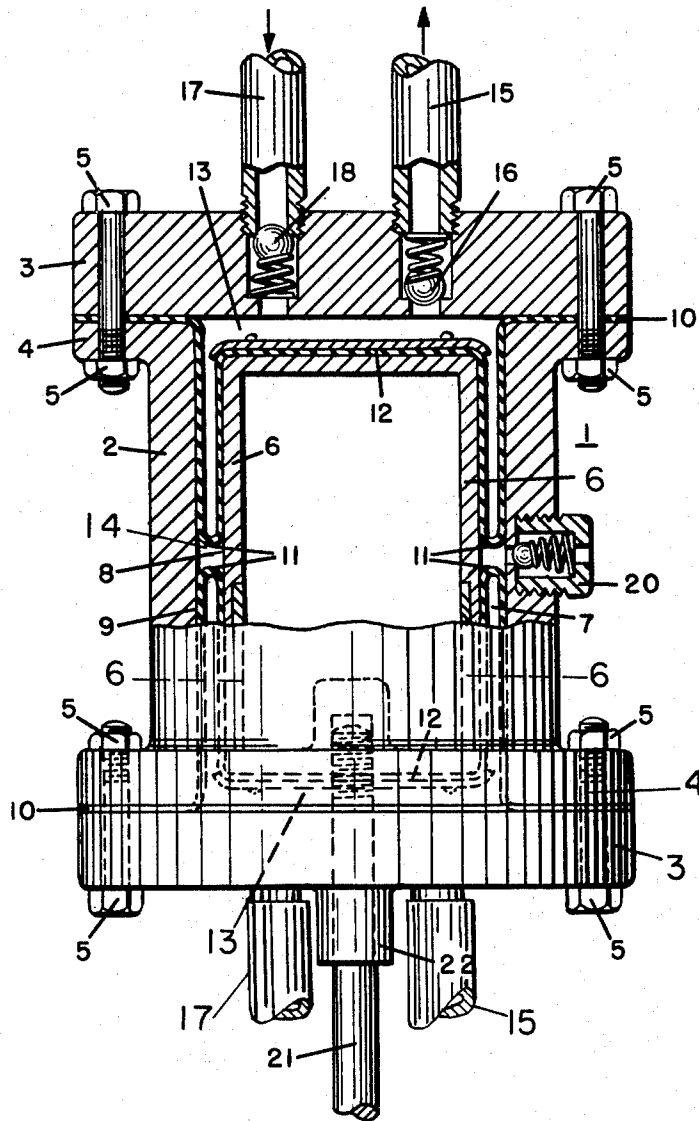


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DOUBLE ACTING ACTUATOR OR PUMP HAVING
A PAIR OF ROLLING DIAPHRAGMS
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DOUBLE ACTING ACTUATOR OR PUMP HAVING A PAIR OF ROLLING DIAPHRAGMS

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This invention relates to double acting actuators, or to double acting piston pumps, having a pair of rolling diaphragms.

The rolling diaphragms of such devices have a radially outer fixed flange portion clamped to the cylinder of the device and a radially inner flange portion which is secured to the top of the tandem piston of the device. The rolling diaphragm further includes an intermediate portion known as the rolling wall thereof. During the stroke of the tandem piston of the device in one direction the rolling wall of one diaphragm rolls off the tandem piston wall onto the cylinder side wall and the rolling wall of the other diaphragm performs a reverse movement, i.e., it rolls off the side wall of the cylinder onto the side wall of the tandem piston. The rolling diaphragms of such a device subdivide the cylinder space into two axially outer chambers and one axially inner chamber. These two axially outer chambers are pump chambers if the device is used as a pump into which a gas or liquid is sucked and out of which the gas or liquid is pressed. The axially inner chamber into which the cylinder space is subdivided by the pair of rolling diaphragms may be referred to as the inactive chamber since the gas or liquid to be moved by the device if used as a pump does not normally enter into that chamber.

In order for an actuator or a piston pump having a pair of rolling diaphragms to properly perform, the pressure in the axially outer chambers must always exceed the pressure in the axially inner or inactive chamber. The term pressure reversal refers to a condition wherein the pressure in the axially inner or inactive chamber exceeds the pressure in the axially outer chambers. Pressure reversal may result in a collapse of the rolling diaphragm which, in turn, renders the device inoperative.

It is, therefore, a principal object of this invention to provide reciprocating double acting actuators or double acting piston pumps having rolling diaphragms, and which devices are not subject to pressure reversal and to collapse of their rolling diaphragms.

United States Patent 3,208,394 to John F. Taplin issued Sept. 28, 1965 for Piston Pump Having Rolling Diaphragm and Pressure Equalization Means discloses and claims a structure for precluding pressure reversal. The present invention is concerned with means other than those disclosed in my aforementioned patent for achieving substantially the same end.

The foregoing and other general and special objects of the invention and advantages thereof will more clearly appear from the following description of the invention as illustrated in the accompanying drawing showing in part a vertical section and in part a side elevation of a tandem piston pump embodying this invention.

