

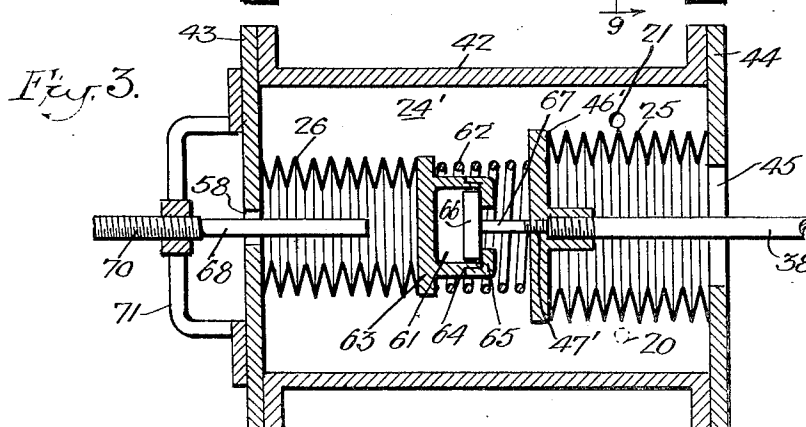
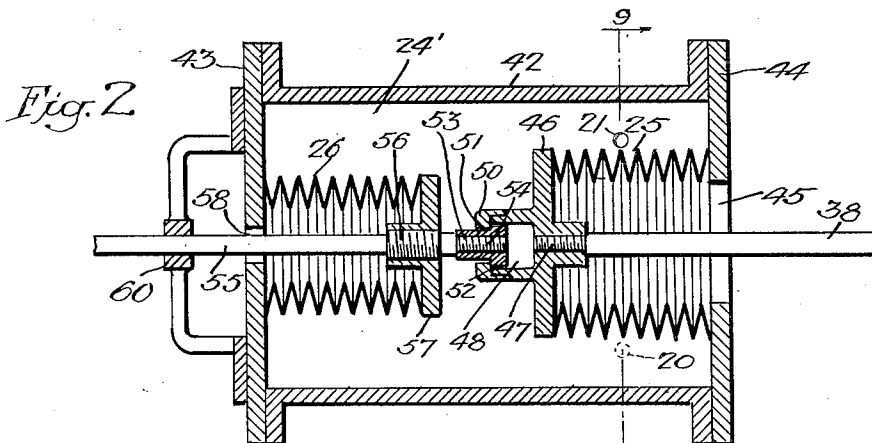
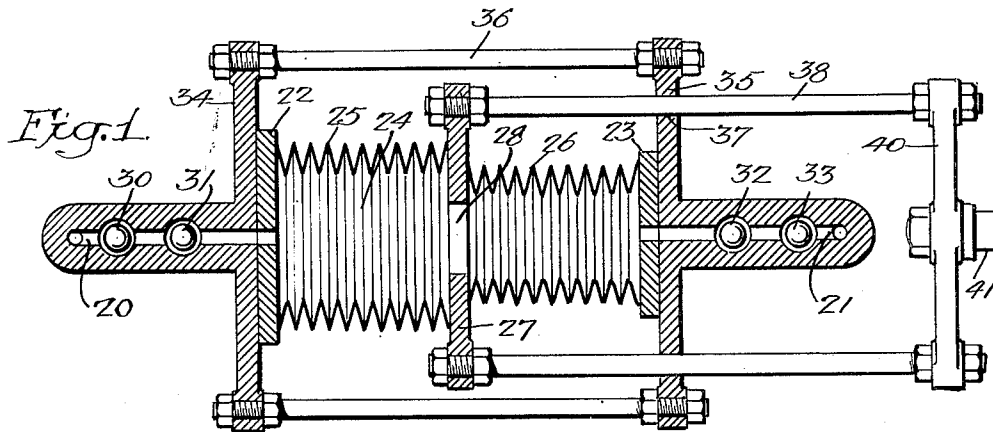
Oct. 14, 1952

