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54 **Fluid motor.**

57 A fluid motor comprising a housing including first and second cylinders. First and second pistons are rigidly fixed to each other and situated in their respective cylinders. First and second flexible seals act to seal between the pistons and their respective cylinders. The housing has an inlet port for receiving working fluid and first and second outlet conduits for exhausting the working fluid. The motor also includes a working fluid valving means for alternately providing pressurized working fluid to the cylinders, including a single spool valve adapted to alternate between first and second positions, and means for moving the working fluid valving means between the first and second positions.

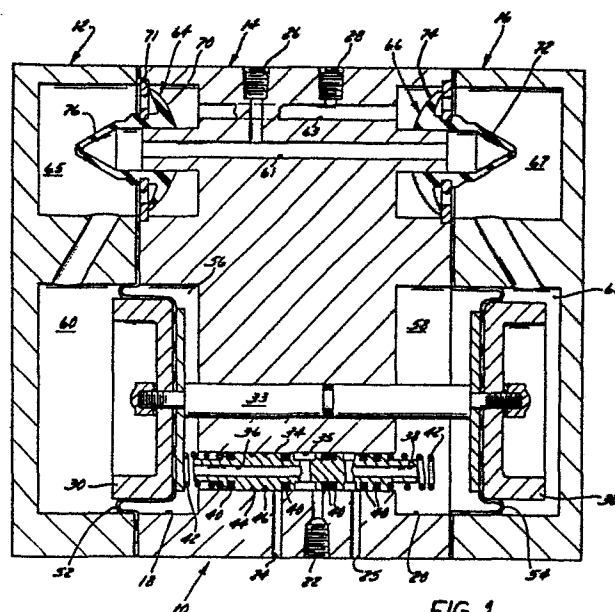


FIG. 1

FLUID MOTOR

This invention relates to fluid motors.

It has been known for many years to provide a motor having two pistons and two cylinders and operated by a fluid pressure alternating in the two cylinders so as to move the pistons back and forth. Such a motor has been used as an actuator, as a pump, and as the driver for a mechanical tool such as a saw. In order to operate the fluid motor, some kind of working fluid must be provided, and a valving apparatus must be used so that the working fluid alternately enters and exits each cylinder. The devices of the prior art provide various valving means for supplying the working fluid. Most of these valving means are quite complicated and involve several moving parts. The mechanism for timing the valving means properly so that the working fluid enters and leaves the appropriate chamber at the appropriate time is susceptible to misadjustment and failure, and the valving means itself is susceptible to jamming or wearing. Excessive wear may cause the loss of a seal around the valving means.

In the case of fluid motors which are used as pumps, a second set of valving means is required in order to control the movement of the pumped fluid. This second set of valving means generally includes four separate valves.

The present invention provides a very simple fluid motor, in which the valving means controlling the flow of the working fluid is a single, integral member having two positions. The term "valving means" as used here for valving the working fluid is meant to be exclusive of seals, although seals may be located around the valving means. Since only one part moves, there is greater reliability in this motor than in motors in which the valving means comprises more than one moving part. Also, because there is only one moving part, there is less surface area which rubs due to movement of the part, and therefore less wear on the components. It is also easier to seal a single, integral member than to seal several members. Furthermore, this single, integral member may be easily removed from the housing in order to replace seals, if that becomes necessary.

The embodiment of the present invention shown here also provides a simple detent means for stopping the valving member at its first and second positions; namely, there is a pair of axially spaced cannelures or grooves in the outer surface of the valving member and two spring-loaded balls in the housing adapted to fit into one or the other of the grooves when the valving means reaches either of its two operative positions. The two spring-loaded balls oppose each other so that the force on the valving member is balanced. This means that a large force can be applied by the spring-loaded balls without causing the valving member to deviate from its axially-oriented direction of travel and without causing high friction forces on the valving member.

In the embodiment shown here, the seals between each piston and its cylinder are rolling diaphragm seals, made of fabric reinforced polymer, such as those manufactured by Bellofram Corporation. In these seals, however, the reinforcing fabric does not extend to the edge of the diaphragm but instead stops short of the edge so that there is a good seal around the perimeter of the diaphragm, thereby preventing wicking of fluid through the fibers of the fabric.

In the embodiment shown here, the fluid motor is used as a pump, and novel valving means are provided in the pumping section in order to control the flow of the pumped fluid. The valving shown here is made up of only two valves, each being a combination umbrella-duck bill valve. The combination umbrella-duck bill valves are very simple, pressure-controlled valves, each doing the job of at least two valves of the prior art.

