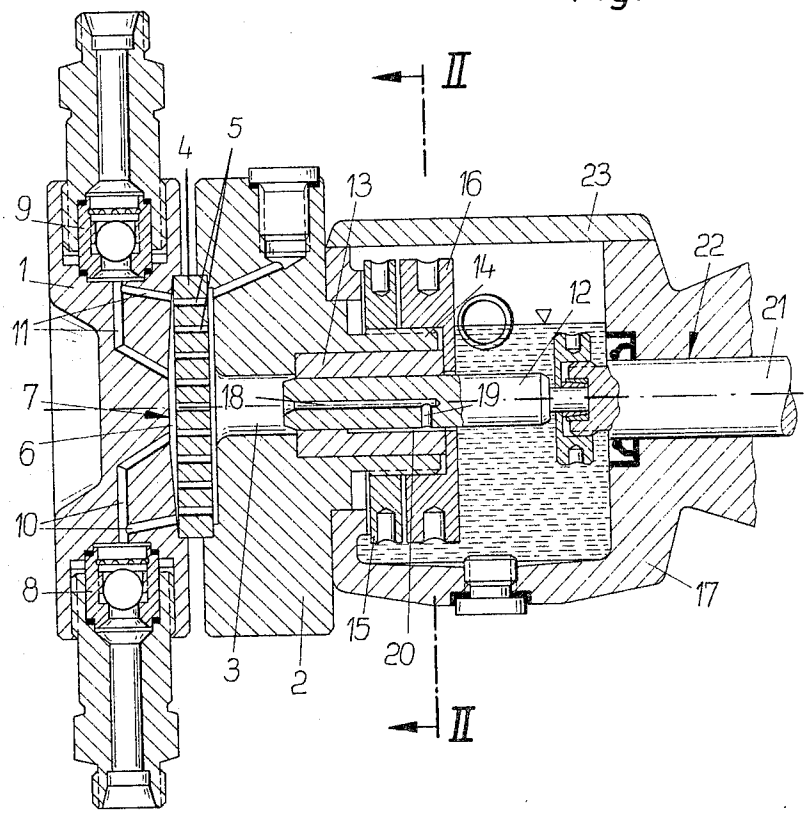
Oct. 11, 1966 H. BURGERT 3,277,829

DIAPHRAGM PUMPS

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Fig. 1



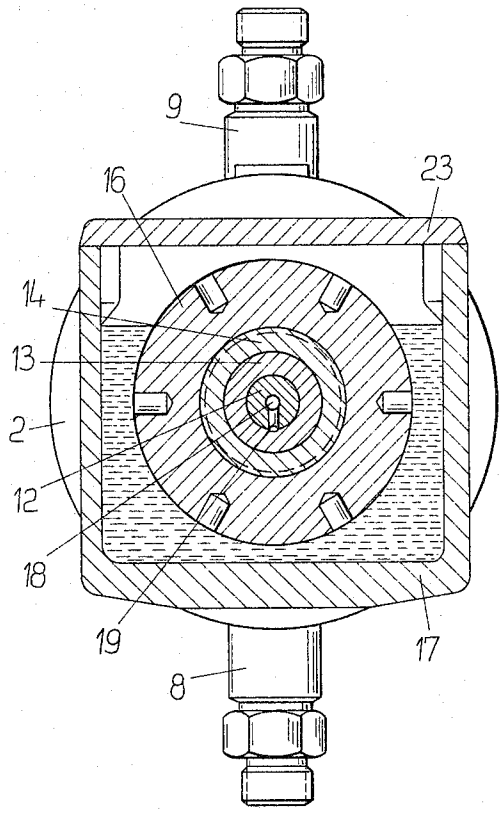
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Fig. 2



