

Nov. 22, 1966

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3,286,645

ROTARY FLUID PRESSURE DEVICE

Filed July 9, 1965

4 Sheets-Sheet 1

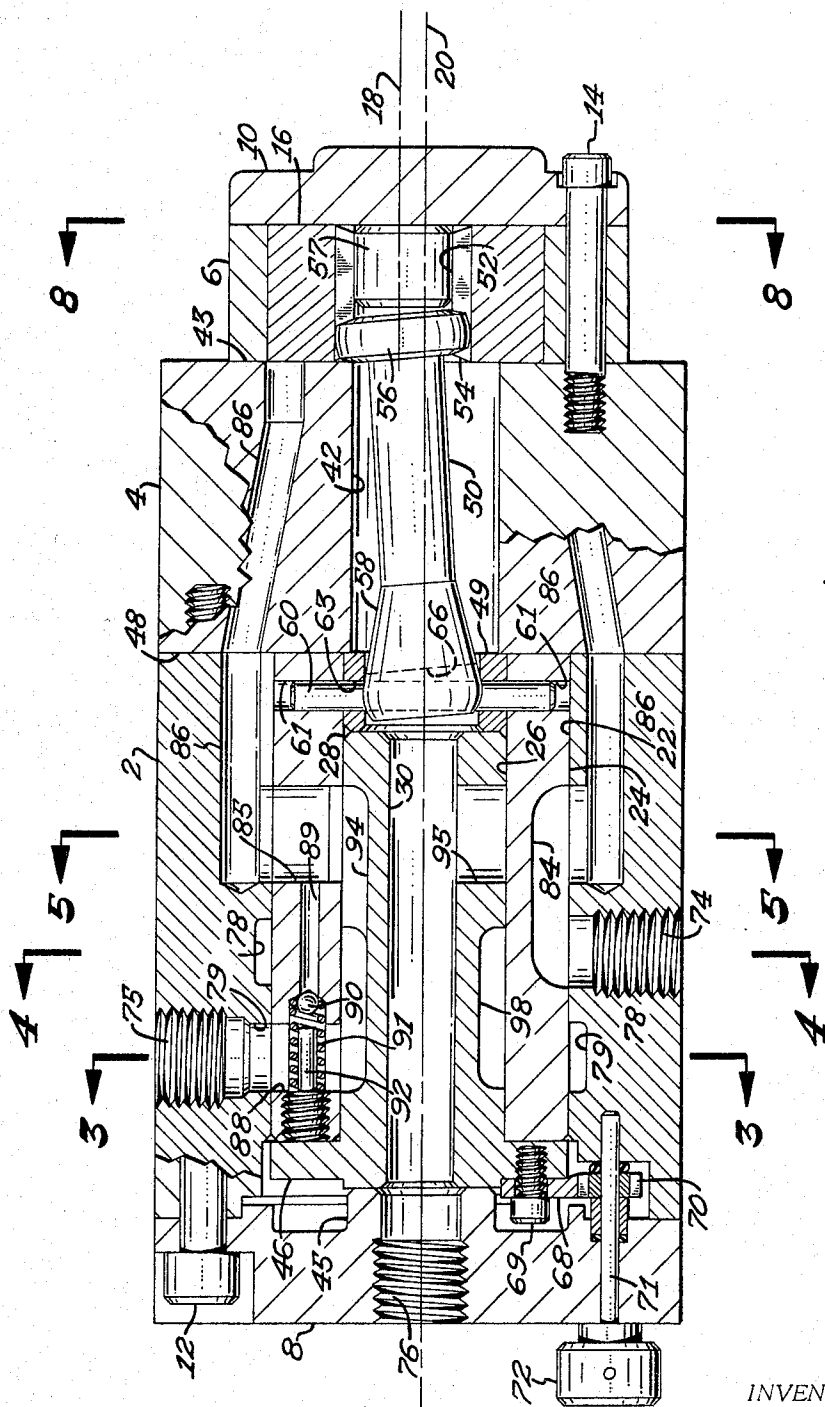


FIG 1

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4 Sheets-Sheet 2

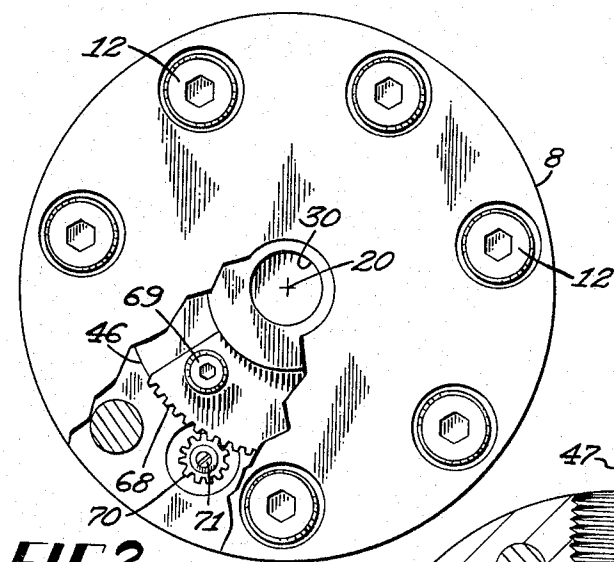


FIG 2

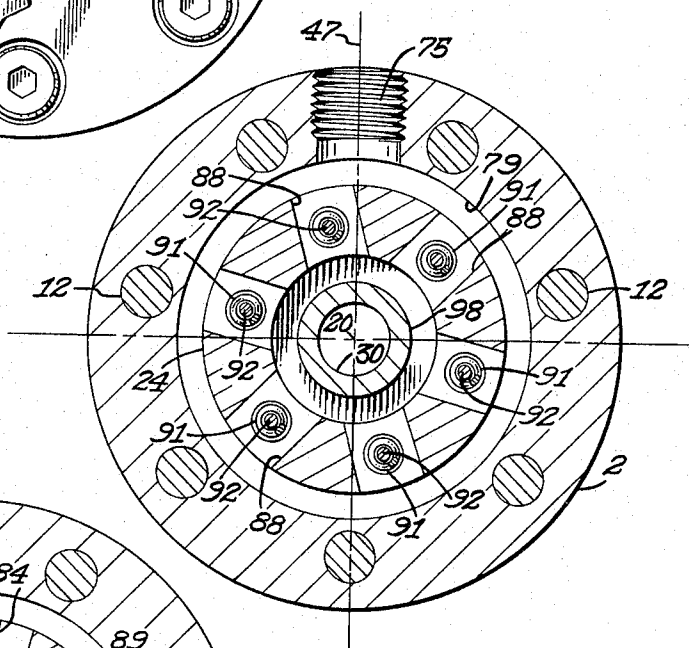


FIG 3

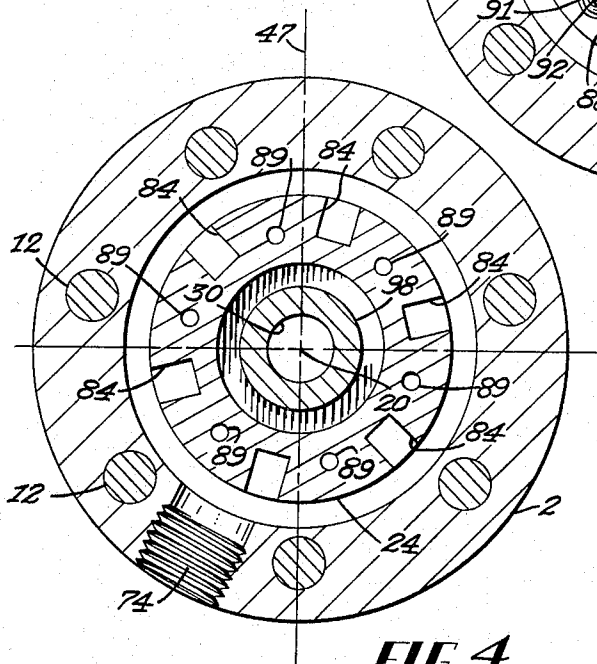


FIG 4

