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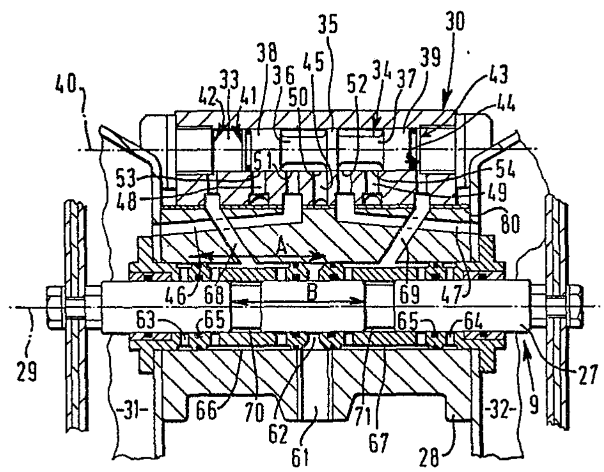
(54) **A pump.**

(57) A double diaphragm pump comprises a pair of chambers (14, 15), each with a plate and diaphragm arrangement (23, 24 and 25, 26) which forms parts of the boundaries thereof. A pressurised fluid such as air is directed alternately to respective spaces (31, 32) outside the chambers and adjacent the diaphragms by means of an actuating means (30) which comprises a spool (34) in a spool chamber (33). A control means (9) which comprises a rod (27) extending between the plates (23 and 25) controls operation of the actuating means. The control means which is movable with the diaphragms directs fluid alternately to the ends of the spool chamber and prevents supply of fluid to an end of the spool chamber opposite to that end to which fluid is directed at a selected moment.



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Title: "A pump"

The invention relates to a pump of the kind comprising two chambers, each chamber having an inlet and an outlet for pumped fluid, the inlet and the outlet being controlled by respective valves, wherein a part of the wall of each chamber is formed of a respective diaphragm, the pump further comprising a rigid connection between the diaphragms of respective chambers whereby movement of the diaphragms increases the volume of one chamber and decreases the volume of the other chamber, an inlet for an operating fluid, and a directing means for directing the operating fluid alternately to respective enclosed spaces which are adjacent those surfaces of respective diaphragms which are outside the chambers, the directing means comprising a spool which is slidable between two positions in a spool chamber, a first passage leading from the operating fluid inlet to the spool chamber, and second and third passages leading from the spool chamber to respective ones of said spaces, wherein,when the spool is in a first of said positions, the first passage communicates with the second passage, and, when the spool is in the second of said positions, the first passage communicates with the third passage.

In published European Patent application number 0018143 of Wilden Pump & Engineering Company, there is disclosed a pump of the kind referred to wherein there is a clearance space between the periphery of the spool and the wall of the spool chamber sufficient for working fluid to pass from a fluid inlet beside the spool to both ends of the spool chamber continuously during operation of the pump. Vent passages are provided for venting respective end portions of the spool chamber and venting of the spool chamber through these passages is controlled by a rigid control rod extending between the diaphragms. It is indicated that alternate venting of the end portions of the spool chamber will cause reciprocation of the spool.

During a major part of the stroke of the control rod of the pump disclosed in the aforesaid published application, venting of both ends of the spool chamber is prevented. Only at the end of each stroke, is venting of one or other end of the spool chamber permitted. When venting of the ends of the spool chamber is prevented or restricted, both ends of the spool will be subjected to a substantial pressure and longitudinal movement of the spool will not continue. If an attempt is made to operate the pump at high speed, venting of one end of the spool chamber may be substantially restricted before longitudinal movement of the spool has been completed and thus the required reciprocation of the spool may fail to occur.

According to the present invention, a pump of the kind referred to has control means movable with the diaphragms for directing fluid to the ends of the spool chamber alternately and for preventing supply of fluid to an end of the spool chamber opposite that end to which fluid is directed at a selected moment.

Fluid is directed to each end of the spool chamber over a fraction only of the range of movement of the diaphragms, the magnitude of that fraction being selected to ensure that the spool reciprocates fully at all operating speeds of the pump.