Referring now to the drawing, numeral 1 has been applied to generally indicate a cylinder body including a central portion 2 and two axially outer portions 3. Central portion 2 is provided with flanges 4, and the axially outer portions 3 are clamped against flanges 4 by screws 5. The central portion 2 of cylinder body 1 accommodates an integral pair of reciprocating tandem pistons 6. Each piston 6 defines a gap 7 between the radially outer lateral cylindrical surface 8 thereof and the radially inner lateral cylindrical surface 9 of portion 2 of cylinder body 1. The pump comprises further a pair of rolling diaphragms. Each rolling diaphragm includes a radially outer flange portion 10 clamped between parts 3 and

4, a rolling wall 11 arranged inside of gap 7 and a radially inner flange portion 12 secured to an end surface of a piston 6. Rolling diaphragms 10, 11, 12 subdivide the inside of cylinder body 1 into a pair of axially outer pump chambers 13 and an axially inner inactive chamber 14. Each axially outer portion 3 of cylinder body 1 defines a compression outlet 15 controlled by a spring-biased check valve 16 and a suction inlet 17 controlled by a spring-biased check valve 18. (The check valve in the lower inlet 17 and the lower outlet 15 are not shown in the drawing.) A check valve 20 connects the inactive chamber 14 to the outer atmosphere. Check valve 20 is arranged in such a way as to allow the flow of fluid from inactive chamber 14 to the outer atmosphere and to preclude the flow of fluid in opposite or reverse direction.

Tandem piston 6 may be operated, or reciprocated, by means of a piston rod 21 secured to tandem piston 6 and slidable in a bearing 22 on cylinder body 1 or the lower axially outer portion 3 thereof.

Tandem piston 6 defines an enclosed space bounded by a pair of flat end surfaces and by a lateral cylindrical surface. The term enclosed space means in this context that the cylindrical piston space does not communicate with any other space, and in particular not with the axially inner or inactive chamber 14. To achieve this end and to minimize the volume of the axially inner or inactive chamber 14, the tandem piston 6 might be made of a solid chunk of metal. In the preferred form of the invention illustrated in the drawing, the tandem piston 6 consists of a fluid-tight cylindrical hollow box, i.e. a box defining a cavity which is carefully sealed and does not communicate with the axially inner or inactive chamber 14, thus minimizing the volume of the latter. A further expedient tending to minimize the volume of the axially inner or inactive chamber 14 consists in that the rolling walls 11 of the rolling diaphragms 10, 11, 12 are sufficiently long to leave but a relatively small clearance between the juxtaposed convolutions formed by the rolling walls 11 of diaphragms 10, 11, 12. That clearance remains as small as shown in the drawing in all positions of the tandem piston 6.

When tandem piston 6 is moved downwardly a partial vacuum is established in the upper pump chamber 13 and the fluid contained in the lower pump chamber 13 is compressed. As a result of the partial vacuum established in the upper pump chamber 13 gas is sucked into the latter through upper suction inlet 17 and check valve 18. Gas sucked through suction inlet 15 is admitted to upper pump chamber 13.

While the upper portion of tandem piston 6 performs its suction stroke the lower portion of tandem piston 6 performs its compression stroke resulting in movement of gas under pressure from lower pump chamber 13 through lower outlet duct 15 and the check valve which is associated with it. During the compression stroke of the lower portion of tandem piston 6 the pressure prevailing in the lower pump chamber 13 is far above the pressure prevailing in the inactive chamber 14, and therefore there is no danger of any collapse of the lower rolling diaphragms 10, 11, 12.

During the subsequent upward movement of tandem piston 6 the gas in the upper chamber 13 is compressed and expelled through upper outlet 15 and check valve 16 and a partial vacuum is established in the lower pump chamber 13 resulting in an inflow of gas through lower passageway 17 and the check valve which is associated with it.

Assuming the pressure in one of chambers 13 to be so much less than in chamber 14 that there is a tendency of collapse of one of the diaphragms 10, 11, 12. The very event of the initiation of the collapse of one of the diaphragms 10, 11, 12 results in a sufficient reduction of the

excess pressure in chamber 14 to preclude an actual collapse of the diaphragm, this critical rapid reduction of pressure in chamber 14 being due to the small volume of chamber 14. In other words, any collapse of one of diaphragms 10, 11, 12 results in a concomitant increase of the volume of chamber 14 which, in turn, as a result of the smallness of its volume, reduces the pressure in chamber 14 so drastically that a condition of equilibrium is established and the collapse of the diaphragm inhibited.

Pressure reversal and collapse of one of the rolling diaphragms 10, 11, 12 may also be caused in a double acting piston pump, or similar device, as a result of a leakage and consequent flow of fluid from one of the axially outer chambers 13, when the pressure therein is high, into the axially inner or inactive chamber 14. The presence of check valve 20—or of several such valves arranged in parallel—precludes any dangerous build-up of pressure inside of the axially inner or inactive chamber 14 which might otherwise result from such leakage. To achieve this end the biasing spring of check valve 20 must be very light, causing opening of check valve 20 when the pressure inside of axially inner or inactive chamber 14 exceeds but slightly atmospheric pressure.