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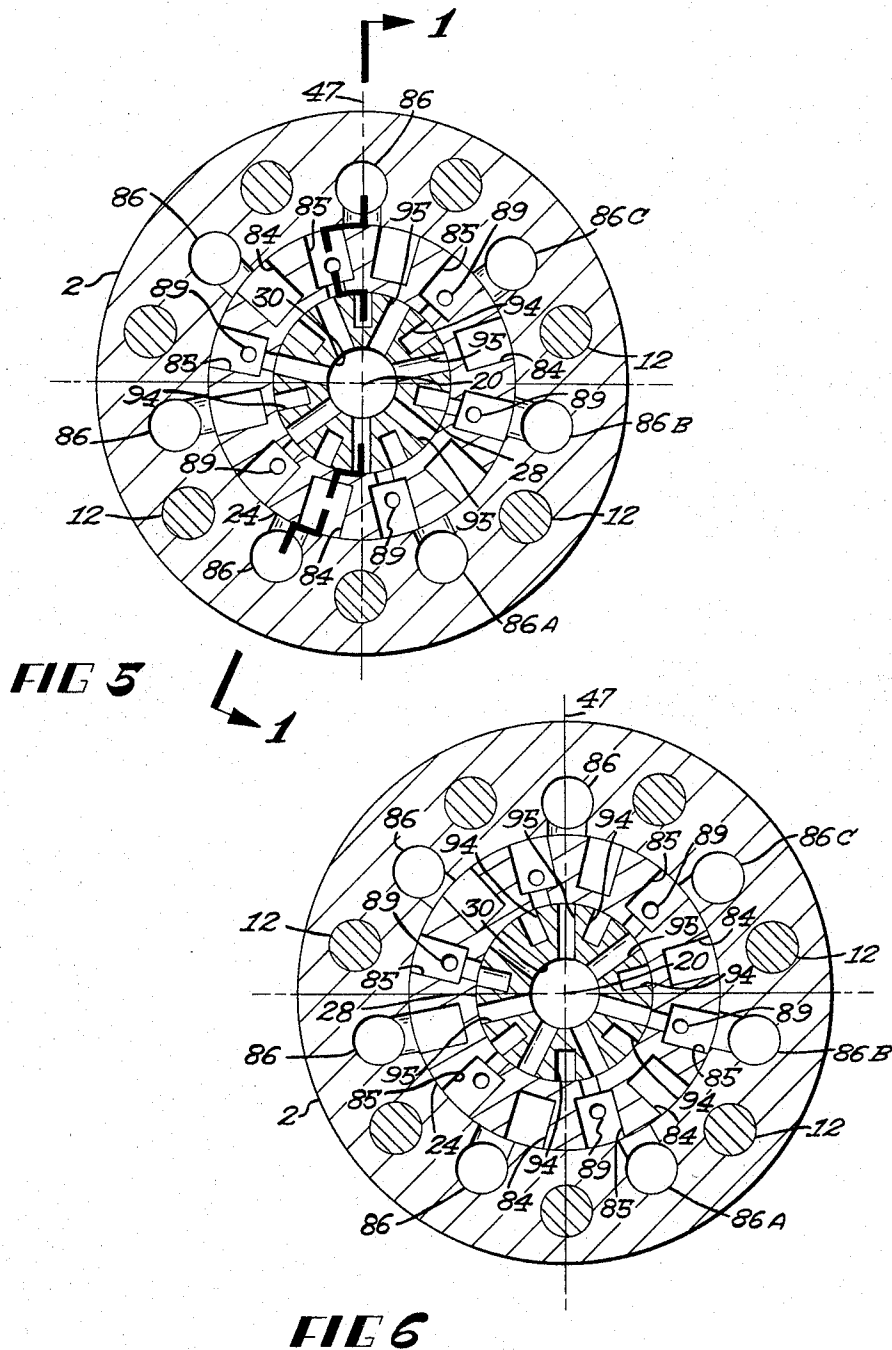
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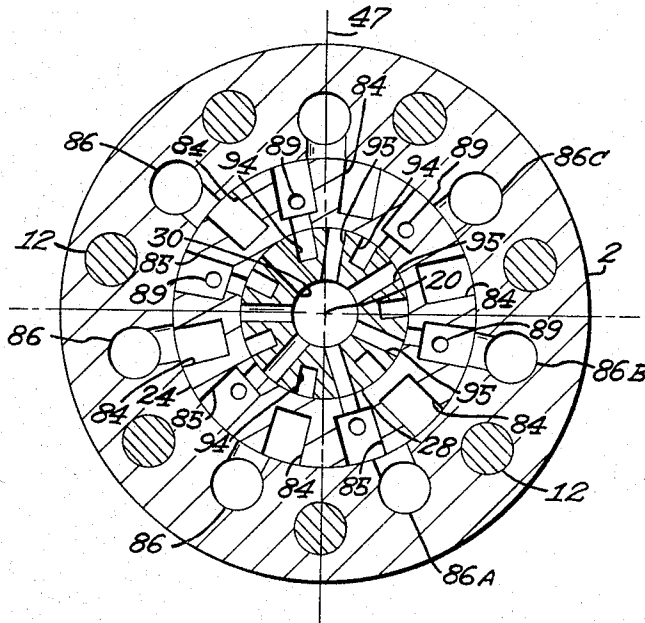


FIG 7

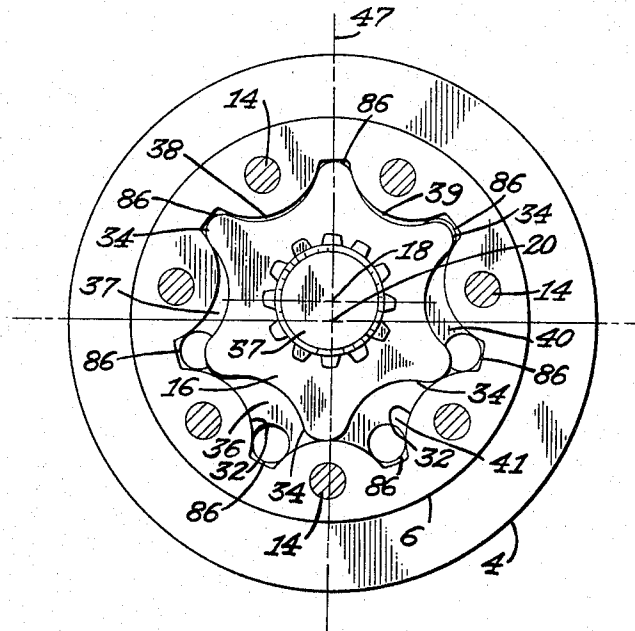


FIG 8

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3,286,645

ROTARY FLUID PRESSURE DEVICE

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6 Claims. (Cl. 103-130)

This invention relates generally to fluid pressure devices of the type having a gear reduction mechanism known in the art as a gerotor which forms expandable and contractible chambers.

A main object of the invention is to provide a new and improved gerotor type fluid pressure device which has the functions of a flow divider, a flow integrator, and a pressure booster.

Other objects and advantages will become apparent from the following specification, appended claims and attached drawings.

