magnetic separator 106, and discharged thence, through coal conveyor 107, to an atmospheric storage tank 108. On demand, the coal is fed through coal feeder 60 and rotary coal transfer pump 10, to primary combustible air feed line 110, the resulting air-borne dispersion of crushed coal particles passing through nozzle pulverizer 111, with simultaneous reduction in pressure of the air stream and pulverization of the entrained coal to flour fineness, whereby a pressurized, combustible, aeriform stream of air-borne pulverized coal is continuously generated and discharged to coal burners 112 of combustors 113. The products of combustion plus heated compressed air (secondary air) from regenerator 114, mounted in the stack of turbine 115, are mixed to form a high temperature, pressurized motive fluid for the turbine. This motive fluid is passed through ash separator 116, wherein the ash is separated and removed through ash discharge 117, the cleaned motive fluid then passing through line 118 to the turbine 115, wherein it is expanded, doing work. The expanded gases discharge through the stack, in heat exchanging relation with the compressed air from main, low pressure compressor 119, which, as noted, discharges

through the regenerator into the combustor, as secondary air, to mix with the products of combustion of the flames and form the motive fluid for the turbine. The primary air or pressure fluid of line 110 comprises compressed air taken from the discharge duct of compressor 119, and then passed through intercooler 120, booster compressor 121, and line 122, to the rotary coal transfer pump 10. The high pressure line 122 is in heat-exchanging relation with a surge control means comprising an after-cooler 123, having the usual coolant entrant, and a coolant discharge line 124, controlled by valve 125. The after-cooler coolant system may be operated with a recirculated coolant which is passed through an air or water cooled stage.

As is well-known, the power output of a gas turbine depends directly upon the amount and the temperature of heated gases expanded therethrough. In the pressurized system herein, where the high pressure combustive air line 122 discharges a constant volume of primary air through the rotary coal transfer pump 10, air-solids feed line 110, and convergent nozzle pulverizer 111, to the coal burners 112, the power generated by the turbine is controlled by the rate of flow of solid fuel to the primary, combustive air in the combustor feed line. With the novel rotary solids feeder herein, functioning as a coal transfer pump, any desired rate of flow of coal solids to the combustive air line can be obtained readily by simply varying the amount of solids in the solids stream 30 fed to the rotary coal transfer pump 10.

While a coal burning gas turbine power plant has been shown and described as a preferred system in which the novel solids pressurizer may be incorporated to distinct advantage, it is to be understood that the rotary solids transfer pump and system herein may be applied to systems generally where fluidization of solid particles in pressurized streaming fluids is contemplated. Among such systems may be mentioned the introduction of solid catalyst and reagents into fluidized catalytic apparatus for chemical reactions generally; transport of solid materials such as sand, talcum powder, lime, cement, and raw materials for burning, in fluidized condition to form cement.

What is claimed is:

1. In a rotary solids transfer pump of the character described, the improvements comprising sealing means seated in annular grooves in the casing walls and appposable with the rotor to seal the gaps between the faces of the rotor and the casing walls, whereby entrance of solids into the spaces between the rotor faces and the casing walls is prevented, fluid pressure means coupled to the said casing wall grooves and operable to bias the sealing means into sealing position, and separate pneumatic fluid entrant means coupled to the pump casing radially inward of the sealing means, the rotor being axially apertured by a circular array of apertures severally extending through the rotor and circumjacent the rotor shaft.

2. Rotary solids transfer pump according to claim 1, characterized by the fact that the sealing means comprises annular rings, and the rings are seated in and have pressure fluid-tight bearing engagement in the annular grooves in the casing walls.

3. Rotary solids transfer pump according to claim 2, characterized by the fact that the sealing means are severally provided with conformable contacting surfaces for pressure-sealing engagement with the faces of the rotor.

4. In a rotary solids transfer pump of the character described, the improved sealing means comprising annular members of lubricated, conformable material having sealing bearing engagement with the opposite faces of the rotor and severally adjacent faces of the pump casing, biasing means in the pump operable to bias the annular sealing members into sealing bearing engagement position, said biasing means comprising a pressurized fluid, and means for applying a pneumatic biasing fluid, at a pressure greater than that of the fluid biasing the said sealing members, to the faces of the rotor circumjacent the rotor shaft,

whereby a positive pneumatic pressure is imposed on the shaft side of the sealing members, and seepage of powdered solids radially inward from the pump pockets and across the sealing members to the shaft journals, is prevented.

5. Rotary solids transfer pump according to claim 4, characterized by the fact that the annular sealing members are severally mounted for inward axial movement in the pump casing walls and are appposable to the rotor faces under the influence of the biasing fluid.

6. Rotary solids transfer pump according to claim 5, characterized by the fact that the pump casing walls are grooved to receive the conformed, reciprocable annular sealing members, and that the said members have self-lubricating bearing faces adapted for sealing bearing engagement when juxtaposed to the rotor faces.

7. Rotary solids transfer pump according to claim 6, characterized by the fact that at least the bearing faces of the annular sealing members are made of a self-lubricating composition.

8. Rotary solids transfer pump according to claim 7, characterized by the fact that the self-lubricating composition is a bearing metal.

9. Rotary solids transfer pump according to claim 7, characterized by the fact that the self-lubricating composition is a graphite base.

10. In a system for continuously feeding powdered solids from one pressure level to a different pressure level, whereby to form a non-pulsating, streaming entrainment of fluidized solids uniformly dispersed in an aeriform fluid, the improved rotary solids transfer pump comprising a casing incorporating a truncated annular body portion and parallel, spaced end plates, and defining a pump chamber, the truncation in the annular body defining an entrant for the admission of powdered solids to the pump chamber; aligned air inlet and discharge openings in the faces of the pump chamber, and angularly displaced with respect to the said solids entrant; a toothed feed wheel mounted for rotation in said pump chamber, and having non-radial peripheral pockets arranged to register successively with the said aligned air inlet and discharge openings, the said teeth having close, non-rubbing clearance, of the order of .002-.004 in. with the walls of the pump chamber; means for exhausting air from each pocket after the pocket passes the discharge opening; self-lubricating, non-seizing, annular sealing means disposed radially inward of the said pockets in bearing sealing engagement with the faces of the feed wheel and the juxtaposed faces of the pump chamber; pneumatic means for biasing said annular sealing means into bearing sealing engagement with the feed wheel and the pump chamber; and separate pneumatic means coupled to the pump casing radially inward of the sealing members, whereby to apply a positive pneumatic fluid pressure to the shaft housings, with discharge radially to the pump chamber from the axis of the rotor across its faces to the said sealing members.

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