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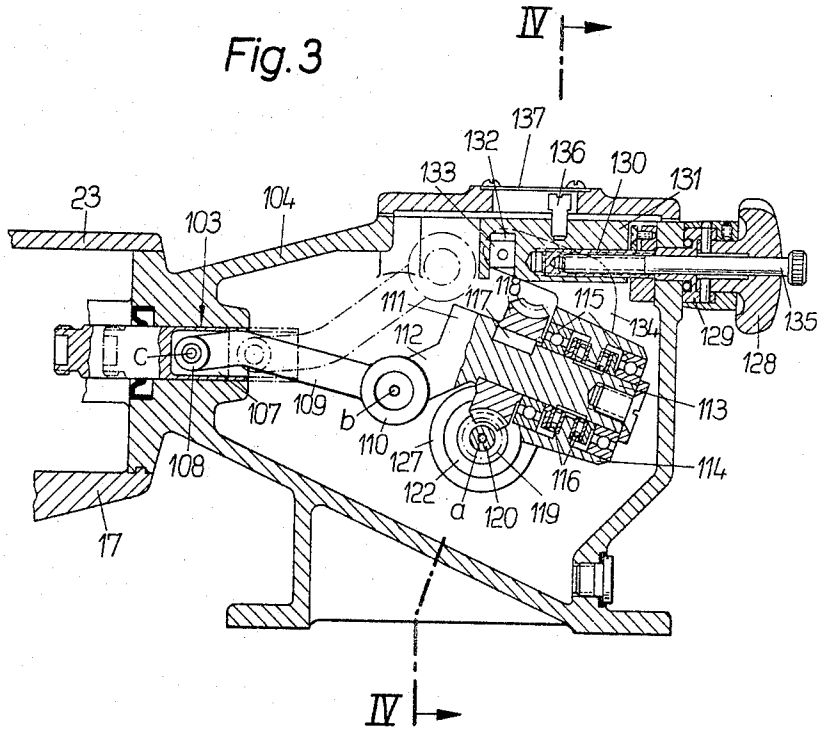
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Fig. 3



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Fig. 4

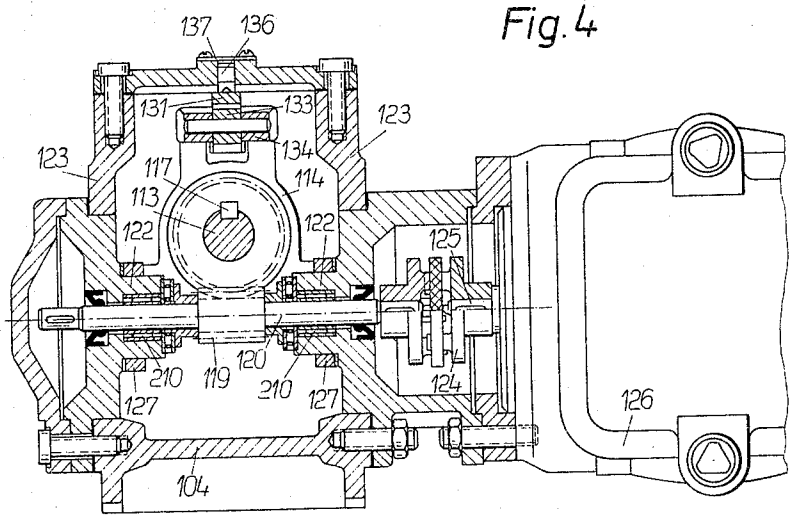
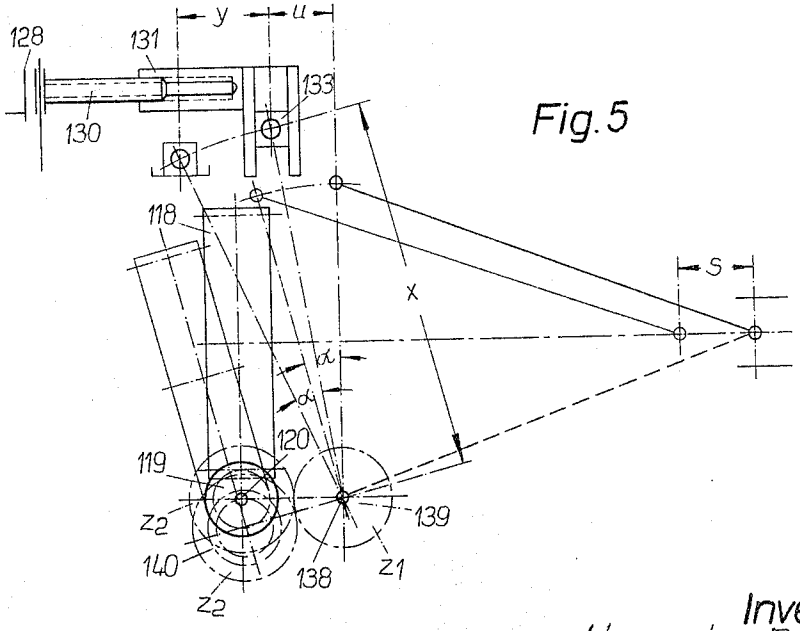


Fig. 5



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DIAPHRAGM PUMPS

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Claims priority, application Germany, Dec. 4, 1962, O 9,109
4 Claims. (Cl. 103—38)

This application is a continuation-in-part of application Serial No. 327,288, filed December 2, 1963, now abandoned.

