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GB-A- 837 737
GB-A-2 085 979
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Description

The invention relates to pumps and has a particularly useful but not exclusive application in pumps of the kind known as double diaphragm pumps.

U.S. Specification No. 4334837 discloses a pump comprising a hollow casing closed at its ends, two diaphragms disposed within the casing and generally parallel to each other adjacent the respective end portions of the casing, each diaphragm forming with its adjacent end portion of the casing a closed first chamber, a fixed internal partition member disposed between the diaphragms and forming two closed second chambers with the respective diaphragms, said second chambers having inlets thereto controlled by respective valves and outlets therefrom controlled by respective valves, a push rod extending in a sealing manner through the partition member to transmit axial displacing forces between the diaphragms, and valve means actuated in dependence on the position of the diaphragms and adapted to open passages for connecting each of the two first chambers alternately to a source of pressure fluid and to exhaust, thereby to cause the push rod and diaphragms to reciprocate in unison and to cause the diaphragms to operate the second chambers as pumping chambers.

According to the present invention the two ends of said push rod are in abutting relationship with but are not connected to the two diaphragms or pistons respectively.

In certain conditions it may be advantageous to use pistons instead of the diaphragms.

Preferably inlet passages providing the inlets to said second chambers and outlet passages providing the outlets from said second chambers are formed in the partition chamber.

In preferred arrangements according to the invention said inlet passages are constituted by branch passages extending from a common inlet opening in the casing, said outlet passages providing the outlets from said second chambers are constituted by branch passages extending from a common outlet opening in the casing, the valves associated with second chambers being mounted in the branch passages.

According to a preferred feature of the invention said end portions of the casing are formed by respective end members which are detachably secured to the partition member, and the two diaphragms or pistons are respectively removably attached at their peripheries to the adjacent end members.

Where diaphragms are employed they may have a reinforcing plate embedded in the central region thereof.

One embodiment of the invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 shows a pump according to the invention in axial section,

Figure 2 is a sectional end view on the line 2—2 of Figure 1, and

Figures 3A to 3F show the sequence of operations to the pump diagrammatically.

Referring to the drawings the pump has an external casing formed by a hollow cylindrical support ring 10 to opposite ends of which end covers 11, 12 are secured by tie bolts or, where frequent cleaning of the pump is necessary, quick-release clamps. A cylindrical diaphragm ring 13 of the same axial length as the support ring 10 enclosed within the support ring and a transverse partition member 14 is in turn enclosed within the diaphragm ring. Two diaphragms 16, 17 having a peripheral bead 18 are respectively clamped between opposite axial ends of the support ring 13 and partition member 14 at one side and the two end covers 11, 12 at the other side. The bead 18 itself is accommodated in channel section grooves in the support ring and the end cover. The groove in the end cover may have a dovetail section (not shown) and the bead may have a correspondingly shaped portion which engages in the groove and serves to attach the diaphragm removably to the adjacent end cover. Each diaphragm 16, 17 divides the space between the adjacent end cover 11, 12 and the partition member 14 into two chambers 19, 20. The two axially outer chambers 19 constitute motor chambers and the two axially inner chambers 20 constitute pumping chambers.

Each diaphragm has its central region stiffened by a reinforcing disc 21 embedded in the diaphragm material and a push rod 22 which is a sliding sealing fit in two sealing rings 23 in the partition member has its ends in abutment with the two diaphragms respectively in operation of the pump. A bush extending over the full axial length of the aperture in the partition member may be used instead of rings 23 if desired.

The partition member has formed in it two bifurcated passages 25, 26 serving respectively as inlets and outlets respectively for the pumped fluid, and each of the branches of each passage incorporates a non-return valve. The two branches of the inlet passage are shown at 25*a* and 25*b* and extend from a common inlet at the outer periphery of the partition member 14 to the two pumping chambers 20 respectively. Each of the branches has mounted in it a valve seating element 28 and a captive ball 29 together constituting the non-return valve. Similarly the two branches 26*a*, 26*b* of the outlet passage extend from the respective pumping chambers 20 to a common outlet at the periphery of the partition member, and each branch incorporates a valve seating element 28 and a captive ball 29 constituting the non-return valve. In the illustrated construction the partition member 14 is made in one piece from a plastics material such as PTFE and each seating element 28 is pressed into place through a chordal aperture 28*a* in the member 14 and comprises a portion 28*b* which blanks off the aperture 28*a* and a portion 28*c* which provides a seat for the captive ball 29. The inner face of portion 28*b* has an arch-like projecting rib 28*d* the limbs of which serve with the opposite wall of the passage to guide the ball for rectilinear movement. In an alternative construc-

tion, not illustrated, the partition member is made in two halves which are clamped together axially between end covers and valve seating rings are located in grooves on the axially inner surfaces of the two halves.

