

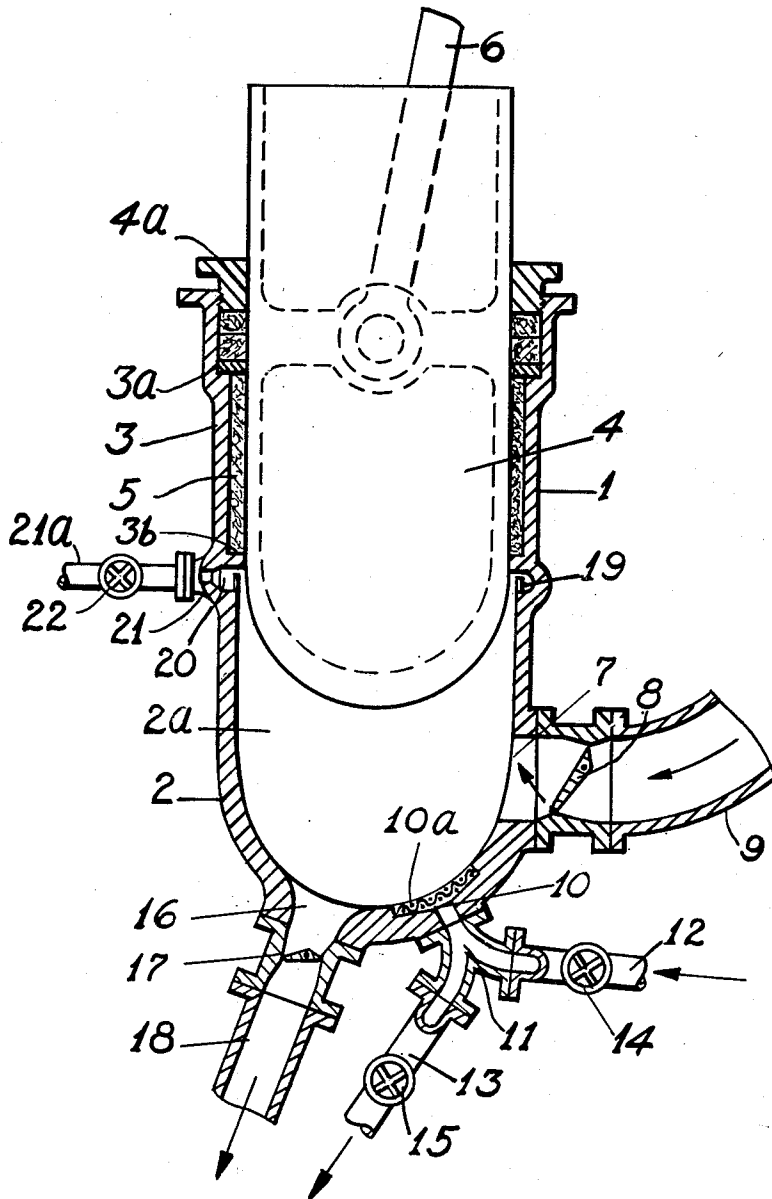
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HANDLING FINELY DIVIDED SOLID MATERIALS

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HANDLING FINELY DIVIDED SOLID MATERIALS

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The present invention relates to a method and apparatus for the handling of finely divided solids. More particularly, the invention relates to a method and apparatus for transferring finely divided solids materials from one pressure zone to a zone of higher pressure in a process requiring the use of such materials.

In the operation of processes involving the handling of finely divided solids at elevated pressures, particularly when using the fluidized solid technique, there is involved the problem of introducing the pulverized solids into a high pressure zone of the apparatus employed. Various systems have been employed in the past for such purpose, as, for example, star feeders, multiple, high pressure lock hoppers or blow cases and other comparable mechanical means. Such means as previously used have had many uneconomical and otherwise undesirable characteristics, such as a tendency to pack the finely divided solids so as to cause injection into a reaction zone in lump form, or to require excessive amounts of fluidizing or injection gases, as when lock hoppers or blow cases are employed. Various forms of pumps have been devised in the past for the handling of finely divided solid materials in an effort to adapt systems for handling liquids to the handling of finely divided solid materials. These efforts have been substantially unsuccessful in large part due to the abrasive and erosive effect of the finely divided solid materials on mechanical sealing elements required to be used under the high pressure conditions encountered.