In the drawings:

FIG. 1 is a longitudinal sectional view of a fluid pressure device embodying the invention, and taken on line I—I of FIG. 5;

FIG. 2 is an end view from the left end of FIG. 1 having portions broken away to show an adjustment feature;

FIG. 3 is a transverse sectional view taken on line III—III of FIG. 1;

FIG. 4 is a transverse sectional view taken on line IV—IV of FIG. 1;

FIG. 5 is a transverse sectional view taken on line V—V of FIG. 1; and

FIGS. 6 and 7 are similar to FIG. 5 except that the control valve is shown in different adjusted positions;

FIG. 8 is a transverse sectional view taken on line VIII—VIII of FIG. 1.

The illustrated embodiment of the invention is a gerotor type fluid pressure device having a casing or housing made of several cylindrically and annularly shaped sections which are a valve casing section 2, a fluid passage casing section 4, a gerotor casing section 6 and end plates 8 and 10. Casing sections 2 and 4 and end plate 8 are held together in axial alignment by a plurality of circumferentially spaced bolts 12. End plate 10, which serves as a side plate for the gerotor casing section 6, and casing section 6 are attached together and to casing section 4 by a plurality of circumferentially spaced bolts 14.

The shape of gerotor casing section 6 is generally cylindrical and annular and has a plurality of internal teeth which will be referred to in detail further on. An externally toothed star member 16 having at least one fewer tooth than casing section 6, which may be referred to as a ring member 6, has the teeth thereof in meshing engagement with the teeth of ring member 6. Star member 16 partakes of a hypocycloidal movement so that the axis 18 of star member 16 travels in an orbit about the axis 20 of ring member 6.

Casing section 2 has a bore 22 and rotatably disposed and supported in bore 22 is cylindrically shaped commutator valve 24 which has a bore 26. Rotatably disposed and supported in the bore 26 of valve 24 is a cylindrically shaped control valve 28 which has a bore 30 which bore, as well as bores 22 and 26, is coaxial relative to ring member axis 20.

With reference to FIGS. 1 and 8, the gerotor casing section 6, which in effect is the ring member 6, has a plurality of internal teeth 32. Externally toothed star member 16, having at least one fewer tooth 34 than ring member 6 with the axis 18 of star member 16 being move-space formed and surrounded by ring member 6. Star member 16 is moveable orbitally relative to the ring member 6 with the axis 18 of star member 16 being move-

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able in an orbital path about the axis 20 of ring member 6. During orbital movement of star member 16 the teeth 34 thereof intermesh with the ring member teeth 32 to form expanding and contracting cells 36 to 41 which are equal in number to the number of teeth 34 of star member 16. Casing section 4 has a bore 42 which is concentric relative to ring axis 20 and is of small enough diameter so that the resulting annular face 43 which abuts gerotor casing section 6, along with cover plate 10, form sides for the gerotor chamber so that the expanding and contracting cells 36 to 41 formed between the teeth of the gerotor star and ring members 16 and 6 will be closed for all orbital positions of the star member 16.

With further reference to FIG. 8, a vertical centerline 47 incidentally represents the line of eccentricity for the star member 16 for that particular position of the star member relative to the ring member 6. The line of eccentricity is defined herein as a line which is perpendicular to and intersects the star and ring axes 18 and 20 for all orbital positions of the star 16. During orbital movement of the star member 16, assuming the orbital movement is clockwise, the cells 36 to 38 on the left side of the line of eccentricity would be expanding and the cells 39 to 41 on the right side would be contracting. In the operation of the device illustrated, fluid under pressure is directed to the expanding cells on the left side of the line of eccentricity and exhausted from the contracting cells on the right side of said line. The valving arrangement which facilitates the feeding and exhausting of the cells 36 to 41 will be described further on herein.

End plate 8 has a centrally located boss 45 extending internally of the fluid pressure device and the left end of control valve 28 abuttingly engages boss 45. Control valve 28 has a flange 46 which is abuttingly engaged by the left end of commutator valve 24. The right end of valve 24 is in abutting engagement with the annular face 48 of casing section 4. Valve bore 26 is somewhat longer than the control valve 28 and a bushing 49 having the same outside diameter as bore 26 is disposed in bore 26 in abutting engagement with the control valve 28 and the annular face 48 of casing section 4.

A shaft 50, which may be referred to as a dogbone because of its general appearance, extends between and mechanically connects star 16 and commutator valve 24 in driving relation. Star member 16 has a bore 52 which is concentric relative to the teeth 34 thereof and the bore 52 is provided with a plurality of circumferentially arranged, axially extending teeth or splines 54. Shaft 50 has an enlarged head 56 at the star end thereof which has a frustospherically shaped portion and is provided with splines which are equal in number to and mesh with splines 54 of the star 16. A spacer spool 57 is disposed in star bore 52 in abutting engagement with shaft head 56 and end plate 10. The other end of the dogbone 50 has a head 58 with a frustospherically shaped portion of the same diameter as the internal diameter of bushing 49 and is disposed in the bushing 49. A pin 60 is attached to valve 24 by being press fitted in holes 61 in valve 24 and pin 60 is also press fitted in holes 63 of bushing 49. Holes 61 and 63 are formed and positioned so that pin 60 extends diametrically across valve bore 26. Shaft head 58 is bifurcated to form a slot 66 having the same width as valve pin 60 which is accommodated by the slot 66.