A more thorough understanding of the present invention will be gained by reading the following description of the preferred embodiments with reference to the accompanying drawings in which:

Figure 1 is a sectional view of a fluid motor made in accordance with the present invention.

Figure 2 is an enlarged, broken-away section of the fluid motor shown in Figure 1, showing the means for stopping the valving member at its two positions.

Figure 1 shows a fluid motor 10, which in this particular case is acting as a pump. The pump shown here was

originally designed for pumping soda syrup but may be used in many other applications. The housing of the fluid pump 10 is made in three pieces 12, 14, and 16. Inside the housing are a first cylinder 18, a second cylinder 20, a working fluid inlet port 22, two working fluid outlet conduits 24, 25, a pumping fluid inlet port 26, and a pumping fluid outlet port 28. The first and second working fluid outlet conduits 24, 25 may exit the housing in two separate ports, as shown, or they may intersect and exit the housing at a single outlet port. A first piston 30 and a second piston 32 are rigidly connected to each other by means of a rod 33 and are situated such that each piston is in its respective cylinder 18, 20.

A spool valve 34 operates in a bore 35 between the cylinders 18, 20 as a working fluid valving means for alternately providing working fluid first to the first cylinder 18 and exhausting the second cylinder 20, and then providing working fluid to the second cylinder 20 and exhausting the first cylinder 18. It is likely that the working fluid will be a pressurized fluid such as compressed air, which then exhausts into the atmosphere. However, the working fluid could instead be at a pressure lower than ambient, in which case the pistons would move opposite to the directions described herein. If a low pressure working fluid were used instead of a high pressure fluid, the working fluid inlet port 26 would allow fluid to flow from the cylinder into the low pressure area, creating a low pressure in the cylinder, and the outlet conduits 24, 25 would serve to exhaust or relieve the low pressure by allowing ambient fluid to move into the cylinder. The spool valve 34 includes a first internal conduit 36, which is in constant fluid communication with the first cylinder 18, and a second internal conduit 38, which is in constant fluid communication with the second cylinder 20. There is a plurality of O-ring seals 40 which seal between the spool valve 34 and the bore 35 in the housing 14. At each end of the spool valve 34 is a spring 42, which is adapted to absorb energy from its respective piston 30, 32 and to transfer that energy to the spool valve 34.

The spool valve 34 also has a detent means for holding the valve in either of two operative positions. The detent means includes two grooves 44, 46 in the outer surface of the spool

valve 34, and a pair of opposed, spring-loaded balls 48, 50 in suitable transverse bores 49, 51 in the housing 14. As shown in Figure 2, the two spring-loaded balls 48, 50 are adapted to fit into the annular grooves 44, 46 to stop the spool valve at two positions. The spring-loaded balls 48, 50 are situated opposite each other so that the force on the spool valve 34 is balanced. Because the two ends of the spool valve 34 always see different pressures, there is always a force tending to push the spool valve in one direction or the other. There must be sufficient force applied to the spool valve 34 so that it does not move due to that force. In this embodiment, that force is provided by the spring-loaded balls 48, 50. If a large, unbalanced transverse force were applied to the spool valve, for example if there were only one spring-loaded ball, the friction force on the spool valve 34 might tend to cause the spool valve to bind. However, with the balanced, opposed balls 48, 50, a large force can be applied in order to retain the spool valve in its position without causing the spool valve to bind.

In each cylinder 18, 20 is a rolling diaphragm seal 52, 54 which seals between each piston 30, 32 and its respective cylinder 18, 20. Each diaphragm seal 52, 54 separates its respective cylinder 18, 20 into inner chambers 56, 58 and outer chambers 60, 62. The inner chambers 56, 58 are in constant fluid communication with the spool valve 34, and are adapted to receive the working fluid. It should be noted that the diaphragms 52, 54 are made of a fabric-reinforced polymer, in which the fabric does not extend all the way to the inner and outer edges of the diaphragm. This provides a good seal so that fluid is not wicked through the fibers of the fabric.

