

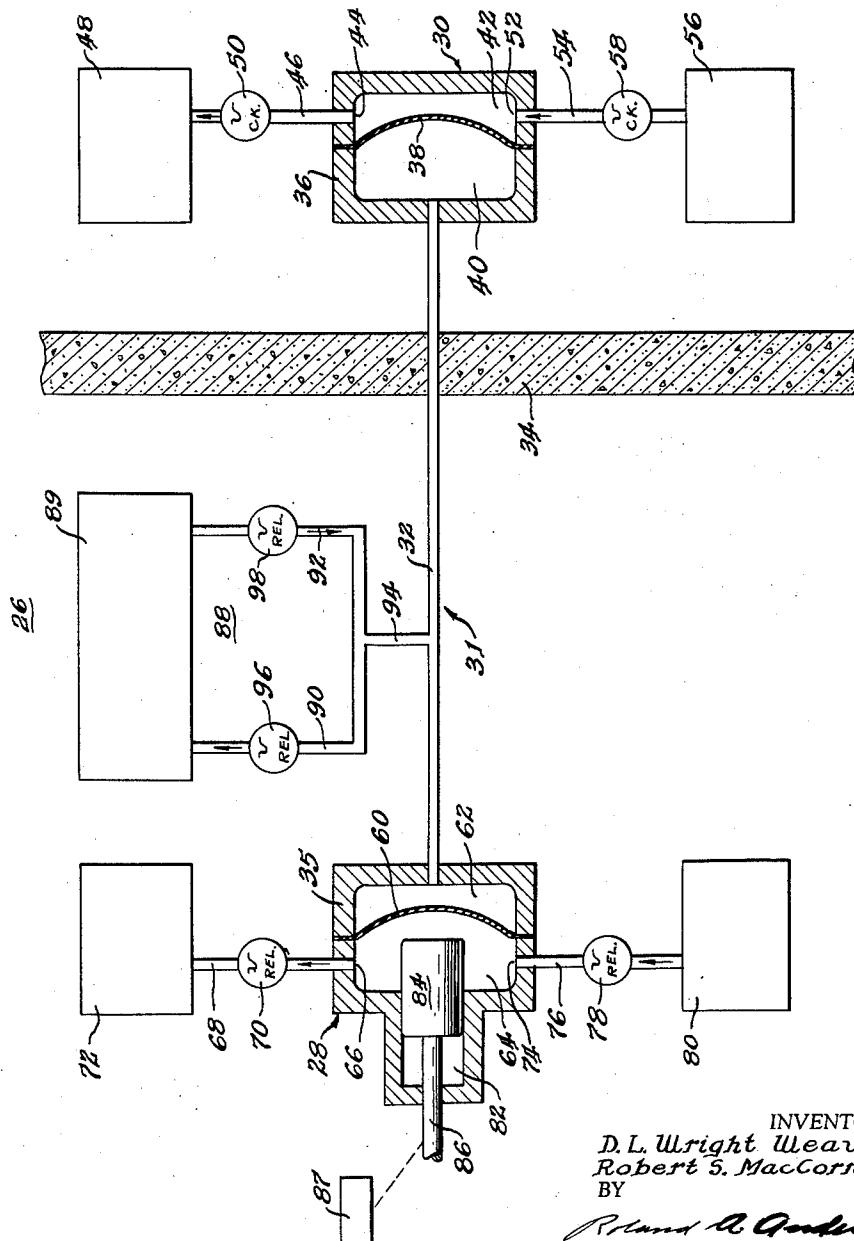
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VOLUME COMPENSATING MEANS FOR PULSATING PUMPS

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VOLUME COMPENSATING MEANS FOR PULSATING PUMPS

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1 Claim. (Cl. 103-44)

This invention relates in general to pumps for moving liquids from one place to another and in particular to pumps adapted for remotely moving radioactive liquids.

