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Falciai et al.

[11] **3,834,841**

[45] **Sept. 10, 1974**

[54] **SYMMETRICAL ROTARY PUMP FOR A VARIABLE SPEED HYDROSTATIC TRANSMISSION**

[76] Inventors: **Fabrizio Falciai; Riccardo Falciai; Giuseppe Falciai; Renzo Falciai,** all of via Martelli 4, 50129, Florence, Italy

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[21] Appl. No.: **204,281**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 47,012, June 17, 1970, abandoned.

[52] **U.S. Cl.** **418/26,** 418/29, 418/138, 417/310, 417/540

[51] **Int. Cl.** **F01c 21/16,** F03c 3/00, F04c 15/04

[58] **Field of Search** 418/24, 25, 26, 29, 32, 418/138, 241, 137; 417/310, 540, 542

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Primary Examiner—Carlton R. Croyle
Assistant Examiner—John J. Vrablik
Attorney, Agent, or Firm—Armstrong, Nikaido & Wegner

[57] **ABSTRACT**

A symmetrical rotary pump is provided which includes a housing and a hollow cylindrical rotor mounted rotatably within the housing. The rotor has a main portion and an extension portion at each end thereof, both the extension portions being rotatably received in mounting means, so that the rotor is supported at both ends. The mounting means are movable radially of the axis of the rotor so as to move the rotor in a radial direction and hence change the eccentricity of the rotor. An input shaft extends longitudinally through the housing and through the interior of the rotor, and a plurality of vanes are freely pivoted on the input shaft, the vanes extending slidably through the main portion of the rotor. Transmission means connect the shaft and the rotor, and fluid is supplied to and removed from the pump by appropriate conduits.

4 Claims, 7 Drawing Figures

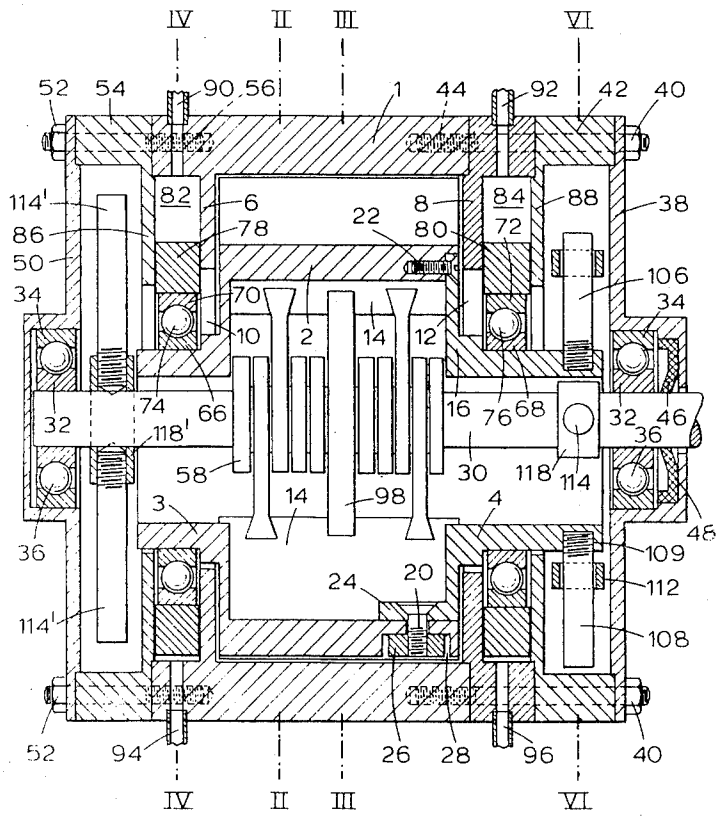


Fig. 1.

