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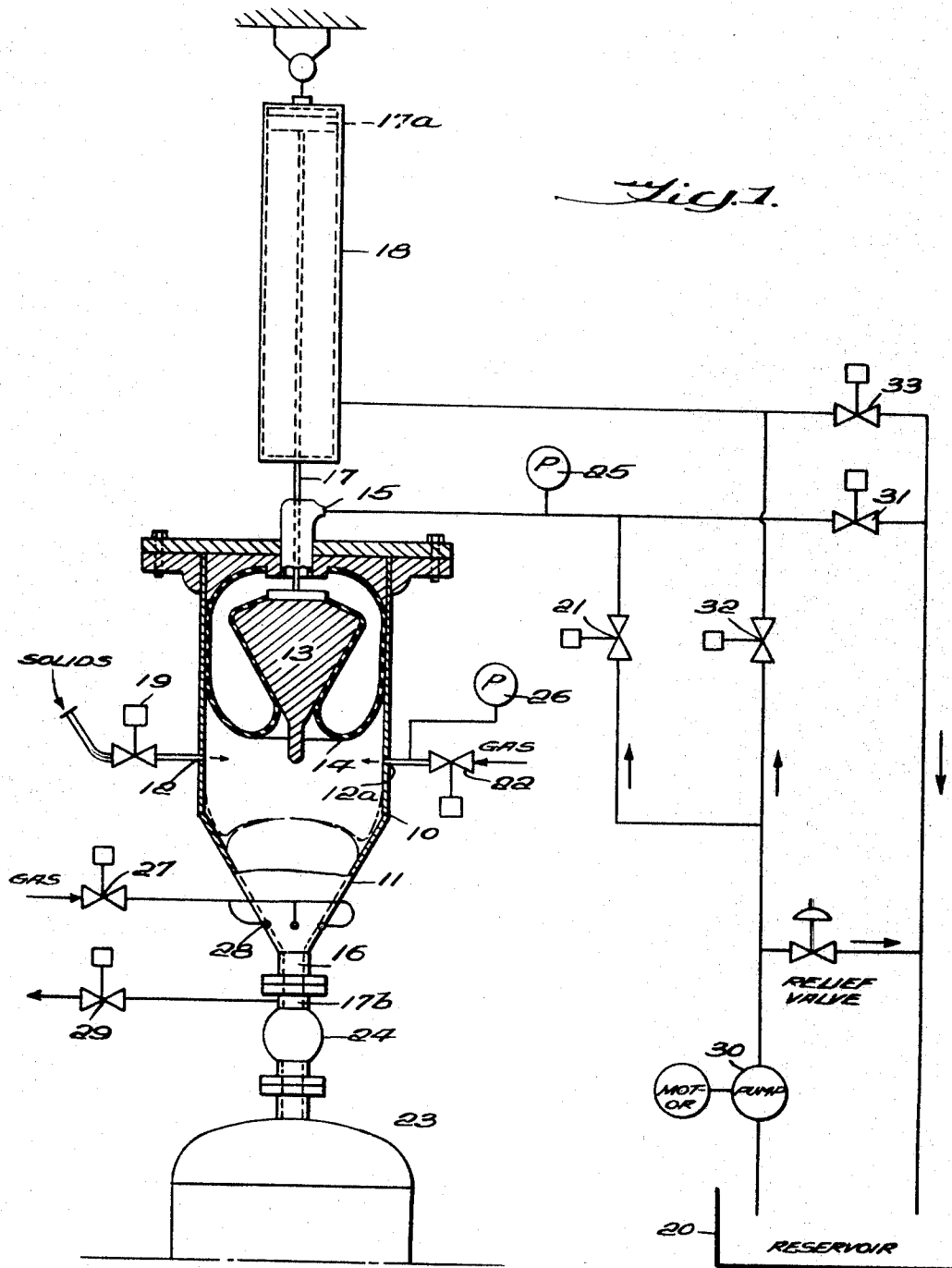
H. REINTJES