Star member 16 is eccentrically disposed relative to ring member 6, as mentioned above, and the dogbone shaft 50 is thus always in a cocked or tilted position relative to valve 24, which has the same axis 20 as ring member 6, and to the axis 18 of star member 16. Dogbone shaft 50 is a universal joint type of shaft functions to cause commutator valve 24 to rotate in synchronism with the rotational movement of star member 16. In operation

a star member 16 having six teeth will make one revolution about its own axis 18 for every six times the star member orbits in the opposite direction about the axis 20 of the ring member 6. Thus the right end of the dogbone 50 has both orbital and rotational movement in common with the star member 16 while the left end of the dogbone has only rotational movement in common with valve 24.

Control valve 28 is rotatably mounted in valve bore 26 but only for the purpose of making it adjustable so that it can be given any desired angular position relative to the casing. Various adjustment means could be provided and the one illustrated is only shown by way of example. In the illustrated adjustment means a gear segment 68 having the teeth thereof in an arc relative to the axis 20 is attached to valve flange 46 with bolts 69. A gear 70 which meshes with gear segment 68 is fixedly attached to a shaft 71 which is parallel to axis 20 and is rotatably mounted in end plate 8 and casing section 2. A knob 72 is fixedly attached to shaft 71 and rotation of knob 72 will cause rotation of control valve 28 to any desired angular position relative to the casing.

Thus far only the mechanical aspects of the device have been referred to and the fluid flow passages and valving will now be described.

It is characteristic of the device that it has one fluid inlet port and at least two fluid outlet ports. Fluid inlet and outlet ports 74 and 75 are provided in casing section 2 which extend therethrough and open into the bore 22. A second fluid outlet port 76 is provided in end plate 8 which is concentric with the boss 45 and has fluid communication with bore 30 of control valve 28.

Commutator valve 24 and casing sections 2 and 4 are provided with fluid passages through which fluid is conveyed from the inlet port 74 to the expanding cells 36 to 38 of the gerotor and controls are provided so that fluid may be returned from the collapsing cells 39 to 41 of the gerotor to either one of the outlet ports 75 or 76, or the flow may be divided between exhaust ports 75 and 76, as desired. Valve 24, by reason of the dogbone connection between it and star 16, will rotate at the same speed as the star 16 but in the opposite direction from the orbiting direction of the star 16. Casing section 2 has two axially spaced annular channels 78 and 79 in the internal bore 22 thereof which are axially aligned and in fluid communication respectively with fluid inlet and outlet ports 74 and 75 in casing section 2. With reference to FIGS. 1 and 4 to 7, valve 24 has a plurality of axially extending, circumferentially arranged and spaced fluid inlet passages which are illustrated herein as a set of six passages 84 which are in fluid communication with annular channel 78 and inlet port 74. Valve 24 is also provided with a set of six passages 85, alternately spaced relative to passages 84, which extend entirely through the annular wall of valve 24 and are in fluid communication with the interior bore 26 of valve 24. In the fluid pressure device illustrated the passages 84, and the passages 85, are equal in number to the number of teeth 34 on the star 16.

Casing sections 2 and 4 have formed jointly therein a plurality of generally axially extending, circumferentially arranged and spaced passages 86 (see FIGS. 1 and 5 to 8) illustrated as being seven in number which is equal to the number of teeth 32 of the ring member 6. The passages 86 extend from points between the ring member teeth 32 in the chamber formed by the ring member 6 through casing sections 4 and 2 and open radially into the bore 26 of casing section 2 where fluid communication is established between passages 86, which are stationary, and passages 84 and 85 which are in the rotatable valve element 24. Upon rotation of valve 24, the passages 84 and 85 therein register successively in fluid communication with each of the passages 86 in casing sections 2 and 4.

In the operation of the device, pressurized fluid is in-

troduced through inlet port 74 from where it flows into annular channel 78, into inlet passages 84 in valve 24, through passages 86 in casing sections 2 and 4 on the left side of the line of eccentricity 47 (as viewed in FIG. 8) to gerotor cells 36 to 38 which, as viewed in FIG. 8, are on the left side of the line of eccentricity 47. The expansion of the cells 36 to 38 on the left side of the line of eccentricity 47 causes star 16 to gyrate in a clockwise direction and cause collapsing of the cells 39 to 41 on the right side of the line of eccentricity 47. Fluid from the collapsing cells 39 to 41 flows through casing passages 86 on the right side of the line of eccentricity 47, as viewed in FIG. 8, to the interior of valve bore 22 where it has fluid communication with the fluid outlet passages 85 of valve 24 as may be noted in FIGS. 5 to 7. The above description of fluid flow is only for an instantaneous condition in that the line of eccentricity 47 rotates about the axis 20 of ring member 6. As long as pressurized fluid is admitted through inlet port 74, however, the pressurized fluid will always be admitted to cells on the same side of the line of eccentricity 47 and fluid will always be exhausted on the other side of said line. Valve 24 could be slightly displaced annularly relative to star 16 so as to cause the feeding and exhausting to be reversed relative to the line of eccentricity and cause the star to gyrate or orbit in the opposite direction.

