

Dec. 1, 1959

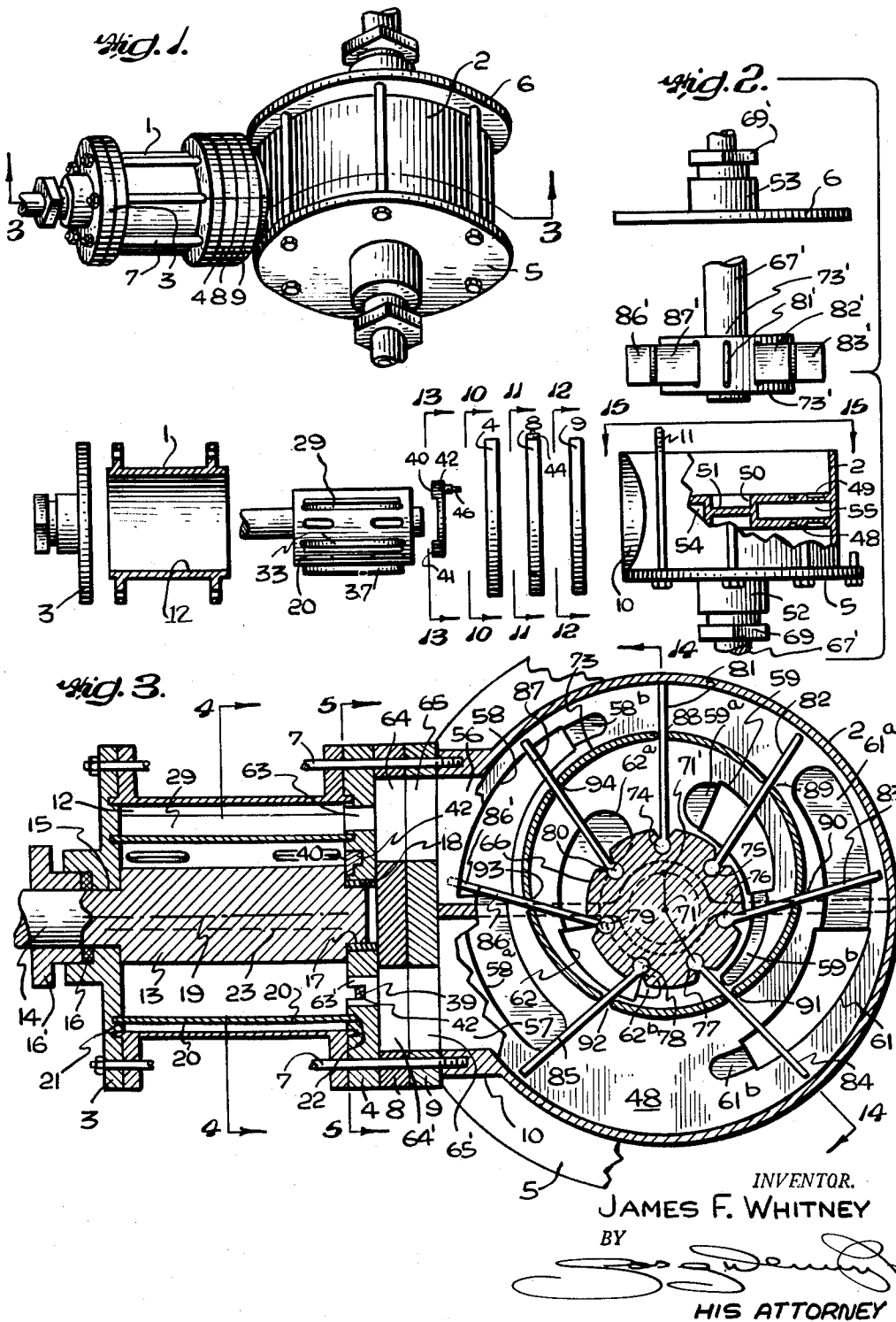
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2,915,017