An example of a pump in accordance with the invention will now be described with reference to the accompanying drawings wherein:-

FIGURE 1 shows diagrammatically a pump with parts thereof cut away;

FIGURE 2 shows diagrammatically and on an enlarged scale certain parts of the pump of Figure 1, the pump again being partly cut away; and

FIGURE 3 illustrates in a manner similar to that of Figure 2 the actuating mechanism of a second example of pump.

Figure 1 shows a pump 10 of the kind commonly referred to as a double diaphragm pump. The pump comprises a main inlet 11 and passages 12 and 13 leading from the inlet to respective chambers 14 and 15. A valve 16 at the inlet of chamber 14 and a valve 17 at the inlet of chamber 15 are capable of closing respective chambers from the main inlet.

Passages 20 and 21 lead from chambers 14 and 15 respectively to a common main outlet 22. Valves 18 and 19 at the outlets of respective chambers 14 and 15 can close said chambers from the main outlet. The valves 16 to 19 are non-return valves and are suitably of a "ball" or "clack" kind.

The volumes of the chambers 14 and 15 vary during the operation of the pump 10. A plate 23 and a diaphragm 24 surrounding the plate forms a part of the boundary of chamber 14. The diaphragm provides a flexible sealed connection between the plate and the remainder of the boundary of the chamber. A part of the boundary of the chamber 15 is defined by a plate 25 and a further diaphragm 26 arranged in the same manner as the plate 23 and diaphragm 24. The plate 23 and diaphragm 24 also define a part of the boundary of an enclosed space 31 outside the chamber 14 and the plate 25 and diaphragm 26 form a part of the boundary of a corresponding space 32 outside the chamber 15.

Various fluids, including air, are suitable for driving the pump. The pump has a main driving fluid inlet 45 through which air under pressure can be supplied from an external source to the pump to drive the diaphragms. Actuating means 30 is provided for directing pressurised air alternately to the spaces 31 and 32 in order to exert pressure on the diaphragms alternately. The pump also includes control means 9 which is movable with the diaphragms for controlling operation of the actuating means 30 in such a manner that air is directed to one of the spaces 31 and 32 and exhausted from the other space until the diaphragms together reach one limit position and then movement of both diaphragms is reversed by directing air to the other of the spaces 31 and 32 and venting the one space.

The control means 9 comprises a connecting member in the form of a rod 27 which extends between the plates 23 and 25 and, in conjunction with the plates, provides a rigid connection between the diaphragms 24 and 26. Conveniently, the diaphragms and plates have apertures through which end portions of the rod extend, the plates being secured on the end portions of the rod. The rod 27 is constrained by a housing 28 to move along an axis 29 defined by the rod and the diaphragms are constrained to reciprocate together with the rod.

Movement of the rod, plates and diaphragms in a direction to the left, as shown in Figure 1, serves to decrease the volume of chamber 14 and increase the volume of chamber 15. The consequent decreasing pressure in chamber 15 serves to hold inlet valve 17 open and outlet valve 19 closed so that material to be pumped is drawn from inlet 11, through passage 13 into the chamber. Simultaneously, the increasing pressure in chamber 14 serves to hold inlet valve 16 closed and outlet valve 18 open so that material is driven out of the chamber along passage 20 to outlet 22. The reverse occurs upon movement of the rod to the right. It will be apparent that the rod can in an alternative embodiment be connected directly to respective diaphragms.

As shown in Figure 2, the actuating means 30 comprises a spool chamber 33 which contains a spool 34. The spool has a central land 35 and recesses 36 and 37 on opposite sides of the land. These recesses are preferably annular. Opposite end portions 38 and 39 of the spool act as pistons within the spool chamber. These end portions and the land 35 are cylindrical about an axis 40 of the spool chamber and are a free sliding fit in the spool chamber so that sliding of the spool is not impeded but there is no substantial gap between the peripheral boundary of the spool chamber and the end portions and land of the spool.

The movement of the spool 34 in one direction is limited by end face 44 of the spool chamber 33 which engages end face 43 of piston portion 39 when the spool is in a first limit position, as shown in Figure 2. Movement of the spool in the opposite direction is limited by end face 42 of the chamber which engages end face 41 of piston portion 38 when the spool has travelled from the first position shown in Figure 2 or Figure 3 to a second limit position (not shown).