During orbiting of star 16 about ring member axis 20, the star rotates in the opposite direction about its own axis 18 at a slower speed. The ratio between the orbiting and rotating speeds is dependent upon the ratio between the ring and star member teeth. If that ratio is seven to six as illustrated herein, the rotating speed of the star will be one-sixth of its orbiting speed. By reason of the dogbone connection 50 between star 16 and valve 24, valve 24 rotates at the same speed and in the same direction as star 16. Valve 24 is a commutating type valve in that it rotates at the same speed that star 16 rotates but it functions to supply and exhaust fluid to and from the gerotor at the orbiting frequency of the star.

It will be understood from the above description that the rotation of valve 24 causes each one of the group of circumferentially arranged passages 84 and 85 to successively register in radial alignment with the passages 86 in casing sections 2 and 4. Considering any cell 36 to 41 individually, pressurized fluid is first admitted through a passage 86 to cause the cell to expand and subsequently, when the cell collapses, fluid is forced out of the cell through the same passage 86 through which the liquid was admitted to the cell.

For the purpose of explaining the operation of the device, and only for that purpose, it will be assumed at this stage that the control valve 28 is not present in the device. If this assumption is made the fluid being exhausted from passages 86 would be exhausted through valve passages 85 to the interior of valve bore 28 and out through the fluid outlet 76. To simply exhaust fluid in this manner would not be invention in view of the prior art, however, and the present invention is directed to a novel way of exhausting fluid from exhaust passages 85 to the exterior of the device so that the device will function as a flow divider and as a pressure intensifier or multiplier.

It will now be assumed that control valve 28 is present in the device as shown in the drawings and as described above. A plurality of circumferentially arranged passages 88 are provided in commutator valve 24 which extend radially through the annular wall of the valve from annular channel 79, where passages 88 have constant fluid communication with the fluid outlet 75, to the interior bore 26 of the valve. Valve passages 88 are equal in number to, and preferably in axial alignment with, the valve passages 85. Extending respectively between and communicating with the valve passages 85 and 88 are a plurality of passages 89 which extend in an axial direction

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between the external and internal surfaces of valve 24. Each of the passages 89 is provided with a spring loaded ball check valve 90 which permits the flow of fluid from each passage 85 to a corresponding passage 86 but not in the other direction. Each check valve includes, in addition to the ball, a spring 91 for resiliently urging the ball to a closed position and a spring guide 92 fastened to commutator valve 24 for maintaining the alignment of spring 91.

Control valve 28 is provided with two sets of circumferentially and alternately arranged passages 94 and 95 with the number of passages in each set being equal to the number of passages 86 which is illustrated as being seven in number. The set of passages 94 are illustrated as grooves in the exterior surface of control valve 28 which extend axially and have sequential fluid communication with passages 85 of valve 24 when valve 24 is rotated. Control valve 28 has a wide and shallow annular groove 98 adjacent passages 94 thereof and in fluid communication with commutator valve ports 90, the effect being that valve ports 90 are in constant fluid communication with control valve passages 94. The other set of passages 95 in control valve 28 are in axial alignment and register sequentially with passages 85 of valve 24 when valve 24 is rotated and extend radially through the annular wall of control valve 28 into the bore 30 of valve 28.

FIG. 5 shows the control valve 28 in the same angular position that it is shown in FIG. 1 with the passages 94 circumferentially aligned with the passages 86 in casing sections 2 and 4. From an analysis which involves comparing FIGS. 5 and 8 it may be observed that fluid inlet passages 84 on the left side of the line of eccentricity are feeding passages 86 on the same side of the line which lead to expanding gerotor cells 36 to 38. At the same instant fluid is being exhausted through passages 86 on the right side of the line of eccentricity from contracting cells 39 to 41 to fluid exhaust passages 85 on the right side of the line of eccentricity. For convenience the three passages 86 which are exhausting fluid from gerotor cells 39 to 41 at that instant are indicated in FIGS. 5 to 7 by the letters A, B and C.

With the control valve in its position shown in FIG. 5 the passages 95 thereof are completely inoperative because they are not in contact with any of the exhaust passages A, B or C. Control valve passages 94 on the right side of the line of eccentricity, however, are in fluid communication with exhaust passages A, B and C and the fluid therein will be exhausted from the device through fluid outlet 75. The physical dimensions of passages 94 may not be sufficient in some cases to permit the cells exhausting into passages A, B and C to completely exhaust into passages 94 and a binding action would occur because fluid would be trapped in cells 39 to 41. The providing of passages 89 in valve 24, which may be referred to as bypass passages, permit fluid which would otherwise be trapped in cells 39 to 41 to bypass the passages 94 in control valve 28 and flow directly to the fluid outlet 75. In some devices it might even be found desirable to omit the control valve passages 94 and only provide the bypass passages 92. Thus in any particular device it can be a matter of choice whether either or both sets of passages 92 or 94 are to be provided. A conclusion that may be drawn with respect to FIG. 5 is that with the control valve 28 in the position shown, fluid will be exhausted only through the fluid outlet 75.