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METHOD FOR PNEUMATICALLY INJECTING SOLID
PARTICLES INTO A HIGH PRESSURE ZONE

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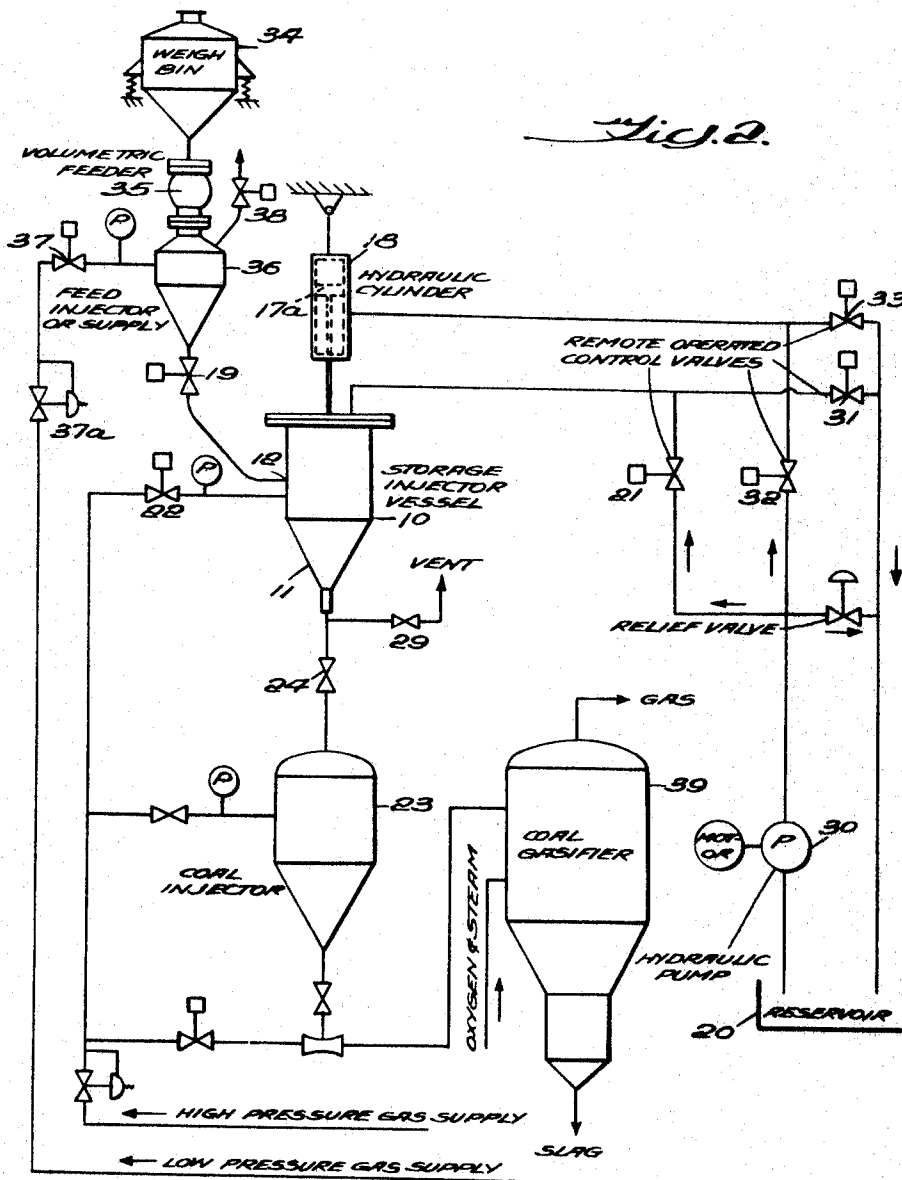
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**METHOD FOR PNEUMATICALLY INJECTING
SOLID PARTICLES INTO A HIGH PRESSURE
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ABSTRACT OF THE DISCLOSURE

A method for pneumatically injecting solid particles into a high pressure zone wherein the particles are first injected under gaseous pressure from a source of supply to a vessel, after which the pressure in the vessel is increased until the pressure in the vessel is greater than the pressure in the high pressure zone and then passing the particles and pressurizing fluid from the vessel into the zone while, or immediately thereafter, substantially filling the vessel with a non-compressible resilient means so that the vessel even if vented after isolation from the high pressure zone will not lose any substantial amount of high pressure fluid on a repeat cycle. The non-compressible resilient means is thereafter retracted to permit another cycle of feeding.

