July 16, 1957 W. M. OSBORN 2,799,371

HYDRAULICALLY-OPERATED DEVICE HAVING AXIAL FLUID INJECTION MEANS

Filed March 28, 1956 3 Sheets-Sheet 1

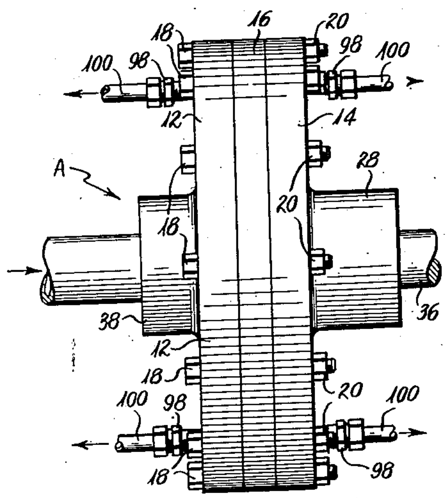

Fig. 1.

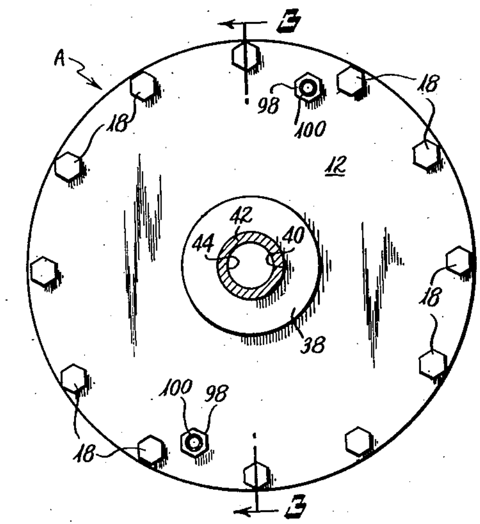

Fig. 2.

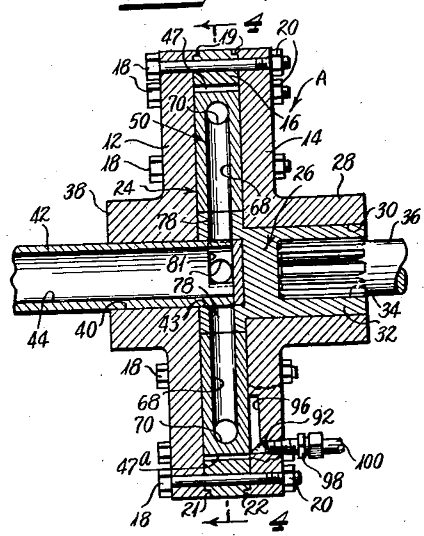

Fig. 3.

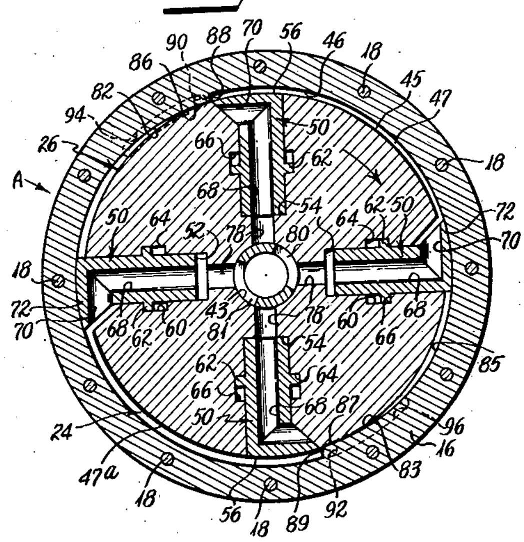

Fig. 4.

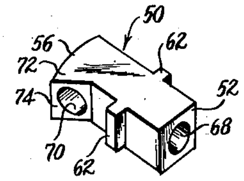

Fig. 5.

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ATTORNEYS

July 16, 1957

W. M. OSBORN

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2,799,371

Filed March 28, 1956

3 Sheets-Sheet 2

Fig. 6.

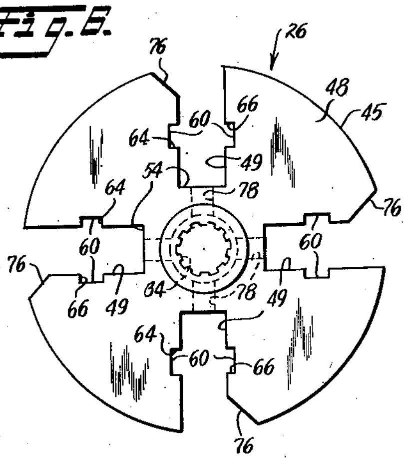


Fig. 7.

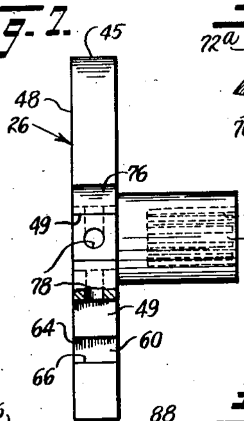


Fig. 12-A.

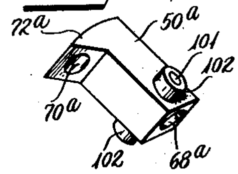


Fig. 10.

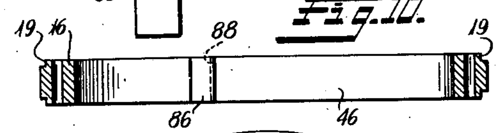
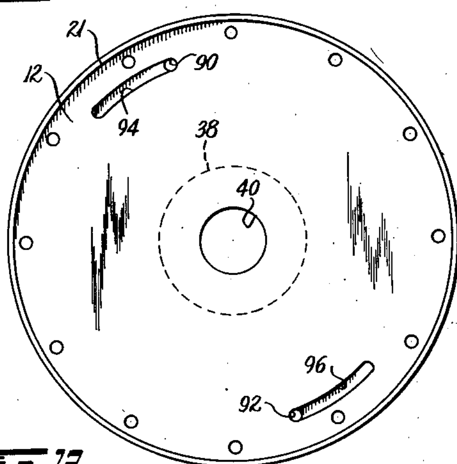


Fig. 8.