This invention relates to diaphragm pumps of the kind in which the diaphragm is actuated by a piston with adjustable stroke, acting thereon through the medium of a pressure transmitting fluid, hereinafter referred to as operating fluid, contained in an operating chamber. In order to maintain always the same volume of fluid flow through the pump, for a given length of pump stroke, the quantity of operating fluid is kept constant by replacing from a storage chamber, at an appropriate time during the pumping cycle the operating fluid which is lost due to leakage past the piston.

The use of return valves allowing the fluid to flow back into the operating chamber is known, and this expedient is employed in pumps in which a given vacuum in the pump chamber is exceeded. As an alternative to using return valves it is known to provide a passage in the piston in diaphragm pumps in which the stroke is adjustable, the said bore connecting the operating chamber to the oil filled storage chamber only when the piston is at the end of the suction stroke, thereby allowing some of the oil in the storage chamber to enter the operating chamber. For this purpose the piston has an axial bore and a radial bore in communication therewith, the radial bore being in such a position as to emerge from the cylinder at the end of the suction stroke thereby forming a connection through the axial bore between the operating chamber and the reservoir containing operating fluid. This known arrangement entails a loss of stroke corresponding at least to the diameter of the radial bore, and consequently the suction stroke ends earlier and the pressure stroke begins later. Since the radial bore must not be less than a minimum size, the loss of stroke may amount to a considerable percentage of the total stroke, particularly if the stroke is to be reduced almost to zero. In this case the loss in stroke is greater than the actual stroke of the pump, which makes it difficult to attain accurate adjustment of the flow.

The object of the present invention is to provide a diaphragm pump in which the aforesaid disadvantages are minimized or avoided.

According to the invention, a diaphragm pump comprises a pump body, an operating chamber in said body, a diaphragm disposed across and movable in said chamber, a fluid inlet and a fluid outlet in said body both communicating with said chamber on one side of said diaphragm, a non-return valve in each said inlet and outlet, an operating fluid storage chamber in said body, a cylinder connecting said storage chamber to said operating chamber on the side of said diaphragm remote from said inlet and outlet, a piston rotatably and slidably disposed in said cylinder with a portion extending through the storage chamber to the exterior of said body, a slot extending axially in the wall of said cylinder from said storage chamber towards said operating chamber, and a passage in said piston extending therein from said operating chamber and opening into the cylindrical surface of said piston within the length of said slot to engage therewith once in each complete rotation of said piston, such that when said chambers and passage are filled with operating fluid, axial reciprocation of said piston will cause movement of said diaphragm to draw in and eject from said operating

chamber the fluid being delivered by the pump and rotation of said piston will cause said passage to communicate with said slot once in each piston rotation when the piston is furthest from the diaphragm to permit operating fluid to flow from the storage chamber to the operating chamber.

The loss in stroke in the case of a pump in accordance with the invention is considerably less than that occasioned in conventional pumps. Connection of the passage in the piston to the axial slot in the cylinder is established only during a small angle of rotation of the piston, which angle, for a given diameter of bore decreases with increasing diameter of the piston. However, the piston performs only a further very small axial movement during the aforesaid angle of rotation in order to reach the end of its stroke, this axial movement being only a fraction of the diameter of the radial bore.

Conventional pumps have the further disadvantage that it is necessary to adjust the pump stroke from the end of the suction stroke which means that the volume of operating fluid, apart from the said leakage loss remains constant in the operating chamber, i.e., is independent of the length of stroke at any time. The operating fluids in question are all now compressible so that, when the pump operates at high pressure, a considerable part of the stroke must always be expended for compression of the operating fluid. For this reason the volume of the operating fluid must be kept low and yet sufficient to give the maximum stroke of the piston so that when the strokes are small, the stroke required for compressing the fluid approaches the length of the total stroke. This makes it difficult to regulate the pump flow when the latter approaches zero. With the diaphragm pump of the invention this disadvantage may be very easily avoided by making the length of the slot in the wall of the cylinder correspond to the maximum length of pump stroke required. When a diaphragm pump is designed in this manner it is possible to maintain the same position of the piston at the maximum pressure stroke for all lengths of pump stroke, whilst verying the position of the piston at the maximum suction stroke according to the size of stroke of the piston required. In this way a lower starting volume of operating fluid is maintained with small strokes of the pump than with large strokes, that is to say, the proportion of stroke required to compress the fluid in the pump chamber remains constant independent of the size of the pump stroke.