In FIG. 6 the position of the valve 24 is the same as in FIG. 5 but the control valve 24 is in an adjusted position in which the passages 95 are circumferentially aligned relative to the casing passages 86. As in FIG. 5, the fluid inlet passages 84 on the left side of the line of eccentricity are feeding passages 86 on the same side of the line which lead to expanding gerotor cells 36 to 38. At the same instant fluid is being exhausted through passages 86 on the right side of the line of

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eccentricity from contracting cells 39 to 41 to fluid exhaust passages 85 on the right side of the line of eccentricity.

With the control valve in its position shown in FIG. 6 the passages 94 thereof are completely inoperative because they are not in contact with any of the exhaust passages A, B or C. Control valve passages 95 on the right side of the line of eccentricity, however, are in fluid communication with exhaust passages A, B and C and the fluid therein will be exhausted from the device through fluid outlet 76. The physical dimensions of passages 95 may not be sufficient in some cases to permit the cells exhausting into passages A, B and C to completely exhaust into passages 95 and a binding action would occur because fluid would be trapped in cells 39 to 41. In that case bypass passages 89 in valve 24 permit fluid which would otherwise be trapped in cells 39 to 41 to flow directly to the fluid outlet 75. A conclusion that may be drawn with respect to FIG. 6 is that with the control valve 28 in the position shown, fluid will be exhausted through the fluid outlet 76 except that a portion of the fluid may be exhausted through bypass passages 92 under the circumstances referred to above.

In FIG. 7 the position of the valve 24 is the same as in FIGS. 5 and 6 but control valve 24 is in an adjusted position in which both the passages 94 and 95 are circumferentially offset relative to casing passages 86. As in FIGS. 5 and 6, fluid inlet passages 84 on the left side of the line of eccentricity are feeding passages 86 on the same side of the line which lead to expanding gerotor cells 36 to 38. At the same instant fluid is being exhausted through passages 86 on the right side of the line of eccentricity from contracting cells 39 to 41 to fluid exhaust passages 85 on the right side of the line of eccentricity.

With the control valve in its position shown in FIG. 7 certain of the passages 94 and 95 on the right side of the line of eccentricity are always in fluid communication with one or the other of exhaust passages A, B and C. It may be noted that exhaust passages A and B are in fluid communication with two of the passages 95 which exhaust to the fluid outlet 76 and exhaust passage C is in fluid communication with one of the passages 94 which exhausts to the fluid outlet 75. A slight adjustment of control valve 28 in either direction will change the division ratio of the flow of fluids to fluid outlet ports 75 and 76 and in this respect the described device functions as a controllable flow divider whereby the fluid introduced through the fluid inlet port 74 may be divided as desired between the fluid outlet ports 75 and 76 or all of the fluid may be directed to either of these ports.

With the conditions illustrated in FIG. 7, the physical dimensions of passages 94 and 95 may not be sufficient in some cases to permit the cells exhausting into passages A, B and C to completely exhaust into passages 94 and 95 and a binding action would occur because fluid would be trapped in cells 39 to 41. In that case passages 89 in valve 24 permit fluid which would otherwise be trapped in cells 39 to 41 to bypass the passages 94 or 95 in control valve 28 and flow directly to the fluid outlet 75.

With further reference to FIG. 7, it will also be seen how the device functions as a pressure intensifier or pressure multiplier. To permit an understanding of this function it should first be observed that pressurized fluid fed to the three expanding cells 36 to 38 is effective over an area which corresponds to the diameter of the star 16 to move the star in its orbital path and thereby force the fluid out of the contracting cells 39 to 41. In this device the fluid exhausted from individual cells is directed to different fluid outlets. With control valve 28 in the position shown in FIG. 7, for example, it will be noted that exhaust passage C connects gerotor cell 39 to the

fluid outlet 75 through one of the exhaust passages 94. Likewise exhaust passages A and B connect gerotor cells 41 and 40 to the fluid outlet 76 through two of the exhaust passages 95. If one of the fluid outlets such as outlet 76 were connected to a drain reservoir with no resistance being offered to the flow of fluid out of outlet 76, the total resultant force of the pressurized fluid in expanding cells 36 to 38 would be concentrated on forcing the fluid out of contracting cell 39 through fluid outlet 75. Fluid outlet 75 must of course be connected to some type of energy absorbing device such as a hydraulic motor which offers resistance to the flow of fluid from fluid outlet 75 so that pressure can be developed in gerotor cell 39. As a pressure intensifier or multiplier the pressure increase realized in a single cell such as cell 39 would be considerably higher than the pressure of the fluid admitted to the fluid inlet 74.

By adjusting the position of control valve 28 the fluid in one or two of the contracting cells may be directed through one of the fluid outlets to a reservoir which offers no back pressure and the fluid in the other one or two contracting cells, as the case may be, which have the pressure of the fluid therein intensified, may be directed through a different fluid outlet to some energy absorbing device.