The partition member is located with the common inlet and the common outlet in circumferential alignment with radial apertures in the diaphragm ring 13 by two axial pins 13*a*, and a liner in the form of a hollow bolt 30 extends through each of these apertures and an aligned aperture in the support ring 10, the head of the bolt being countersunk in the diaphragm ring 13 and the shank of the bolt being in screw-threaded engagement in the aperture in the support ring. A jointing boss extends about the outer end of each of these apertures in the support ring 10.

An air-supply/exhaust passage 40 shown in Figure 3A is formed in each end cover 11, 12 through which compressed air is admitted to and exhausted from the associated motor chamber 19 by way of a servo valve 39.

In the outer end of a bore extending centrally through each end cover is secured a pilot valve unit 33 which is screw-threaded into the end cover and which carries a pilot valve member 34 loaded lightly into sealing engagement with a valve seat 35 by a compression spring 36. An intermediate enlarged portion of the bore forms a chamber 38 about the unit and each of the chambers communicates through a passage 41 with an associated pilot chamber 37 of a pneumatic servo changeover valve 39. This valve (see Figure 3A) is of the kind comprising a valve body 42 having a bore in which a valve spool 44 is slidably mounted. The chambers 37 at opposite ends of the spool are in permanently open but restricted communication with a source of compressed air through passages 45.

The operation of the pump is illustrated in Figures 3A to 3F to which reference is now made. Compressed air supplied to the left hand chamber 19 causes the diaphragm 16 to move to the right as shown in Figure 3A, pushing the push rod 22 and diaphragm 17 to the right also. In this stroke, fluid in the left hand chamber 20 is expelled through the non-return valve 28*c*, 29 in the passage 26*a*, fluid is drawn into the right hand chamber 20 through the non-return valve in passage 25*b*. The right hand air chamber 19 is open to exhaust via its inlet/exhaust passage shown at 40 and an exhaust port 48 in the servo valve 39. When the diaphragm 17 contacts the adjacent pilot valve member 34 (Figure 3B), the member is lifted away from the seat 35 and allows compressed air in the chamber 38 of the bore to flow into the adjoining chamber 19 and thence to exhaust through passage 40. The reduction of pressure in the corresponding end chamber 37 of the servo valve 39 causes the valve spool 44 to be moved to that end of its stroke by the air pressure in the other end chamber 37 (Figure 3C) and to reverse the connection of the air supply port 50 and exhaust ports 48 to chambers 19, so that air under pressure is supplied to the right hand chamber 19, and the left hand chamber 19 is connected to exhaust. During the resulting leftward movement (Figure 3D) of the diaphragms 16 and 17 and push rod 22, the fluid drawn into the right hand chamber 20 in the previous stroke is discharged through the non-return valve in passage 26*b* and a fresh charge of fluid is drawn into the left hand chamber 20 through the non-return valve in passage 25*a*. A similar cycle of events takes place when the left hand diaphragm contacts its adjacent pilot valve member (Figure 3E), setting in train (Figure 3F) the next rightward movement of the diaphragm and the push rod.

Electric solenoid devices may be provided which control movements of the spool valve member in both directions independently, similarly electric solenoid devices may be provided which control movements of the spool valve in both directions independently and which are also capable of moving the spool valve member into either of its end positions from a central position into which it is urged by centralising springs provided in the end chambers; in this case, the valve ports and lands are arranged so that both motor chambers 19 are connected to exhaust when the spool valve member is in its central position.

The ends of the push rod 22 are flat but may be suitably domed and profiled to avoid pressing sharp edges against the diaphragms whatever the attitude of the latter. The diaphragms themselves may be made from any suitable materials, including PTFE, rubber, neoprene, viton and PTFE-faced rubber, and may be reinforced locally or across the full face of the diaphragm if required. The diaphragms may be of the tandem or double-skin type with a liquid held captive between the two skins to transmit the pressures from one skin to the other, and a device responsive to the pressure of the liquid and/or to a change in the composition of the liquid may be provided to indicate rupture of one of the skins.

The partition member and the bolts 30 may be made from stainless steel, plastics, glass, wood or any material suitably resistant to corrosive properties of the fluid to be pumped, and it will be apparent that the diaphragms 16, 17 prevent leakage of the pumped fluid between the partition member 14 and the bolts 30, so that these five components jointly confine the pumped fluid during the whole of its passage through the pump.

Flap valves may be employed in place of the ball valves and may advantageously be arranged so as to enable the pumped fluid to enter by the top passage 26 and be delivered through the bottom passage 25.

A major advantage of the illustrated pump is that it enables dangerous or unpleasant fluids to be pumped with relative safety in that the partition member 14 can be made of plastics, glass or wood or any other material which in itself is relatively fragile but which is appropriately resistant to the effects of the fluid, because the partition member is protected by the support ring and the

end covers against accidental damage. In addition, there is no external pipework connecting the pumping chambers and requiring joints and seals which are potentially sources of leakage.