POWER TRANSMISSION APPARATUS

Filed Jan. 10, 1955

3 Sheets-Sheet 1



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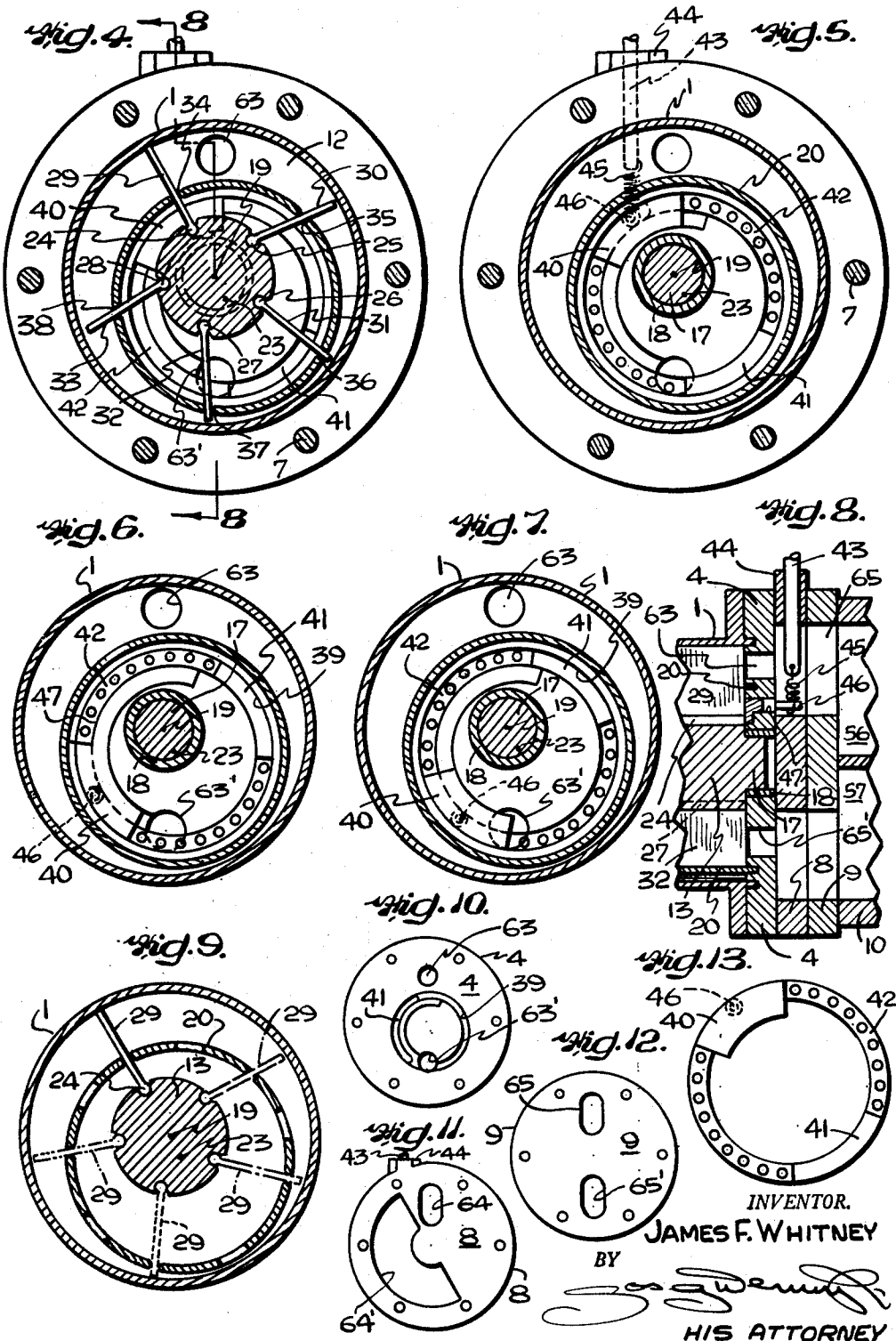
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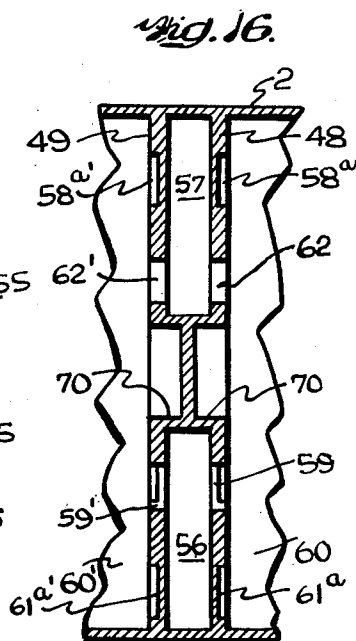
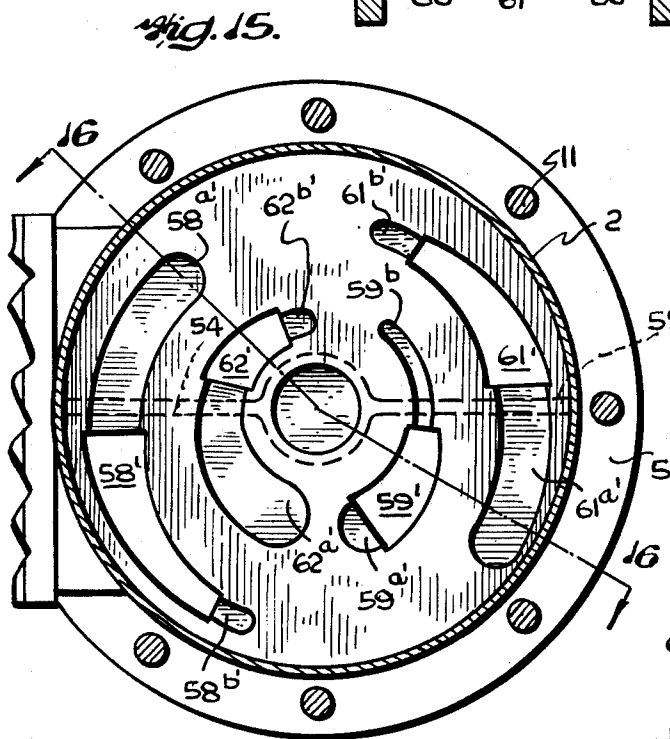
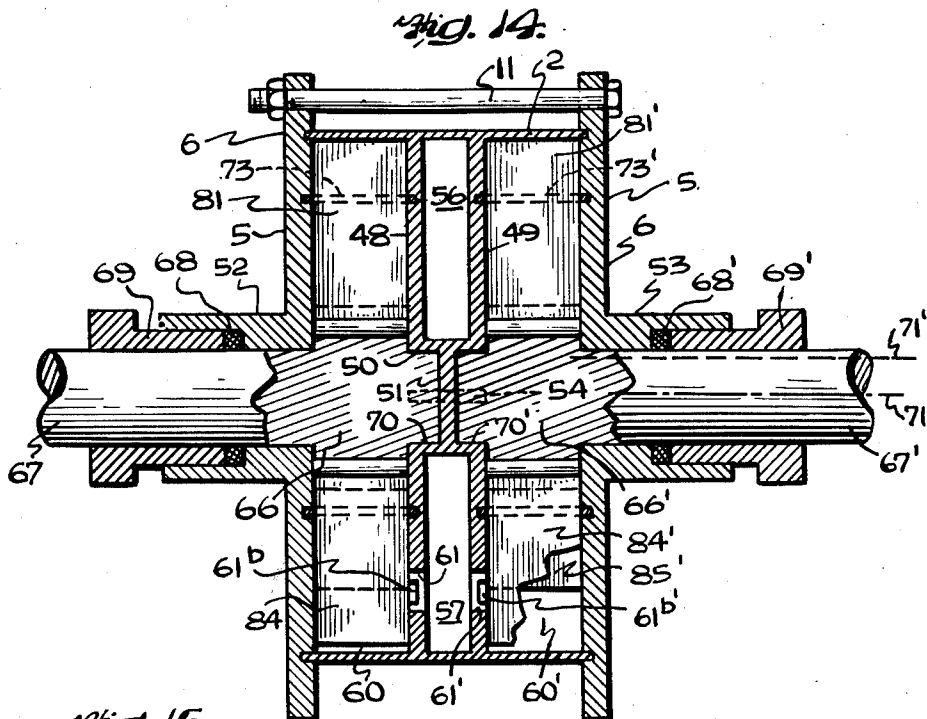
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3 Sheets--Sheet 3