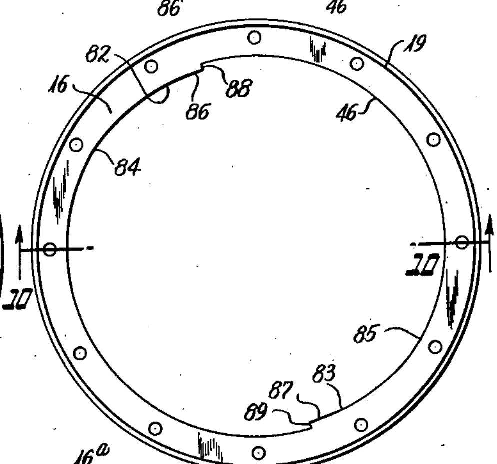
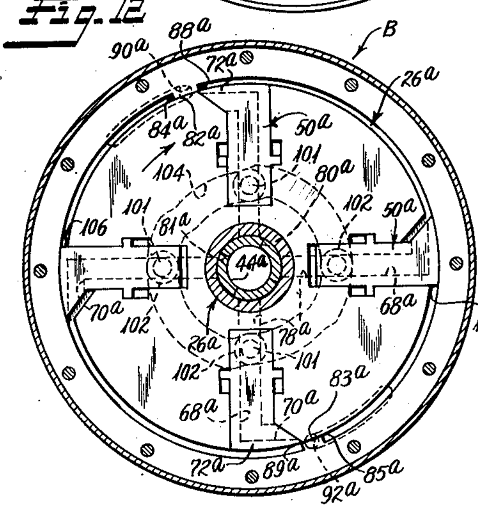


Fig. 9.

Fig. 12



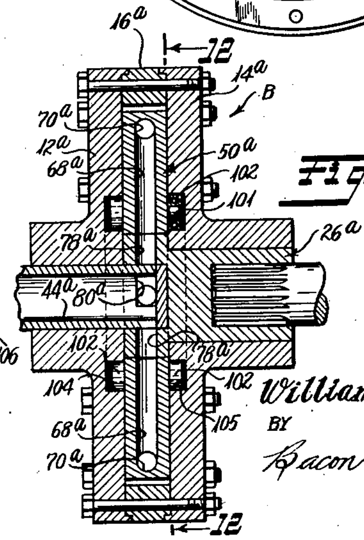


Fig. 11.

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Fig. 13.

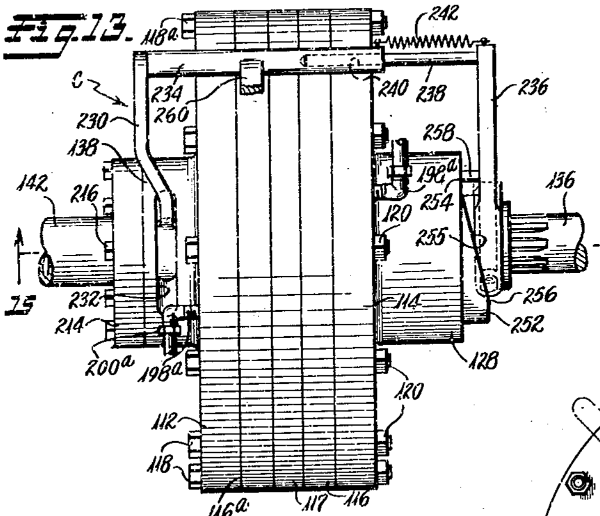


Fig. 19.

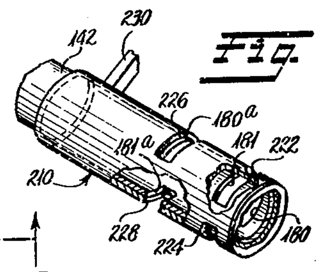


Fig. 14.

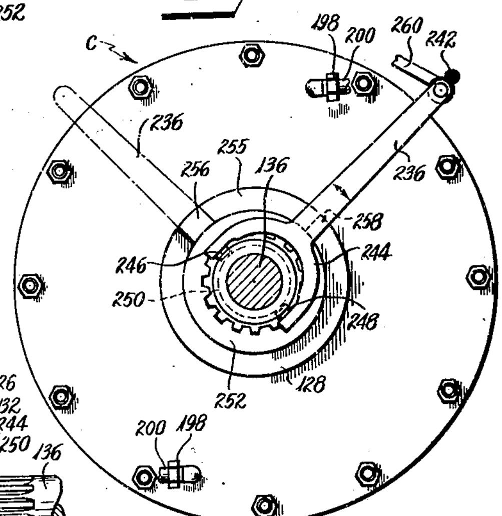


Fig. 15.

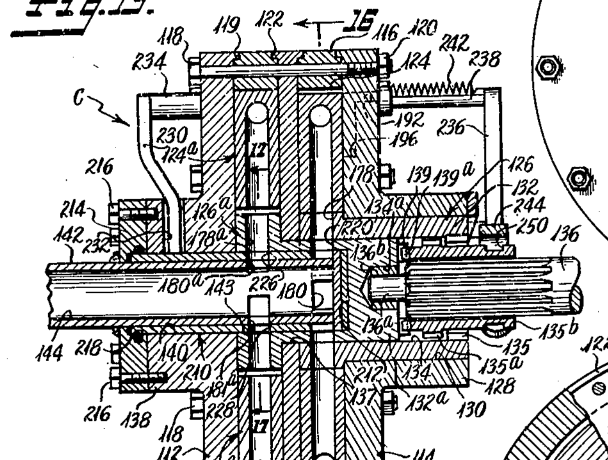
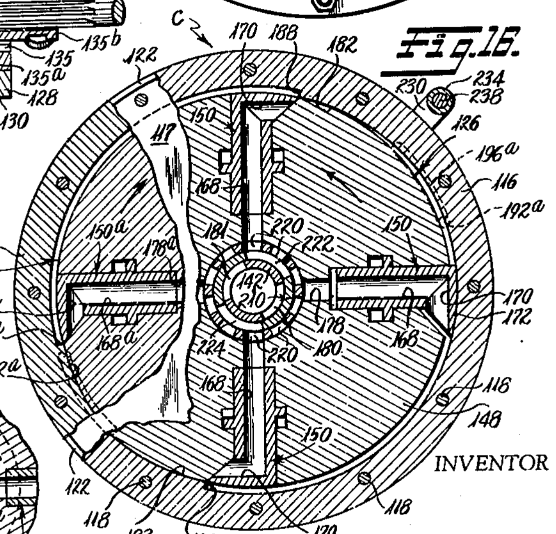


Fig. 16.



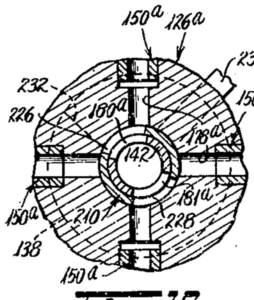


Fig. 17.

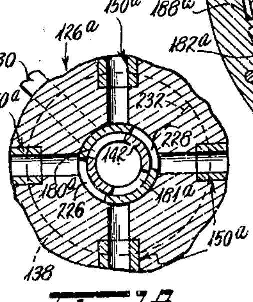


Fig. 18.

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HYDRAULICALLY-OPERATED DEVICE HAVING AXIAL FLUID INJECTION MEANS

William M. Osborn, Denver, Colo.

Application March 28, 1956, Serial No. 574,448
22 Claims. (Cl. 192—.098)

This invention relates to a novel hydraulically-operated device adapted for various uses such as positive power transmission, an infinitely-variable-speed motor, etc., and, more particularly, to a device of this type which is highly efficient, simple in design, and which may be readily and economically manufactured.