R. B. SAALFRANK
DIFFERENTIAL BELLOWS PUMP

2,613,610

Filed Feb. 4, 1949

5 Sheets-Sheet 1



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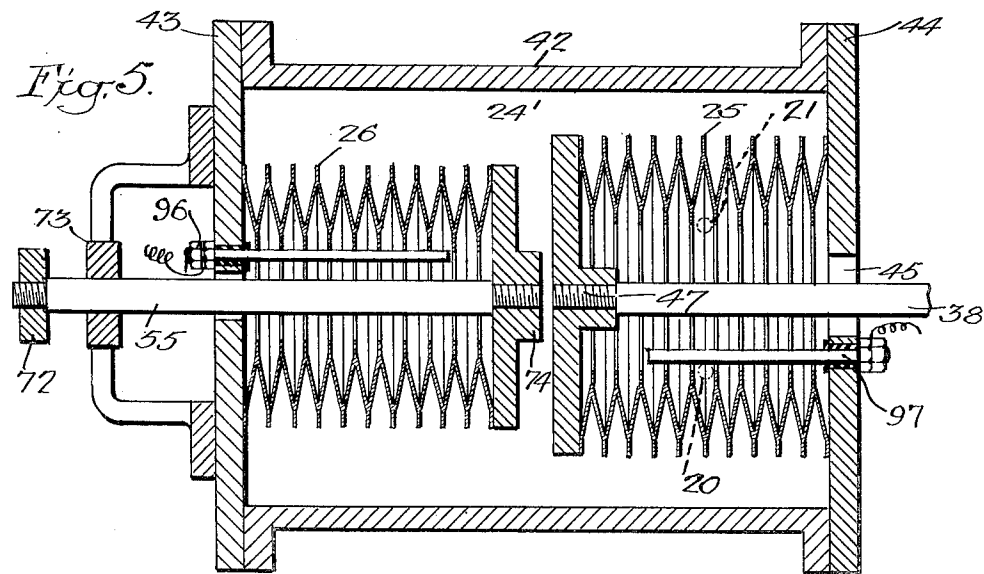
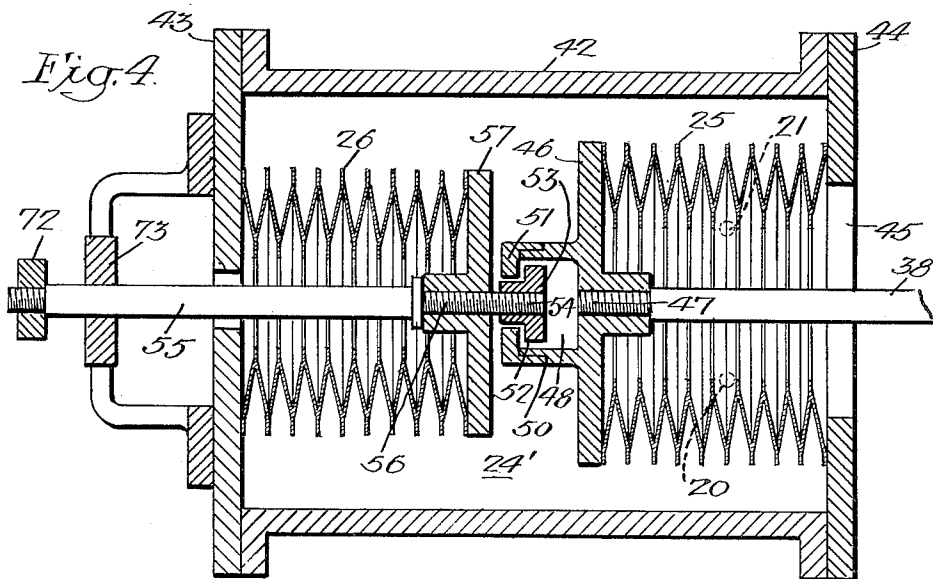
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2,613,610

DIFFERENTIAL BELLOWS PUMP

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5 Sheets-Sheet 2



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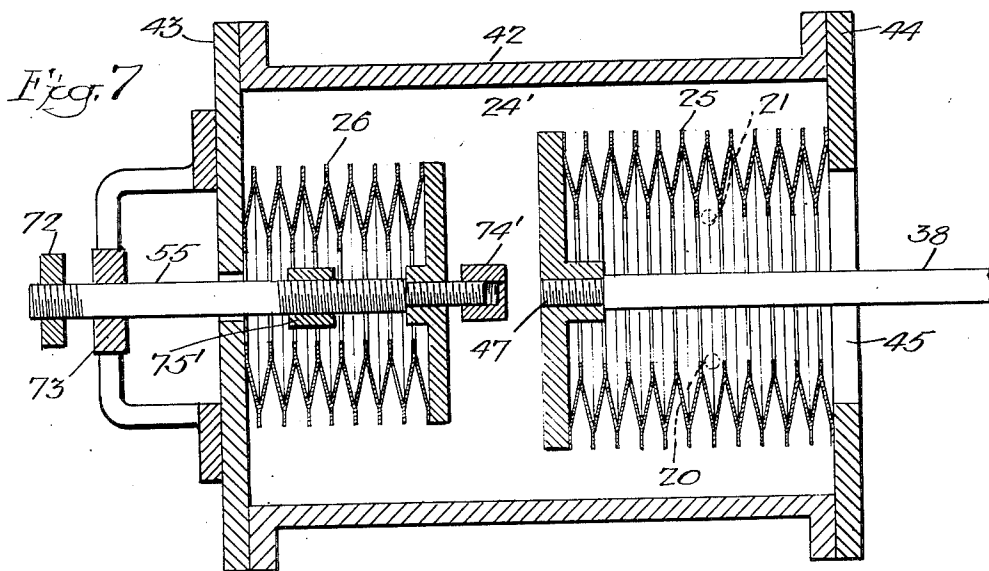
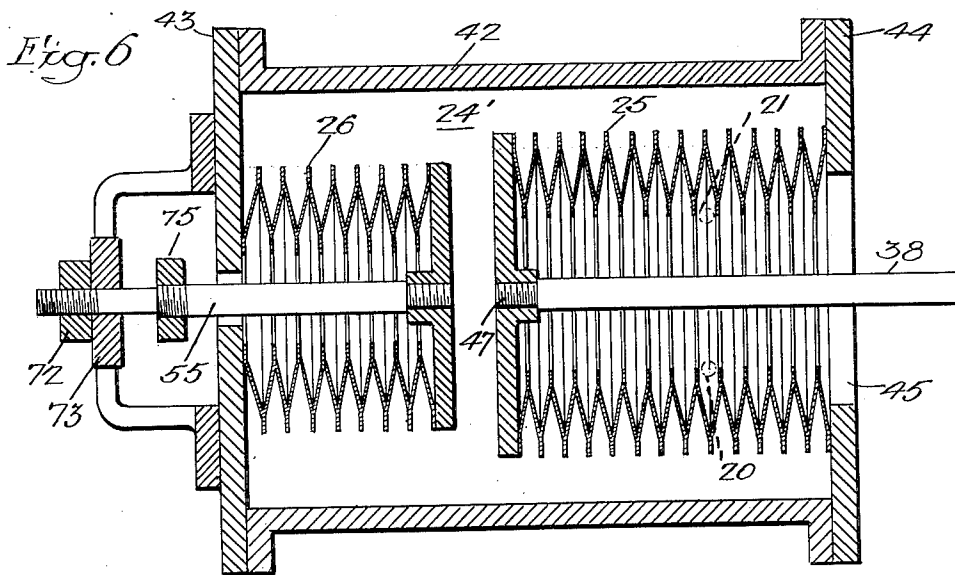
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DIFFERENTIAL BELLOWS PUMP