In conventional double diaphragm pumps, the pumping chambers are at opposite ends of the pump and the air chambers are adjacent each other, and a pneumatic switching mechanism is disposed between the diaphragm and is consequently difficult of access, but in the illustrated pump the pneumatic switching mechanism can be conveniently mounted in the casing to be readily accessible and removable for servicing. Furthermore, since the air chambers are at the ends of the pump, the rod 22 extending between the diaphragm is never in tension and is therefore not connected to the diaphragms. Thus the diaphragms can be unperforated and the simple abutment contact between the rod and the diaphragm allows the latter to find their natural position during pumping. The previously mentioned optional attachment of the diaphragms of the end covers and the simple abutment of the diaphragm against the push rod enables the diaphragms to be removed and replaced easily without extensive dismantling of the pump; moreover, the attachment of the diaphragms to the end covers serves to protect the diaphragms against accidental damage during servicing of the pump.

The length of the working stroke can be adjusted by altering the length of the pilot valve member 38 projecting into the cylinder.

Although the invention has been described principally as applied to a diaphragm pump, it will be apparent that the diaphragms can be replaced by pistons.

Claims

1. A pump comprising a hollow casing closed at its ends, two diaphragms (16, 17) or pistons disposed within the casing and generally parallel to each other adjacent the respective end portion of the casing, each diaphragm (16, 17) or piston forming with its adjacent end portion of the casing a closed first chamber (19), a fixed internal partition member (14) disposed between the diaphragms or pistons and forming two closed second chambers (20) with the respective diaphragms or pistons, said second chambers having inlets thereto controlled by respective valves and outlets therefrom controlled by respective valves, a push rod (22) extending in a sealing manner through the partition member (14) to transmit axial displacing forces between the diaphragms or pistons, and valve means (33, 39) actuated in dependence on the position of the diaphragms or pistons and adapted to open passages for connecting each of the two first chambers (19) alternately to a source of pressure fluid and to exhaust, thereby to cause the push rod (22) and diaphragms (16, 17) or pistons to reciprocate in unison and to cause the diaphragms or pistons to operate the second chambers (20) as pumping chambers characterised in that the two ends of the push rod (22) are in abutting relationship with but are not connected to the diaphragms (16, 17) or pistons.

2. A pump as claimed in claim 1, characterised in that inlet passages (25) which provide the inlets to said second chambers and outlet passages (26) which provide the outlets from said second chambers (20) are formed in the partition chamber (14).

3. A pump as claimed in claim 2, characterised in that said inlet passages (25) are constituted by branch passages (25*a*, 25*b*) extending from a common inlet opening in the casing, and in that said outlet passages (26) providing the outlets from said second chambers (20) are constituted by branch passages (26*a*, 26*b*) extending from a common outlet opening in the casing, the valves associated with said second chambers being mounted in the branch passages.

4. A pump as claimed in any one of claims 1 to 3, characterised in that said end portions of the casing are formed by respective end members (11, 12) which are detachably secured to the partition member (14), and in that the two diaphragms (16, 17) or pistons are respectively removably attached at their peripheries to the adjacent end members (11, 12).

5. A pump as claimed in any one of claims 1 to 4, characterised in that the internal partition member (14) is formed in two valves which abut each other axially.

6. A pump as claimed in any one of claims 1 to 5, characterised in that each of said valves comprises a ball (29) mounted for free but guided rectilinear movement into and out of engagement with an annular valve seat (28) so as to operate as a non-return valve.

7. A pump as claimed in claim 6 in conjunction with claim 5, characterised in that said valve seats (28) are constituted by annular inserts disposed between the two halves of the partition member (14).

8. A pump as claimed in any one of claims 1 to 5, characterised in that one or more of said valves are flap valves.

9. A pump as claimed in any one of claims 1 to 8, characterised in that said valve means (33, 39) comprises a pilot valve (34) mounted in each end portion which pilot valve is opened by abutment therewith of the adjacent diaphragm (16, 17) at the end of a stroke of the pump and operates to open an external servo pressure line (41) to exhaust.

10. In combination, a pump as claimed in claim 9 and a servo valve (39) comprising a valve spool slidably disposed in a valve housing (42), opposite ends of the spool being arranged to have air under pressure supplied thereto through permanently open restricted passages (45) and having exhaust connections controlled by the two pilot valves (34) respectively, said housing providing inlet and exhaust ports controlled by the valve spool to supply compressed air from said inlet to said first chamber (19) alternately

and to connect to exhaust (48) the chamber not being supplied with compressed air.