The hydraulically-operable device of the invention briefly comprises: a housing providing a rotor chamber; a rotor unit mounted within said rotor chamber for rotation about a central axis and adapted to be connected to a shaft, said rotor unit having a plurality of radially-movable vanes and said housing providing working chambers for said vanes; fluid-passage means in a peripheral portion of said housing for admitting operating fluid to or discharging operating fluid from said working chambers; and fluid-passage means in said rotor unit and housing to direct the flow of operating fluid along a path extending along said central axis through said housing and rotor unit, and radially outward through said rotor unit and radially-movable vanes into said working chambers when said vanes are in an outwardly extended position.

In a simple embodiment of the invention, operating fluid is admitted through the passageway along the central axis and forces the radially-movable rotor vanes outwardly into the working chambers and acts upon them in such position to drive the rotor in a forward angular direction. Retraction of the rotor vanes at the discharge end of the working chambers is accomplished by contact of the rotor vanes with an inwardly extending portion of the periphery of the rotor chamber which also provides an abutment for reaction of the operating fluid.

In a modification of the invention, the hydraulically-operated device includes means independent of fluid pressure for positively controlling the radial movement of the rotor vanes at all angular positions of the rotor. In such modification, the rotor may be made to rotate in a forward angular direction by introducing operating fluid into the housing and rotor along the central axis and out through the rotor vanes and exit ports, or may be made to reverse its direction by simply reversing the direction of the flow of the operating fluid, i. e. by injecting the operating fluid into the ports in the peripheral portion of the rotor chamber and discharging it through the rotor vanes and axially outward through the rotor and rotor housing, the rotor unit will be caused to rotate in the reverse direction.

In a still further modification, the device is provided with a pair of rotor units adapted to be driven in opposite directions, and control means are provided for selectively directing operating fluid axially to one or the other of the rotor units, whereby a reversible drive is obtainable. The separate rotor units in this instance are selectively clutchable to a common shaft so as to turn such shaft in a forward or reverse direction.

An object of the invention is to provide a simple, well-balanced, hydraulically-operated device of the type described.

Another object of the invention is to provide a novel hydraulically-operable device having a rotor unit mounted for rotation about a central axis, wherein said rotor unit is provided with a plurality of movable vanes and means are provided for admitting or discharging operating fluid to said vanes along said central axis and for controlling the flow of operating fluid to said vanes depending upon the angular position of the rotor unit.

Another object of the invention is to provide a hydraulically-operable unit which is immediately self-starting in all positions of the rotor upon admission of operating fluid.

Another object of the invention is to provide a hydraulically-operable device having a rotor unit provided with radially-movable vanes, and having means to cause said vanes to move radially outward of said rotor by the action of fluid pressure alone.

Another object of the invention is to provide a hydraulically-operated device having a rotor unit provided with radially-movable vanes, wherein means independent of fluid pressure are provided to positively control the radial position of said rotor vanes at all angular positions of the rotor unit.

Another object of the invention is to provide a reversible hydraulically-operable device having a single rotor unit provided with radially-movable vanes and including fluid-passage means in said vanes for flow of operating fluid.

A further object of the invention is to provide a hydraulically-operable device having a pair of rotor units adapted to be driven in opposite directions and provided with means for selectively admitting operating fluid to said rotors and for selectively connecting said rotors with a common shaft to thereby selectively effect forward and reverse rotation of said shaft.

The invention will be made clear by reference to the ensuing description taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a side elevation of a hydraulically-operable device having a single rotor unit and constructed in accordance with the present invention;

Fig. 2 is an end elevation of the hydraulically-operable device as viewed from the left of Fig. 1;

Fig. 3 is a sectional view taken on the line **3—3** of Fig. 2;

Fig. 4 is a sectional view taken on the line **4—4** of Fig. 3;

Fig. 5 is a perspective view of one of the radially-movable rotor vanes of the hydraulically-operated device as shown in Figs. 3 and 4;

Fig. 6 is an end elevational view of the body of the rotor unit of the device shown in Figs. 3 and 4, the rotor vanes having been removed from the rotor unit for clarity of illustration;

Fig. 7 is a side elevation of the rotor body shown in Fig. 6;

Fig. 8 is an elevational view showing the inner face of one of the end housing plates of the rotor device shown in Figs. 1–3;

Fig. 9 is an elevational view of the annular rotor housing section of the device shown in Figs. 1–3;

Fig. 10 is a sectional view on the line **10—10** of Fig. 9;

Fig. 11 is a sectional view through a modified hydraulic unit having cam track and cam follower means for positively actuating the radially-movable rotor vanes;

Fig. 12 is a sectional view taken on the line **12—12** of Fig. 11.

Fig. 12*a* is an enlarged perspective view of one of the rotor vanes of the device of Fig. 11 showing the cam followers thereon;

Fig. 13 is a top plan view of a reversible, hydraulically-operable device employing a pair of rotor units adapted to be driven in opposite angular directions and having control means for selectively directing operating fluid to said rotor units and for selectively connecting said rotor units to a common shaft, the control means being in position to admit operating fluid to the left rotor unit and to connect this unit to the shaft;

Fig. 14 is a side elevation of the reversible hydraulically-operable device as viewed from the right of Fig. 13;

Fig. 15 is a sectional view substantially on the line **15—15** of Fig. 13;

Fig. 16 is a sectional view on the line **16—16** of Fig. 15 showing one rotor unit and having a portion thereof cut away to show a portion of the other rotor unit;

Fig. 17 is a fragmentary sectional view on the line **17—17** of Fig. 15, and showing the left rotor unit, the fluid control means being in a position to supply operating fluid to this rotor unit;

Fig. 18 is a view similar to Fig. 17, but showing the fluid control means in a position to cut off the supply of operating fluid to the left rotor unit and to supply operating fluid to the right rotor unit, as viewed in Fig. 15; and

Fig. 19 is an enlarged fragmentary perspective view of the fluid control means of the device in Figs. 13–18.

Referring now to the drawings in detail, and specifically to Figs. 1 through 10 thereof, the hydraulically-operated device A comprises end housing sections **12** and **14** having disposed therebetween an annular rotor housing section **16** the configuration of which is best shown in Fig. 9. These housing sections are secured together in tightly-assembled, fluid-sealed relationship by means of a plurality of bolts **18** which pass through suitable registering openings in the housing sections and have nuts **20** threadedly engaged with the ends thereof. The annular housing section **16** is undercut on each side of the periphery thereof to provide shoulders **19**, and the end housing plates **12** and **14** are provided with peripheral flanges **21** and **22** respectively, which engage the shoulders **19** and thereby facilitate a fluid-tight joint. The end plates **12** and **14** in co-operation with the annular housing section **16** provide a rotor chamber **24** in which a rotor unit **26** is disposed. The end plate **14** is provided with an outwardly-extending axial hub **28** having a central bore **30** which forms a bearing for rotor axle **32**. The rotor axle **32** is bored and grooved as shown at **34** to thereby receive the end of a splined shaft **36**, the other end of which, for example, may be connected to a device (not shown) to be driven. The end plate **12** is also provided with an outwardly-extending axial hub **38**, which is centrally bored at **40** to receive a hollow shaft or tubular member **42** which extends into the rotor chamber **24** and into an axial bore **43** (Fig. 6) within the rotor unit **26**. The shaft **42** may be force-fitted into the bore **40** of the axial hub **38**, and is adapted to remain stationary relative thereto and to form a fluid-tight seal therewith. Operating clearance is provided, however, between the inner end of the shaft **42** and the rotor bore **43** so that the rotor unit **26** may freely rotate with respect to this member, which acts as a bearing therefor. The hollow shaft **42** provides a passageway **44** for operating fluid to or from the rotor unit **26** as will hereinafter be more fully described.