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5 Sheets-Sheet 3



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2,613,610

DIFFERENTIAL BELLOWS PUMP

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Fig. 8.

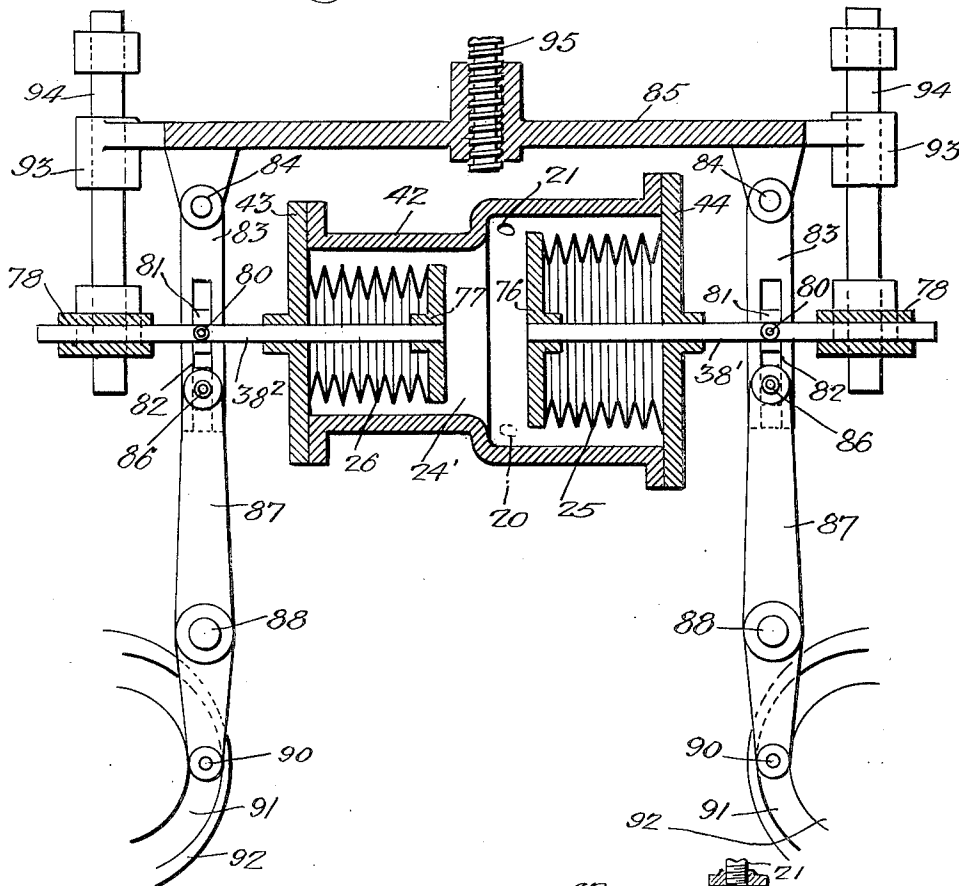
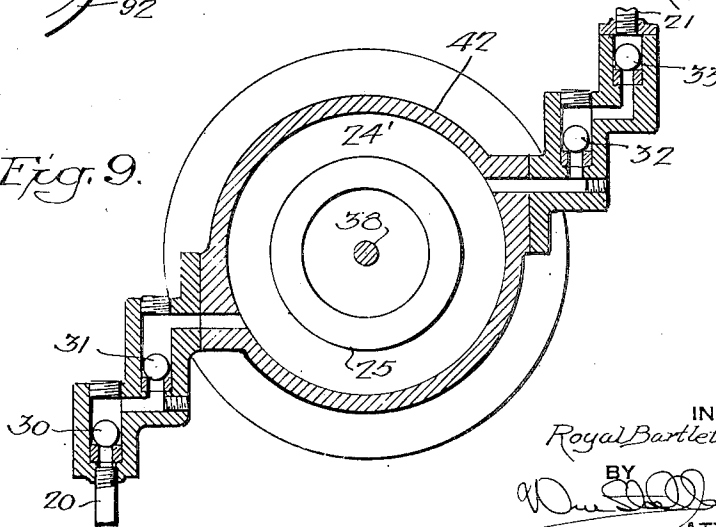