The inlet passage 45 leads to a port 50 of the spool chamber 33, which port 50 is approximately equally spaced from the opposite ends of the chamber. Passages 46 and 47 lead to spaces 31 and 32 respectively from respective further ports 51 and 52 which are equally spaced in opposite axial directions from the centre of the spool chamber and from the port 50. Outlet passages 48 and 49 lead from respective ports 53 and 54 of the spool chamber to the housing 28. The ports 53 and 54 are spaced axially between port 50 and end face 41, and port 52 and end face 42 respectively.

The passage 46 defines the sole path for flow of fluid into and from the space 31 so that the spool 34 controls both flow of fluid to this space and venting of the space. Similarly, the passage 47 defines the sole path for flow of fluid into and from the space 32 so that the spool controls both flow of fluid to this space and venting thereof.

When the spool 34 is in the first limit position in spool chamber 33, shown in Figure 2, air is directed by the spool to pass from inlet passage 45 to passage 46 and thence to space 31 adjacent plate 23 and diaphragm 24 of the chamber 14. The fluid is able to pass along the spool chamber through recess 36. Land 35 provides a seal against fluid passing into the passge 47, and piston portion 38 similarly provides a seal against fluid entering outlet passage 48.

At the same time as a path from inlet passage 45 to passage 46 is open, a path from passage 47 to outlet passage 49 is also open. Land 35 and piston portion 39 each provide a seal which ensures that fluid passing along the spool chamber through recess 37 from passage 47 leaves the actuating means by outlet passage 49. In place of recesses in the external surface of the spool 34, there may be provided passages which extend through the interior of the spool.

It can be seen that, as fluid is directed through the spool chamber to space 31, the control rod 27 is driven to the left causing fluid to be expelled from space 32 through the spool chamber via outlet passage 49. When the spool is at the opposite end of the spool chamber from that shown in Figure 2, a path between inlet passage 45 and passage 47, and a further path between passage 46 and outlet passage 48 are open, and the reverse operation will occur. The length of the path of the spool in the spool chamber is approximately equal to the combined axial extent of land 35 and the port 50. The axial distance between the ports 51 and 52 is approximately equal to the addition of the axial length of the port 50 and twice the axial length of land 35. The axial length of piston portions 38 and 39 are approximately the same, and the axial length of each is approximately equal to the axial distance between respective adjacent port 53 and end face 41 or between port 54 and end face 42 of the spool chamber.

Thus, an axial end face of the land 35 is adjacent to port 50,and an inwardly directed axial face of either piston portion is adjacent a respective outlet passage when the spool is in the first or second position.

Transfer of the spool 34 between the first and second positions occurs when the control rod 27 reaches a limit position. As shown in Figure 2, a passage 61 leads from the source of operating fluid to a port 62 in the housing 28. The port occupies a central position in the housing.

Outlet passages (not shown in Figure 2) lead from ports 63 and 64 and may suitably combine with outlet passages 48 and 49 to provide a path by which fluid can leave the pump and be discharged to atmosphere. The ports 63 and 64 are equally spaced apart on either side of the inlet port. The rod 27 is a free sliding fit in portions of the housing adjacent to the outlet ports 63 and 64 and inlet port 62. Seals 65, which are positioned axially on either side of each of the ports, serve to prevent fluid leaking along the interface between the internal surface of the housing and the surface of the control rod. The seals may comprise O-rings.

Between the inlet port 62 and each of the outlet ports 63 and 64, the housing defines respective annular spaces 66 and 67 about the control rod. Further passages 68 and 69 lead from respective annular spaces 66 and 67 to respective end portions of the spool chamber 33 at the end faces 41 and 42. In the rod there are two recesses in the form of annular grooves 70 and 71 which communicate with respective annular spaces 66 and 67.

For the greater part of the operating cycle of the pump, and as illustrated in Figure 2, the ports 62, 63 and 64 are sealed from the further passages 68 and 69. The control rod 27 co-operates with the seals 65 to prevent supply of air from the passage 61 to either end of the spool chamber 33.

When the rod 27 reaches one of its two limit positions, two of the seals 65 are ineffective because they surround one or other of the grooves 70 and 71 in the control rod. The control rod, in particular the surfaces thereof defining the grooves 70 and 71, direct air from the passage 61 to one end of the spool chamber and permit air to flow from the other end of the spool chamber to the ambient atmosphere through a corresponding one of the passages 63 and 64.