In order that the invention may be more clearly understood, an embodiment thereof will now be described by way of example with reference to the drawings in which:

FIG. 1 shows a longitudinal section through one form of diaphragm pump,

FIG. 2 is a cross-section along the line 2—2 of FIG. 1, looking in the direction of the arrows,

FIG. 3 is a longitudinal section through the housing of a dispensing pump showing a reciprocating piston which is also rotatable and adjustable,

FIG. 4 is a section taken on line 4—4 of FIG. 3 in the direction of the arrows, and

FIG. 5 shows diagrammatic view of a modified embodiment of the drive.

Referring to the drawings, the diaphragm head marked 1 in FIG. 1 is attached by screws (not shown) to a disk shaped housing 2, the bore 3 of which forms the operating chamber, and is filled with operating fluid. Between the head 1 and the housing 2 is a disk 4, having a large number of fine bores 5. This disk serves as a supporting disk on the suction stroke, for the diaphragm marked 6, which, during the maximum pressure stroke can lie against a bow-shaped wall 7 of the pump head 1. The suction valve 8 and the pressure valve 9 are seated in the head 1, and are connected by pipes 10 and 11 respec-

tively to the operating chamber. The piston **12** is slidably disposed in a cylinder **13** inserted in the housing **2**, the free end of which housing is formed as a threaded appendage **14**. On the threaded appendage are two annular nuts **15** and **16**, the first of which serves to secure a casing **17** to the housing, the second to fix the cylinder **13** in the housing. The threaded appendage **14** may be compressed by the nut **16** to eliminate play between the piston and the cylinder **13**.

The piston **12** has a longitudinal passage **18** and a radial bore **19** which communicates, when in a predetermined peripheral position, with a longitudinal slot **20** in the cylinder **13**. A piston rod **21** serves to drive the piston **12** imparting thereto both reciprocal and rotary motions for each working cycle of the piston. A drive of a simultaneous rotation and an oscillating movement is shown in FIGS. 3 to 5 and described herein. The casing **17** closed by means of a cover **23** and forming a fluid storage chamber is filled with the same fluid as the operating chamber **3**. The ambient atmospheric pressure prevails in the casing, so that a partial vacuum occurring in chamber **3** by leakage of fluid past the piston **12** is obviated by flow through channels **18**, **19** and **20** of operating fluid at the maximum suction position of the piston, i.e., as shown in the drawings, during each cycle.

The piston **12** always attains the same position at its maximum pressure stroke and the drawings show the position of the piston at the end of the suction stroke. When the pump is operating with a small suction stroke, the connection is made earlier between the operating and storage chambers. Thus, on changing from a large to a smaller suction stroke, operating fluid flows into the storage chamber and the reverse takes place when a transition is made from the smaller to a larger suction stroke.

In the following and with reference to FIGS. 3 to 5, there is described a drive in which the piston stroke is regulated and the piston may be adjusted during its oscillating movements. In FIGS. 3 to 5 the piston itself is not shown but only the piston rod to which the piston is connected.

The piston rod **101** has a cylindrical hollow **107** at its rear end, and also carries a pivot **108**. On this is fixed a connecting rod **109** so that it may swivel, and which rod **109** is coupled by means of a spherical joint **110** to rotary driving means **111**, that is to an arm **112** of the driving means. The driving means **111**, with its shaft **113**, is rotatably mounted in a cast metal part **114** in the form of a housing, by means of radial bearings **115** and the axial bearing **116**.

On the shaft **113** a worm wheel **118** is fastened by a key **117**. The worm wheel **118** meshes with a worm **119** on a second shaft **120**, which as shown in FIG. 4, is positioned by bearings **121** in the tubular bushings **122** extending from the side walls **123** of the gear box **104**. This second shaft acts as a driving shaft and is connected to a shaft **125** of an electric motor **126** through a coupling **124**.

The housing **114** has two bearing lugs **127** and is pivotably positioned with these engaging the bushings **122**, that is to say the housing **114** including the driving means **111** can be swivelled around the axis of the second drive shaft **120**.