Fig. 9.



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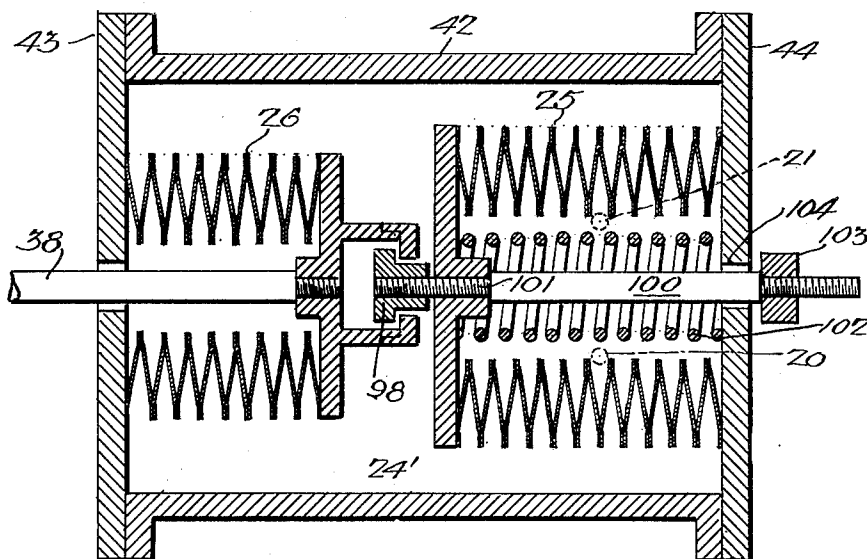
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DIFFERENTIAL BELLOWS PUMP

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5 Sheets-Sheet 5

Fig. 10.



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UNITED STATES PATENT OFFICE

2,613,610

DIFFERENTIAL BELLOWS PUMP

Royal Bartlett Saalfrank, Gulfport, Fla., assignor
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Application February 4, 1949, Serial No. 74,676

16 Claims. (Cl. 103—148)

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The present invention relates to bellows fluid pumps.

A purpose of the invention is to provide accurate metering of fluid by a pump particularly when operating at very small discharge rates or under intermittent conditions.

A further purpose is to permit adaptation of a metering pump discharge to a complicated curve of varying flow with a minimum of mechanism.

A further purpose is to simplify the construction of metering pumps and avoid the necessity of employing packings.

A further purpose is to reduce the variation in pumping by metering pumps due to wear of moving parts.

A further purpose is to eliminate the error due to resilience of the drive and to minimize the effect of expansion and contraction in the drive parts.

A further purpose is to permit the discharge of a pump to vary markedly according to a predetermined plan during the discharge cycle of the pump, for example discharging first at a high rate for a predetermined interval and then at a much lower rate.

A further purpose is to permit wholly independent motion of individual pumping elements in a pumping cylinder.

A further purpose is to employ as a pump chamber the internal space inside connected differential bellows of different displacement characteristics.

A further purpose is to employ lost motion between differential bellows, desirably providing lost motion which backs up on compression or on expansion of one bellows, or on compression and expansion as required, and suitably with adjustment of the lost motion.

A further purpose is to adjustably limit the expansion, contraction or both expansion and contraction of one differential bellows without similarly limiting the other.

A further purpose is to provide heating on the walls of the differential bellows opposite to the other pump chamber.

A further purpose is to provide a suction and a discharge cycle on each stroke of a reciprocating operator of a differential bellows pump.

Further purposes appear in the specification and in the claims.

In the drawings I have chosen to illustrate a few only of the numerous embodiments in which my invention may appear, choosing the forms shown from the standpoints of convenience in illustration, satisfactory operation and clear demonstration of the principles involved.

Figures 1 to 8 inclusive are diagrammatic axial sections of pump chambers conforming to the present invention, each of the views showing a different variation.

Figure 1 is a horizontal axial sectional top plan and Figures 2 to 8 are vertical axial sections.