11. The combination claimed in claim 10, wherein the servo valve (39) has electrical control means operable to delay changeover movements of the valve spool initiated by operation of the pilot valves (34).

Patentansprüche

1. Pumpe mit einem an seinem Enden geschlossenen Gehäuse, mit zwei Membranen (16, 17) oder Kolben, die innerhalb des Gehäuses und im wesentlichen parallel zueinander nahe dem jeweiligen Ende des Gehäuses angeordnet sind, wobei jede Membran (16, 17) oder jeder Kolben mit seinem benachbarten Endbereich des Gehäuses eine erste geschlossene Kammer (19) bildet, mit einem festen, inneren Trennglied (14), das zwischen den Membranen oder Kolben angeordnet ist und zwei zweite geschlossene Kammern (20) mit den jeweiligen Membranen oder Kolben bildet, wobei die zweiten Kammern durch entsprechende Ventile gesteuerte Eintritte und durch entsprechenden Ventile gesteuerte Austritte haben, mit einem Druckstab (22), der sich abdichend durch das Trennglied (14) erstreckt, um axiale Verschiebekräfte zwischen den Membranen oder Kolben zu übertragen, und mit Ventileinrichtungen (33, 39), die in Abhängigkeit von der Lage der Membranen oder Kolben betätigt werden und Durchtritte öffnen, um jede der beiden ersten Kammern (19) abwechselnd mit einer Druckmediumsquelle zu verbinden und zu entleeren und dabei den Druckstab (22) und die Membranen (16, 17) oder Kolben zu veranlassen, gemeinsam sich zurückzubewegen, und die Membranen oder Kolben zu veranlassen, die zweiten Kammern (20) als Pumpkammern zu betätigen, dadurch gekennzeichnet, daß die beiden Enden des Druckstabes (22) in Anlage mit den Membranen (16, 17) oder Kolben sind, jedoch nicht mit diesen verbunden sind.

2. Pumpe nach Anspruch 1, dadurch gekennzeichnet, daß die Einlaßdurchtritte (25), die die Eintritte in die zweiten Kammern darstellen, und die Auslaßdurchtritte (26), die die Auslässe von den zweiten Kammern (20) darstellen, in der Trennkammer (14) ausgebildet sind.

3. Pumpe nach Anspruch 2, dadurch gekennzeichnet, daß die Einlaßdurchtritte (25) durch Verzweigungsdurchtritte (25a, 25b) gebildet sind, die sich von einer gemeinsamen Eintrittsöffnung in das Gehäuse erstrecken, und daß die Auslaßdurchtritte (26), die die Austritte von den zweiten Kammern (20) darstellen, durch Verzweigungsdurchtritte (26a, 26b) gebildet sind, die sich von einer gemeinsamen Austrittsöffnung im Gehäuse erstrecken, wobei die den zweiten Kammern zugeordneten Ventile in den Verzweigungsdurchtritten vorgesehen sind.

4. Pumpe nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß die Endbereiche des Gehäuses durch entsprechende Endglieder (11, 12) gebildet werden, die lösbar mit dem Trennglied (14) verbunden sind, und dadurch, daß die beiden Membranen (16, 17) oder Kolben jeweils lösbar an ihren Umfängen mit den benachbarten Endgliedern (11, 12) verbunden sind.

5. Pumpe nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, daß das innere Trennglied (14) aus zwei Hälften besteht, die axial aneinander anliegen.

6. Pumpe nach einem der Ansprüche 1 bis 5, dadurch gekennzeichnet, daß jedes Ventil eine Kugel (29) aufweist, die frei beweglich, jedoch geradlinig geführt in und außer Eingriff mit einem ringförmigen Ventilsitz (28) angeordnet ist, um so als Rückschlagventil zu arbeiten.

7. Pumpe nach Anspruch 6 in Verbindung mit Anspruch 5, dadurch gekennzeichnet, daß die Ventilsitze (28) durch ringförmige Einsätze gebildet sind, die zwischen den beiden Hälften des Trenngliedes (14) angeordnet sind.

8. Pumpe nach einem der Ansprüche 1 bis 5, dadurch gekennzeichnet, daß ein oder mehrere der Ventile Klappenventile sind.

9. Pumpe nach einem der Ansprüche 1 bis 8, dadurch gekennzeichnet, daß die Ventileinrichtungen (32, 39) ein in jedem Endbereich angeordnetes Steuerventil (34) aufweisen, wobei das Steuerventil durch Anschlag an die benachbarte Membran (16, 17) am Ende eines Pumpenhubes geöffnet wird und eine äußere Hilfsdruckleitung (41) zum Ablassen öffnet.