The rotor unit **26** substantially completely fills the rotor chamber **24** with just sufficient clearance being provided between the side faces of the rotor unit **26** and the inside faces of the end plates **12** and **14** to permit substantially frictionless rotation of the rotor unit **26**. However, a clearance is provided between the periphery **45** of the rotor unit **26** and the inside periphery **46** of the annular housing section **16** to provide working chambers **47** and **47a** for the rotor vanes as will hereinafter be described.

The rotor unit **26**, as may best be seen in Figs. 3–7, comprises a disk-like body portion **48** provided with two pairs of oppositely-disposed radial slots **49** extending the full width of the rotor body **48** and in which rotor vanes **50** are adapted to be received. The rotor vanes **50** are adapted to move radially in the slots **49** from a retracted position (top and bottom rotor vanes as viewed in Fig. 4), wherein the bottoms **52** of the rotor vanes **50** are substantially in engagement with the bottoms **54** of the slots **49** and the upper surfaces **56** of the rotor vanes **50** are substantially flush with the rotor periphery **45** to an extended position wherein the upper surfaces **56** are closely adjacent the periphery **46** at the maximum diameter of the annular housing section **16** (left and right rotor vanes as viewed in Fig. 4). In order to provide limitation of the rotor vanes **50** to radial movement between these positions, lateral guide-ways **60** are provided in the rotor body **48** on either side of the slots **49** and the rotor vanes **50** are provided with a pair of oppositely-extending projections **62** adapted to extend into the lateral guide-ways **60** and to engage the bottom and top shoulders **64** and **66** provided by such lateral guide-ways at the retracted and extended positions respectively of the rotor vanes **50**. The engagement of the projections **62** with the top shoulders **66** of guide-ways **60** permits a small operating clearance to be maintained between the top surfaces **56** of the rotor vanes **50** and the periphery **46** of the annular housing section **16**, thereby eliminating friction between these surfaces as the rotor rotates. The upper surface **56** of each rotor vane **50** is arcuate in configuration so that in the retracted position of the rotor vanes **50** the surfaces **56** form a substantially smooth continuous portion of the rotor periphery **45**. Each rotor vane **50** is provided with a longitudinally-extending bore **68** (Figs. 3, 4, 5) and with a communicating lateral bore **70** to provide a passageway for operating fluid through such vane as will hereinafter be described. The top portion of each rotor vane **50** is provided with an extension **72** which is adapted to form the trailing portion of the rotor vane **50** as the rotor unit **26** is rotated in a forward angular direction. The extension **72** is provided at the rear thereof with an inclined face **74** which, when the rotor vane **50** is in retracted position, is adapted to flushly engage a cutout portion **76** in the rotor body **48**. The lateral bore **70** in the rotor vane **50** forms an opening in the face **74**. In order to provide for the passage of operating fluid to the rotor vanes **50**, the rotor body **48** is provided with radial passageways **78** connecting the bottom of each of the slots **49** with the axial bore **43**. As may best be seen in Fig. 4, the bores **68** in the vanes **50** substantially form radial extensions of the passageways **78**. The end of the hollow shaft **42** within the rotor bore **43** is cut out to provide oppositely-disposed ports **80** and **81** respectively, which provide means for selectively admitting or discharging operating fluid to the passageways **78** of the rotor unit **26**, depending upon the angular position of the rotor. Each of the ports **80** and **81** extends about one-quarter of the way around the periphery of the shaft **42** so that as the rotor unit **26** rotates two of the ports **78** communicating with the bore **43** are in open communication with passageway **44** in the hollow shaft **42**, where as the other two ports **78** are closed off. The hollow shaft **42**, upon assembly of the device, is stationarily and angularly disposed with respect to the housing sections **12**, **14**, and **16**, so that communication between passageway **44** and the ports **78** is beginning to be established by control ports **80** and **81** at the angular position of the rotor unit **26**, at which the rotor vanes **50** are beginning to enter the working chambers **47** and **47a** and communication is cut off as the rotor vanes **50** approach the ends of the working chambers **47** and **47a**.

As will best be seen from Figs. 4 and 9, the inner periphery **46** of the annular housing section **16** is provided with a pair of oppositely-disposed, inwardly-extending portions **82** and **83**, respectively, which curve gradually inwardly beginning at points **84** and **85** near the discharge end of the working chambers 47 and 47a, respectively, and terminate in portions 86 and 87 which are adapted to just clear the rotor periphery 45 and surfaces 56 of rotor vanes 50 when such vanes are in their retracted position. The ends of the inwardly extending portions 82 and 83 provide abutments 88 and 89 defining the beginning of working chambers 47 and 47a, respectively, and providing reaction surfaces against which the operating fluid may act.

Each of the end housing sections or plates 12 and 14 is provided with a pair of ports 90 and 92 for discharging operating fluid from the working chambers 47 and 47a near the end thereof. The ports 90 and 92 are disposed adjacent the end portions 86 and 87 of the inwardly extending portions 82 and 83 of the annular housing section 16. In order to permit flow of fluid from the working chambers 47 and 47a to discharge ports 90 and 92, the end plates 12 and 14 are further provided with peripheral grooves 94 and 96 respectively, which extend arcuately along the inner faces of these plates for a substantial distance adjacent the inwardly-extending portions 82 and 83 of the annular housing section 16. Thus, there is no substantial restriction to the flow of fluid from the working chambers 47 and 47a on the discharge side of the vanes 50. Conventional fittings 98 threadedly engage the ports 90 and 92 and connect such ports with suitable conduits 100 for carrying the discharged fluid to a return sump or to waste.