This invention relates to a method and apparatus for pneumatically injecting solid particles into a high pressure zone and, while not limited thereto, has particular utility in conveying coal particles to a coal gasifier.

Coal gasifiers operate normally at atmospheric pressure or somewhat above atmospheric. However, there is a trend towards development and use of coal gasification processes utilizing super-atmospheric pressures (above 1,000 p.s.i.). There are practical limitations to these processes because of the difficulty in feeding coal to the gasifiers at an acceptable cost. At the present time, there are two commercial systems of feeding coal to a super-atmospheric pressure coal gasifier, one known as the lock hopping system as disclosed and described in the Gilbert and Reintjes Patent 3,230,016. The other system pumps a coal slurry into the gasifier. While both systems are commercial, each has its drawback. The lock hopping system requires high power, with its ensuing costs, for recompressing the gas used for filling the lock hopper. The pumping of a coal slurry creates a temperature limitation of the steam used in the gasifier and also has other drawbacks. It has also been suggested that coal particles might be fluidized and then the fluidized coal be injected into a coal gasifier by means of a piston. While such a method might be theoretically feasible, it is not believed that the same could be commercial because of the abrasion and hence wear on the cylinder walls and the piston. Furthermore, the piston would be incapable of pushing the coal particles from the cylinder unless the particles were completely or at least substantially completely fluidized and remain in that state until the cylinder is emptied. In practice with a cylinder approaching commercial size, particles will not remain fluidized without a flow of fluidizing gas, and pushing with a piston promotes defluidization.

The present invention is an improvement on the lock hopping system, and while it utilizes the basic concept of injecting solid particles into a high pressure zone, it overcomes the requirements of recompressing the pressurizing gas which is necessary in the lock hopping system and of maintaining the solid particles in a fluidized state during transfer operations.

The principal object of the present invention is to cyclically move solid particles, such as pulverized dry

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coal, from a zone or supply initially at low pressure to a high pressure zone with minimal loss of high pressure gas.

In the drawings:

FIGURE 1 is a flow diagram and a sectional view of the pneumatic injector vessel; while

FIGURE 2 is a flow diagram incorporating the apparatus of FIGURE 1 showing a complete system for feeding solids into a high pressure zone such as a coal injector and then into a coal gasifier.

Referring to FIGURE 1, reference character 10 indicates a generally upright pressure vessel with inlet ports 12 and 12a for solid particles and gas, respectively. Mounted within the vessel 10 is a plunger 13 connected to rod 17 of a hydraulic piston 17a mounted in cylinder 18. The plunger 13 is of smaller diameter than the diameter of vessel 10 and has, at its upper end thereof, an elastomer sleeve 14 secured thereto. The sleeve 14, which is preferably formed of rubber reinforced with nylon fibers, has its other end secured to the upper portion of the pressure vessel 10 in any suitable manner so that the sleeve 14 forms a flexible, extensible diaphragm which may be expanded and contracted. The expansion of the diaphragm is by means of a liquid entering a port in the vessel 10 and into the diaphragm through inlet 15. The vessel has a conically shaped bottom portion 11 and terminates in an outlet 16. The outlet 16 of the vessel is connected to conduit 17b controlled by an outlet valve 24, the conduit 17b in turn being connected to a high pressure receiving vessel or zone 23.