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2,915,017

POWER TRANSMISSION APPARATUS

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Application January 10, 1955, Serial No. 480,964

5 Claims. (Cl. 103—120)

My invention is an improved apparatus for transmitting power hydraulically from driving mechanism to one or more driven mechanisms through independently rotatable rotors each having vanes hinged thereto and rockable thereon toward and from one another and toward and from the cylindrical inner surfaces of casings enclosing the respective rotors.

In accordance with my invention, each such vane is moved bodily around an orbit by, or to cause, the rotation of its rotor, and during part of a vane's orbital movement its web is rocked on its hinge in the direction of rotation of the rotor so that its outer edge has an angular velocity (relative to the axis of rotation of its rotor) greater than that of the hinge portion of such vane or the portion of the rotor to which the vane is hinged. The outer portion of the vane may therefore be considered as "leading" the hinge portion during this part of the orbital movement of the vane.

During the other part of the orbital movement of the vane, its web is rocked on its hinge contra to the direction of rotation of the rotor so that its outer edge has an angular velocity (relative to the axis of rotation of the rotor) less than that of the hinge portion of such vane or the portion of the rotor to which the vane is hinged. The outer edge portion of the vane may therefore be considered as "trailing" the hinge portion during this part of the orbital movement of the vane.

During each rotation of a rotor, each vane hinged thereto will be rocked through two positions radial to the rotor, and in such radial positions the vane will make close sliding contact with the inner cylindrical surface of its casing. As each vane moves away from one of its radial positions, its outer edge will gradually recede from the cylindrical surface of its casing until the vane hinge approaches a perpendicular to such radial position; and, as the vane approaches its next radial position, its outer edge will again gradually approach the inner cylindrical surface of its casing.