In operation of the device as shown in Figs. 1 through 10, operating fluid under pressure is admitted to passageway 44 of hollow shaft 42 by actuation of a suitable control valve (not shown) and passes into the rotor unit 26. Assuming the rotor unit 26 to be at a standstill and that the rotor vanes 50 are in the position shown in Fig. 4, the operating fluid passes through control ports 80 and 81 and through ports 78 into passageways 68 and 70 of the rotor vanes 50 shown at the left and right of Fig. 4. These rotor vanes are forced by the pressure of the operating fluid radially outward, as shown, to the full extent permitted by periphery 46 of the rotor chamber or by engagement of the projection 62 with the outer shoulder 66 of the lateral guideway 60 in the rotor vane slots 49. The action of the operating fluid directed by lateral passageway 70 against the inclined cut-away portion 76 also tends to raise the rotor vanes 50 and maintain them in extended position. In the extended position, operating fluid is directed by the lateral passageways 70 substantially tangentially to the periphery of the rotor unit and acts against the rotor vanes 50 and against abutments 88 and 89 to start the rotor unit 26 moving in a clockwise direction. As each rotor vane clears the abutments 88 and 89 in the course of rotation of the rotor unit 26, operating fluid begins to be admitted to it through the control ports 80 and 81, respectively. As the rotor vanes 50 approach the gradually-inclined inward extensions 82 and 83 in the course of rotation of the rotor unit 26, the ports 78 begin to pass out of registry with control ports 80 and 81 and the flow of operating fluid is completely cut off by the time the trailing portion 72 of the rotor vanes clear the discharge grooves 94 and 96 in the end plates 12 and 14. Loss of operating fluid without performance of useful work is thereby avoided. At the time the trailing portion 72 of each rotor vane 50 clears the beginning of the discharge grooves 94 and 96, the discharge of operating fluid ahead of the next rotor vane is permitted. This fluid flows out through the ports 90 and 92 in the end plates 12 and 14 and thence through conduits 100 to a return sump (not shown) or to waste.

It will be seen that at each angular position of the rotor unit 26 diametrically-opposed rotor vanes 50 are being subjected to exactly the same forces. Fluid pressure is uniformly supplied to the opposed vanes through the central injection system. A smoothly-operating, well-balanced device is thereby provided.

In the embodiment described above, the rotor vanes 50 are forced outward by fluid pressure and gravity without the aid of mechanical control other than to limit such outward movement. Retraction of the rotor vanes is accomplished by means of the camming action of the inwardly-extending portions 82 and 83 of the periphery 46 of the annular rotor housing section 16. In the modification generally designated as B, shown in Figs. 11 and 12, mechanical means are provided for controlling the radial position of the rotor vanes at each angular position of the rotor unit.

Referring now specifically to Figs. 11, 12, and 12a, the modified unit B is provided with rotor units 26a, which are identical to the rotor units 26 of the device previously described, except that the rotor vanes 50a at their lower ends have projecting studs 101 upon which are mounted cam-followers 102. The cam-followers 102, for example, may comprise ball-bearing rings. End housing plates 12a and 14a are provided in their inner faces with cam-tracks 104 and 105, respectively, adapted to receive the cam-followers 102 of rotor vanes 50a and to guide them along a path forcing the rotor vanes 50a radially inward and outward as the rotor unit 26a turns thereby to positively control the movement of such vanes. The annular rotor housing section 16a is provided with inwardly-extending peripheral portions 82a and 83a which instead of being gradually inclined in the forward direction of the travel of rotor unit 26a, may be relatively short and have sharply defined abutments 84a—88a and 85a—89a, respectively, on each side thereof. The curvature of the cam-tracks 104 and 105 (Fig. 12) is such that the rotor vanes 50a are fully retracted just before engaging the rear abutments 84a and 85a, and are extended to maximum position as quickly as possible after the trailing edge 72a clears the forward abutments 85a and 89a. The rotor vanes 50a are fully extended by the cam means for an angular distance of at least about 90° in each working chamber. The camming action, however, should be sufficiently gradual to ensure smooth operation of the device.

The device shown in Figs. 11, 12 and 12a permits reversal of the rotor unit 26a by simply reversing the direction of flow of the operating fluid. For example, in operating the rotor unit 26a in a forward or clockwise direction, as viewed in Fig. 12, operating fluid may be brought in through the axial system including passageway 44a, ports 78a, and outwardly through passages 68a, 70a in the rotor vanes 50a, finally discharging from the ports 90a, 92a in exactly the same manner as described above. In order to reverse the direction of travel of the rotor unit 26a, operating fluid may be introduced into the ports 90a, 92a by means of a suitable valving arrangement in the fluid control system (not shown) whereby the fluid entering the working chambers acts on the rear faces 106 of the rotor vanes 50a to drive the rotor unit 26a in a reverse or counterclockwise direction. Operating fluid ahead of each vane 50a, as such vane is being forced in reverse direction and is in its extended position, is discharged through the lateral passageway 70a of the vane, down through radial passageway 68a, ports 78a, control ports 80a and 81a and out out of the axial passageway 44a which is now connected to a sump or to waste.

In the reversible double unit shown in Figs. 13 through 19, the hydraulic device generally indicated as C is provided with end housing plates 112 and 114 having a pair of annular rotor housing sections 116 and 116a disposed therebetween and spaced apart by means of a central housing section 117. These housing sections are held together in fluid-tight engagement by means of bolts 118 which pass through suitable registering openings, and are provided at their other ends with nuts 120. As shown in Fig. 15, the rotor housing sections 116 and 116a are provided with undercut peripheral portions 119 which are engaged by annular flanges 122 on the end plates 112, 114 and on the central housing section 117 respectively. The end plates 112 and 114 in conjunction with the annular housing sections 116 and 116a and central housing member 117 are provided with a pair of rotor chambers 124 and 124a respectively, wherein the rotor units 126 and 126a are disposed.

The end housing plate 114 is provided with an outwardly extending hub 128 having a central bore 130, which forms a bearing for axle 132 of rotor unit 126. The rotor axle 132 has an axial bore 134 which at its outer end is provided with inwardly-extending teeth 135 adapted to mesh with teeth 135a on a clutch member 135b carried by splined shaft 136. The teeth 135 mesh with the clutch teeth 135a when the clutch member 135b is in its outer position. When the clutch member 135b is in its inner position as shown in Fig. 15, the clutch member 135b has disengaged shaft 136 from rotor unit 126.

The central housing section 117 has a central bore 137 which forms a bearing for axle 132a of the second rotor unit 126a (left rotor unit as viewed in Fig. 15). Axle 132a extends through the bore 137 of the central housing section 117 and into the bore 134 of the first rotor unit 126, terminating in the bore 134 about half way through the axle 132. The two rotor units 126 and 126a are adapted to rotate independently of each other, just sufficient operating clearance being allowed for this purpose. The axle 132a of rotor unit 126a at the end terminating in bore 134 is provided with a central bore 134a which receives an axial extension 136a of splined shaft 136, whereby shaft 136 is maintained in proper alignment with the hydraulic unit. A bushing 136b disposed in the bore 134a between this bore and the shaft extension 136a permits free rotation of shaft 136 with respect to rotor 126a when these elements are not clutched together.

The outer annular portion of the axle 132a of rotor 126a is provided with teeth 139 which are adapted to mesh with teeth 139a carried by the end of clutch member 135b. When the clutch member 135b is in an inner position as shown in Fig. 15, the teeth 139 and 139a are engaged, and the rotor 126a is thereby operably connected in driving relation to shaft 136.