It will be apparent from the foregoing that the ratio of the volume of the axially inner chamber 14 to the volume of each of the axially outer chambers 13 is a critical quantity. The successful operation of the device depends upon the correct choice of that ratio for the intended purpose. The axially inner chamber 14 must have such a small volume relative to the volume of each of the pair of axially outer chambers 13 that any force resulting from the formation of a vacuum in one of the axially outer chambers 13 incident to the suction action of tandem piston 6 acting upon one of rolling diaphragms 10, 11, 12 is balanced by an opposite force resulting from the formation of a vacuum within the axially inner chamber 14.

If the structure shown in the drawing is intended to be used as an actuator rather than a piston pump, the four check valves 16, 18 are dispensed with, and each pair of check valves 16, 18 is replaced by a simple fluid duct.

While, in accordance with the patent statutes, I have disclosed the specific details of a preferred embodiment of my invention, it is to be understood that these details are merely illustrative and that many variations thereof may be made without departing from the spirit and scope of the invention.

I claim as my invention:

1. In a double acting actuator or pump the combination of:
 - (a) a cylinder body defining a cylindrical space;
 - (b) a reciprocating tandem piston inside said cylinder body defining a gap between the radially outer lateral surface thereof and the radially inner surface of said cylinder body, said tandem piston defining a totally enclosed space bounded by a pair of end surfaces and by a lateral surface; and
 - (c) a pair of rolling diaphragms subject to collapse in case of pressure reversal, each of said pair of rolling diaphragms having a radially outer portion secured to said cylinder body, a radially inner portion secured to one of said pair of end surfaces of said tandem piston and a rolling wall intermediate said radially outer portion and said radially inner portion arranged inside said gap between said radially outer surface of said tandem piston and said radially inner surface of said cylinder body, said rolling wall of each of said pair of diaphragms being sufficiently long to leave but a relatively small clearance between the juxtaposed convolutions formed by said rolling wall of each of said pair of diaphragms, said pair of diaphragms subdividing said cylindrical space defined by said cylinder body into a pair of axially outer chambers and an axially inner chamber not communicat-

ing with said totally enclosed space defined by said tandem piston and having such a small volume relative to the volume of each of said pair of axially outer chambers that any force resulting from formation of a vacuum in one of said pair of axially outer chambers incident to the suction action of said tandem piston and acting upon one of said pair of rolling diaphragms is balanced by an opposite force resulting from the formation of a vacuum within said axially inner chamber.

2. A double acting actuator or pump as specified in claim 1 having a check valve connecting said axially inner chamber with the outer atmosphere and allowing fluid inside of said axially inner chamber to flow to the outer atmosphere and precluding a reverse flow of air, said check valve including a biasing spring being so light to cause opening of said check valve when the pressure inside said axially inner chamber exceeds but slightly atmospheric pressure.

3. In a double acting actuator or pump the combination of:

- (a) a cylinder body;
- (b) a hollow tandem piston inside of said cylinder body defining an internal cavity bounded by a pair of end walls and a lateral wall of said tandem piston sealed off the space outside said piston, said piston further defining a gap between the radially outer lateral surface thereof and the radially inner surface of said cylinder body; and

(c) a pair of rolling diaphragms subject to collapse in case of pressure reversal, each of said pair of rolling diaphragms having a radially outer portion secured to said cylinder body, each having a radially inner portion secured to one of the end surfaces of said piston and each having a rolling wall arranged in said gap, said rolling wall of said pair of diaphragms forming a pair of narrowly spaced convolutions, and said pair of rolling diaphragms subdividing said cylinder body into a pair of axially outer chambers and an axially inner chamber, the volume of said axially inner chamber being so small in comparison to the volume of each of said pair of axially outer chambers that any force resulting from formation of a vacuum in one of said pair of axially outer chambers incident to the suction action of said tandem piston and acting upon one of said pair of convolutions of said rolling wall of one of said pair of rolling diaphragms is balanced by an opposite force resulting from the formation of a vacuum within said axially inner chamber.

4. A double acting actuator or piston pump as specified in claim 3 including a check valve arranged between said pair of convolutions and allowing fluid under pressure inside said axially inner chamber to flow out of said axially inner chamber, said check valve including a biasing spring being so light to cause opening of said check valve when the pressure inside said axially inner chamber exceeds but slightly atmospheric pressure.

References Cited

UNITED STATES PATENTS

2,702,023	2/1955	Seeloff	92—98 X
2,851,957	9/1958	Ragland	103—150
3,192,865	7/1965	Klempay	103—152
3,208,394	9/1965	Taplin	103—150

FOREIGN PATENTS

292,203	6/1928	Great Britain.
949,213	9/1956	Germany.

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