In certain types of chemical processing involving movement of liquids from one process area to another, it is advisable to keep pumping equipment and process vessels behind a barrier or a shield, because of the toxicity of the pumped liquid, to protect operating personnel. For example, in chemical processing of spent nuclear fuels to recover the residue of unburnt fissionable isotopes, spent fuel elements are dissolved in various acids to render them into a solution form to facilitate remote handling. Since the resultant solution is highly corrosive and radioactive, the solution and the processing equipment including pumps are located in shielded areas to minimize radiation exposure to operating personnel. It has been found that the pumping equipment requires periodic maintenance, the periodicity of the maintenance being dependent on the degree of complexity of the pumping structure and the manner of the pumping action. The pumps which utilize rotating elements within their structure are particularly troublesome. The disadvantage of frequent maintenance can be overcome by utilizing a diaphragm pump apparatus comprising two conventional diaphragm pumps remotely coupled by an intermediate liquid wherein a primary head (pump 1) is located in a control area and a remote head (pump 2) is located in a process area. A conduit coupling the remote head to the primary head is filled with an inert (non-radiation absorbing) intermediate (transmission) liquid for transmitting pulsations from the actuated diaphragm in the primary pump to the diaphragm in the remote pump. The volume of the intermediate liquid in the conduit and in chambers of both of the pumps varies with temperature changes and introduces operating difficulties by affecting in-phase positions (correspondence) of the diaphragms in both of the pumps. The inventor has designed a means for maintaining constant the volume of the intermediate liquid thus overcoming operational difficulties.

One of the objects of this invention is to improve the performance of a diaphragm pump apparatus.

Another object of the invention is to maintain constant the volume of an intermediate fluid transmitting pulsating action from one pump to another.

According to the teachings of this invention there is provided a compensating means for maintaining constant the volume of an intermediate liquid in a transmission means connected between diaphragms of two diaphragm pumps distantly separated, wherein actuation of one pump transmits pulsations through the intermediate liquid to actuate the diaphragm of the remotely placed other pump. The compensating means comprises a pair of valves interconnected between a reservoir of the intermediate liquid and the transmission means, one of the valves being adapted to pass excess liquid into the reservoir whenever a certain pressure is exceeded in the

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transmission means and the other valve is adapted to pass the liquid out of the reservoir into the transmission means whenever a certain vacuum is reached in said means thereby maintaining the volume of the liquid in the transmission means at a substantially fixed value.

The foregoing and other objects and advantages of the apparatus of the present invention will become apparent from consideration of the specification in conjunction with the accompanying drawing showing a simplified sectional view of the diaphragm pump apparatus having novel means for compensating for the expansion in the intermediate liquid coupling the two diaphragm pumps used therein.

A pumping apparatus 26 comprises a pair of diaphragm pumps, primary head pump 28 and remote head pump 30, separated by a distance and coupled together by interconnecting or transmission means 31 including a conduit 32. As was indicated before, the pumping apparatus 26 is utilized for moving radioactive fluids during chemical processing without exposing operating personnel to harmful irradiation. The remote head pump 30 is located in a process area behind a radiation barrier or shield 34 while the pump 28 is located on the other side of the radiation barrier 34 in a control area. The pump 28 has a housing 35 and the pump 30 has a housing 36. The remote head pump 30 has a resilient member, such as a diaphragm 38, stretched across the entire interior of the housing 36 subdividing said interior into a receiving chamber 40 and an actuated chamber 42. The housing 36 has a port 44 connected through a conduit 46 which connects to a vessel 48 via a check valve 50, said vessel being adapted to receive liquid pumped by the pump 30. As shown, opposite to the port 44, there is located another port 52 which engages a conduit 54 which connects through a check valve 58 to a vessel 56 filled with a liquid which is desired to be pumped into the vessel 48. The check valve 50, when operated, opens a path to liquid movement within the conduit 46 whenever the diaphragm 38 is displaced in the manner shown, so that the liquid is forced out of the actuated chamber 42 into the vessel 48. Whenever the diaphragm 38 is displaced in the opposite direction, opposite to that shown in the drawing, the movement of the diaphragm 38 in said opposite direction will cause suction in the actuated chamber 42 and thereby open the check valve 58 to allow passage of liquid out of the vessel 56 into the chamber 42.

