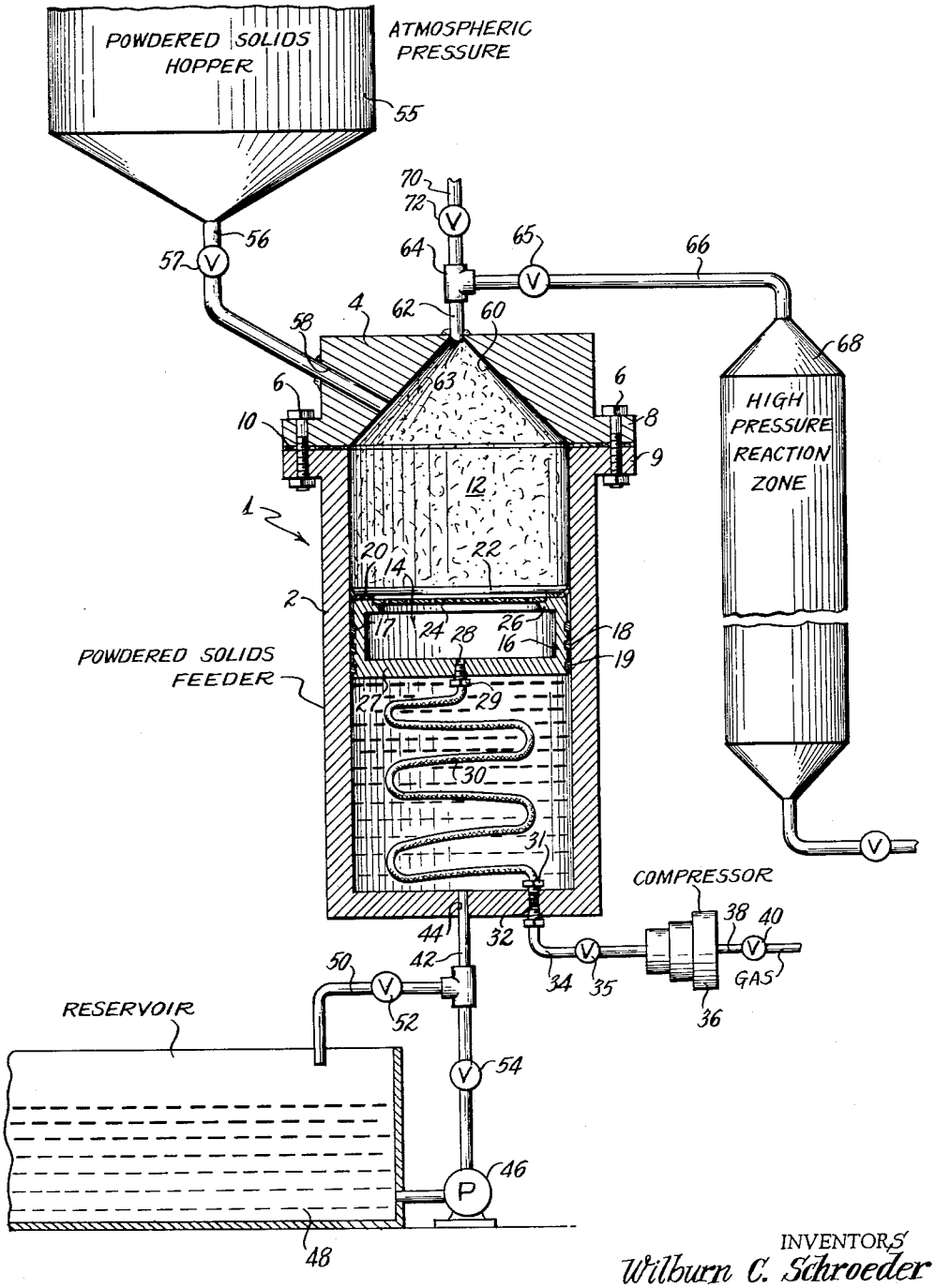
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APPARATUS FOR FEEDING FINELY DIVIDED SOLIDS

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APPARATUS FOR FEEDING FINELY DIVIDED SOLIDS

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This invention relates to the feeding of finely divided or powdered solids from a low-pressure or reservoir zone to a zone of higher pressure. It is especially useful in the feeding of finely divided solids to high-pressure reactors along with a fluid to be utilized in the reaction, for example, the feeding of pulverized coal with hydrogen to hydrogenation systems operating at pressures of from 500 to 6000 pounds per square inch, the feeding of powdered catalyst with aerating fluid to high-pressure catalytic conversion systems, etc.