It is an object of the present invention to provide a pump-type apparatus for handling finely divided solid materials, and a method of operation in which the construction of the apparatus is simplified as compared with apparatus previously used, and also in which a minimum quantity of supplemental fluidizing gas must be used in order to maintain the solid materials in a fluidized form. It is also an object of the invention to provide a pump-type apparatus in which the abrasive effect of the finely divided solid materials on sealing means for a pump piston, or on the piston and cylinder walls, is substantially minimized. Further, it is an object of the present invention to provide a method and apparatus for transferring finely divided solid materials from one zone to another by positive displacement without substantially compacting the material handled.

The invention and the objects thereof may be more fully understood from the following description when read in conjunction with the accompanying drawing in which a representative

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form of the apparatus is illustrated schematically and partly in vertical section.

Referring more specifically to the drawing, the apparatus is now described with reference to a system operating on gases and finely divided solid materials. In the drawing, the numeral 1 designates a representative pump cylinder, having a head portion 2 and a tail portion 3, in which a loosely fitted piston 4 is disposed for reciprocal movement in the cylinder in appreciable annularly spaced relation to the walls of the head portion 2. The tail portion 3 is provided with a stuffing box assembly 4a, and an annular soft packing material 5 supported respectively against flange portions 3a and 3b formed in the walls of the cylinder tail portion 3. By means of the stuffing box and soft packing, a pressure and fluid-tight seal is maintained between the cylinder portion 3 and the piston 4, providing for a high pressure chamber 2a between the piston and the cylinder head portion 2.

Any suitable means may be provided for reciprocal movement of the piston in the cylinder as through connecting rod 6 and the cylinder may be one of several arranged and connected in tandem or parallel to a driving means. For example, the apparatus may be arranged in a form resembling that of an ordinary engine driven compressor, or cylinders of the type indicated may be included in the same engine block structure with other cylinders driven as an internal combustion engine, or by use of steam or of high pressure waste gas from the process system. In this instance, the cylinders according to the present invention, and the driven cylinders, would be connected in the same crank shaft. Comparable apparatus construction is well known in the art of air and gas compressors, and its application in the present instance should be evident.

Communicating with the chamber 2a through the wall of the cylinder portion 2, by way of port 7 and back pressure valve 8, is a conduit 9 through which finely divided solid materials may be fed into the chamber 2a. Normally, these materials will be at a substantially lower pressure than that existing in the process system, and may be derived from any conventional form of supply means such as hoppers, or a stand-pipe in which the fluidized solids are maintained, in an at least partially fluidized condition, under a pressure equivalent to that of the static head of a column of such materials in the stand-pipe. Such sources of supply are not shown in the drawing because they are of well-known characteristics, and no unusual arrangements are required for connec-

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tion to apparatus according to the present invention except as specifically set forth and later described.