Figure 9 is a transverse section of Figure 2 on the line 9—9, showing the check valve arrangement, and illustrating likewise the check valve arrangement in Figures 3 to 8 inclusive.

Figure 10 is a vertical axial section of a further variation.

Describing in illustration but not in limitation and referring to the drawings:

In the industrial field there has been increased need recently for metering pumps which will measure fluids very precisely, and in some cases will dispense the same according to some complex predetermined schedule, often in very small quantities. In some instances due to the dangerous character of the materials employed, the pumps must operate at remote locations which are not subject to examination by personnel.

Typical illustrations are in the feeding of chemicals for the purpose of producing reactions, the introduction of treating ingredients or additives in industrial processes, and the application of components in food processing. The fluids pumped may be common industrial liquids, special chemical solutions or liquids, or food liquids such as oils, liquefied fats, or the like.

Conventional piston pumps, while lending themselves to metering, are not readily applied to very small discharges, and are subject to errors through the effects of leakage of packings and wear of frictionally engaging parts. Many of such prior art pumps have also been subject to error due to resilience of the driving parts, which lead to variations in stroke of a character which would be minor in many applications but are seriously objectionable when very accurate metering is required.

In accordance with the present invention, the pump is based upon the action of oppositely moving differential bellows, which have respectively different displacement characteristics per unit of expansion or contraction. Broader aspects of the differential bellows subject matter are included in my application Serial No. 53,953, filed October 11, 1948, for Bellows Pump, which matured into Patent No. 2,578,265 on December 11, 1951.

In some cases it is very desirable to produce an accurate metering pump without the expense of fabricating a pump cylinder of the normal type. It has been found that for many purposes a very satisfactory pump can be produced by intercon-

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necting the internal spaces of a pair of differential bellows, which together form a single pump chamber.

Figure 1 illustrates, suitably in axial top plan, a differential bellows pump having an inlet passage 20 and an outlet passage 21 suitably at opposite ends of the pump, and extending through end plates 22 and 23 to the interior pump chamber 24 inside aligned differential bellows 25 and 26. At the adjoining ends the two bellows are secured together in coaxial alignment as by welding to a connection 27 having an internal passage 28 which permits free flow between the respective parts of the pump chamber 24. The respective bellows in this and in each of the various other forms shown in the present application have different displacement characteristics, that is, their displacement (internally in this form and externally in other forms) for a given unit of contraction or expansion (for example an inch) is different in the case of the two bellows, preferably by virtue of difference in diameter. The bellows will suitably be metallic bellows of beryllium copper, bronze, stainless steel or the like, preferably welded together at each corrugation. Depending on whether the discharge per cycle of the pump is to be small or large, the difference in displacement characteristics of the bellows per unit of contraction or expansion may be very slight or correspondingly larger.

In the inlet and outlet passages are arranged check valves of the character shown in Milton Roy Sheen U. S. Patents Nos. 2,263,429 and 2,367,893. These may conveniently be any suitable type of check valves, here shown as ball check valves 30 and 31 in series in the inlet passage and 32 and 33 in series in the outlet passage. Similar valves are used in the other forms, as shown in Figure 9, and the valves in Figure 1 are arranged in steps as shown in Figure 9.

The end plates 22 and 23 as well as the inlet and outlet passages are supported by end frame members 34 and 35 interconnected by tie rods 36. The end frame member 35 has guide openings 37 for a reciprocating operator 38 which is suitably attached to the connection 27 and includes a head 40 and an operating rod 41.

In operation of the form of Figure 1 it will be seen that the entire pump chamber is provided inside the differential bellows, which are axially aligned and connected together at their adjoining ends, and reciprocated back and forth by the operator 38. On each direction of reciprocation one bellows is expanded as the other bellows is compressed, the discharge stroke occurring when the bellows having the greater displacement characteristics per unit of reciprocation is contracting and the suction stroke occurring when it is expanding. It will be evident that the form of Figure 1 requires very few high tolerance parts associated with the pump chamber, so that the manufacture is greatly simplified with respect to that of piston pumps.

Figures 2 to 8 inclusive show forms in which the pump cylinder 24', instead of being internal with respect to the bellows, is external of the bellows in the space between the bellows and a housing of the chamber.

In all of these forms there is a housing 42 surrounding the bellows, which are preferably axially aligned therein. The housing has end plates 43 and 44 secured thereto, and the housing in each case has inlet and outlet passages 20 and 21 as shown in Figure 9.

In Figure 2 the operator 38 reciprocates back

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and forth as in Figure 1, but in this case it is a single rod extending through an opening 45 in the end plate 44. The bellows 25 having the higher displacement rate per unit of reciprocation is connected to the operator 38, as by securing a rigid metallic head 46 on the bellows 25, for example by welding. The operator 38 suitably threads into the head 46 at 47, and is conveniently made adjustable by turning the operator to change its position at the thread 47. The bellows 26 having lower displacement per unit of motion has freedom with respect to the bellows 25, due to the provision of a lost motion connection 48 between the two bellows, consisting of a cylinder 50 extending axially beyond the end wall 46 and having an annular internal end flange 51 which engages an external stop flange 52 on a lost motion nut 53 threaded at 54 on to a lost motion connection rod 55 which is threaded at 56 into the rigid forward head 57 of the bellows 26. The head 57 is suitably joined to the bellows 26 by welding. The connection rod 55 is desirably carried out through an opening 58 in the end plate 43 and guided at 59, so that it is accessible beyond the pump for rotation to screw the connection rod in or out of the thread 56 to adjust the point of pick-up of the lost motion both from the standpoint of contraction and expansion of the bellows 26.