The diaphragm pump 28 has a resilient member, such as a diaphragm 60, stretched completely across the interior of the housing 35 subdividing the interior thereof into a transmitting chamber 62 and an actuating chamber 64. The actuating chamber 64 has a port 66 engaging a conduit 68 which is connected through a pre-set pressure valve 70 to a reservoir 72. Opposite to the port 66, there is disposed a port 74 engaging a conduit 76 which is connected through a pre-set pressure valve 78 to a reservoir 80. The housing 35 has a cylinder 82 which contains a movable member, such as a piston 84, having a rod 86 extending through the extremity of said cylinder. The rod 86 is mechanically coupled to actuating means, such as a motor 87, to provide a reciprocating movement of the piston 84 within the cylinder 82. The conduit 32 connects the transmitting chamber 62 of the pump 28 to the receiving chamber 40 of the pump 30. The actuating chamber 64 in the pump 28 is filled with oil for imparting movement from the piston 84 to the diaphragm 60. The pre-set pressure valve 78 is adapted to permit a substantially incompressible liquid, such as oil, in the reservoir 80 to be fed into the chamber 64 whenever a certain amount of vacuum occurs in said chamber. The pressure valve 70 is pre-set to operate whenever a certain pressure is ex-

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ceeded within the chamber 64 to allow excess oil to be stored in the reservoir 72. Both of the valves 70 and 78 are pre-set at particular pressures to maintain constant the volume of the oil in the actuating chamber 64. Of course, it is to be understood that these pressure settings are above and below the range of pressures exerted by the piston 84 during a pumping action and do not interfere with normal operation of the pumping apparatus 26. Since the volume of the transmission liquid in the conduit 32, also, may vary because of temperature changes, a compensating means 88 is connected to said conduit to improve the efficiency of the pumping action. The compensating means 88 comprises a reservoir 89 filled with a substantially incompressible liquid, such as kerosene, which communicates through individual conduits 90 and 92 and a common conduit 94 with the conduit 32. Intermediate of the conduit 90, there is located a valve 96 which opens up whenever a certain pressure exists in the conduit 32. Similarly, intermediate of the conduit 92, there is located a valve 98 which opens whenever a certain vacuum exists in the conduit 32.

The piston 84 coupled through the rod 86 to the motor 87 imparts reciprocating motion through oil to the primary diaphragm 60 causing it to be displaced outward during one phase of operation, i.e., in a direction away from the piston 84. The pressure relief valves 70 and 78 regulate oil volume within the actuating chamber 64, as was pointed out hereinbefore. The displacement of the primary diaphragm 60 in the manner indicated imparts pressure through the kerosene within the conduit 32 to the remote diaphragm 38, causing it to be displaced in a direction away from the entrance of the kerosene into the receiving chamber 40. The displacement of the remote diaphragm 38 forces the radioactive liquid contained within the actuated chamber 42 through the conduit 46 and the ball check valve 50 into the vessel 48. The return stroke of the piston 84 releases pressure on the primary diaphragm 60 which returns to normal (non-distended) position. Similarly, the relief of pressure causes the remote diaphragm 38 to return to its normal position. As the remote diaphragm 38 returns to its normal position, a vacuum is created within the actuated chamber 42 and the radioactive liquid is withdrawn out of the vessel 56 through the conduit 54 and the ball check valve 58 into said chamber, at which time, the ball check valve 50 closes to prevent the return of liquid or air from the vessel 48. It is evident that efficient operation is dependent upon the two diaphragms 38 and 60 being positionally coordinated. Obviously, a deviation in the volume of kerosene within the conduit 32 destroys this coordination, detracts from pumping efficiency, and increases maintenance problems. The variation in the volume of the pumping liquid in the conduit 32 is counterbalanced by using the compensating means 88.

The method of volume regulation will now be described. When the piston 84 is actuated by the motor 87 and moved in a direction towards the interior of the housing 35, i.e., towards the diaphragm 60, force is applied by said piston through the liquid in the actuating chamber 64 to the diaphragm 60, through the liquid in the transmitting chamber 62, the conduit 32 and the receiving chamber 40 to the remote diaphragm 38 in the pump 36. When this pressure is applied by said piston, there exist three points of pressure release listed in the order in which they occur; ball check valve 50, kerosene pressure relief valve 96, and oil pressure relief valve 70. The ball check valve 50 releases under a slight pressure (relative pressure I) and allows radioactive liquid to be forced out of the actuated chamber 42 into the vessel 48 when the remote diaphragm 38 is displaced by the transmission liquid within the receiving chamber 40. The displacement of the remote diaphragm 38 continues until it reaches its maximum in the housing 36. As the piston 84 continues to move and exert further pressure,