The device may also be used as a fluid flow integrator whereby fluid admitted through fluid outlet ports 75 and 76 will be integrated and flow out of inlet port 74. The device may also be used as a pump or motor if a power shaft is provided in driving relation relative to the dogbone shaft 50 and in such cases the characteristics of the device which are controllable by the control valve 28 as described above may be utilized in various ways as will be obvious to those skilled in this art.

While one embodiment of the invention is described here, it will be understood that it is capable of modification, and that such modification, including a reversal of parts, may be made without departure from the spirit and scope of the invention as defined in the claims.

What I claim is:

1. In a fluid pressure device, fluid inlet means and at least two fluid outlet means, casing means, an internally toothed ring member defining the outer wall of a chamber, a cooperating externally toothed star member having fewer teeth than said ring member disposed eccentrically in said chamber, one of said members having orbital movement about the axis of the other of said members and one of said members having rotational movement about its own axis, the teeth of said members intermeshing to form expanding cells on one side of the line of eccentricity and contracting cells on the other side of said line during relative movement between said members, valve means including a first valve element which has a plurality of circumferentially arranged fluid passages communicating with said chamber which passages correspond in number to the number of teeth of one of said members, said valve means including a second valve element operatively connected to one of said members which has rotation about its own axis for rotation in synchronism with said rotational movement of said member, said valve means including a third valve element which slidably engages said second valve element and is adjustably moveable relative to said casing means, said second valve element having fluid supply passage means for admitting fluid from said fluid inlet means to said expanding cells and fluid exhaust passage means controlled by said third valve element to selectively exhaust all of the fluid from said contracting cells to only one of said fluid outlet means or to simultaneously and separately exhaust fluid from at least two different contracting cells to different ones of said fluid outlet means.

2. A fluid pressure device according to claim 1 wherein said second valve element has alternately arranged fluid supply and exhaust passages which sequentially communicate with said plurality of passages of said first valve

element upon relative rotation between said first and second valve elements, said third valve element having a series of exhaust passages which sequentially communicate with said group of exhaust passages of said second valve element upon relative rotation between said second and third valve elements, the number of passages in said series of passages corresponding to the number of teeth of said ring member, and means for moving said third valve element to selectively position said series of passages relative to said plurality of passages.

3. A fluid pressure device according to claim 1 wherein said third valve element has a series of exhaust passages which correspond to the number of teeth of said ring member and which have fluid communication with one of said fluid outlet means, said second valve element having alternately arranged fluid supply and exhaust passages connected respectively to said fluid inlet means and the other of said fluid outlet means which sequentially communicate with said plurality of passages of said first valve element and said series of exhaust passages of said third valve element upon relative rotation between said first and second valve elements, and means for moving said third valve element to selectively position said series of passages relative to said plurality of passages for selectively directing a desired portion of exhaust fluid from said second valve exhaust passages to said one of said fluid outlet means.

4. A fluid pressure device according to claim 1 wherein said second valve element is disposed between and slidably engages said first and third valve elements, said second valve element having alternately arranged fluid supply and exhaust passages which are respectively connected to said fluid inlet and outlet means and which sequentially communicate with said plurality of passages of said first valve element upon relative rotation between said first and second valve elements, said third valve element having a series of exhaust passages corresponding to the number of teeth of said ring member which sequentially communicate with said exhaust passages of said second valve element upon relative rotation between said second and third valve elements and which have fluid communication with one of said outlet means, and means for moving said third valve element to selectively position said series of passages therein relative to said plurality of passages of said first valve element.

5. A fluid pressure device according to claim 1 wherein each of said three elements has a cylindrical bore with said second element being rotatably disposed in said bore of said first element and said third element being rotatably disposed in said bore of said second element, said fluid inlet means and a first one of said fluid outlet means opening into said first element bore and a second one of said fluid outlet means opening into said third element bore, said plurality of first element passages opening into said first element bore, said second valve element having alternately arranged fluid supply and exhaust passages which are respectively connected to said fluid inlet means and to said first outlet means and which sequentially communicate with said plurality of passages of said first valve element upon relative rotation between said first and second valve elements, said second valve element exhaust passages opening into said bore of said second valve element, said third valve element having a series of exhaust passages corresponding to the number of teeth of said ring member which sequentially communicate with said exhaust passages of said second valve element upon relative rotation between said second and third valve elements and which have fluid communication with one of said second outlet means, and means for moving said third valve element to selectively position said series of passages therein relative to said plurality of passages of said first valve element.

6. A fluid pressure device according to claim 5 wherein portions of said second valve element exhaust passages extend radially through said second valve element and

said third valve element series of passages extend radially through said third valve element.

References Cited by the Examiner

UNITED STATES PATENTS

Re. 25,126	2/1962	Charlson	91—56
Re. 25,291	12/1962	Charlson	91—56
2,132,812	10/1938	Wahlmark	103—130

5

2,758,573	8/1956	Zrozal	91—56
2,871,831	2/1959	Patin	123—8
2,912,937	11/1959	Insley	103—130
2,989,951	6/1961	Charlson	103—130
3,215,043	11/1965	Huber	230—145
3,233,524	2/1966	Charlson	91—56

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