The outer chambers 60, 62 are in fluid communication with the pumping fluid inlet and outlet ports 26, 28 by way of conduits 61 and 63 and are adapted to receive the fluid which is being pumped. Between the outer chambers 60, 62 and the pumping inlet and outlet ports 26, 28 are located a pair of valve chambers 65, 67 containing the pumping fluid valving means 64, 66 which regulate the flow of the pumped fluid so that the fluid is pumped into the housing through the pumping fluid inlet port 26 and out of the housing through the pumping fluid outlet port 28. In this case, the pumping fluid valving means is made up of two

combination umbrella-duckbill valves 64, 66, said valves being in fluid communication with the outer chambers 60, 62 and with the pumping fluid ports 26, 28. The first umbrella-duckbill valve 64 has an umbrella portion 70, which bears against an apertured valve plate 71 to seal the valve chamber 65 from the fluid outlet 28 when the chamber 65 pressure is less than the pumping fluid outlet pressure but flexes to allow pumped fluid to move from the first outer chamber 60 and the valve chamber 65 to the pumping fluid outlet port 28 when the pressure in the chamber 65 exceeds the outlet pressure. The valve 64 also includes a duckbill portion 76, which allows pumped fluid to move from the pumping fluid inlet port 26 through the valve chamber 65 and into the first outer chamber 60 when the pressure in chambers 65 and 60 is less than the inlet pressure, but which closes when the pressure in chambers 65 and 60 exceeds the inlet pressure. Likewise, the second umbrella-duckbill valve 66 has an umbrella portion 74, which permits pumped fluid to move from the second outer chamber 62 to the pumping fluid outlet port 28 while preventing movement of fluid in the opposite direction, and a duckbill portion 72, which flexes to permit fluid to move from the pumping fluid inlet port 26 to the second outer chamber 62 while preventing movement of fluid in the opposite direction.

Assembly of the fluid motor 10 may be accomplished as follows: the spool valve 34, rod 33 which connects the pistons, and umbrella-duckbill valves 64, 66 may be inserted into position in the center member 14 of the housing. The diaphragms 52, 54 and pistons 30, 32 may be fixed into place, and then the outer housing members 12, 16 may be brought into position and fixed in place either by bolting or by some other known means. The outer housing members 12, 16 clamp the diaphragm seals 52, 54 in position. While this fluid motor 10 is expected to be much more reliable than previous motors, if any repairs are required, such as the replacement of a seal, the repair can usually be accomplished simply by removing one of the end members of the housing either 12 or 16. With either end member 12 or 16 removed, the spool valve 34 can be removed and all the O-rings 40 replaced.

Operation of the fluid motor 10 is as follows: When the spool valve 34 is in its first position, with the balls 48, 50

located in the groove 44, as shown in Figures 1 and 2, the working fluid enters the first inner chamber 56 through the working fluid inlet port 22 and through the first internal conduit 36 in the spool valve 34. At the same time, the second inner chamber 58 is exhausted through the second internal conduit 38 and through the second working fluid outlet conduit 25. Because a high pressure is acting on the first piston 30 while a low pressure acts on the second piston 32, the pistons move toward the left. When the pistons move toward the left, any fluid which is in the first outer chamber 60 will be pumped through the umbrella portion 70 of the umbrella-duckbill valve 64 and will leave the housing through the pumping fluid outlet port 28. At the same time, pumped fluid is pulled into the second outer chamber 62 through the pumping fluid inlet port 26 and through the duckbill portion 72 of the second umbrella-duckbill valve 66. As the second piston 32 moves toward the left, it contacts the spring 42 at the end of the spool valve 34. The spring 42 stores up the force from the second piston 32 until the force is great enough to overcome the retaining force which is exerted by the balls 48, 50 in the groove 44. When that retaining force is overcome, the balls 48, 50 move out of the groove 44, the force which has been stored in the spring 42 is released, and the spool valve 34 is pushed toward the left until the balls 48, 50 rest in the groove 46.

The spool valve 34 is now in its second position, and the working fluid communication with the inner chambers 56, 58 is reversed. The working fluid enters the inner chamber 58 through the working fluid inlet port 22 and through the second internal conduit 38. At the same time, the first inner chamber 56 is exhausted through the first internal conduit 36 and through the first working fluid outlet conduit 24. Because the second piston 32 now sees a high pressure while the first piston 30 sees a lower pressure, the pistons will move toward the right. This causes the pumped fluid in the second outer chamber 62 to be pumped out through the umbrella portion 74 of the valve 66 and out the pumping fluid outlet 28. At the same time, pumped fluid will be pulled into the first outer chamber 60 through the pumping fluid inlet 26 and through the duckbill portion 76 of the first valve 64. This will continue until the first piston 30

hits the spring 42 on the left end of the spool valve 34 and compresses the spring 42 with enough force to dislodge the balls 48, 50 from the second groove 46, so that the spool valve 34 moves to the right until the balls 48, 50 fit into the first groove 44, returning the spool valve to its first position, where the process will be repeated.