With the pump at the stage of its operating cycle shown in Figure 2, the rod 27 is moving to the left and approaching the first limit position. When the rod has reached the limit position, groove 71 provides a path for operating fluid from port 62 about a seal 65 to annular space 67. Fluid is thereby permitted to pass from the source via further passage 69 to an end of the spool chamber 33 between piston portion 39 and end face 44. At the same time, groove 70 provides a passage from annular space 66 around a seal 65 to outlet port 63. Fluid is thereby permitted to evacuate the space between piston portion 38 and end face 42. The pressure of fluid on end face 43 of the piston portion is sufficient to drive the spool along the spool chamber to the second position. Operating fluid is thereby redirected to space 32 to drive the rod in the opposite direction, to the right as shown in Figure 2. The grooves will accordingly move out of communication with ports 63 and 62 which become closed from annular spaces 66 and 67 by the seals 65.

The fluid which has been retained between end faces 42 and 41 is sufficient to hold the spool in the second position until the converse of the above described operation takes place. This will occur when groove 71 moves into alignment with one of the seals 65 adjacent to the outlet port 64 (to establish communication between this port and space 67) and groove 70 moves into alignment with another seal 65 adjacent to inlet port 62, when the rod is at the second limit position.

It will be noted that each of the grooves remains in communication with a respective annular space 66 and 67 during the operating cycle of the pump and is never aligned with one of the outermost seals 65. It is therefore not possible for any pumped fluid which has passed into either of spaces 31 or 32 across a fractured diaphragm to enter the actuating means via either of the grooves. The distance between corresponding edges of the grooves, dimension B in Figure 2, is slightly greater than the distance between the inlet port and either of the outlet ports, dimension A. By this means, fluid from one end of the spool chamber is permitted to evacuate slightly in advance of fluid being permitted to enter the opposite end of the spool chamber in the operating cycle. This achieves a more efficient transfer of the spool when the rod reaches a limit position.

Figure 3 illustrates the control means of a modified version of the pump shown in Figures 1 and 2. The general arrangement of the pump illustrated in Figure 3 is the same as that of the pump illustrated in Figures 1 and 2 and the preceding description is deemed to apply to the pump of Figure 3, except for the differences hereinafter mentioned.

The control rod 127 of the pump shown in Figure 3 is formed with three V-shaped grooves, 172, 173 and 174. The smallest radius of each groove, measured from the intersect of the V to the axis of the rod, lies within the range one half to five sixths of the radius of a main portion of the rod.In the example illustrated, the minimum radius is approximately two thirds that of the main portion of the rod. In an alternative embodiment the grooves may be annular. The housing 128 for the control rod defines a single annular space 175 surrounding a central part of the control rod. When the control rod 127 reaches a first limit position, groove 174 establishes communication between outlet port 164 and passage 169 leading to one end of the spool chamber 133. At the same time, the groove 173 establishes communication between an inlet port 162 and a passage 170 which leads to the other end of the spool chamber. Accordingly, air is admitted to this other end of the spool chamber and is exhausted from the one end of the spool chamber to cause the spool to be driven from the position shown in Figure 3.

The spool and spool chamber of the pump illustrated in Figure 3 are arranged in the same manner as are the corresponding parts of the pump of Figures 1 and 2 and reciprocation of the spool causes the operating fluid for the pump to be redirected as hereinbefore described.

At the second limit position of the control rod 127 shown in Figure 3, the groove 172 establishes communication between the passage 170 and the outlet port 163 whilst the groove 173 establishes communication between the inlet port 162 and the passage 169.

In both the pump illustrated in Figures 1 and 2 and the pump illustrated in Figure 3, the spool chamber is preferably formed in a body which is separable from the housing of the control rod. An elastomeric gasket, designated 80 in Figure 2 and 180 in Figure 3, is provided at the interface between this body and the housing of the control rod, in order to prevent leakage of fluid at the interface from those passages which extend between the spool chamber and the control rod.

Both of the pumps illustrated may be modified by the provision of at least one bleed passage which provides communication between part of the spool chamber through which fluid under pressure flows to one or other of the diaphragms and part of the spool chamber to which fluid is directed by the control rod. Conveniently, the bleed passage or each bleed passage may be provided in or adjacent to the gasket between the body containing the spool chamber and the housing of the control rod. Thus, a groove may be cut in the gasket to extend between two of the passages.