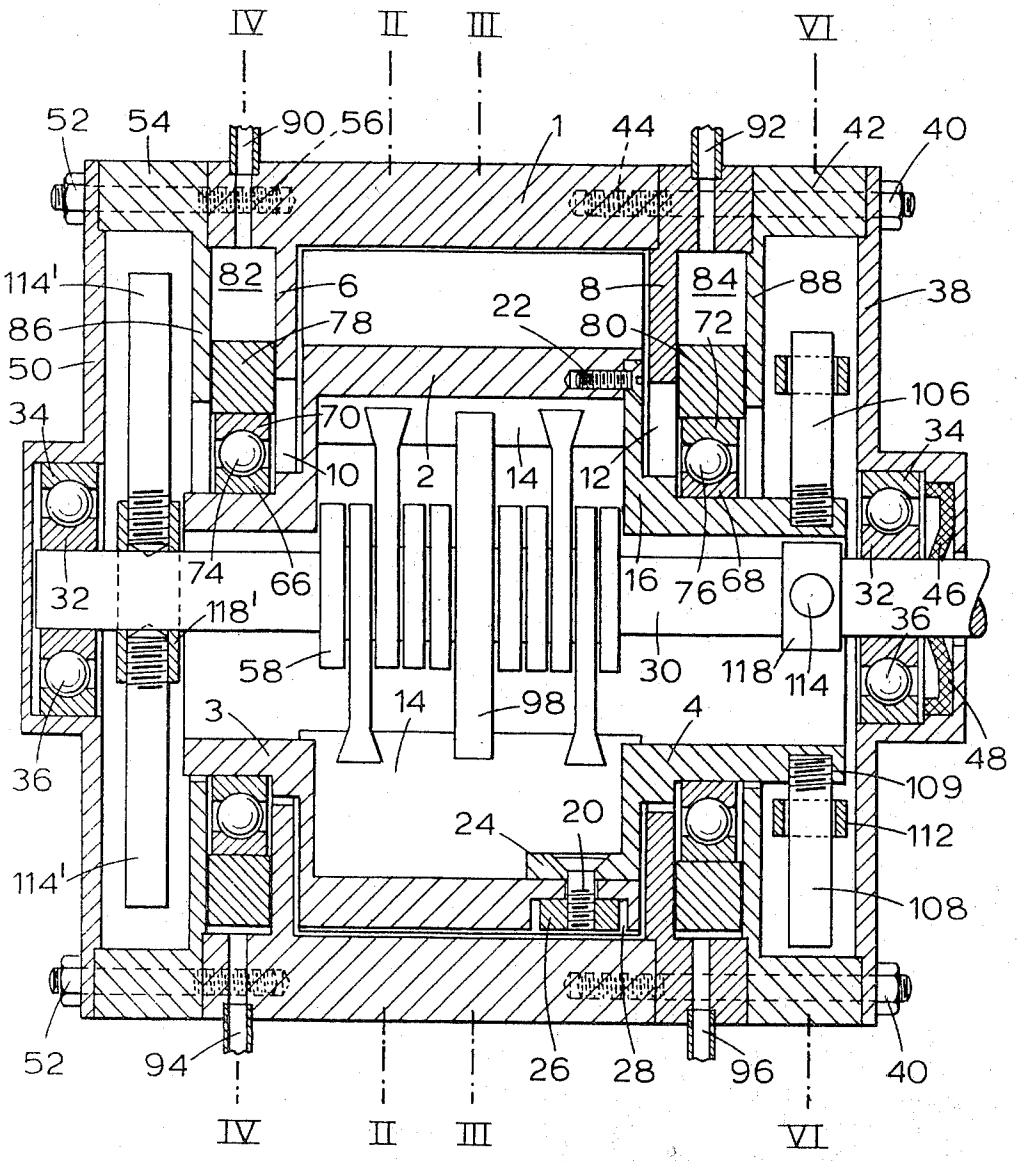

IV
II
III
VI
52
54
90
56
1
44
92
42
40
114'
82
6
8
84
88
38
86
78
22
80
72
50
34
70
106
10
2
14
12
34
74
66
16
76
68
32
46
32
118'
36
58
30
118
114
14
98
4
3
48
36
109
24
20
112
114'
108
52
94
26
28
96
40
IV
II
III
VI

Fig. 2.