Also, communicating with the chamber 2a, as through a port 10, and a dual conduit connection 11 is a high pressure gas inlet line 12 and vent line 13, each provided with suitable valves 14 and 15 respectively. A screen element 10a is provided over the inner end of the port 10 which aids in distributing gas admitted through port 10, increasing the fluidizing effect thereof on the finely divided solid material admitted through port 7 and present in the chamber. An outlet port 16 opens from the chamber 2a through a check valve connection 17 into a line 18 for discharge of finely divided solid materials into the high pressure side of the system. The valves 14 and 15 in the lines 12 and 13 respectively may be connected in any conventional fashion to the means for driving the piston 4, as through cam shafts and timing gears, whereby their operation may be coordinated with the piston stroke and cycle. Where desired, similarly actuated valves may be substituted for the check valves 8 and 17. At the outer end of the chamber 2a is provided a means for introducing a gaseous material annularly of the piston 4, for example, a lantern-type, ring member 19 set into the wall of the cylinder 1, and substantially flush with the inner surface thereof, the annular groove provided to receive this ring being of greater depth than the ring and providing a passageway 20 around the wall behind the ring. A port 21 opens through the cylinder wall into communication at one end with the passageway 20, and at the other, with a high pressure gas line 21a provided with a valve 22 connected for automatic operation according to the stroke and cycle of the piston as may be valves 14 and 15. The high pressure gas employed, both that introduced by way of line 12, and that by way of line 21a may be derived from a variety of sources. For example, the high pressure gas may be supplied stepwise from a series of chambers having successively higher pressures. Process gases or tail gases from the system may also be recompressed and returned. Also, compressor cylinders and the pump-type device now contemplated may be combined in the same apparatus. The gas introduced by way of line 12 may or may not contain finely divided solid material primarily derived from other parts of the system, such as when process gases are recycled for the purpose described. The gaseous material admitted through line 21a, however, should be substantially free of solid particles.

In operation, as the piston 4 is moved outwardly from the chamber 2a, valves 14, 15 and 17 being closed, the suction valve 8 is opened, or opens under the effect of the differential pressure created between the chamber 2a and the pressure of solid materials in the line 9, to admit such materials from the low pressure side of the system into the chamber 2a. With a given solids content in the feed stream from line 9, the quantity of materials admitted may be varied in any desired fashion, by adjustment of the piston stroke or timing of the valve opening sequence, and vice versa. At the same time, the valve 22 may be opened to introduce a small amount of gaseous material in order to prevent the finely divided solid material from entering the space between the piston and the cylinder wall. The admission of gas through valve 22 may be delayed, however, until the end of the suction stroke to increase the effective capacity of the chamber, or it

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may be omitted entirely. At the end of the suction stroke of the piston, the valve 14 may be opened to admit a gaseous material, which may or may not contain finely divided solid materials, at substantially the pressure of the high pressure side of the system, automatically closing the valve 8, when a check valve is employed. Pressure in the chamber 2a is then raised to at least equal that of the pressure existing on the high pressure side of the system. Preferably, the entrance of the high pressure gas is arranged in such fashion as to produce turbulence, and a fluidizing effect in the mass of finely divided solid material present in the chamber 2a as by a distributing means such as screen 10a. If desired, the gas introduced by way of line 12 and valve 14 may be introduced, alternately, by way of line 21a, valve 22, and port 21, but then, as stated, the gas preferably is to be substantially free of solid particles. When this is done, the incoming gas sweeps down the walls of the chamber 2a from several points with a turbulent effect tending to fluidize the charge of solid materials in the chamber.

When the pressure in the chamber 2a has reached the desired predetermined value, the valve 14 is closed and the piston starts its stroke. At that point at which the pressure in the chamber substantially equals that in the high pressure side of the system, the valve 17 opens, or is opened, and during completion of the stroke of the piston, the fluidized solid materials and fluidizing gas will be discharged into the high pressure side of the system through the line 18. During such discharge, a gaseous material may be admitted through the line 21a by way of valve 22 so as to flush the side walls of the piston during its stroke and to help maintain fluidization of the charge in the chamber 2a, and to minimize any compacting effect on the solid charge in the chamber, tending to be created by movement of the piston during its displacement stroke. In this connection, the primary object to be obtained is to accomplish the discharge of gaseous and solid materials in the chamber by displacement, preferably while maintaining the solid materials in an optimum fluidized condition. At the end of the discharge or displacement stroke of the piston, there may be a small residue of solid particles remaining in the chamber 2a, and in any event, the pressure in the chamber probably will be such as to make reduction desirable before introduction of a new solids charge. These conditions may be overcome by scavenging and then venting the chamber, or by a combination scavenging and venting step. In the one instance, while withdrawal of the piston is slightly delayed, high pressure gas may be introduced, as by way of line 21a, to sweep the annular space around the piston and to clear the head space thereof. With the gas at substantially the pressure of the high pressure zone, this scavenging gas and the residual solid material may be discharged directly into the high pressure zone. Following scavenging, the valve 17 is closed, or closes automatically, and the gas remaining in the chamber vented in any suitable manner, as through connection 11, line 13, and valve 15. The vented gas may be disposed of in any desired fashion, as by introducing it into the line 9 to aid in fluidizing the finely divided solid materials contained therein. Alternately, upon completion of the displacement stroke, the chamber 2a may be vented immediately, the pressure differential created by opening valve 15 being sufficient to effect substantial scavenging of residual solid particles by the escaping gas. Where