Previous means for feeding finely divided solids and gases to zones of high pressure have involved the use of a closed hopper maintained under the same gas pressure as the system and the transfer of the finely divided solids from this hopper to the system by means of a screw conveyor. It has also been proposed to use a closed hopper under somewhat higher gas pressure than that of the system which it feeds. A small amount of gas is circulated through the hopper to keep the finely divided solids in an aerated or fluidized state. The aerated solids are then blown out through a pipe line at the bottom of the hopper, the flow being controlled by valves in the line. These methods of feeding have several major disadvantages: (1) when the hopper is empty, it is under full gas pressure and the energy of compression is largely lost before the hopper can be filled again, and (2) if there is any variation in pressure between the hopper and the system, this often causes major changes in the smoothness of the feed. These disadvantages are multiplied as the pressure under which the system is operated increases. Thus, the loss of energy and volume of gases become an appreciable problem as the pressures increase into the range of 500 pounds per square inch and above.

An object of the present invention is to provide apparatus which will overcome the aforementioned difficulties and provide an economical and readily controllable means for transferring finely divided solids from one zone to another.

Another object of the invention is to provide apparatus for feeding powdered solids along with a fluid into a zone of higher pressure whereby the rate of solids' flow can be varied substantially independently of the rate of fluid flow, within relatively wide limits.

Another object of the invention is to provide apparatus for incorporating powdered solids into a high-pressure fluid stream in an efficient and continuous manner.

Briefly, the present invention comprises the feeding of aerated solids from a feed zone into a high-pressure zone while simultaneously replacing the volume occupied by said aerated solids with a movable piston so that substantially all of the solids and gases are displaced. A fluid at substantially the operating pressure of the high-pressure zone may be utilized as the aerating medium, such fluid being fed continuously to the feed zone during movement of the feed piston and the flow of fluid then being cut off while the piston is retracted and the feed zone replenished. In this manner, there is very little loss of compression energy or volume of gases.

The invention will be further described by reference to the accompanying drawing in which the sole figure is a diagrammatic representation of a system incorporating the finely divided solids feeder and method of the present invention, the feeding apparatus being shown in cross-section.

Referring now to the drawing in detail, the powdered solids feeder generally designated as 1, comprises a steel cylinder 2 closed by a top 4 which is secured thereon by means of a plurality of bolts 6 through flanges 8 and 9. A suitable sealing means 10 is placed between the flanges 8 and 9 so as to form a high-pressure seal when the bolts 6 are tightly drawn. It is understood that for high-pressure use, the walls of the cylinder 2 and cover 4 should be of substantial thickness. The cylinder 2 provides a powdered solids feed chamber 12 in which a hollow cylindrical feed piston 14 is mounted for reciprocal movement, the piston 14 being shown in a position about midway between its upper and lower limits of travel. The side walls 16 of the piston 14 are provided with a series of sealing rings 17, 18 and 19, which slidably engage the walls of chamber 12 in the manner of automobile engine piston rings. The upper rim of the piston 14 is provided with an annular gasket member 20, which has an upwardly extending lip 22 adapted to wipe against the inner walls of the cylinder 2 and keep them clear of powdered solids in the path of forward piston movement. This gasket may be suitably made from leather, rubber, or appropriate oil-resistant plastic.

The top portion of the piston 14 within the confines of the gasket 20 is provided with a distributing screen or gas-diffusion member 24 which rests upon an inwardly extending annular lip 26. The member 24 is of sufficient strength and rigidity to support the column of solids above it in chamber 12 when the piston 14 is fully retracted and the chamber 12 filled. Piston 14 is provided with a closed bottom 27 having an opening 28 accommodating a fitting 29 of a flexible hose 30. The other end of hose 30 is connected by means of fitting 31 through an opening 32 in the bottom wall of the cylinder 2. The opening 32 is connected by means of gas line 34 and valve 35 to a gas compressor 36 connected to a source of gas through line 38 and valve 40. Compressed gas can thereby be supplied to the hollow piston 14 to be uniformly distributed by means of distributing screen 24 into the upper part of the chamber 12.

The bottom of cylinder 2 is also connected to a source of hydraulic fluid for raising the piston 14. The means for supplying hydraulic fluid comprise conduit 42 welded or otherwise connected within an opening 44 through the bottom of cylinder 2, pump 46, and hydraulic fluid reservoir 48. A branch line 50 is provided to enable hydraulic fluid to drain back into the reservoir 48 when the piston 14 is to be retracted. Valves 52 and 54 control the direction of flow of hydraulic fluid.

When the piston 14 is retracted to its lower limit of travel, the chamber 12 is ready to be filled with powdered solids. This is accomplished by means of a feed hopper 55, provided with a supply conduit 56 having a valve 57. Conduit 56 may be welded or otherwise secured in opening 58 through the cover member 4, as shown.