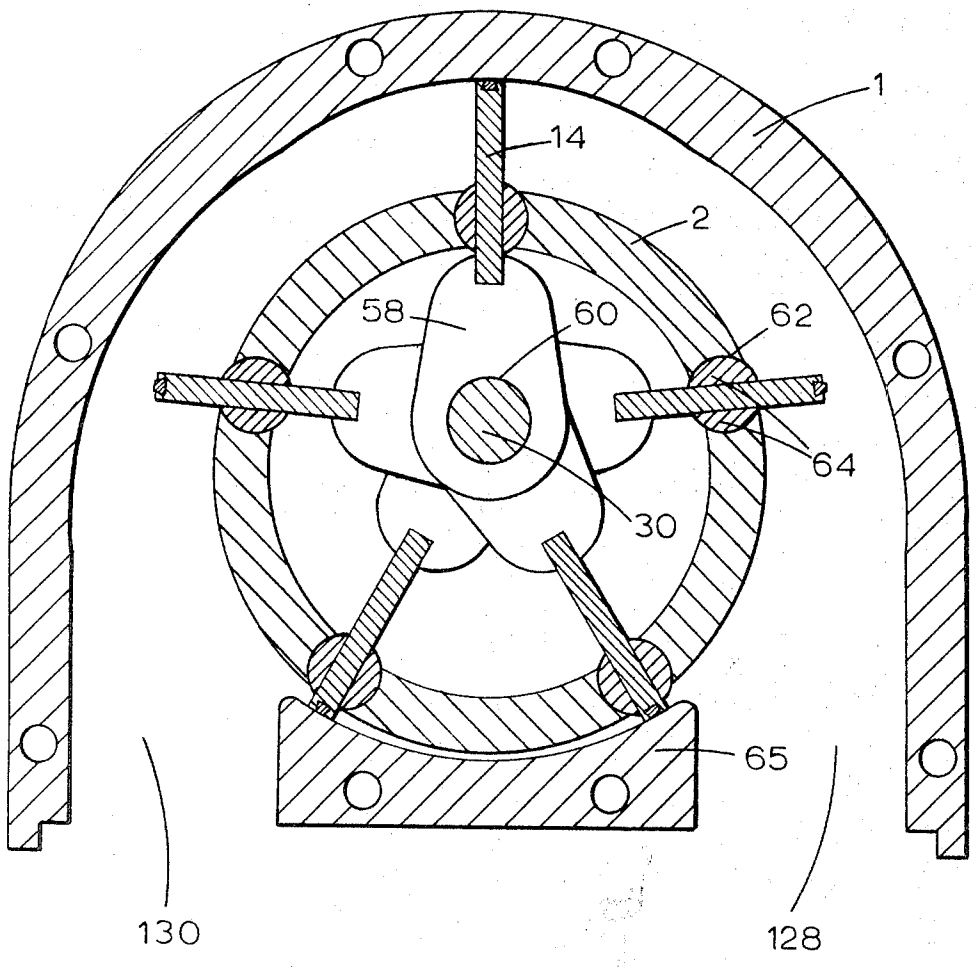


Fig. 3.

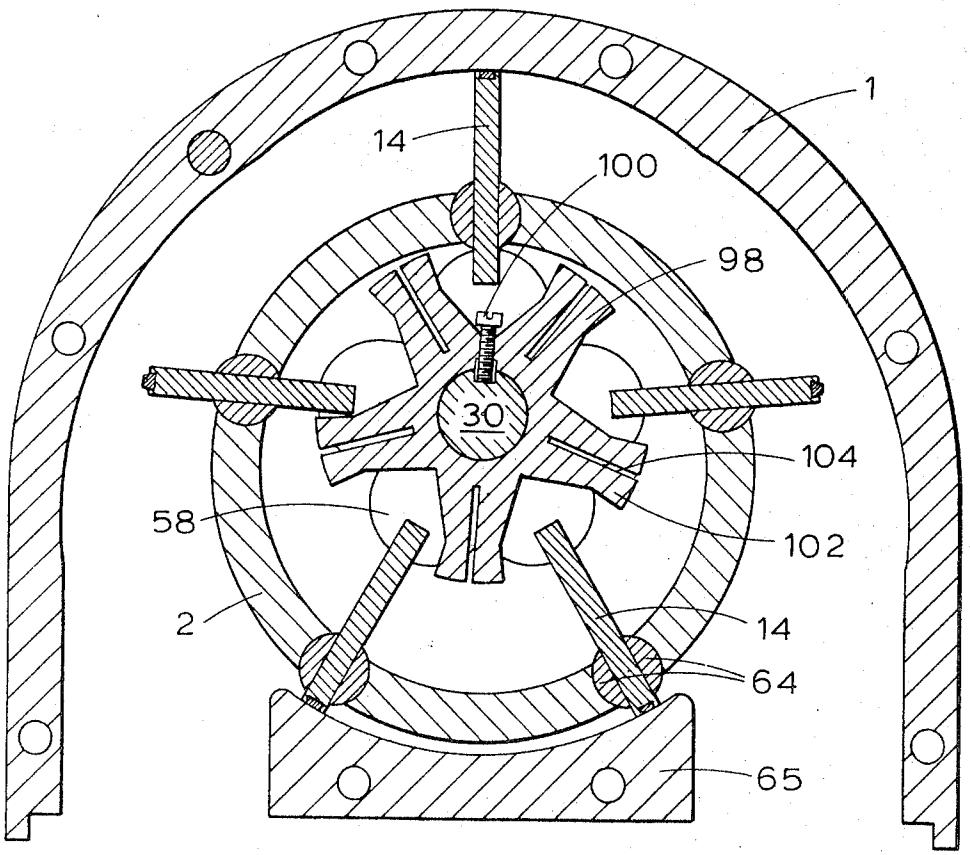


Fig. 4.