Thus, the present embodiment of the invention provides a simple valving means made up of a single spool valve adapted to move to two operative positions. The movement of the spool valve is controlled by the pistons which push the spool valve as they move back and forth, by the spring which stores the force of the piston until it is large enough to overcome the retaining force provided by the spring-loaded balls and which then releases the stored force in order to push the valve to its other position, and by the spring-loaded balls which stop the spool valve at its two positions. This mechanism is simple, easily timed so that fluid communication opens and closes at the correct time, and is balanced to reduce the opportunity for hang-ups and jamming and to increase the probability for smooth operation. This mechanism is likely to experience less wear than devices of the prior art and is easily repaired in the event a malfunction does occur. The valving for the pumped fluid is also simplified in this device, again increasing the reliability of the pump.

While the embodiment as shown and described herein is the preferred embodiment of the present invention, it will be obvious to those skilled in the art to make various modifications within the scope of the present invention.

CLAIMS:

1. A fluid motor, comprising:
 - a. first and second pistons (30, 32) rigidly fixed to each other;
 - b. a housing (12, 14, 16) including first and second cylinders (18, 20) situated such that each piston is in its respective cylinder;
 - c. first and second flexible seals (52, 54) acting to seal between said pistons and their respective cylinders;
 - d. said housing having an inlet port (22) for receiving working fluid and first and second outlet conduits (24, 25) for exhausting said working fluid;
 - e. working fluid valving means for alternately providing working fluid to said first cylinder and exhausting said second cylinder in a first position and then providing working fluid to said second cylinder and exhausting said first cylinder in a second position, consisting of a single spool valve (34) operating in a bore (35) and adapted to alternate between said first and second positions;
 - f. means for sealing around said spool valve;
 - g. means for moving said working fluid valving means between said first and second positions; and
 - h. means for deriving useful work from the movement of said pistons caused by the alternating pressures in said cylinders.
2. A fluid motor, comprising:
 - a. first and second pistons (30, 32) rigidly fixed to each other;
 - b. a housing (12, 14, 16) including first and second cylinders (18, 20) situated such that each piston is in its respective cylinder;
 - c. first and second flexible seals (52, 54) acting to seal between said pistons and their respective cylinders;
 - d. said housing having an inlet port (22) for receiving working fluid and first and second outlet conduits (24, 25) for exhausting said working fluid;
 - e. working fluid valving means for alternately providing working fluid to said first cylinder and exhausting said second cylinder at a first position and then providing

working fluid to said second cylinder and exhausting said first cylinder at a second position, comprising a spool valve (34) which has first and second internal conduits (36, 38) in constant fluid communication with said first and second cylinders, respectively, said spool valve being adapted to move to two different positions such that, in the first position the first internal conduit (36) is in fluid communication with said inlet port (22) and said second internal conduit (38) is in fluid communication with said second outlet conduit (25), and, in the second position the first internal conduit (36) is in fluid communication with said first outlet conduit (24) and the second internal conduit (38) is in fluid communication with said inlet port (22); and

f. means for moving said working fluid valving means between said first and second positions.

3. A fluid motor as recited in claim 1 or 2, wherein said flexible seals comprise rolling diaphragms, and further comprising means for stopping said valving means at said first and second positions.

4. A fluid motor as recited in claim 3, wherein said means for moving said spool valve between said first and second positions comprises said pistons applying force to said spool valve and includes a spring (40) at each end of said spool valve for storing the force applied by said pistons and transmitting said force to said spool valve.

5. A fluid motor as recited in claim 4, wherein said spool valve lies in a bore connecting said first and second cylinders, and wherein said spool valve protrudes into said cylinders such that each of said pistons engages the spring at its end of the spool valve as the piston travels toward the spool valve.

6. A fluid motor as recited in claim 1, wherein said single spool valve has first and second internal conduits (36, 38) in constant fluid communication with said first and second cylinders (18, 20), respectively, and alternates between putting said internal conduits in fluid communication with said inlet port (22) and with their respective outlet conduits (24, 25).

7. A fluid motor as recited in claim 4, wherein said means for stopping said working fluid valving means at said first and second positions comprises a groove (44) in the outer surface of

said spool valve and two opposed, spring-loaded balls (48, 50) adapted to fit in said groove.