The rotor units 126 and 126a, as may be observed from Fig. 16, are similar with respect to rotor vanes 150 and 150a and with respect to fluid-communicating ports 178 and 178a to those previously described for the single rotor hydraulic unit A. The rotor units 126 and 126a are disposed in the rotor chambers 124 and 124a so as to be adapted to turn in opposite directions. It will be observed from Fig. 16 that the extending portions 172 of the vanes 150 in rotor unit 126 are so disposed as to drive this rotor unit in a counterclockwise direction, whereas the extending portions 172a of the vanes 150a in rotor unit 126a are so disposed as to drive this rotor unit in a clockwise direction.

The annular rotor housing sections 116 and 116a of the double unit C are also similar to the annular rotor housing section 16 of the single unit A described herein, these sections in the double unit being disposed in such manner as to correspond to the direction of rotation of the particular rotor unit housed therein. Thus, in annular housing section 116, the portions 182 and 183 defining the ends of the working chambers extend gradually inward in a counterclockwise direction terminating in abutments 188 and 189, whereas in the annular housing section 116a the corresponding portions, such as 182a shown to the left of Fig. 16, extend inwardly in a clockwise direction terminating in abutments 188a also shown to the left of Fig. 16. The annular housing sections 116 and 116a, as shown in the device C (Fig. 16) have in effect been reversed and angularly shifted 90° with respect to one another.

The end plate 114 is provided with discharge ports 192 and discharge grooves 196 for discharging operating fluid from rotor chamber 124 through conventional fittings 198 to suitable conduits 200 leading to a return sump or to waste. The end plate 112 likewise is provided with discharge ports 192a, and discharge grooves 196a for discharging operating fluid from rotor chamber 124a through conventional fittings 198a and thence through conduits 200 to a return sump or to waste.

In order to supply operating fluid to the hydraulic device C, the end plate 112 is provided with a hub 138 which is centrally bored at 140 to receive hollow shaft 142 having a fluid-control sleeve 210 concentrically disposed over the end thereof. The hollow shaft 142 and control sleeve 210 extend into an axial bore 143 in the rotor unit 126a and terminate at the end 212 of bore 143 at a position wherein the axle 132a of rotor unit 126a extends within the bore 134 of the first rotor unit 126. Sufficient operating clearance is provided between control sleeve 210 and the rotor bore 143 to permit free rotation of the rotor unit 126a with respect to the control sleeve 210. Likewise, sufficient operating clearance is provided between control sleeve 210 and hollow shaft 142 to permit rotation of the control sleeve on shaft 142. In order to hold the shaft 142 stationary with respect to end housing plate 112 and to form a fluid-tight seal between these elements, the hollow shaft 142 is provided with an outer annular flange 214 adapted to fit flush with the end of hub 138 and to be tightly secured thereto by means of bolts 216. The control sleeve 210 extends within an annular groove 218 in the flange 214, thereby further preventing leakage of the assembly structure.

The hollow shaft 142 provides a fluid passageway for axial flow of operating fluid selectively into rotor units 126 and 126a depending on the angular position of control sleeve 210 as will hereinafter be described. The end of hollow shaft 142 is provided with ports 180 and 181 which control the timing of the flow of operating fluid into the first rotor unit 126, as previously described with respect to the single rotor unit 26. In order to permit the flow of operating fluid from the ports 180 and 181 into radial passageways 178 of rotor unit 126, the axle 132a of the second rotor unit 126a is provided with a plurality of slots 220 around the entire peripheral portion engaged by passageways 178 on their path of rotation around axle 132a. The size and spacing of the slots 220 is such that flow of fluid from ports 180 and 181 may pass into the ports 178 regardless of the angular position of rotor unit 126a with respect to rotor unit 126. The control sleeve 210 is positioned over the hollow shaft 142 and is provided with control ports 222 and 224 in the end thereof adapted to register with the ports 180 and 181 in hollow shaft 142 at a selected angular position of the control sleeve 210. The length of the control ports 222 and 224 is slightly less than that of ports 180 and 181 so that upon rotation of control sleeve 210 to the position as shown, for example, in Fig. 16, the ports 222 and 224 may be moved completely out of registry with ports 180 and 181 so that ports 180 and 181 are completely closed off by the control sleeve 210.

In order to control the flow of operating fluid to the second rotor unit 126a the hollow shaft 142 is provided with ports 180a and 181a which permit the flow of operating fluid from passageway 144 into radial passageways 178a when such passageways are in the proper angular position to open the vanes 150a into their respective working chambers as previously described with respect to the single hydraulic unit A. The control sleeve 210 is provided with control ports 226 and 228 which, in one angular position as shown in Figs. 15 and 17, are adapted to register with ports 180a and 181a, respectively, whereby to permit free access of fluid from passageway 144 through the ports 180a and 181a to radial passageways 178a. The control ports 226 and 228 are of slightly less length than ports 180a and 181a, so that the control ports may be moved completely out of registry with ports **180a** and **181a** as shown in Fig. 18, to thereby cause control sleeve **210** to completely shut off flow of operating fluid from passageway **144** to the rotor unit **126a**.

In order to control the rotation of the control sleeve **210**, this sleeve is provided with a radially-extending control lever **230** which extends through an elongated slot **232** provided in the hub **38** of the end plate **112**. The length of slot **232** is such as to permit rotation of the control sleeve **210** through an angle of 90°. Simultaneous control of the flow of operating fluid to a particular rotor unit and engagement of the selected rotor unit to the shaft **136** is provided by means of a laterally-extending control arm **234** connected to control lever **230**. The lateral control arm **234** is connected to a clutch-engaging lever **236** by means of a rod **238** extending from the outer end of clutch-control lever **236** into a bore **240** extending longitudinally into arm **234**. A spring **242** connected to the end of clutch lever **236** and to the end of arm **234** tends to urge rod **238** into the bore **240** and to prevent lateral disengagement of these parts. Clutch-lever **236** at its lower end is provided with a yoke **244** having inwardly extending projections **246** and **248** received within an annular channel **250** provided in the outer end of clutch member **135b**. The end of hub **128** of end plate **114** is provided with a cam **252** having a cam surface **255** beginning at a point **254** and extending from point **254** for an angular distance of 90° to a point **256**. The lever **236** is provided with a cam follower **258** adapted to follow the cam surface **255** upon rotation of lever **236** from the position shown in full lines in Fig. 14 to the position shown in phantom lines in this figure. By the camming action effected by movement of the lever **236** by control arm **234** counterclockwise as viewed in Fig. 14, the lever **236**, yoke **244** and clutch member **135b** are caused to shift laterally outward from the position shown in Figs. 13 and 15 whereby the clutch teeth **135a** are meshed with teeth **135** on the axle **132** of the first rotor unit **126**. At the same time lever **230** has caused the control sleeve **210** to be rotated counterclockwise to cause control ports **222** and **224** to register with ports **180** and **181**, whereby operating fluid may be supplied from passageway **144** to the first rotor unit **126**.