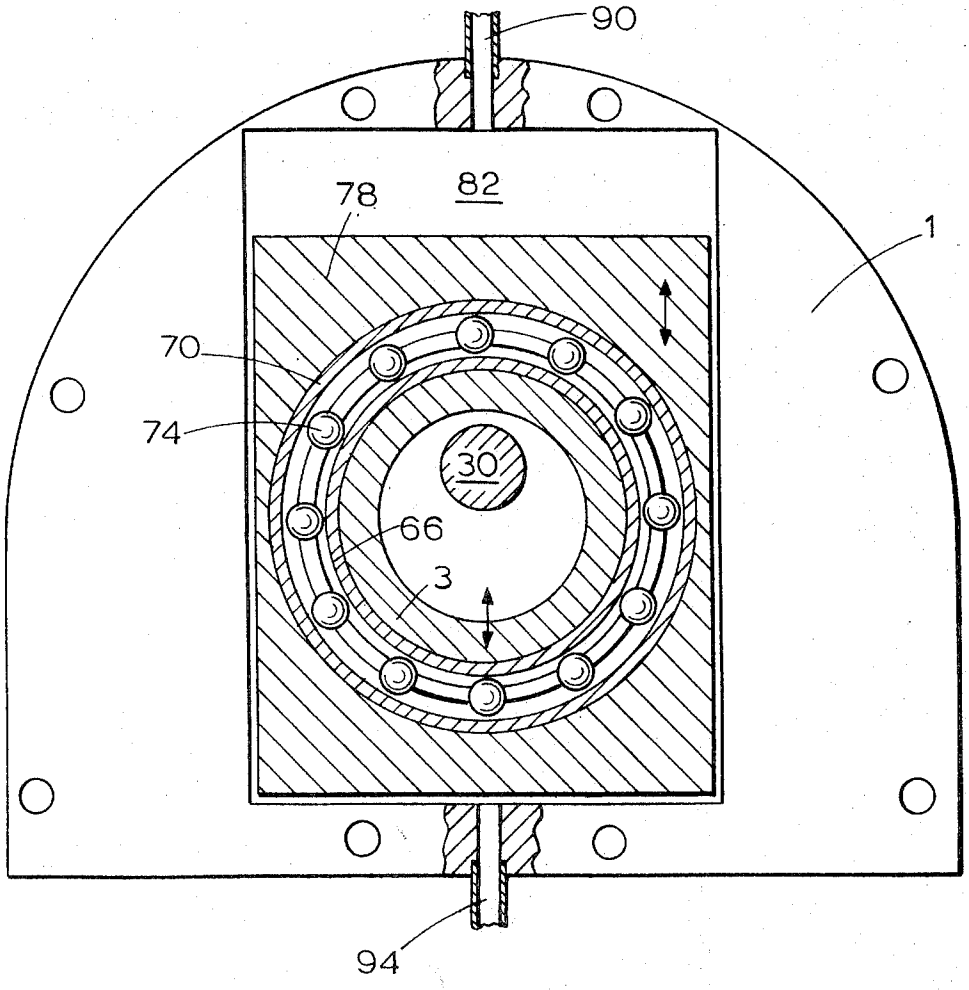
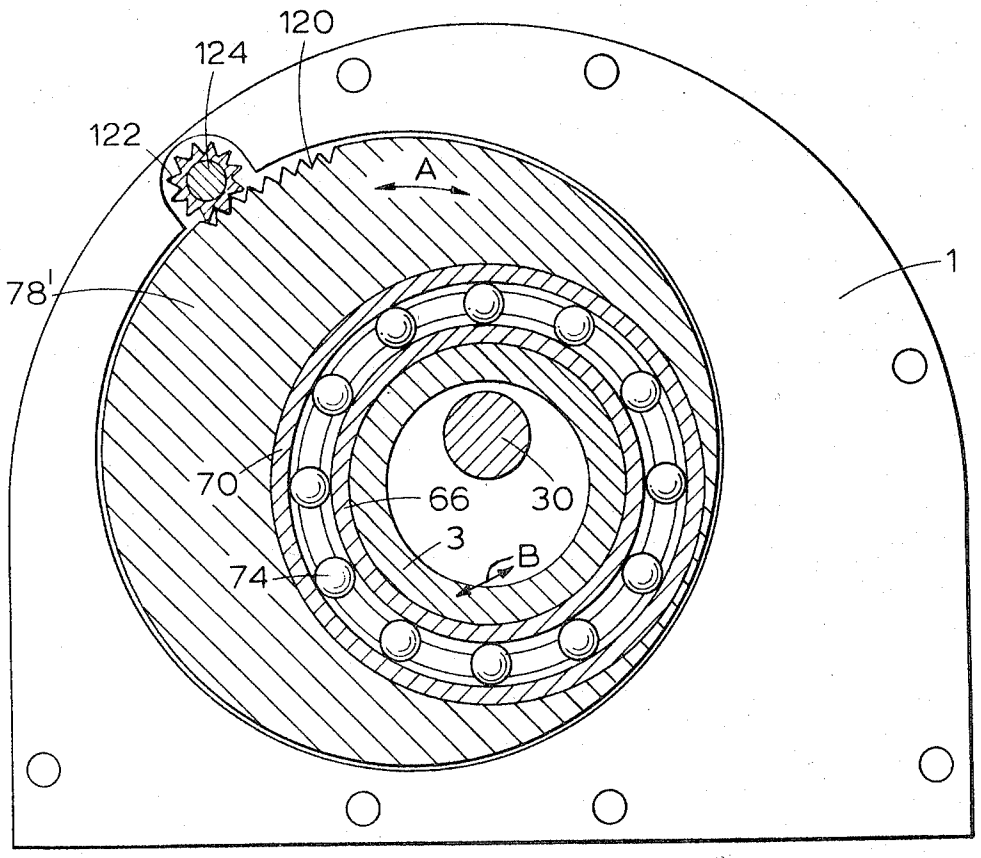


Fig. 5.