10. In Kombination, eine Pumpe gemäß Anspruch 9 und ein Hilfsventil (39) mit einem Ventilschieber, der verschiebbar in einem Ventilgehäuse (42) angeordnet ist, wobei die gegenüberliegenden Enden des Schiebers so angeordnet sind, daß Luft unter Druck innen über ständig offene, begrenzte Durchtritte (45) zugeführt wird, und Ablaßverbindungen vorgesehen sind, die von zwei Steuerventilen (34) gesteuert werden, wobei das Gehäuse Eintritts- und Ablaßöffnungen besitzt, die vom Ventilschieber gesteuert werden, um Druckluft aus dem Eintritt zur ersten Kammer (19) abwechselnd zuzuführen und den Ablaß (48) mit der Kammer zu verbinden, der keine Druckluft zugeführt worden ist.

11. Die Kombination gemäß Anspruch 10, wobei das Hilfsventil (29) elektrische Steuermittel hat, die zur Verzögerung der Umschaltbewegungen des Ventilschiebers betätigbar sind, die durch die Betätigung der Steuerventile (34) eingeleitet werden.

Revendications

1. Pompe comportant un corps creux fermé à ses extrémités; deux diaphragmes (16, 17) ou pistons disposés à l'intérieur du corps et, d'une manière générale, parallèlement l'un à l'autre, à proximité de la partie d'extrémité correspondante du corps, chaque diaphragme (16, 17) ou piston formant, avec la partie d'extrémité du corps qui lui est adjacente, une première chambre fermée (19); un organe de séparation interne fixe (14) disposé entre les diaphragmes ou pistons et

formant, avec les diaphragmes ou pistons correspondants, deux secondes chambres fermées (20), lesdites secondes chambres comportant des admissions commandées par des vannes respectives, et des évacuations commandées par des vannes respectives; une tige-poussoir (22) qui s'étend d'une manière étanche à travers l'organe de séparation (14) pour transmettre des forces de déplacement axial entre les diaphragmes ou pistons; et des moyens formant vannes (33, 39) actionnés en fonction de la position des diaphragmes ou pistons et adaptés pour ouvrir des passages destinés à relier chacune des deux premières chambres (19) à une source de fluide sous pression et à un échappement, alternativement, pour ainsi contraindre la tige-poussoir (22) et les diaphragmes ou pistons à aller et venir d'une manière synchronisée et obliger les diaphragmes ou pistons à faire fonctionner les secondes chambres (20) comme des chambres de pompage; caractérisée en ce que les deux extrémités de la tige-poussoir (22) sont dans une relation en butée avec les diaphragmes (16, 17) ou pistons, mais ne sont pas reliées à ceux-ci.

2. Pompe telle que définie dans la revendication 1, caractérisée en ce que des passages d'admission (25) assurant les admissions dans lesdites secondes chambres, et des passages d'évacuation (26) assurant les évacuations hors desdites secondes chambres (20) sont ménagés dans l'organe de séparation (14).

3. Pompe telle que définie dans la revendication 2, caractérisée en ce que lesdits passages d'admission (25) sont constitués par des passages ramifiés (25*a*, 25*b*) qui s'étendent depuis un orifice d'admission commun ménagé dans le corps, et en ce que lesdits passages d'évacuation (26) assurant les évacuations hors desdites secondes chambres (20) sont constitués par des passages ramifiés (26*a*, 26*b*) qui s'étendent depuis un orifice d'évacuation commun ménagé dans le corps, les vannes associées à ces secondes chambres étant montées dans les passages ramifiés.

4. Pompe telle que définie dans l'une quelconque des revendications 1 à 3, caractérisée en ce que lesdites parties d'extrémité du corps sont formées par des organes d'extrémité (11, 12) respectifs, fixés d'une manière amovible à l'organe de séparation (14), et en ce que les deux diaphragmes (16, 17) ou pistons sont, au niveau de leurs périphéries, respectivement fixés d'une manière amovible aux organes d'extrémité (11, 12) adjacents.

5. Pompe telle que définie dans l'une quelconque des revendications 1 à 4, caractérisée en ce que l'organe de séparation interne (14) se compose de deux moitiés qui viennent en butée l'une contre l'autre axialement.

6. Pompe telle que définie dans l'une quelconque des revendications 1 à 5, caractérisée en ce que chacune desdites vannes comporte une bille (29) montée en vue d'un mouvement rectiligne libre, mais guidé, pour s'engager dans un siège de vanne annulaire (28) et se dégager de celui-ci, afin de jouer le rôle d'une soupape de non-retour.

7. Pompe telle que définie dans la revendication 6 en combinaison avec la revendication 5, caractérisée en ce que lesdits sièges de vanne (28) sont constitués par des pièces d'insertion annulaires disposées entre les deux moitiés de l'organe de séparation (14).

8. Pompe telle que définie dans l'une quelconque des revendications 1 à 5, caractérisée en ce que l'une au moins desdites vannes est une soupape à clapet.