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kerosene pressure relief valve 96 releases (relative pressure II), allowing the excess kerosene to be ejected from the line 32 through the common conduit 94, the conduit 90 and through the valve 96 into the reservoir 89. During the time that the diaphragm 60 is causing sufficient pressure to eject fluid out of the conduit 32 into the reservoir 89, said diaphragm continues to move until it reaches its maximum within the housing 35. At this time, both of the diaphragms 38 and 60 are in their maximum displaced positions and are in phase. The valve 96 closes. If the piston 84 continues to move further toward the diaphragm 60, pressure is built up sufficiently so that the oil pressure relief valve 70 is operated (relative pressure III). The valve 70 remains open until the piston 84 completes the pressure stroke. As the piston 84 begins the return stroke, all the pressure valves 50, 96 and 70 are closed, the diaphragms 38 and 60 are in phase, and the kerosene within the interconnecting means 31 including the conduit 32 and the chambers 40 and 62 is at a correct volume.

Since the diaphragm pumps 28 and 30 are operated intermittently, a temperature change between runs frequently occurs. A drop in temperature could result in too little volume of kerosene in the interconnecting means 31 to operate properly said pumps. In this case, the pressure stroke of the piston 84 would have no appreciable effect on the pumping apparatus, but the return stroke would adjust the volume as follows: As the piston 84 begins a return stroke, i.e., it moves in a direction away from the diaphragm 60, it creates a vacuum for which there exist three points of vacuum release listed in the order in which they are activated; ball check valve 58, kerosene suction release valve 98, and oil suction release valve 78. The ball check valve 58 releases as the pressure drops inside the interconnecting means 31 (relative suction I) and allows radioactive liquid to flow from the vessel 56 through the valve 58 into the actuated chamber 42. When the remote diaphragm 38 reaches its maximum displacement within the housing 36 and suction continues, the suction release valve 98 opens (relative suction II) and admits kerosene from the reservoir 88 through the conduits 92 and 94 into the conduit 32 until the primary diaphragm 60 reaches its maximum displaced position within the housing 35, at which time the valve 98 closes. If the piston 84 continues to exert further suction, the suction created in the actuating chamber 64 causes the valve 78 to open (relative suction III), said valve remaining open and allowing oil to be withdrawn out of the reservoir 80 into the actuating chamber 64 until completion of the suction stroke by the piston 84. At this time, both of the diaphragms 38 and 60 are displaced in a maximum direction toward the piston 84, both of the diaphragms being now in phase, and the volume of the liquid within the interconnecting means 31 is at a correct value. The pumping apparatus 26 is now able to operate at maximum efficiency.

As was shown hereinbefore, the various valves which operate at certain pressure and vacuum settings are adjusted in the relative order described. Although the pumping apparatus 26 has been described using kerosene in the interconnecting means 31, it is to be understood; that other substantially incompressible liquids may be used therein.

While there has been described what is at the present considered to be the preferred embodiment of the invention, it will be understood that various modifications may be made therein and it is intended in the appended claim to cover all such modifications as found within the true spirit and scope of the invention.

What is claimed is:

A remotely operated double diaphragm pumping apparatus comprising a primary head pump consisting of a casing, a diaphragm separating the casing into an actuating chamber and a transmitting chamber, a first liquid in said actuating chamber, means for acting on said dia-

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phragm through said first liquid, means for maintaining the volume of said first liquid constant comprising a pair of reservoirs, a pair of conduits containing preset pressure-release valves connecting said actuating chamber with said reservoirs, a remote head pump consisting of a casing, a diaphragm separating the casing into a receiving chamber and an actuated chamber, said actuated chamber being provided with inlet and outlet lines containing preset pressure-release valves, and a conduit containing a second liquid connecting said transmitting chamber and said receiving chamber, means for compensating for changes in the volume of said second liquid due to temperature fluctuations comprising a reservoir filled with said second liquid, a pair of conduits connected to said reservoir each containing a preset pressure-release valve, a common conduit which in turn is connected to said conduit containing a second liquid and to said second pair of conduits, said preset pressure-release valves in said inlet and outlet lines being constructed and arranged to operate at a relatively low pressure, said preset pressure-

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release valves in said first mentioned pair of conduits being constructed and arranged to operate at a relatively high pressure with respect to that of said preset pressure-release valves in said inlet and outlet lines, and said preset pressure-release valves in said second mentioned pair of conduits being constructed and arranged to operate at an intermediate pressure with respect to the aforesaid low and high pressures.

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