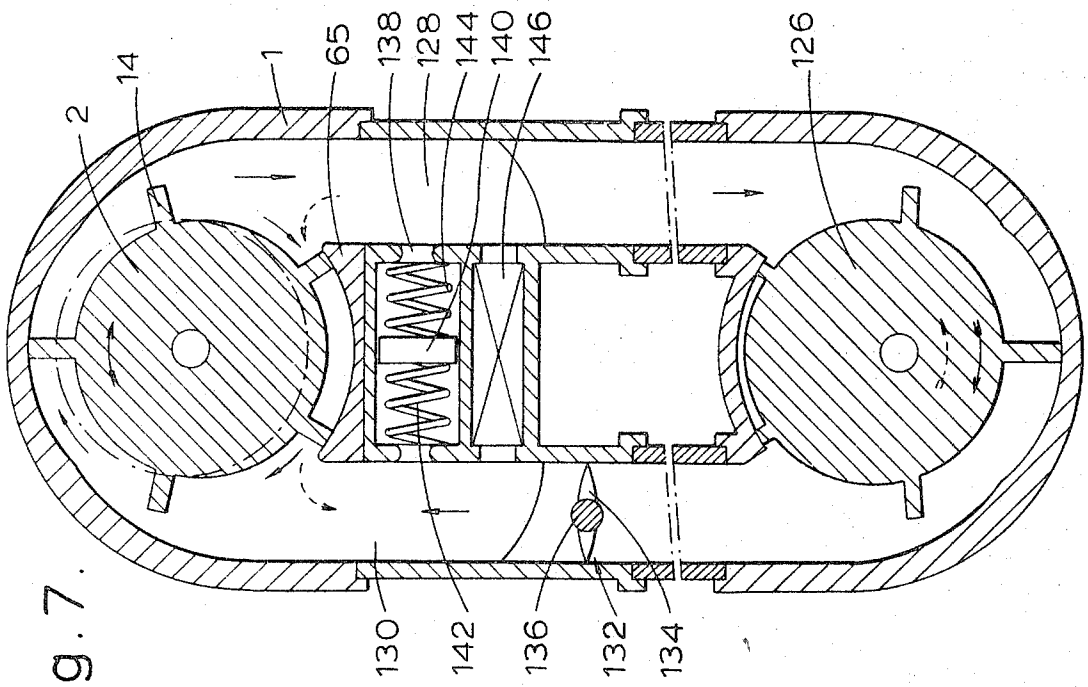

2
14
1
65
138
128
144
140
146
126
130
142
136
132
134

Fig. 7.

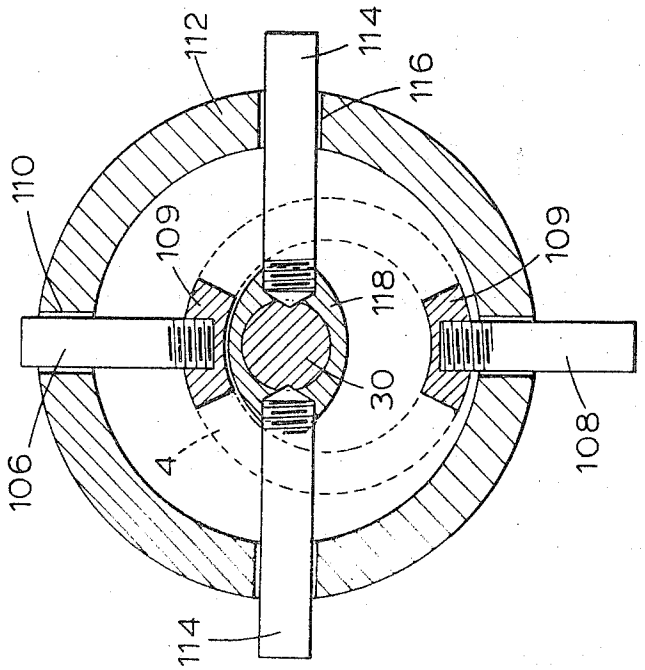

112
114
116
110
109
109
118
30
4
106
108
114

Fig. 6.

SYMMETRICAL ROTARY PUMP FOR A VARIABLE SPEED HYDROSTATIC TRANSMISSION

CROSS-REFERENCE TO RELATED APPLICATION

The present application is a continuation-in-part of co-pending application Ser. No. 47012 filed 17th June 1970 now abandoned.

BACKGROUND OF THE INVENTION

The present invention relates to a variable capacity rotary pump which is particularly, though not exclusively, useful in a stapless variable fluid type transmission. In this particular use of the pump it is connected to at least one drive unit functioning as a motor by conduits.

Pumps are known which have vanes in the form of pivoted blades. However these pumps usually have the rotor supported at one end only, and at high pressure this causes flexion of the rotor and consequently a considerable increase in the friction between it and the walls of the housing within which it rotates. Furthermore, with this form of construction it is difficult to make the rotor displaceable to change its eccentricity and thereby to change the delivery capacity of the pump.

SUMMARY OF THE INVENTION

The present invention provides a symmetrical rotary pump comprising a housing; a hollow cylindrical rotor having a main portion and an extension portion at each end thereof, the rotor being situated rotatably within the housing, mounting means for receiving each of the said extension portions rotatably therein; means for moving the mounting means radially of the axis of the rotor whereby to move the rotor in a radial direction; an input shaft extending longitudinally through the housing and through the interior of the rotor; a plurality of vanes freely pivoted on the shaft and extending slidably through the main portion of the rotor; transmission means providing a driving connection between the shaft and the rotor; input conduit means for supplying fluid to the pump; and output conduit means for taking fluid away from the pump.