9. Pompe telle que définie dans l'une quelconque des revendications 1 à 8, caractérisée en ce que lesdits moyens formant vannes (33, 39) comportent une vanne pilote (34) montée dans chacune des parties d'extrémité, laquelle vanne pilote est ouverte par la vanue en butée contre elle du diaphragme (16, 17) adjacent, à la fin d'une course de la pompe, et opère pour ouvrir une ligne sous pression asservie (41) extérieure, en direction d'un échappement.

10. Pompe telle que définie dans la revendication 9, en combinaison avec une servovanne (39) comportant une bague de vanne disposée à coulissement dans une boîte de vanne (42), des extrémités opposées de la bague étant disposées de manière à recevoir de l'air sous pression par l'intermédiaire de passages restreints (45), ouverts en permanence, et ayant des raccordements d'échappement respectivement commandés par les deux vannes pilotes (34), ladite boîte définissant des orifices d'admission et d'évacuation commandés par la bague de vanne pour fournir de l'air comprimé provenant de ladite admission, à ladite première chambre (19), alternativement, et pour relier à l'échappement (48) la chambre qui n'est pas en train d'être alimentée en air comprimé.

11. Combinaison telle que définie dans la revendication 10, dans laquelle la servovanne (39) possède des moyens de commande électriques aptes à opérer pour retarder des mouvements de permutation de la bague de vanne, amorcés par un actionnement des vannes pilotes (34).

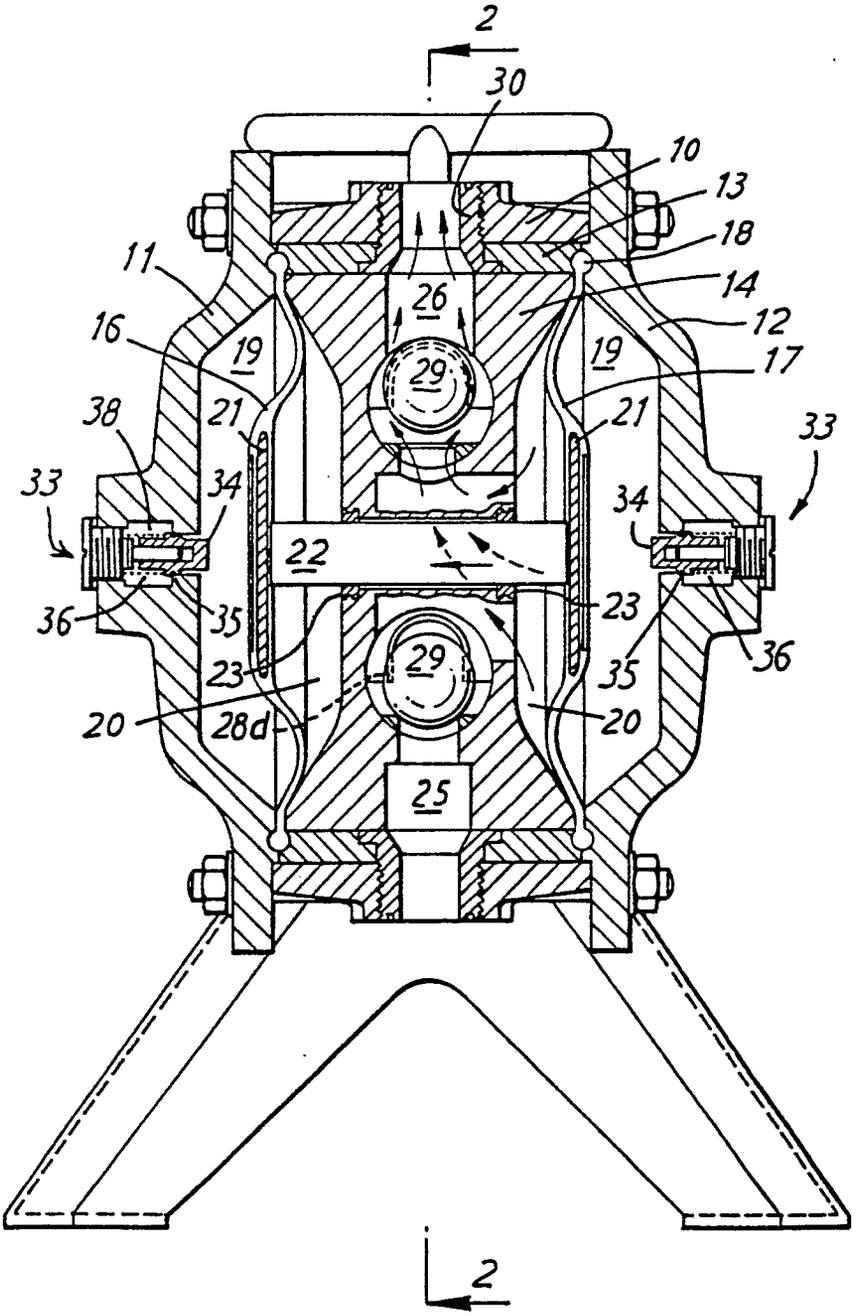
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FIG. 1