In describing the invention in connection with a system of feeding bituminous coal to a coal gasifier, and referring to FIGURES 1 and 2, weigh bin 34 filled with coal particles preferably having 1% total moisture and pulverized so that 85% passes through a 200 mesh sieve and 45% passes through a 325 mesh sieve is connected to a volumetric feeder 35. The feeder 35, by way of example, may be calibrated to deliver a volume of coal approximately 10 pounds to feed injector or supply 36. The feeder 35 is designed so that when it returns to its initial filling position after having fed the coal to the feed injector or supply 36 it effectively seals the opening in the top of the supply 36. After vent valve 38 has been closed, which can optionally be closed before activating feeder 35, the feed injector or supply 36 is pressurized with a fluid, which fluid is preferably a gas such as nitrogen, to approximately 95 pounds per square inch absolute pressure by the opening of valve 37 in the low pressure gas supply line which has a pressure regulator 37a. Thereafter, valve 19 in a conduit between vessel 10 and 36 is opened, thus feeding the solid coal particles from a supply vessel 36 to vessel 10 through port 12. The size of the vessel 10, location of port 12 and volumetric feeder 35 are preferably calibrated so that the coal or other solid particles fill the vessel 10 to a predetermined level which level is generally below the inlet port 12. It will be understood, of course, that during the feeding of the vessel 10 valve 24 is closed and the flexible diaphragm 14 with its plunger 13 are in its fully retracted position as shown in full lines in FIGURE 1. After the vessel 10 has been filled as aforementioned, valve 19 is closed and valve 22 in a high pressure product-gas supply line is opened to further pressurize vessel 10 through port 12a or optionally through multiple ports. The product-gas or its equivalent is obtained by boosting the pressure of the gas displaced from cylinder 10 by plunger 13 and flexible diaphragm 14 in the cyclic operation, either directly or after recycling through the high pressure gasification process. Thus, from a conservation standpoint the gas used in pressurizing vessel 10 is reused substantially at the same energy or pressure level

present in zone 23. The net loss of gas is the very small amount vented from valve 29 at the end of the cycle as described later.

After valve 24 is opened, the solids, along with the pressurized fluid in vessel 10 flow out of the vessel into pressure vessel 23 and the plunger 13 is lowered by hydraulic fluid entering the flexible diaphragm 14, the hydraulic fluid being at a pressure somewhat higher than the gas pressure on the opposite side of the flexible diaphragm, as indicated by pressure gauges 25 and 26, after operation of the pump 30 and the opening of valve 21. The hydraulic fluid entering the diaphragm 14 is controlled so that the plunger 13 does not exert any force or at least no appreciable force on the solids while the solids flow out of the vessel 10. If desired, small amounts of gas under pressure may enter the bottom conical section of the vessel 10 through ports 28 by opening valve 27. The plunger and the flexible diaphragm connected thereto are lowered in the vessel 10 as the solids flow therefrom or optionally immediately thereafter to substantially fill the space or volume within the vessel 10, as shown in dotted lines in FIGURE 1. After discharging from vessel 10, outlet valve 24 and valve 21 are closed. The small amount of compressed gas remaining in the vessel 10 may be vented by the rapid opening and closing of valve 29 and then the plunger 13 is raised or retracted to its upper position for a repeat cycle. This is accomplished by opening valve 31 to permit the hydraulic fluid on the upper side of the diaphragm 14 to flow back into the reservoir 20 when the cylinder 18 receives hydraulic fluid through pump 30 with valve 32 opened and valve 33 closed. After the plunger 13 is raised to its upper level, valves 31 and 32 are closed in preparation for the next cycle.