In operation it will be understood that during the earlier part of the stroke the bellows 25 will move positively under the action of the operator, while the bellows 26 will be free at this point and will only move to the extent that pressure or suction transmitted through the fluid causes such motion or spring action of the bellows makes it move (as in retraction). As soon, however, as the lost motion picks up, the bellows having the smaller displacement per unit reciprocation will move positively for the rest of the stroke in either direction. The position of positive pick-up in both compression and expansion of the bellows 26 is adjusted by rotating the rod 55.

In the form of Figure 2 the bellows having smaller displacement per unit of reciprocation responds to the motion of the bellows having the greater displacement per unit of reciprocation prior to the take-up of the lost motion only by virtue of the action of the fluid tending to overcome or to cooperate with the spring of the bellows, since the bellows in itself has spring properties. In the form of Figure 3, however, in addition to the provision of a lost motion connection 61 between the two bellows, a compression spring 62 is interposed, so that during the period of the lost motion the bellows having the smaller displacement per unit of reciprocation will respond to the motion of the bellows having the greater displacement per unit of reciprocation under the action of the spring and also under the action of the fluid but not positively, whereas as soon as the lost motion is taken up there will be positive response for the remainder of the particular stroke. In this form a rigid head 63 on the bellows 26 (suitably welded thereto) carries a lost motion cylinder 64 having an internal end flange 65. In the lost motion cylinder a disc 66 moves back and forth. The disc is supported on an extension 67 of the operator 38. The operator is adjustably threaded at 47' in the head 46' of bellows 25 so that by rotating the operator the lost motion can be adjusted as to the position at which it loses effect.

A rigid stop 68 is threaded at 70 in a support 71 on the head 43 and limits the contraction of

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the bellows 26. The stop will normally be set at a point near the end of the stroke where it can serve to eliminate the effect of elasticity in the operator by assuring a definite stopping point. While the difference accomplished by the stop might be of the order of 0.001 of an inch in some cases, this difference is very significant in some instances.

In the form of Figure 4 there is an adjustment provided on the expansion of the bellows 26 which tends to have the effect of removing elasticity in the suction stroke. Otherwise this form is similar to that of Figure 2. The stop is provided by an adjustable stop nut 72 on the adjustment rod 55 which engages an abutment 73 on the expansion stroke of the bellows 26 having the smaller displacement per unit of reciprocation. The lost motion in the form of Figure 4 operates like that of Figure 2.

In some instances it is desirable to avoid entirely a lost motion connection, and to permit one bellows to be free entirely except that it is contracted by the other bellows on the forward stroke and follows the other bellows in the early stages of the suction stroke. This is shown in Figure 5 where the bellows 26 has no lost motion connection, but is contacted by and therefore contracted by the bellows 25 after a certain amount of motion on the forward stroke of bellows 25. In this case the rigid head of the bellows 26 has a boss 74 at the center which will be engaged by the bellows 25 in its forward stroke. The expansion of the bellows 25 under its own spring action and under the action of the fluid is limited by a stop similar to that shown in Figure 4.

In some instances, especially where a free bellows is used, it is desirable to limit its motion by adjustable stops on both directions. This is shown in Figure 6 where the stop rod 55 carries an additional adjustable stop 75 which limits the contraction of the bellows 26. This will be useful to eliminate the effect of elasticity or backlash in the operator 38, and the stop on contraction of the bellows 26 will normally be set at a position differing by perhaps only a fraction of 0.001 of an inch from the position to which this bellows would be pushed on the forward stroke of bellows 25 except for the stop.

In some cases it is desirable to be able to adjust the position at which the floating bellows 26 is picked up and compressed by the driven bellows 25. As shown in Figure 7, this is accomplished by an adjustment 74' which in effect is the equivalent of an adjustable stop. In this case the stop 75' applied to limit contraction has been moved to a position within the bellows 26 merely to illustrate that this location is regarded as optional.