The inner portion of the cover member 4 is in the form of an inverted cone having walls 60. An outlet conduit 62 from the chamber 12 is welded or otherwise secured in an opening 63 at the apex of the inverted cone. It will be understood that all connections should be of a type capable of withstanding high pressures. Conduit 62 is connected by means of T 64 through a valve 65 to a conduit 66 so that high-pressure reactor 68 can be supplied with gas and solids from feed chamber 12. A vent 70 having a control valve 72 is also connected to T 64.

In operation, valves 65 and 35 are closed, thereby isolating the feeder 1 from the reactor 68 and the gas supply. Valve 52 is opened so that hydraulic fluid drains to reservoir 48 and the piston 14 settles by gravity within the chamber 12 to its lowermost limit, the flexible hose

30 for the gas supply coiling within the bottom of the chamber. The valve 72 to the vent 70 is opened so that chamber 12 is at atmospheric pressure. Valve 57 to the powdered solids hopper 55 is now opened and powdered solids flow by gravity into the chamber 12, substantially filling it but leaving an unfilled space in the conical area of the cover member 4. Valves 57 and 72 are now closed and valve 35 to the compressor 36 is opened to permit the passage of gas into the chamber 12 through the hose 30 and distributing screen 24. The gas pressure is substantially the same or slightly above that which is utilized in the high-pressure zone. The solids in the chamber 12 are fluffed up upon the introduction of gas, and expand into the previously unfilled part of the cover member. Valve 65 to the high-pressure reactor 68 is now opened and hydraulic fluid is pumped beneath the piston 14 by means of pump 46 at a rate selected in accordance with the desired rate of powdered solids feed. A gas-solids' mixture is continuously forced out of the feed chamber 12 and into the high-pressure reactor 68 until the piston 14 has reached its upper limit of travel, i.e., up to the bottom of the conical area of the cover member 4. This position can be determined by the metering of the hydraulic fluid supplied to the space beneath the piston or by other suitable means (not shown). Gas from compressor 36 is continuously supplied during the upward movement of the piston 14 to keep the pulverized solids in a fluffy state and supply the gas desired for the reactor. The amount of this gas can be controlled over a wide range limited only in its upper range by the velocity at which a substantial amount of solids would be removed from the feed chamber 12, by the gas alone, and at its lower range by the velocity necessary to aerate the solids sufficiently to permit free movement of the piston 14.

When the piston has reached the top of its stroke, valves 65 and 35 are closed, valve 54 to the source of hydraulic fluid is closed, and valve 52 is opened to permit hydraulic fluid to drain back into the reservoir 48. The piston then moves downward to the bottom of chamber 12 under the combined force of gravity and the compressive force of any residual gas in the top of the cover member. The vent 70 is then opened and powdered solids are again admitted to the chamber 12 through the line 56 and valve 57. For continuous feeding operations, it will be understood that a pair of feeding devices 1 connected to the same reactor would be utilized so that one could be filled while the other is feeding solids. The operation can be made entirely automatic by using automatic valves and valve controls arranged to operate in response to a determination of the upper and lower positioning of the piston 14.

For a coal hydrogenation plant set up to hydrogenate 300 pounds of coal of 100- to 200-mesh particle size per minute at a pressure of 2000 pounds per square inch with a hydrogen flow of 27 pounds per minute, the feed device 1 may have an inside chamber diameter of 2.2 feet and an inside height of about 26 feet, thereby providing volume of about 100 cubic feet. Such a feeder will accommodate a charge of about 3250 pounds of powdered coal, which is enough for a 10-minute feed cycle at the aforementioned hydrogenation rate. The hydrogen is supplied through the piston at a superficial linear velocity of 8.5 feet per minute, which is well above the minimum velocity necessary to keep the coal in properly aerated condition for feeding, but is not sufficient to entrain any great amount of solids. The piston 14 within the chamber 12 is moved upwardly at about 2.6 feet per minute, thereby completing its operation in 10 minutes and displacing about 10 cubic feet of hydrogen and aerated coal per minute. At the end of the piston stroke, the feeder 1 is removed from the stream to the reactor 68 and a filled, duplicate feeder is placed on stream. The exhausted feeder is then reloaded from the supply hopper. Substantially continuous operation of the reactor 68 can thereby be obtained. The only compression of and volume loss of hydrogen is that due to the small amount of hydrogen remaining in the top of the feeder at the end of a piston stroke, i.e., a very small percentage with respect to the total volume of the feeder. The rate of hydrogen flow can be increased or decreased over relatively wide limits without substantially changing the rate of solids feed. Thus, more hydrogen can be supplied if it is desired to produce a more highly hydrogenated product. Pressures can also be varied without adverse effect on the rates of feed.