It has been found that the pressure within the vessel 10 in relation to the pressure in the high pressure vessel or zone 23 is critical, particularly if the solid particles in the vessel 10 are not completely or substantially completely fluidized. If the particles in vessel 10 are substantially completely fluidized, then the pressure within vessel 10 in relation to that in vessel or zone 23 is not critical so long as flow of fluid continues into vessel 10 to promote fluidization and flow of solids from the vessel into the high pressure zone 23 and the hydraulic pressure on the diaphragm 14 is sufficient to cause the plunger and diaphragm to push the particles from vessel 10 into the high pressure zone 23. However, if the solid particles in vessel 10 are not completely or substantially completely fluidized then the fluid pressure within the vessel 10 must be initially greater than that in the vessel or zone 23 in order to initiate the flow of particles. Pressure on the plunger 13 and diaphragm 14 could not be utilized to push unfluidized particles from the vessel 10 because of "bridging." If the particles in vessel 10 are not fluidized and an attempt is made to force the particles out of the vessel 10 by means of the plunger 13 and diaphragm 14 or a piston, the particles will be forced and bridged against the side walls of the vessel, becoming completely compacted within the vessel thus preventing the removal of the particles from the vessel even with extremely high pressures by the plunger. It has been found that with vessels of a size approaching that of a commercial unit that unless special provisions are made to maintain fluidization of solids by the continuous introduction of multiple jets of gas the solids will bridge and flow will stop when a piston exerts mechanical force on the mass of solids in an attempt to push them through a conduit.

If a fluidizing gas is supplied to maintain the solids in fluid suspension, then plunger 13, assuming the pressures in the two vessels are equal, can exert a slight pressure on the solid particles to force the particles out of the vessel 10 without the bridging effect. Normally, the pressure within vessel 10 is initially established at a greater value than in zone 23 but no provision has to be made to maintain the solids in a fluidized state. When

valve 24 is opened fluid continues to enter vessel 10 to flow concurrent with the solids as they leave the vessel and to fill any resultant void space in vessel 10. Thus the main function of the plunger 13 and flexible diaphragm 14 is to fill the space within the vessel 10 as the solid particles leave the vessel or, optionally, as previously mentioned, fill the vessel after the particles have left the vessel and before starting the next cycle. Thus, as an example, if the pressure in the pressurized zone or vessel 23 labeled "coal injector" is 1,500 pounds per square inch absolute, then before valve 24 is opened and after valve 19 has been closed and the particles are fed into vessel 10 to a predetermined level generally below the port 12, the valve 22 from the high pressure line, which in this example supplies a regulated pressure of 1,530 pounds per square inch absolute, opens providing this pressure within vessel 10, as measured by the pressure gauge 26. When valve 24 is opened, the initial pressure differential between vessels 10 and 23 plus the continued flow of fluid through valve 24 will be sufficient to cause the solid particles to flow out of vessel 10 into vessel 23 (whether or not the particles are fluidized) after which time valves 22 and 24 are closed. As the plunger 13 and flexible diaphragm 14, non-compressible when combined, because the space above the units is filled with a substantially non-compressible liquid, descend and fill the space in vessel 10, substantially all of the high pressure fluid has been utilized in the passage of solid particles into the high pressure zone or vessel 23. Without the function of the plunger and diaphragm to fill the space in the vessel, as in the lock hopping system, the vessel 10 would have to be vented before a repeat cycle could start and hence the full original volume of high pressure fluid in the vessel 10 would be lost. In the present invention, as the high pressure fluid in the vessel 10 has been substantially completely utilized for conveying purposes or at least recovered without recompression and the space substantially filled with non-compressible means, all that is necessary to start the repeat cycle is to retract the plunger 13 and diaphragm 14. If all valves controlling input and output to vessel 10 are closed at the time the plunger 13 and flexible diaphragm 14 are retracted, the small amount of high pressure gas having been vented by the rapid opening and closing of valve 29, a vacuum is created within the vessel which may aid in the next cycle feeding operation.

The use of a flexible diaphragm in filling the space or volume within the vessel 10 upon the discharge of the particles therefrom, either simultaneously or thereafter, is of importance in that as the diaphragm expands and extends in a substantially frictionless manner through the hydraulic liquid pressure as it is pressed against the inner periphery of the vessel 10 it covers the port 12 so as to prevent clogging thereof. As seen in FIGURE 1, in dotted lines, the diaphragm completely covers and seals the port during the discharge cycle.