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required, however, additional gas may be introduced by way of line 21a to remove any remaining solids. The reduction of pressure in the chamber created by opening valve 15 will normally effect the closing of valve 17, but they may be arranged for synchronized mechanical operation. Also, the gas and solids thus removed from the chamber 2a may be introduced into the line 9, or otherwise disposed of.

As thus set forth, the operation involves the use of a pump-type fluid transfer apparatus, operated on a cycle involving successively: (1) the intake of a finely divided solid material at low pressure; (2) the injection of a high pressure gaseous material into the low pressure, finely divided solid material previously introduced; and (3) the discharge of the resulting high pressure mixture by displacement, the operation being accomplished substantially without mechanically compacting the mass of finely divided, solid materials. The invention also provides an apparatus of the type described, in which any deleterious effect of finely divided solid materials on a seal for the piston element in the apparatus, or on the opposed piston and cylinder surfaces, is substantially avoided by the controlled injection of a high pressure gas at the juncture of the piston seal and the displacement chamber.

Although the operation has been described with reference to a sequence of steps in which the piston operates only to displace a pressurized charge from the chamber 2a, alternatively, the pressure developed by means of gas admitted by way of lines 12 and/or 21a may be limited to substantially less than the system pressure, utilizing the piston displacement stroke as a means for imposing the additional pressure required to supply the deficiency as compared with the system pressure. When operating in this fashion, it is only necessary that actual contact of the piston with the main body of the solid charge be avoided, and physical compacting prevented.

What is claimed is:

1. In a system for handling finely divided solid materials, including an initial pressure zone containing fluidized finely divided solid materials, a zone of higher pressure, and an intermediate zone of variable volume and pressure, a method for transferring said solid materials from the initial pressure zone to said zone of higher pressure comprising introducing a measured quantity of fluidized finely divided solid materials from said initial pressure zone into said inter-

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mediate zone, under substantially the pressure of the initial zone, injecting a stream of pressurized gaseous material upwardly into said intermediate zone and the finely divided solid materials therein, maintaining fluidity of said materials and raising the pressure of said zone substantially to that of the zone of higher pressure, and then displacing said solid and gaseous materials from the intermediate zone into said zone of higher pressure primarily by reducing the volume of said zone, while continuing to inject said gaseous material as required to maintain fluidity of said solid materials during displacement thereof, and substantially without compacting said solid materials.

2. A method according to claim 1, according to which the gaseous material injected during displacement of said solid and gaseous materials is injected peripherally downward in said intermediate zone under a pressure at least equal to that of the zone of higher pressure.

3. A method according to claim 1, including the steps of scavenging residual solid material from the intermediate zone by continued injection of said gaseous material following the displacement steps, peripherally downward in said intermediate zone, and at a pressure at least equal to that of the zone of higher pressure.

4. A method according to claim 3, in which said intermediate zone is vented and the pressure therein reduced substantially to that of the initial zone following the scavenging step.

5. A method according to claim 1, in which the measured quantity of finely divided solid materials is introduced into said intermediate zone under pressure of a fluidizing gas.

6. A method according to claim 1, in which the measured quantity of finely divided solid material is introduced into said intermediate zone under static pressure of a fluidized column of said material communicating with said intermediate zone.

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