For swivelling the housing **114** a handle **128** is provided, which is coupled to the head **129** of the worm gear spindle **130**. This spindle is located in a plate shaped nut **131** which has a cut-out section **132** near to its front end. This cut-out section passes through a slide block **133** fastened pivotably in the arms **134** of the housing **114**. Between these arms, the nut **131** is positioned in such a way that it cannot turn, that is, a rotation of the hand wheel **128** effects displacement of the nut **131** and consequently swivels the housing **114**. A retaining peg is indicated at **135**.

The threaded bore of bolt **130** is slotted, and it may be widened by the retaining peg to prevent undesirable displacement of the nut **131**. A peg or pin **136** serves as a measuring pin. A transparent scale is marked **137**.

The swivel lug or pivotal movement of housing **114** in clockwise direction is limited as soon as the axis of shaft **113** lies parallel to the axis of the piston rod **101**. This position corresponds to the maximum pivotal angle of housing **114**, that is the position of flow 0. The position of points *a*, *b* and *c*, that is to say the position of the axis of drive shaft **120** and the positions of the pivotal points of connecting rod **9** on arm **112** of the driving means **111** and on the piston rod **101** in relation to each other, are such that the total of the distances *a–b* and *b–c* within the angle of traverse of the plane of rotation of point *b*, is approximately equal to the distance between points *a* and *c*. In this way, the foremost position of point *c* remains approximately the same for each position of the plane of drive and therewith also the position occupied by the pump. The same result may be achieved if point *a* lies between points *b* and *c*. In this case the said points are to occupy such a position that the total of the distances from *a* to *b* and from *a* to *c* are approximately the same as the distance from *b* and *c*.

In the embodiment of FIGS. 3 and 4, a small alteration has been permitted to the space occupied. The embodiment of FIG. 5 shows that the space occupied may also be maintained fully the same. For this purpose a third shaft **138** is necessary. This serves as a fixed drive shaft and is coupled to motor **126**. The second shaft **120**, the axis of which, and likewise of shaft **138**, is represented in FIG. 5, is coupled to shaft **138** by gear wheels **139**, **140**. The shaft **120** is positioned in the pivotal housing **114** and the worm **119** is coupled to the worm wheel **118**.

In FIG. 5, point *b* coincides with the axis of shaft **138**, that is the plane of rotation of point *b* intersects the axis of shaft **138**. The distance of points *b* and *c* from each other for every angle of traverse of the plane of rotation remains constant, however, and with it also the foremost position of the piston rod **101**, that is the space taken up.

In apparatus according to FIGS. 3 to 5, the alteration of stroke is not exactly proportional to the angle of traverse of the plane of rotation of point *b*. It is possible, however, to obtain sufficient linear correlation between the rotation of hand wheel **128** and the stroke of the piston rod **101** by determining the point of application of nut **131** on housing **114** in such a manner that the deviation of the stroke from the linear movement is just compensated. For this it is necessary only to move the slide block **133** in the position of the stroke zero by the distance *u* in FIG. 5 in relation to the plane of rotation.

I claim:

1. A diaphragm pump comprising a pump body having an operating chamber therein, a diaphragm disposed across and moveable in said chamber, a fluid inlet and a fluid outlet in said body both communicating with said chamber on one side of said diaphragm, a non-return valve in each said inlet and outlet, an operating fluid storage chamber in said body, a cylinder connecting said storage chamber to said operating chamber on the side of said diaphragm remote from said inlet and outlet, a constantly rotating piston slidably disposed in said cylinder with a portion extending through the storage chamber to the exterior of said body, said cylinder having a slot extending axially in the wall thereof from said storage chamber towards said operating chamber, and said piston having a passage extending therein from said operating chamber and opening into the cylindrical surface of said piston within the length of said slot to engage therewith once in each complete rotation of said piston so that when said chambers and passage are filled with operating fluid, axial reciprocation of said piston will cause movement of said diaphragm to draw in and eject from said operating chamber the fluid being delivered by the pump and rotation of said piston will cause said passage to communicate with

said slot once in each piston rotation when the piston is furthest from the diaphragm to permit operating fluid to flow from the storage chamber to the operating chamber.

2. A diaphragm pump according to claim 1, wherein the piston is axially adjustable in the cylinder and the slot in the cylinder wall is at least the length that at all adjustments of the pump in the back "dead" point of the piston channel will move from the slot.

3. A diaphragm pump according to claim 1, wherein the piston extends at all times into the storage chamber.

4. A diaphragm pump according to claim 1, wherein said passage extends axially in said piston from said operating chamber and communicates with a radial bore extending to the cylindrical wall of the piston.

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