In one example of a pump as illustrated in Figures 1 and 2 but modified by the provision of two bleed passages, a bleed passage formed in the gasket extends between the passage 46 and the passage 68. Thus, when air under pressure is directed from the inlet passage 45 through the passage 46 to the space 31, air is permitted to bleed at a relatively low rate from the passage 46 to the passage 68 and the corresponding end of the spool chamber. This maintains a substantial pressure on the end face 41 of the spool to ensure that the spool is moved fully to and is held in the required position engaging the end face 44 of the spool chamber. The end portion of the spool chamber adjacent to the face 44 is vented by a further bleed passage, formed in the gasket, and extending between the passage 69 and the passage 47.

The provision of the bleed passages avoids any tendency for the spool to stick in an intermediate position in which the central land 35 partly covers the inlet passage 45 and restricts the supply of air to one or other of the spaces 31 and 32.

It will be understood that, if movement of the spool within the spool chamber is not completed before the control rod 27 moves out of its limit position, supply of air under pressure other than through a bleed passage to one end portion of the spool chamber would be interrupted and the spool may fail to reciprocate fully. This could lead to the control rod failing to complete its stroke so that the pump stalls.

The bleed passages provided in the gasket would be of small cross-sectional area, compared with the cross-sectional area of the flow passage extending to and from the spool chamber. Thus, whilst the passages extending to and from the spool chamber are typically 10mm to 12mm in diameter, it is intended that the bleed passages be between 0.5mm and 1mm in diameter.

In place of bleed passages formed in the gasket, bleed passages may be formed in respective piston portions 38 and 39 of the spool. It will be noted that such bleed passages do not provide for the continuous supply of air under pressure from the inlet 45 to both ends of the spool chamber, since only one of the recesses in the spool is in communication with the air inlet passage at any one time.

CLAIMS:

1. A pump comprising two chambers, each chamber having an inlet and an outlet for pumped fluid, the inlet and the outlet being controlled by respective valves, wherein a part of the wall of each chamber is formed of a respective diaphragm, the pump further comprising a rigid connection between the diaphragms of respective chambers whereby movement of the diaphragms increases the volume of one chamber and decreases the volume of the other chamber, an inlet for an operating fluid, and a directing means for directing the operating fluid alternately to respective enclosed spaces which are adjacent those surfaces of respective diaphragms which are outside the chambers, the directing means comprising a spool which is slidable between two positions in a spool chamber, a first passage leading from the operating fluid inlet to the spool chamber, and second and third passages leading from the spool chamber to respective ones of said spaces, wherein,when the spool is in a first of said positions, the first passage communicates with the second passage, and, when the spool is in the second of said positions, the first passage communicates with the third passage, characterised by control means (9) movable with the diaphragms (24,26) for directing fluid to the ends of the spool chamber (33) alternately and for preventing supply of fluid to an end opposite to that end to which fluid is directed at a selected moment.

2. A pump according to Claim 1 wherein the control means (9) is arranged also for controlling flow of fluid from ends of the spool chamber (33).

3. A pump according to Claim 2 wherein the control means includes a rigid connecting member (27) which provides the rigid connection between the two diaphragms (24,26) and is mounted in a housing (28) for sliding

between first and second limit positions, in the first of which positions the control means directs fluid to one end of the spool chamber and allows fluid to leave the other end of the spool chamber and in the second of which positions the control means directs fluid to the other end of the spool chamber and allows fluid to leave the one end of the spool chamber.

4. A pump according to any preceding claim wherein the spool (34) comprises respective end portions (38,39) and a single land (35) which lies between the end portions and is separated therefrom by respective recesses (36,37), wherein each of the end portions acts as a piston in the spool chamber when fluid is directed to a corresponding end of the spool chamber so that the spool is driven from one of said positions to the other position.

5. A pump according to Claim 4 wherein movement of the spool (34) from one position to the other position carries the land (35) from one side of the first passage (45) to the other side thereof.

6. A pump according to any preceding claim wherein a face of one end portion (38,39) engages the face at a respective end of the spool chamber (33) when the spool is in one of said positions.