While the specific example relates to coal hydrogenation, for which the feed device is eminently suited, it will be understood that the means may be applied to the transfer of a wide variety of powdered solids from one zone to another in an economical and readily controlled manner.

We claim.

1. Apparatus for feeding finely divided solids from a reservoir zone at substantially atmospheric pressure to a high-pressure reaction zone, comprising: a feed vessel having a cylindrical feed chamber, a piston mounted in said chamber for movement throughout substantially its entire length, valved inlet means communicating with one end of said chamber for introduction of said finely divided solids from said reservoir zone, valved outlet means communicating with the same end of said chamber for feeding said solids therefrom to said high-pressure zone upon advancement of said piston, means for admitting hydraulic fluid into said chamber on the side of said piston opposite said inlet and outlet means to force said piston through said chamber and displace solids therein, means for withdrawing hydraulic fluid from said chamber to permit said piston to retract, and means for introducing a pressure-equalizing and aerating gas through said piston and into said chamber ahead of said piston before and during the forward movement of said piston.

2. Apparatus for feeding finely divided solids from a reservoir zone at low pressure to a high-pressure reaction zone and for simultaneously feeding a gas to said reaction zone at a controlled rate, comprising: a feed vessel having a vertically disposed cylindrical feed chamber, a piston mounted in said feed chamber for movement throughout substantially the entire chamber length, valved inlet means at the top of said feed vessel communicating with the upper end of said chamber for filling same with a charge of finely divided solids when said piston is in a downwardly retracted position, valved outlet means at the top of said feed vessel communicating with said chamber for transferring said powdered solids and gas out of said chamber upon advancement of said piston, means for supplying a gas through said piston and upwardly into said chamber to aerate the solids therein and provide a supply of gas to said reaction zone, said gas supply means including means for distributing the gas supply uniformly upward through the cross-sectional area of the chamber in advance of the piston, and means for advancing and retracting said piston.

3. The apparatus of claim 2 wherein the bottom of said piston is connected to a gas supply line and the upper face of said piston is provided with a gas-distributing means.

4. The apparatus of claim 2 wherein said means for advancing and retracting said piston include means for introducing and withdrawing hydraulic fluid into the chamber beneath said piston.

5. Apparatus for feeding powdered solids from a reservoir zone at low pressure to a high-pressure zone, comprising: a feed vessel having a vertically disposed cylindrical feed chamber, a hollow piston mounted in said chamber for movement throughout substantially the entire chamber length, a flexible conduit connected to the bottom of said piston and communicating with the hollow interior of said piston, the other end of said flexible conduit communicating with the exterior of said feed vessel at the bottom of said chamber, means for connecting said con-

duit to a source of gas under pressure, gas distribution means mounted on the upper face of said piston so as to distribute gas supplied through said conduit uniformly upward from said piston into said chamber, means for admitting hydraulic fluid into said chamber below said piston to thereby advance said piston upwardly through said chamber, means for withdrawing said hydraulic fluid from said chamber below said piston to thereby permit said piston to retract, inlet means communicating with the top of said chamber for filling said chamber above said piston with powdered solids, and outlet means at the top of said chamber for feeding aerated powdered solids and gas to said high-pressure zone during upward movement of said piston.

6. Apparatus for use in a plurality of units for substantially continuously feeding finely divided solids and a gas to a high-pressure system without substantial pulsation comprising: a vertically disposed chamber for holding said solids, said chamber having inlet and outlet means at the upper end thereof, a vertically movable piston within said chamber, means for supplying a gas through said piston and upwardly into said chamber to aerate the solids therein and provide a supply of gas to said high-pressure system, said gas supply means including means for distributing the gas uniformly upward through substantially the entire cross-sectional area of the chamber in advance of the piston, means for moving the piston to displace said solids upwardly from said chamber at a rate independent of gas flow, and means for controlling the flow of aerating gas through said piston at a selected controlled rate independent of the rate of movement of the piston.

7. Apparatus for feeding finely divided solids and gas to a high-pressure system at substantially uniform, separately controlled rates, comprising: means defining a closed chamber, a free-floating piston mounted for vertical movement within said chamber, valved inlet means at the upper end of said chamber for filling said chamber above the piston with powdered solids when the piston is in a retracted position, valved outlet means in the upper end of the chamber for flow of solids and gas from said chamber during upward movement of said piston, means movable with said piston for supplying a gas immediately forward of said piston and upward into said solids above the piston, means for supplying hydraulic fluid to said chamber below the piston to thereby effect advancement of said piston upwardly through said chamber to displace solids and gas therein, and means for withdrawing said hydraulic fluid from said chamber to permit said piston to return to its lower position.

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