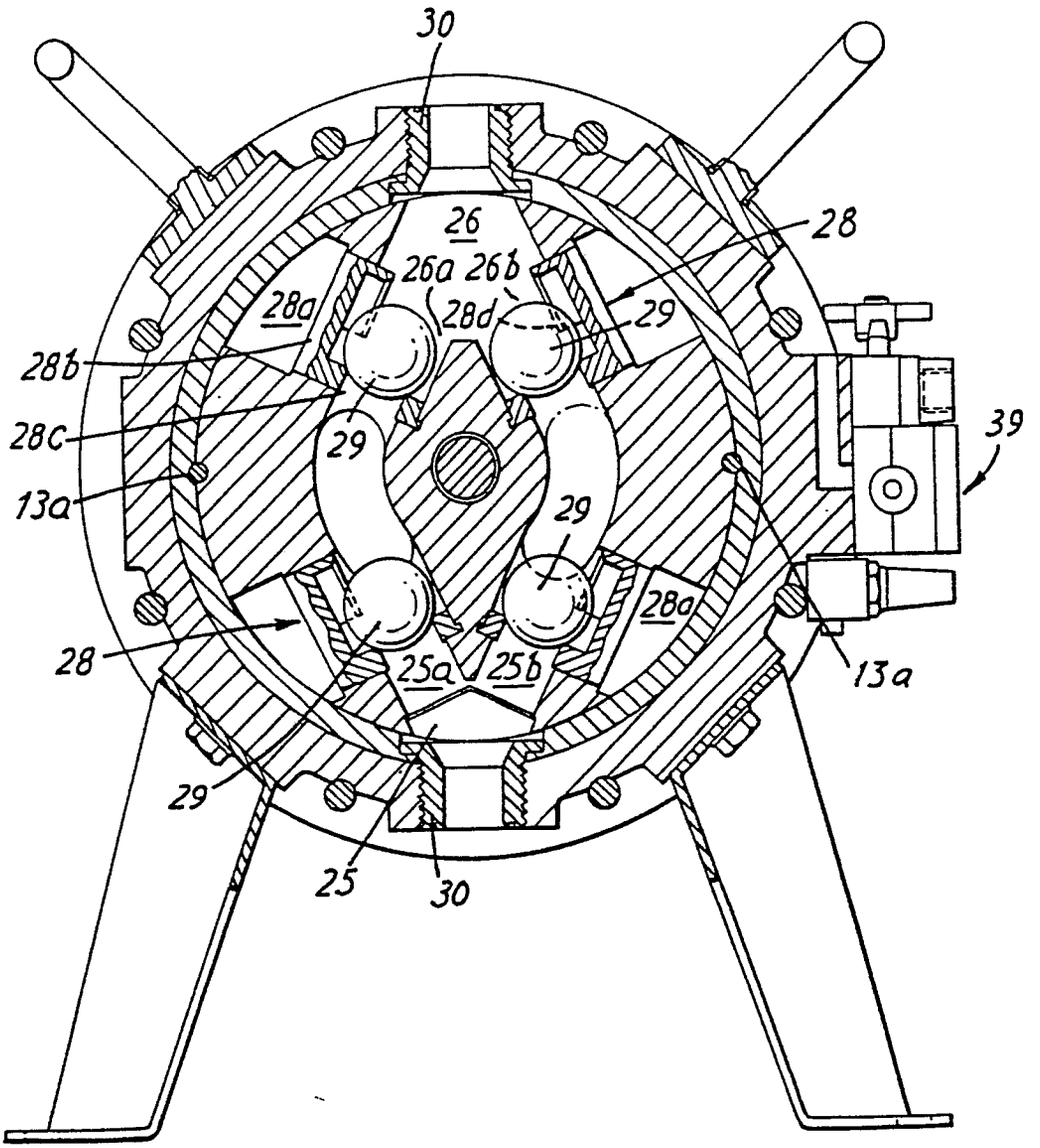
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FIG.2