This pump can be constructed in a separate block to the, or each motor, and connected to the motor or motors by means of flexible conduits provided with branches to that the power can be supplied where it is necessary. These conduits may be provided with a throttle valve and a safety valve may also be provided.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal section through one embodiment of the invention,

FIG. 2 is a cross-section taken along line II—II in FIG. 1,

FIG. 3 is a cross-section taken along line III—III in FIG. 1,

FIG. 4 is a cross-section taken along line IV—IV in FIG. 1,

FIG. 5 is a cross-section through an alternative embodiment of the invention, showing an alternative means for varying the eccentricity of the pump.

FIG. 6 is a cross-section taken along line VI—VI in FIG. 1,

FIG. 7 shows on a reduced scale a pump according to the invention in operative connection with a fluid motor.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring first to FIG. 1, the pump comprises a casing 1 defining an inner cavity within which a cylindrical rotor 2 is rotatably arranged. Connected to the main portion of the rotor at either end are cylindrical extensions 3, 4 having a smaller diameter than the main portion. The extensions pass through oblong orifices formed in internal walls 6, 8. In the position shown in FIG. 1 the rotor is eccentrically positioned and spaces 10, 12 are defined between the extensions 3, 4 and the internal walls 6, 8 respectively. The existence of the space 10 and 12 permits the rotor to be displaced in a direction which is vertical as viewed in FIG. 1.

The rotor is provided with a plurality of vanes 14 the mounting of which is described further below with reference to FIG. 2. In order to make it possible to assemble the rotor one of the extensions 4 is formed by a separate member 16 which is bolted to the main portion of the rotor by longitudinal bolts 18 (one of which is shown) or radial bolts (one of which is shown) 20. In any particular case only longitudinal bolts or only radial bolts will be used and the two types of bolts have been shown together purely for convenience of illustration. Each longitudinal bolt is received in a longitudinal screw threaded bore 22 in the main portion of the rotor and each radial bolt passes through an aperture in a longitudinal flange 24 of the member 16 and is received by a nut 26 positioned within a recess 28 on the exterior of the main portion of the rotor 2.

The rotor 2 has a power input shaft 30, connected thereto in a manner described below. The shaft 30 has a bearing member 32 connected to each end thereof, and each member 32 is rotatably mounted in a bearing block 34 by means of a plurality of balls 36. The righ hand bearing block 34 is fast with an end plate 38 which in turn is connected to the housing 1. The connection is made by means of a plurality of bolts 40 each of which passes through a respective aperture in the end plate 38, an aperture in an intermediate member 42, and an aperture in a member carrying the wall 8, and is received in a screw threaded bore 44 in the casing 1. In order to ensure that the pump is leak tight at the right hand end a seal illustrated diagrammatically at 46 is mounted around the shaft 30 on a radially inwardly directed flange 48 of the end plate 38. The shaft passes through the aperture defined by the flange 48 and is driven by means (not shown) positioned to the right of the pump.

The left hand end of the pump is closed by an end plate 50 which needs no flange corresponding to flange 48. The end plate 50 is attached to the casing 1 by means of a plurality of bolts 52 each of which passes through a respective aperture in the end plate 50, and an intermediate member 54, and is received in a screw threaded bore 56 in the casing 1.

FIG. 2 shows the manner in which the vanes are mounted. Each of the vanes 14 is fixed to a respective vane holder 58 which has an aperture 60. The shaft 30 passes through the aperture 60 in such a way that the vane holders are freely rotatable about the shaft. The main portion of the rotor 2 has a plurality (five as

shown in FIG. 2) of cylindrical bores **62** extending in an axial direction. A respective pair of nearly semicylindrical elements **64** are received in each bore in such a way as to be slidable therein about an axis parallel to the axis of the rotor. Each vane **14** passes slidably between a pair of the elements **64.** A vane guiding element **65** having a vane guiding surface is positioned to contact the ends of the vanes **14.**

As shown in FIGS. **1** and **4,** the extensions **3** and **4** carry bearing sleeves **66** and **68** respectively on their exteriors. The sleeves form part of bearings for the rotor which further comprises bearing sleeves **70** and **72** concentric with sleeves **66** and **68,** and balls **74** and **76** received between the sleeves **66** and **70,** and **68** and **72** respectively. The sleeves **70** and **72** are fixedly connected to blocks **78** and **80** respectively which have cylindrical apertures adapted to receive those sleeves. The blocks are slidably received in cavities **82** and **84** respectively which are defined by lateral portions of the casing **1,** as viewed in cross-section as in FIG. **4** and at either end by walls **6** and **86,** and **8** and **88.** The wall **86** extends radially inwardly from the intermediate member **54,** and the wall **88** extends similarly from the intermediate member **42.** The blocks **78** and **80** act as pistons sliding within their respective cavities. Movement of the blocks is accomplished by fluid pressure supplied through fluid lines **90, 92, 94** and **96.** The pistons are thus fitted into their respective cavities with a sliding fit, the spacing have been exaggerated in the drawings somewhat for the sake of clarity.