What is claimed is:

1. The method of pneumatically injecting solid particles into a high pressure zone which includes the steps of providing a supply of particles, providing communication between the supply and a vessel, feeding the particles under gaseous pressure from the supply to the vessel, discontinuing the feeding of particles to the vessel by closing the communication between the supply and the vessel, increasing the pressure in the vessel by injecting gas therein until the pressure in the vessel is greater than the pressure in the high pressure zone, providing communication between the vessel and the zone to permit the particles and pressurizing gas to pass from the vessel into the zone, extending a non-compressible means in the vessel as the particles pass from the vessel into the zone without substantially increasing the pressure on the particles and continuing the extension of the non-compressible means in the vessel to substantially fill the volume therein after substantially all of the particles have passed from the ves-

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sel into the zone while maintaining communication between the vessel and zone, closing the communication between the vessel and the zone and retracting the non-compressible means in the vessel while communication between the supply and vessel and vessel and zone is closed.

2. The method of pneumatically injecting solid particles into a high pressure zone which includes the steps of providing a supply of particles, providing communication between the supply and a vessel, feeding the particles under gaseous pressure from the supply to the vessel, discontinuing the feeding of particles to the vessel by closing the communication between the supply and the vessel, increasing the pressure in the vessel by injecting gas therein until the pressure in the vessel is greater than the pressure in the high pressure zone, providing communication between the vessel and the zone to permit the particles and pressurizing gas to pass from the vessel into the zone, expanding a flexible diaphragm against the walls of the vessel as the particles pass from the vessel into the zone without substantially increasing the pressure on the particles and continuing the expansion of the diaphragm in the vessel to substantially fill the volume therein after substantially all of the particles have passed from the vessel into the zone while maintaining communication between the vessel and zone, closing the communication between the vessel and the zone and contracting the diaphragm in the vessel.

3. The method of pneumatically injecting solid particles into a high pressure zone which includes the steps of providing a supply of particles, providing communication between the supply and a vessel, feeding the particles under gaseous pressure from the supply to the vessel, discontinuing the feeding of particles to the vessel by closing the communication between the supply and the vessel, increasing the pressure in the vessel by injecting gas therein until the pressure in the vessel is greater than the pressure in the high pressure zone, providing communication between the vessel and the zone to permit the particles and pressurizing gas to pass from the vessel into the zone, expanding a flexible diaphragm against the walls of the vessel after the particles have passed from the vessel into the

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zone to substantially fill the volume in the vessel while maintaining communication between the vessel and zone, closing the communication between the vessel and the zone and contracting the diaphragm in the vessel.

4. The method of pneumatically injecting solid particles into a high pressure zone which includes the steps of providing a supply of particles, providing communication between the supply and a vessel, feeding the particles under gaseous pressure from the supply to the vessel, discontinuing the feeding of particles to the vessel by closing the communication between the supply and the vessel, increasing the pressure in the vessel by injecting gas therein until the pressure in the vessel is greater than the pressure in the high pressure zone, providing communication between the vessel and the zone to permit the particles and pressurizing gas to pass from the vessel into the zone, extending a non-compressible means in the vessel to substantially fill the volume therein after substantially all of the particles have passed from the vessel into the zone while maintaining communication between the vessel and zone, closing the communication between the vessel and the zone and retracting the non-compressible means in the vessel while communication between the supply and vessel and vessel and zone is closed.

5. The method as set forth in claim 2 wherein the communication inlet to the vessel is positioned below the diaphragm when the diaphragm is fully contracted and the feeding to the vessel from the supply continues until the particles reach a predetermined level in the vessel, which level is generally below the inlet.

6. The method as set forth in claim 5 further characterized in that the expansion of the diaphragm covers the inlet to prevent clogging thereof during the passage of the particles into the zone.

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