In some cases it is desirable that both bellows be driven independently, either on 180° displaced or other different cycles, so that there can be adjustment of position at any time in the cycle independently in the case of the respective bellows. In Figure 8 the bellows 25 and 26 each has an operator 38' or 38² which reciprocates its rigid head 76 or 77 back and forth. The operators are guided in guides 78. Each operator is reciprocated by a pivot pin 80 on a sliding block 81 which is carried in a guideway 82 of a rocker 83 pivotally secured at 84 on an adjustment support 85. At the opposite end of each rocker from the block 81 it makes sliding pivotal connection at 86 with a cam lever 87 having fixed pivot at 88 and having at its opposite end a cam

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follower 90 which follows a cam track 91 of a suitable face cam 92 on a shaft not shown. It will be evident that the tracks on the face cams can be different and can permit either large or slight deviations between the courses followed by the two bellows. Thus at one part of the cycle when bellows 25 is advancing bellows 26 can contract at the same rate or a greater or less rate, and at another time in the cycle when bellows 25 is contracting bellows 26 can advance at the same rate or a greater or less rate or can even momentarily contract if that be desired in the particular cycle.

For adjustment purposes the adjustment support has sliding guides 93 which follow stationary guideways 94. The adjustment support is moved toward and away from the axes of the coaxial bellows as by an adjustment screw 95. The adjustment in effect changes the throw of the rockers and thus permits variation of the stroke of both bellows in unison. Other adjustments may be made by changing the cams.

In some cases it is desirable to apply heat to the bellows on the side opposite from that in contact with the pumping fluid. In Figure 5 this is suggested by showing electric heaters 96 and 97 in the interiors of the bellows. Any other suitable heating or cooling means or medium may be used.

Figure 10 illustrates a pump in which there is a suction and discharge stroke on each stroke of the operator. In this form the operator 38 is operatively connected to the moving end of the smaller bellows 26. A lost motion connection 98 is interposed between the small bellows 26 and the large bellows 25, which are opposed and coaxial, and the lost motion is made adjustable by an adjustment rod 100 threaded at 101 into the movable end of the large bellows. A compression spring 102, stiff enough to overcome any effect of the fluid, acts against the movable end of the large bellows from the head of the pump chamber, urging the large bellows toward maximum extension. Extension of the large bellows is limited by an adjustment nut 103 acting against a stop 104.

In operation of this form, assuming the mechanism is in its limiting position to the left of Figure 10, motion of the operator 38 toward the right will cause the small bellows 26 to extend, while the large bellows 25 will remain stationary since the lost motion has not been taken up. This will result in a discharge by the pump chamber. As soon as the lost motion has been taken up, the large bellows will contract, moving with the operator 38, and since its displacement per unit of motion is greater than that of the small bellows, suction will occur. Thus there will be both discharge and suction on the stroke of the operator 38 reciprocating toward the right.

On the motion of the operator 38 in reciprocation toward the left, the compression spring 102 will first cause the large and small bellows to move together, in extension of the large bellows and contraction of the small bellows, resulting first in discharge by the pump. As soon as the large bellows reaches the limit of its motion toward the left due to the action of the nut 103 impinging against the stop 104, forward motion of the large bellows will cease and further contraction to the left of the small bellows will occur due to the lost motion connection 98, resulting in suction by the pump. In this case the small bellows is not intended to move toward the left beyond the range permitted by the lost motion once the nut 103 has engaged the stop 104.

It will be evident that by the invention it is possible to make adjustments which will overcome to a large extent the effects of elasticity in the drive or back-lash in the drive.

It will also be understood that advantage can be taken of the action of the bellows themselves as springs due to the spring metal of which they are made by permitting one bellows to be free and to respond to its internal spring action and to the action of the fluid.

It will further be evident that lost motion may be provided, in accordance with which a certain portion of either or both strokes of one of the bellows can be positive, while the remainder of the stroke can be free, with suitable adjustment. It will be evident also that the response between one bellows and another can be controlled by an independent spring acting between the two bellows.

In the case of a free bellows or of a bellows which is partially free and partially controlled by lost motion connections, there can be adequate limitation by adjustable stops on compression or expansion or both.

It will also be evident that the individual bellows can be independently driven.

Advantage can also be taken of the possibility of using the interior of the differential bellows for the pump chamber.

In operation of any of the forms, it will be understood that it will be preferable to employ the simplest form which will give consistently the type of pump discharge which is desired. The stops will be adjusted to permit the required limitations on the action of the bellows, after which the pump can be operated in the conventional manner of a bellows pump.

In view of my invention and disclosure, variations and modifications to meet individual whim or particular need will doubtless become evident to others skilled in the art, to obtain all or part of the benefits of my invention without copying the structure shown, and I, therefore, claim all such insofar as they fall within the reasonable spirit and scope of my claims.

Having thus described my invention what I claim as new and desire to secure by Letters Patent is:

1. In a pump, walls forming a pump chamber including in the walls of the pump chamber two bellows having different displacement characteristics per unit of motion, an operator for reciprocating one of the bellows back and forth, and the other bellows being at least in part free from the one bellows, whereby the motion to the other bellows is imparted by fluid in the pump during at least a part of the stroke.