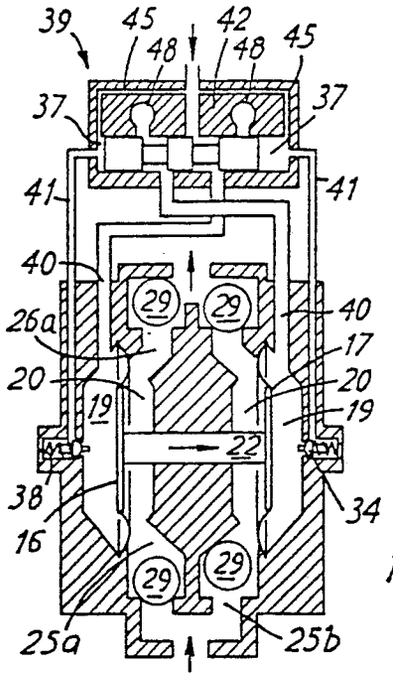

FIG. 3A

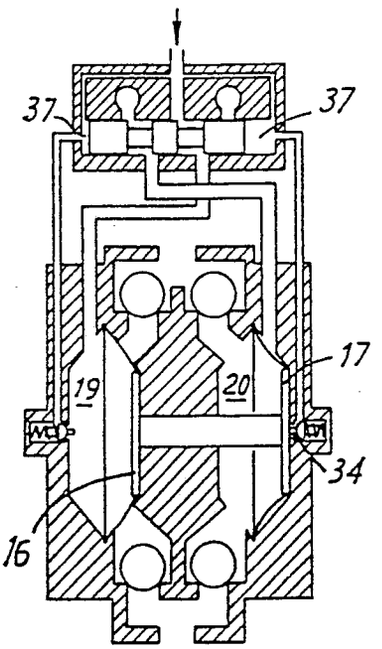

FIG. 3B

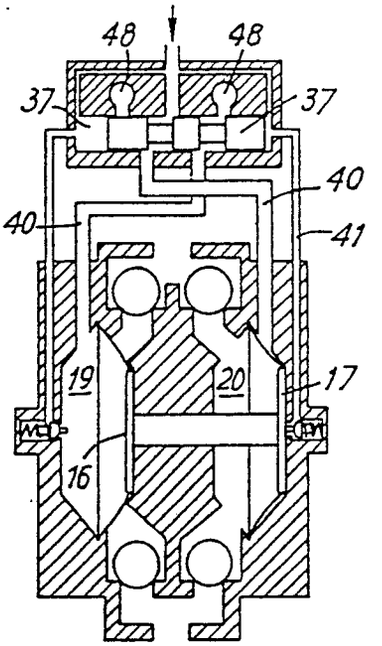

FIG. 3C

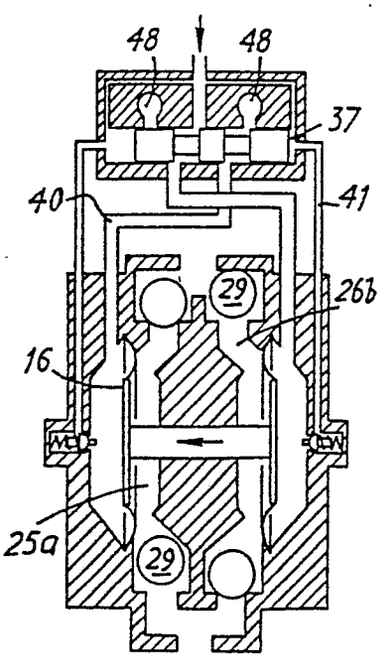

FIG. 3D

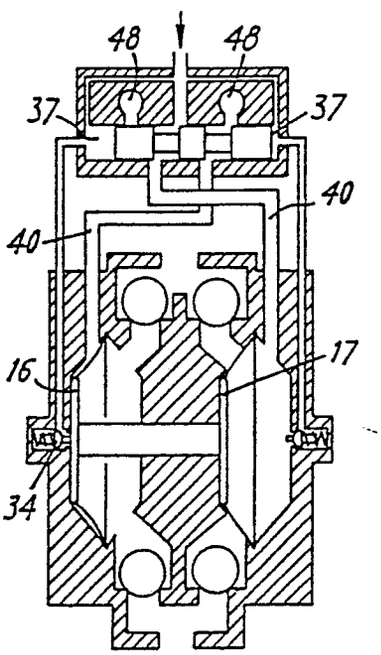

FIG. 3E

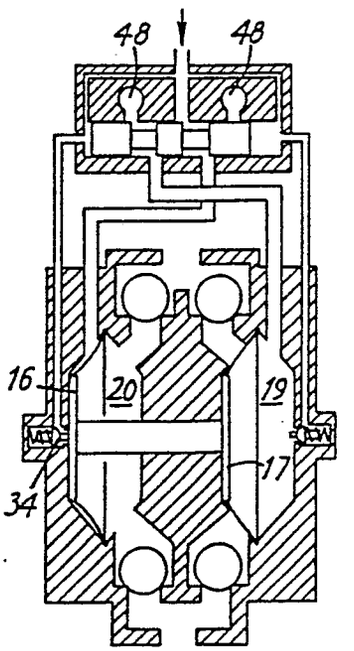

FIG. 3F