For the pump to function, rotational movement of the shaft **30** must be transmitted to the rotor **2.** FIG. **1** shows two alternative systems for performing this function, though of course only one would be used on any particular pump. The first system is shown in more detail in FIG. **3.** This includes a wheel **98** secured to the shaft **30** by means of a screw **100.** The wheel is provided with teeth **102** which are given a slight degree of resilience by being provided with radial slots **104.** The teeth engage the radially inner parts of the vanes **14** and thus exert a force on the vanes when the shaft **30** rotates. This causes the rotor **2** to rotate also.

The second system is illustrated at the right and left hand ends of FIG. **1** and in FIG. **6.** FIG. **6** shows pins **106** and **108** which are screwed into apertures in the axially projecting end portions **109** of the extensions **4** and pass slidably through apertures **110** in an annulus **112.** A further pair of pins **114** pass slidably through corresponding apertures **116** in the annulus, the apertures **116** being spaced 90° from the apertures **110.** A sleeve **118** is fixed to the shaft **30** and the ends of the pins **114** are screwed into the sleeve **118,** the ends of the pins **114** penetrating slightly into the shaft **30.** In this way the annulus **112** couples the shaft **30** and the rotor extension **4** for rotation together, while at the same time allowing radial movement of the rotor **4** relative to the shaft **30.** A similar structure is used at the left hand end of the shaft **30.** Purely for the purposes of illustration, it is shown as being displaced by 90° relative to the structure at the right hand end though this is not, of course, necessary for the functioning of the pump. The same reference numerals have been used to denote the corresponding parts with the addition of a superscript.

The apertures **110** and **116** are made slightly oversized so that in use a film of lubricating oil is trapped between the pins **106, 108, 114** and the walls of the apertures.

An alternative system to that shown in FIGS. **1** and **4** for adjusting the eccentricity and hence the delivery capacity of the pump, is illustrated in FIG. **5.** In FIG. **5** the reciprocable blocks **78** of FIG. **4** is replaced by a rotatable block **78'.** The block **78'** is provided on its circumference with teeth **120** which mesh with the teeth of a toothed wheel **122** secured for rotation on a shaft **124.** Rotation of the shaft **124** causes rotation of the block **78'** in the direction indicated by arrow A and this in turn causes movement of the rotor extension **3** in the direction indicated by the arrow B.

FIG. **7** shows diagrammatically a pump according to the present invention in operative connection with a fluid motor **126.** The rotor **2** of the pump has been drawn for convenience as a solid block though it is actually the same as the one illustrated in FIG. **2.** The motor has a fixed axis of rotation unlike the pump motor whose axis is radially adjustable. The pump communicates with the motor through conduits **128** and **130.** Preferably each conduit **128** and **130** divides into a pair of secondary conduits axially spaced from one another and a pair of motors **126** are provided each of which is fed by a respective one of the secondary conduits leading from conduit **128** and a respective one of the secondary conduits leading from conduit **130.** When used in a motor vehicle this means that a separate motor is used to drive each of a pair of driving wheels. The system then effectively acts as a differential with more fluid being supplied to the motor which is required to rotate faster (that is the motor driving the wheel on the outside of a bend around which the vehicle is travelling).

A throttle control **132** is positioned in the conduit **130** or a pair of controls actuated by a common actuator is mounted in each of the secondary conduits leading therefrom since the system is symmetrical it could alternatively be positioned in conduit **128.** The control **132** comprises a throttle valve **134** mounted on a pivot **136** and movable by suitable linkage under the control of an operator to brake the vehicle. The throttle valve is shown in the position of maximum braking in FIG. **7.** The pivot **136** is eccentrically arranged so that when no force is applied by the operator it automatically assumes a position in which the valve **134** lies parallel to the direction of flow of fluid in the conduit and hence provides the minimum resistance to flow. This effect can be further enhanced by providing a spring to bias the valve **134** to its non-throttle position.

Since the rotor **2** has only a small number of vanes **14,** five are shown in the illustrated embodiment, the flow produced by the pump is not steady but in the form of a succession of pulses. To compensate for this effect a conduit **138** connects the conduits **128** and **130** and receives a piston **140** which is urged into a central position by a spring **142** and **144.** The piston prevents flow from conduit **128** to conduit **130** or vice versa but compensates for pulsations in the fluid flow by virtue of its resilient mounting.

A safety valve diagrammatically illustrated at **146** provides for interconnection of the conduits **128** and **130** in the event of an excessively high pressure building up in one of them, so as to prevent damage to the pump. The valve **146** may be provided by a control means which enables it to operate as a fluid bypass when so required.

To improve the fluid tightness of the pump a groove is preferably formed at the end of each vane and a sealing strip biassed outwardly by a spring is inserted therein. These strips slide along the surrounding part of the housing during rotation of the rotor. Similar measures may be taken to ensure fluid tightness between the vanes and the semicylindrical elements **64.** Any suitable hydraulic fluid such as oil, for example, may be used in the pump as the operating fluid.