2. In a pump, walls forming a pump chamber including a pair of bellows having different displacement characteristics per unit of motion, inlet and outlet connections to the pump chamber, check valves in the connections, an operator for reciprocating one of the bellows back and forth, the other bellows being free from the one bellows during at least a portion of the stroke, and a stop limiting the expansion of the other bellows.

including a pair of bellows having different displacement characteristics per unit of motion, inlet and outlet connections to the pump chamber,

3. In a pump, walls forming a pump chamber check valves in the connections, an operator for reciprocating one of the bellows back and forth, the other bellows being free from the one bellows

during at least a portion of the stroke, and a stop limiting the contraction of the other bellows.

4. In a pump, walls forming a pump chamber including a pair of bellows having different displacement characteristics per unit of reciprocation, inlet and outlet connections to the pump chamber, check valves in the connections, an operator for reciprocating one of the bellows back and forth, the other bellows being free from the one bellows during at least a portion of the stroke, and a stop limiting the expansion and contraction of the other bellows.

5. In a pump, walls forming a pump chamber including a pair of bellows having different displacement characteristics per unit of motion, walls forming inlet and outlet passages to the chamber, check valves in the passages, an operator for reciprocating one of the bellows and lost motion contacting surfaces between the one bellows and the other bellows which abut in pushing and which interconnect after relative separation of the bellows in pulling when the lost motion is taken up.

6. In a pump, walls forming a pump chamber including a pair of bellows having different displacement characteristics per unit of motion, walls forming inlet and outlet passages to the chamber, check valves in the passages, an operator for reciprocating one of the bellows and lost motion contacting surfaces between the one bellows and the other bellows which abut in pushing and which interconnect after relative separation of the bellows in pulling when the lost motion is taken up.

7. In a pump, walls forming a pump chamber including a pair of bellows having different displacement characteristics per unit of motion, walls forming inlet and outlet passages to the chamber, check valves in the passages, an operator for reciprocating one of the bellows and lost motion contact surfaces between the one bellows and the other bellows which abut in pushing and which interconnect after relative separation of the bellows in pulling when the lost motion is taken up.

8. In a pump, walls forming a pump chamber including a pair of bellows in line with one another and having different displacement characteristics per unit of reciprocation, walls forming inlet and outlet passages to the pump chamber, check valves in the passages, an operator for reciprocating one of the bellows back and forth, lost motion contacting surfaces between the one bellows and the other bellows which abut in pushing and which interconnect after relative separation of the bellows in pulling when the lost motion is taken up, and adjustment for the lost motion contacting surfaces which varies the amount of lost motion.

9. In a pump, walls forming a pump chamber including a pair of bellows in line with one another and having different displacement characteristics per unit of motion, walls forming inlet and outlet passages to the pump chamber, check valves in the passages, an operator for reciprocating one of the bellows back and forth, a lost motion connection between the bellows and a string interposed between the respective bellows.

10. In a pump, walls forming a pump chamber including a pair of bellows in line with one another and having different displacement characteristics per unit of motion, walls forming inlet and outlet passages to the pump chamber, check valves in the passages, an operator for reciprocating one of the bellows back and forth, a lost

motion connection between the bellows, a spring interposed between the respective connections and an adjustment for the lost motion connection.

11. In a pump, walls forming a pump chamber including a pair of bellows having different displacement characteristics per unit of reciprocation, walls forming inlet and outlet passages to and from the pump chamber, check valves in the connection, an operator for reciprocating one of the bellows back and forth, lost motion contacting surfaces between the one bellows and the other bellows which abut in pushing and which interconnect after relative separation of the bellows in pulling when the lost motion is taken up and an adjustable stop for limiting the compression of the other bellows.

12. In a pump, walls forming a pump chamber including a pair of bellows having different displacement characteristics per unit of reciprocation, walls forming inlet and outlet passages to and from the pump chamber, check valves in the connection, an operator for reciprocating one of the bellows back and forth, lost motion contacting surfaces between the one bellows and the other bellows which abut in pushing and which interconnect after relative separation of the bellows in pulling when the lost motion is taken up and a stop for limiting the expansion of the other bellows.

13. In a pump, walls forming a pump chamber including a plurality of bellows having different displacement characteristics per unit of reciprocation, means for reciprocating the bellows, means for applying heat to the opposite side of the bellows from the pump chamber, walls forming inlet and outlet passages to the chamber and check valves in the passages.

14. In a pump, walls forming a pump chamber including a pair of bellows having different displacement characteristics per unit of reciprocation, there being lost motion between the respective bellows and operative connection in a particular position and an operator for reciprocating that bellows having the smaller displacement characteristic per unit of reciprocation, whereby there is a suction and a discharge on each stroke of the operator.

15. In a pump, walls forming a pump chamber including a pair of bellows having different displacement characteristics per unit of reciprocation, a lost motion operative connection between the bellows, and an operator for reciprocating the smaller bellows, whereby there are both a suction and discharge on each stroke of the operator.

16. In a pump, walls forming a pump chamber including opposed aligned bellows having different displacement characteristics per unit of reciprocation, an operative lost motion connection between the bellows, a spring urging the bellows having the larger displacement characteristics toward extension and an operator for reciprocating the smaller bellows.

ROYAL BARTLETT SAALFRANK.

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