In operation of the hydraulic device C, assuming that it is desired to drive the shaft **136** in a clockwise direction, the control arm **234** is actuated as by means of a suitable control member **260** to position control levers **230** and **236** as shown in full lines in Figs. 13, 14, 15, 16, and 17. In this position control ports **226** and **228** are in registry with ports **180a** and **181a**, so that operating fluid may be admitted to the rotor unit **126a** (Fig. 17). Control ports **222** and **224** are out of registry with ports **180** and **181** whereby operating fluid to the rotor unit **126** is cut off (Fig. 16). Clutch member **135b** is in its inner position as shown, whereby teeth **139a** are in engagement with teeth **139** on hub **132a** of the rotor unit **126a**, and teeth **135a** are disengaged from teeth **135** carried by hub **132** of the rotor unit **126**. Operating fluid is now admitted to passageway **144** by actuation of a suitable control valve (not shown) and flows through ports **180a 181a** and **226, 228** into radial passageways **178a** thence into the passageways **168a** of rotor vanes **150a**, lifting these vanes into their respective working chambers and then passing out through the lateral passageways **170a** to force the vanes and rotor unit **126a** in a clockwise direction. Fluid is exhausted from the ends of the working chambers through grooves **196a** and ports **192a**.

If it is now desired to reverse the direction of rotation of shaft **136**, the flow of operating fluid through passageway **144** is stopped by actuation of the control valve (not shown) and after rotation of the rotor unit **126a** and shaft **136** has slowed down, the control arm **234** may be actuated by the actuating means **260** to move levers **230** and **236** through an angle of 90° counterclockwise, as viewed in Fig. 14, whereby clutch member **135b** is shifted to the right to disengage teeth **139a** from the teeth **139** of the rotor unit **126a** and engage teeth **135a** with teeth **135** carried by the axle **132** of the rotor unit **126**. At the same time, control sleeve **210** has been rotated so that the ports **226** and **228** are now out of registry with ports **180a** and **181a** of the rotor unit **126a** (Fig. 18), and the ports **222** and **224** are in registry with ports **180** and **181**, whereby to admit operating fluid to the rotor unit **126**. Operating fluid may now be admitted through passageway **144** and passes through the ports **180** and **181**, **222** and **224** through ports **220** in sleeve **210** in the rotor axle **132a** and into radial passageways **178**. Operating fluid then passes into the passageways **168** and **170** in the rotor vanes **150**, lifting the vanes **150** and causing them to move the rotor unit **126** in a counterclockwise direction, thereby driving shaft **136** in this direction. Operating fluid is discharged through grooves **196**, discharge ports **192**, and passes through conduits **200** to a return sump or to waste, as previously described.

It will be understood that various changes may be made in the details of construction and configuration of the parts of the hydraulic units herein disclosed without departing from the principles of the invention or the scope of the annexed claims.

I claim:

1. A hydraulically-operable device, comprising: a housing providing a rotor chamber; a rotor unit mounted within said rotor chamber, said rotor unit having an axle on one side thereof extending through said housing and adapted to be connected to a shaft and having an axial bore on the other side thereof, said rotor unit having a plurality of movable vanes and said housing providing a working chamber for said vanes; fluid-passage means extending through said housing and communicating with one end of said working chamber; fluid-passage means extending through said housing and communicating with the axial bore of said rotor unit; and fluid-passage means in said rotor unit for establishing communication from said axial bore of said rotor unit to said working chambers, whereby operating fluid may flow through said housing and rotor unit and act upon said rotor vanes in said working chamber to thereby drive said rotor.

2. A hydraulically-operable device as defined in claim 1 wherein said housing provides a pair of oppositely-disposed working chambers around the periphery of said rotor unit and said rotor vanes are radially extendable into said working chambers for a portion of a revolution of the rotor unit and are radially retractable at the ends of said working chambers during another portion of said revolution of the rotor unit.

3. A hydraulically-operable device as defined in claim 2 wherein the fluid-passage means in said rotor unit include passageways in said rotor vanes for flow of operating fluid when said rotor vanes are radially extended into said working chambers.

4. A hydraulically-operable device as defined in claim 3 wherein said passageways in said rotor vanes are disposed to direct flow of operating fluid from said rotor vanes generally tangentially to the periphery of said rotor unit.

5. A hydraulically-operable device as defined in claim 3 wherein fluid-control means are provided for timing the flow of operating fluid to the passageways in said rotor vanes so that flow of operating fluid through said passageways is permitted when said rotor vanes are in the path of said working chambers and is cut off when said rotor vanes are adjacent the ends of said working chambers.

6. The hydraulically-operable device of claim 2 wherein said rotor unit includes means responsive to the pressure of operating fluid admitted to said rotor unit through the axial bore thereof to extend said rotor vanes radially into said working chambers.

7. The hydraulically-operable device of claim 2 wherein cam means are provided for controlling the radial position of said rotor vanes at all angular positions of said

rotor to thereby move said rotor vanes into and out of said working chambers.

8. A hydraulically-operable device, comprising: a housing providing a rotor chamber, said housing having hub portions projecting outwardly therefrom on opposite sides thereof; a rotor unit in said rotor chamber, said rotor unit having an axle on one side thereof extending into one of said hub portions of said housing and adapted to be connected to a shaft and having an axial bore on the other side thereof, said rotor unit having a plurality of radially-movable vanes slidably mounted in openings in the peripheral portion thereof, and said housing providing a pair of oppositely-disposed working chambers around the periphery of said rotor unit into which said rotor vanes are adapted to be radially extended; a hollow shaft extending through the other of said hub portions of said housing and into said axial bore in said rotor unit, said hollow shaft having peripheral ports in the end thereof within said rotor unit; said rotor unit having radial passageways adapted to register with the ports in said hollow shaft during at least a portion of a revolution of said rotor unit, said radially-movable vanes of said rotor unit having passageways establishing communication between said radial passageways and said working chambers when said vanes are in a radially-extended position; and fluid-passage means in said housing communicating with the ends of said working chambers whereby operating fluid for driving said rotor unit may pass through said hollow shaft, through passageways in said rotor unit and rotor vanes into said working chambers, and be discharged through the fluid-passage means in said housing.

9. The hydraulically-operable device of claim 8 wherein the rotor unit comprises a body portion having radial slots in a peripheral portion thereof for receiving said radially-movable vanes, the outer portions of said radially-movable vanes in a retracted position forming a substantially uniform peripheral portion of said rotor body; a lateral extension at an outer portion of each rotor vane providing an outwardly-inclined face and said rotor body having cutout portions adapted to receive said lateral extensions and providing inclined faces mating with the inclined faces of said rotor vanes when said vanes are in a retracted position, the passageways in said rotor vanes opening upon the inclined faces of said rotor vanes whereby operating fluid admitted to said rotor vanes through the radial passageways of said rotor unit is directed against the inclined faces of the rotor body and acts to force the rotor vanes radially outward into the working chambers.