The operation of the pump according to the invention will now be described. Power is supplied from an engine, such as an internal combustion engine for example, to drive the shaft **30.** Drive is transmitted from the shaft **30** via the coupling shown in FIG. **3** or **6** to the rotor **2** and the vanes **14** rotate with the rotor. Depending on the degree of eccentricity of the rotor fluid is pumped at a given rate to the motor or motors **126** which in turn drive the output shaft or shafts, such as the half-shaft of a motor vehicle, for example.

The degree of eccentricity of the rotor is controlled by the means shown in FIGS. **1** and **4,** or FIG. **5.** In the case of FIGS. **1** and **4,** fluid such as oil, is supplied to the conduits **90** and **92** or **94** and **96** to move the block **78** down and up respectively. Flow of fluid to these conduits can be controlled directly by an operator or via an automatic control in dependance on the vehicle speed and load. In the case of the system shown in FIG. **5** the eccentricity of the pump is controlled by rotation in the appropriate sense of the shaft **124.** This can be operated by a servo control directly by the operator or via an automatic control.

The pump has the characteristic that the direction of flow of fluid from the pump can be reversed without reversing the direction of rotation of the rotor. Referring to FIG. **7** it will be seen that the pump is shown in two positions, one represented by solid lines and the other represented by dashed lines. The direction of fluid flow for each of these positions is shown by solid and dashed arrows respectively. As the rotor **2** is displaced from a central position upwardly (as viewed in FIG. **7**) to a position such as that shown in dashed lines the delivery capacity of the pump increases thus producing an increase in the speed of rotation of the motor or motors **126.** As the rotor **2** is displaced from the central position downwardly (as viewed in FIG. **7**) to a position such as that shown in solid lines the delivery capacity of the pump increases in the reverse direction, thus causing an increase in the speed of rotation of the motor or motors **126** in the reverse direction. In the central position the rotor produces no flow of fluid out of the pump and hence the motor or motors is or are stationary.

An additional application of the pump is as a fluid motor in which case fluid is supplied to it by a pump. Varying the eccentricity of the "rotor" then causes a variation in the speed of rotation thereof for a given rate of supply of fluid. It is to be understood that references in the claims to a pump are intended to include references to the use of the structure operating in reverse as a motor.

We claim:

1. A symmetrical rotary pump comprising a housing; a hollow cylindrical rotor having a main portion and an extension portion at each end thereof, the rotor being situated rotatably within the housing; mounting means for receiving each of the said extension portions rotatably therein; means for moving the mounting means radially of the axis of the rotor to thereby move the rotor in a radial direction; an input shaft extending longitudinally through the housing and through the interior of the rotor; a plurality of vanes freely pivoted on the shaft and extending slidably through the main portion of the rotor; transmission means comprising a wheel fixed to the input shaft adjacent the main portion of the rotor, the wheel having a plurality of resilient teeth extending radially outwardly and engaging portions of the vanes located inwardly of the rotor for providing a driving connection between the shaft and the rotor; input conduit means for supplying fluid to the pump; and output conduit means for taking fluid away from the pump.

2. A symmetrical rotary pump comprising a housing; a hollow cylindrical rotor having a main portion and an extension portion at each end thereof, wherein at least one of the said extension portions has a pair of segments extending longitudinally outwardly therefrom, the rotor being situated rotatably within the housing; mounting means for receiving each of the said extension portions rotatably therein; means for moving the mounting means radially of the axis of the rotor to thereby move the rotor in a radial direction; an input shaft extending longitudinally through the housing and through the interior of the rotor; a plurality of vanes freely pivoted on the shaft and extending slidably through the main portion of the rotor; transmission means comprising an annulus surrounding the segments, a sleeve secured to the shaft at a location radially inwardly of the annulus, a pair of pins passing slidably through respective apertures in the annulus and fixedly received by the sleeve, and a further pair of pins passing slidably through respective apertures in the annulus and fixedly received by the segments; providing a driving connection between the shaft and the rotor; input conduit means for supplying fluid to the pump; and output conduit means for taking fluid away from the pump.

3. A symmetrical rotary pump comprising a housing; a hollow cylindrical rotor having a main portion and an extension portion at each end thereof, the rotor being situated rotatably within the housing; mounting means for receiving each of the said extension portions rotatably therein; means for moving the mounting means radially of the axis of the rotor to thereby move the rotor in a radial direction; an input shaft extending longitudinally through the housing and through the interior of the rotor; a plurality of vanes freely pivoted on the shaft and extending slidably through the main portion of the rotor; transmission means providing a driving connection between the shaft and the rotor; input conduit means for supplying fluid to the pump; output conduit means for taking fluid away from the pump, and a further conduit extending between the input conduit and the output conduit, the said further conduit slidably receiving a piston therein, the piston being resiliently biased to a mean position and acting to compensate for pulsations in pump output.

4. A rotary pump according to claim **3,** wherein a relief conduit interconnects the input conduit and the output conduit, a relief valve being situated in the relief conduit and being adapted to open in the event of excessive pressure in either conduit thereby to relieve the said excessive pressure.

* * * * *