8. A fluid motor as recited in claim 4, wherein said means for stopping said spool valve at said first and second positions comprises first and second annular grooves (44, 46) in the outer surface of said spool valve and two spring-loaded balls (48, 50) aligned opposite each other and adapted to fit in opposite sides of said grooves, such that, when said balls are aligned with said first groove they move into said first groove, thereby stopping the spool valve at said first position, and, when said second piston pushes said spool valve, said balls are forced out of said first groove and move into said second groove, thereby stopping said spool valve at said second position.

9. A fluid motor as recited in claim 1 or 2, wherein each of said seals separates its respective cylinder into inner and outer chambers, each of said inner chambers (56, 58) being in fluid communication with said working fluid valving means, and said housing further having pumping fluid inlet (26) and outlet (28) ports in fluid communication with said outer chambers (60, 62); and

pumping fluid valving means between said pumping fluid ports and said outer chambers, said pumping fluid valving means operating such that the movement of said pistons causes pumped fluid to be pumped into said housing through said pumping fluid inlet port and out of said housing through said pumping fluid outlet port.

10. A fluid motor as recited in claim 9, wherein said pumping fluid valving means comprises two combination umbrella-duckbill valves (64, 66).

11. A fluid-operated pump, comprising:

a. a housing (12, 14, 16) having pumping fluid inlet and outlet ports (26, 28), a working fluid inlet port (22), and first and second working fluid outlet conduits (24, 25);

b. first and second cylinders (18, 20) in said housing and first and second pistons (30, 32) situated in their respective cylinders, said pistons being rigidly connected to each other;

c. first and second flexible seals (52, 54), each seal operating to seal between one piston and its respective cylinder

so as to divide each cylinder into inner and outer chambers, said outer chambers (58, 60) being in fluid communication with said pumping fluid ports, and said inner chambers (56, 58) being in fluid communication with their respective working fluid outlet conduits and with said working fluid inlet port;

d. a spool valve (34) located between said inner chambers and said working fluid inlet and outlets, said spool valve having first and second internal conduits (36, 38), the first internal conduit (36) being in constant fluid communication with said first inner chamber (56), and the second internal conduit (38) being in constant fluid communication with said second inner chamber (58), said spool valve being adapted to move to two different positions, wherein, in the first position, the first internal conduit is in fluid communication with the working fluid inlet port and the second internal conduit is in fluid communication with the second working fluid outlet conduit, and, in the second position, the first internal conduit is in fluid communication with the first working fluid outlet conduit and the second internal conduit is in fluid communication with the working fluid inlet port; and

e. pumping fluid valving means located between said pumping fluid ports and said outer chambers and operating such that the movement of said pistons causes pumped fluid to be pumped into said housing through said pumping fluid inlet port and out of said housing through said pumping fluid outlet port.

12. A fluid-operated pump as recited in claim 11, wherein said pumping fluid valving means comprises two combination umbrella-duck bill valves (64, 66) in fluid communication with said outer chambers and with said pumping fluid ports.

13. A fluid-operated pump, comprising:

a housing (12, 14, 16), having a pair of internal cylinders (18, 20), and a pair of pistons (30, 32) located in said cylinders, wherein the movement of said pistons in said cylinders is caused by working fluid pressure alternating in said cylinders;

said housing having first and second pumping fluid chambers (60, 62) in fluid communication with said pistons;

said housing also having pumping fluid inlet and outlet ports (26, 28) in fluid communication with said pumping fluid chambers; and

a pair of combination umbrella-duck bill valves (64, 66) situated between said pumping fluid ports and said pumping fluid chambers, such that the motion of said pistons causes pumping fluid to be pumped in through said pumping fluid inlet port and out through said pumping fluid outlet port.

14. A fluid-operated pump as recited in claim 13, further comprising a pair of rolling diaphragm seals (52, 54), each seal operating to seal between a piston and its respective cylinder, each of said seals being made of a fabric-reinforced polymer, wherein the reinforcing fabric terminates short of the innermost and outermost diameters of said diaphragm so as to prevent wicking of fluid through said fibers.

15. A fluid-operated pump as recited in claim 14, further comprising a spool valve (34) having first and second internal conduits (36, 38), each of said internal conduits being in constant fluid communication with its respective cylinder and adapted to alternately supply pressurized working fluid to and exhaust working fluid from said cylinders.

1 / 1