10. A rotor unit for a hydraulically-operable device, comprising: a rotor body having a plurality of radial slots around the periphery thereof; a plurality of rotor vanes slidably mounted for radial movement in said slots; said rotor body having a central bore and fluid-passage means in said rotor body and in said rotor vanes for flow of operating fluid from said central bore to the periphery of said rotor.

11. A rotor unit for a hydraulically-operable device, comprising: a cylindrical rotor body having an axle extending from one side thereof and adapted to support said rotor body for rotation about a central axis, said rotor body having an axial bore extending into the other side thereof, said rotor body further having a plurality of radial slots around the periphery thereof and having ports establishing communication between said axial bore and the bottom of said radial slots; and rotor vanes slidably mounted in said radial slots and adapted to be radially movable therein between a retracted and extended position, the outer portions of said rotor vanes in said retracted position forming a substantially uniform peripheral portion of said rotor body, said rotor vanes having radial passageways forming a substantially radial extension of the ports in said rotor body and having lateral passageways at their outer ends communicating with said radial passageways and adapted to be uncovered when said vanes are in said radially-extended position.

12. The rotor unit defined in claim 11 wherein means are provided for limiting the radial movement of said rotor vanes between said retracted and extended positions.

13. The rotor unit of claim 11 wherein said radial slots and radially-movable vanes extend the entire width of said rotor body.

14. The rotor unit of claim 11 wherein said rotor vanes have a lateral extension at the end thereof and wherein said rotor body is cut away at the peripheral edge of said slots to receive said lateral extensions.

15. The rotor unit of claim 14 wherein said lateral extensions of the rotor vanes form an inclined face mating with a similar inclined face in said rotor body when said vanes are in retracted position and wherein the lateral passageways in said vanes open upon said inclined face.

16. A hydraulically-operable device comprising: an annular housing section; an end housing section on opposite sides of said annular housing section and cooperating therewith to form a rotor chamber; means securing said housing sections together, each of said end housing sections having a hub projecting outwardly therefrom; a rotor unit in said rotor chamber having an axle on one side extending into the hub of one of said end housing sections and having an axial bore in the other side thereof said axle being adapted to be connected to a shaft, said rotor unit having a plurality of radially-movable vanes slidably mounted in openings in a peripheral portion thereof, said annular housing section having an inner periphery spaced from said rotor unit and having inwardly-extending portions defining working chambers for said rotor vanes; a hollow shaft extending into the hub of the other of said end housing sections and into the axial bore of said rotor unit, said hollow shaft having peripheral ports in the end thereof within said rotor bore; fluid-passage means in said rotor unit and rotor vanes establishing connection between the ports in said hollow shaft and said working chambers when said rotor vanes are in an outwardly extended position; and fluid-passage means extending through at least one of said housing sections and communicating with said working chambers.

17. The hydraulically-operable device of claim 16 wherein said rotor unit comprises a rotor body having radial ports establishing communication between said rotor vanes and said axial bore and wherein the peripheral ports in the end of said hollow shaft are angularly disposed to selectively register with said radial ports during that portion of a revolution of said rotor unit wherein said rotor vanes are in the path of said working chambers.

18. A reversible, hydraulically-operable device, comprising: an annular housing section; an end housing section on opposite sides of said annnlar housing section and co-operating therewith to form a rotor chamber; means securing said housing sections together, each of said end housing sections having a hub projecting outwardly therefrom; a rotor unit in said rotor chamber having an axle on one side extending into the hub of one of said end housing sections and adapted to be connected to a shaft and having an axial bore in the other side thereof, said rotor unit having a plurality of radially-movable vanes slidably mounted in openings in a peripheral portion theerof, said annular housing section having an inner periphery spaced from said rotor unit and having inwardly-extending portions defining working chambers for said rotor vanes; means providing a camway in one of said end housing sections; cam-follower means on said rotor vanes projecting from said rotor unit into said camway in said end housing section, said camway and cam-followers controlling the position of said radially-movable rotor vanes at all angular positions of said rotor unit so that said vanes are moved

into and out of said working chambers during rotation of said rotor units; a hollow shaft extending into the hub of said end housing section opposite said rotor axle and into the axial bore of said rotor unit; fluid-passage means for flow of operating fluid from said hollow shaft into said rotor unit and through said rotor vanes into said working chambers when said vanes are in the path of said working chambers; and fluid-passage means in at least one of said end housing sections to admit or discharge operating fluid from said working chambers.

19. A reversible, hydraulically-operable device comprising: a housing providing a pair of rotor chambers; a pair of rotor units in said rotor chambers adapted to be driven in opposite directions; and control means for selectively admitting operating fluid to said rotors and for selectively connecting said rotors to a common shaft to thereby selectively effect forward and reverse rotation of said shaft.

20. A reversible, hydraulically-operable device, comprising: a housing providing a pair of rotor chambers and having a hub extending outwardly on each side thereof; a first rotor unit in one of said rotor chambers having an axle extending from one side thereof into one of said hubs, said first rotor unit having an axial bore therethrough; a second rotor unit disposed in the other of said rotor chambers and having an axle extending from one side thereof into the axial bore of said first rotor unit, said second rotor unit also having an axial bore; said rotor units having a plurality of radially-movable vanes slidably mounted in openings in a peripheral portion thereof, said housing providing working chambers for the rotor vanes and said rotor units being disposed in said rotor chambers to be driven in opposite directions; a hollow shaft extending into the other hub of said housing and into the axial bore of said second rotor unit; fluid-passage means for the admission of operating fluid from said hollow shaft through each of said rotor units to said working chambers; outlet means in said housing for discharging operating fluid from said working chambers; and control means for selectively admitting operating fluid to said rotor units and for selectively engaging the axles of said rotor units to a common shaft whereby said shaft may be driven selectively in a forward or reverse direction by said rotor units.

21. A reversible, hydraulically-operable device comprising: a housing providing a pair of rotor chambers, said housing having a hub extending on each side thereof; a first rotor unit mounted within one of said rotor chambers and having an axle extending outwardly through one of said hubs, said first rotor unit having an axial bore extending completely therethrough; a second rotor unit mounted for rotation within said other rotor chamber, said second rotor unit having an axle extending within the axial bore of said first rotor unit and terminating at a midportion therein, said rotor units being adapted to rotate in opposite directions within said rotor chambers, said second rotor unit having an axial bore in that portion of its axle extending within the axial bore of said first rotor unit; a shaft extending within the axial bore of said first rotor unit and journaled within the axial bore of said second rotor unit; clutch means carried by said shaft and slidably movable thereon to selectively connect said rotor units in driving engagement to said shaft; means extending into the other hub of said housing and into said rotor units for supplying operating fluid to said rotor units; and control means for selectively admitting operating fluid to one or the other of said rotor units.

22. The hydraulically-operable device as claimed in claim 21, wherein common control means are provided for selectively admitting operating fluid to one or the other of said rotor units and for moving said clutch member to selectively engage said one or the other of said rotor units to said shaft.

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