7. A pump according to any one of the preceding claims comprising a bleed passage for admitting fluid to an end of the spool chamber (33) from a respective one of the other spool passages of the pump whenever the pressure in said one of the other passages exceeds the pressure in said end of the spool chamber.

8. Any novel feature or novel combination of features disclosed herein or in the accompanying drawings.

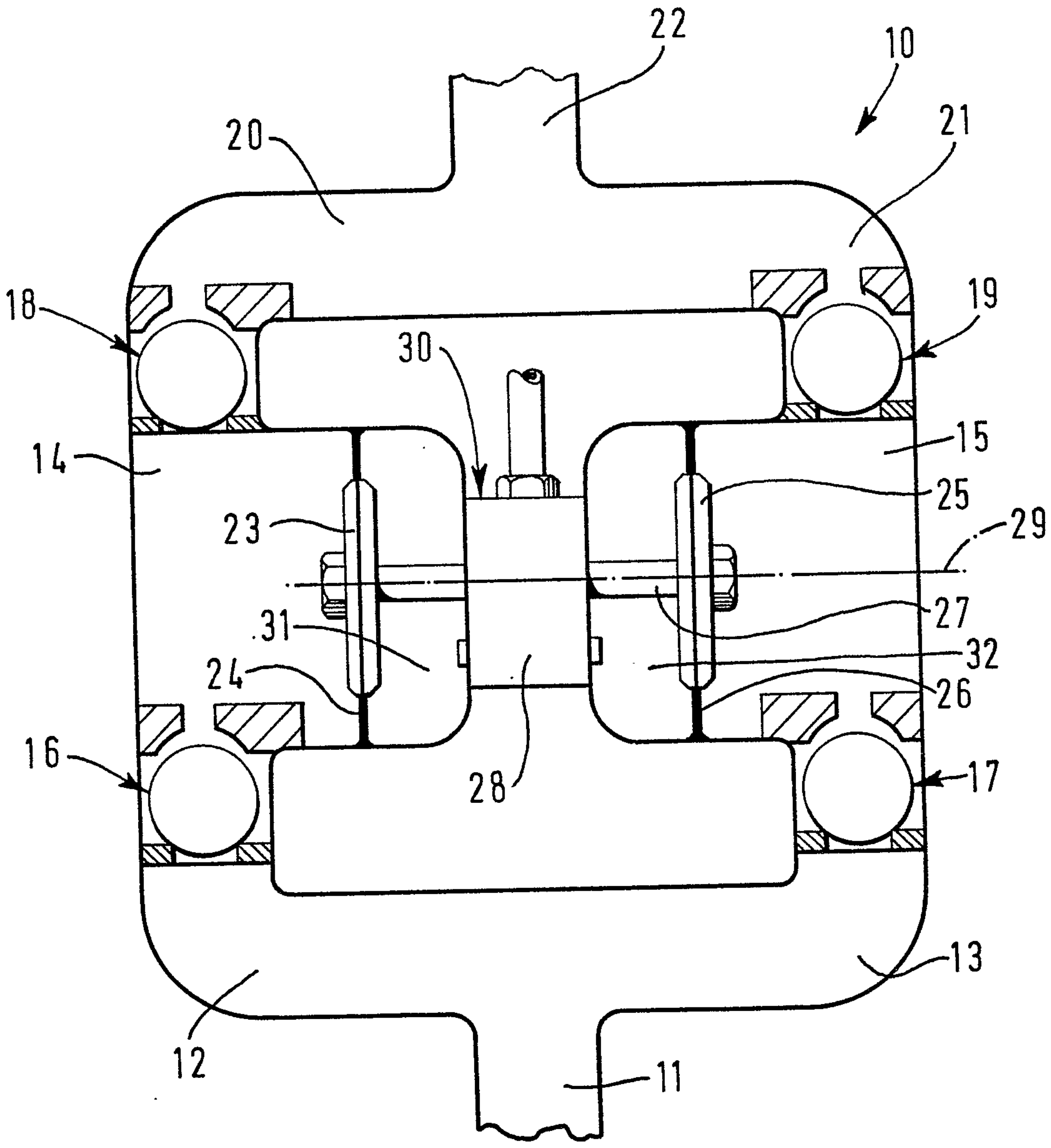

FIG 1

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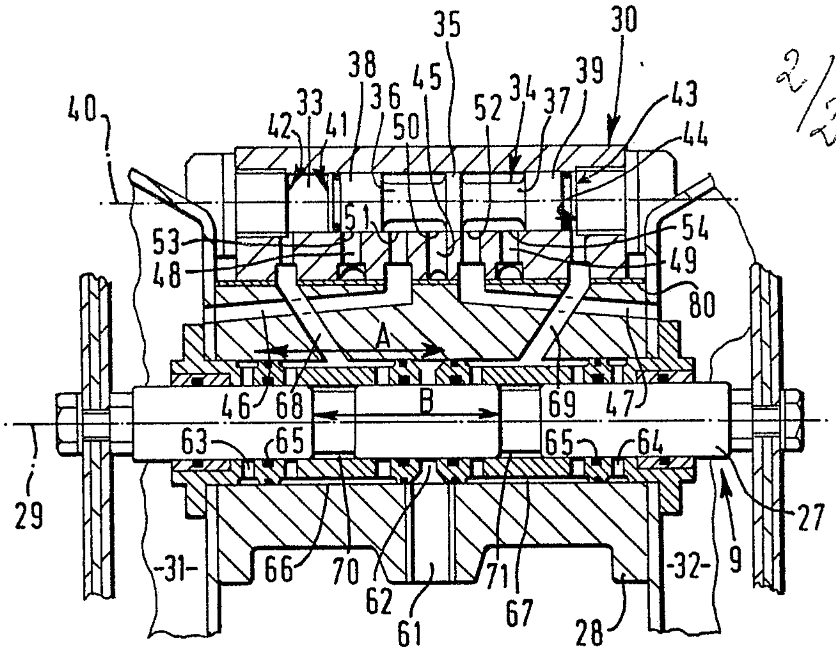
FIG 2



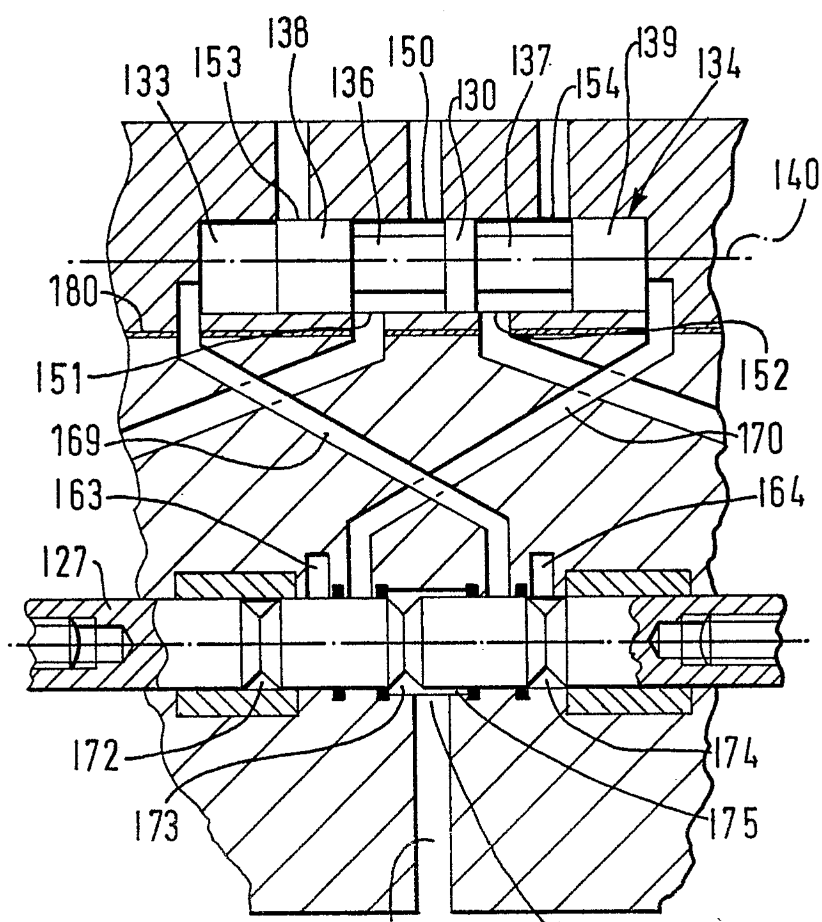


FIG 3