When a vane's outer edge is approaching the inner cylindrical surface of its casing, fluid flow between them is gradually restricted to a minimum, and as such outer edge recedes from the cylindrical inner surface of its casing, fluid flow between them may gradually increase to a maximum.

The webs of vanes in opposite zones of an orbit may be rocked toward the cylindrical surface of a casing to restrict flow between such surface and both outer edges by rocking the vanes in opposite directions. If the vanes are being rotated by their rotor, they exert pressure on fluid between the converging surfaces of the vanes and create suction on fluid between the diverging surfaces of the vanes. Contrariwise, if fluid under pressure be applied between the proper portions of the webs of such complementary vanes having outer edges near the cylindrical surface and suction applied to opposite faces of such vanes, and if the vanes be fulcrumed on fulcrums eccentric to the rotor, the resultant rocking of the vanes will rotate the rotor to which the vanes are hinged.

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The rocking of the vanes rotated by a driving rotor and the fulcruming of vanes hinged to a driven rotor may be effected by cylindrical cages encircling the respective rotors and each rotating in a fixed circular path having an axis offset from the axis of rotation of the rotor which it encircles. The axes of the rotor and its encircling cage are parallel and the cage rotates eccentrically to its rotor.

Each cage contains slots for the passage therethrough of the respective vanes of its rotor; each vane passing through the cage at a different angle which varies as the rotor and cage rotate in unison. The offsetting of the axis of rotation of the cage from the axis of rotation of the rotor gives part of the cage an angular velocity (relative to the axis of rotation of the rotor) greater than the angular velocity of half the rotor adjacent thereto, and gives the other part of the cage an angular velocity (relative to the axis of the rotor) less than the angular velocity of the part of the rotor adjacent thereto. Such changes in relative angular velocities between the rotor and cage cause the vanes to apply pressure and suction to fluid when the rotor and cage are rotated in unison and cause the vanes to rotate the rotor and cage when fluid pressure and suction are applied to vanes adjacent to the inner cylindrical surface of a casing therefor.

My invention further provides readily adjustable means for permitting or preventing the by-passing of fluid around the ends of vanes at various points in their orbital movements to permit idling rotation of the driving mechanism, or to vary the degree of pressure and suction developed, and to reverse the points of discharge of fluid from, and its return to, the driving mechanism.

Fluid discharged under pressure from the driving mechanism may be concurrently fed between vanes of a pair of independently rotatable rotors having a common axis of rotation transverse to the axis of rotation of the driving rotor; such fluid being drawn back into the driving mechanism by the suction created by the divergence of surfaces of vanes whose outer edges are adjacent to the cylindrical inner surface of the casing of the driving mechanism.

By my invention, the power of a unidirectional engine can be effectively applied to the wheels of a motor vehicle to provide various speeds relatively to the speed of the engine and permit the turning of the vehicle without the intervention of speed change gears or differential gears.

The principles of my invention and the best mode I have contemplated of utilizing such principles will further appear from the following description and the accompanying drawings in illustration thereof.

In the drawings Fig. 1 is a perspective view of power transmitting apparatus embodying my invention; Fig. 2 is an exploded view of the principal elements of the apparatus shown in Fig. 1; Fig. 3 is a longitudinal sectional view taken on the line 3—3 of Fig. 1; Fig. 4 is an enlarged transverse sectional view of the driving mechanism of the power transmitting apparatus taken on the line 4—4 of Fig. 3; Fig. 5 is an enlarged transverse sectional view of the driving mechanism of the power transmitting apparatus taken on the line 5—5 of Fig. 3, and showing fluid bypass controls positioned for effecting rotation of driven mechanism in one direction; Fig. 6 is a view similar to Fig. 5 but showing the fluid bypass controls in a neutral position preventing transmission of power from the driving mechanism to the driven mechanism; Fig. 7 is a view similar to Fig. 5 but showing the fluid bypass controls positioned to effect a rotation of the driven mechanism in a direction opposite to the direction effected by the positioning of the fluid bypass controls as shown in Fig. 5; Fig. 8 is a fragmentary ir-

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regular sectional view taken approximately on the line 3—3 of Fig. 4; Fig. 9 is a diagrammatic view illustrating positions to which each vane of the driving and driven mechanisms are rocked during a single rotation about the axis of a rotor to which the vanes are hinged; Fig. 10 is a front elevation of the inner header of the casing of the driving mechanism looking in the direction indicated by the line 10—10 in Fig. 2; Fig. 11 is a front elevation of a disc abutting the header shown in Fig. 10 and looking in the direction indicated by the line 11—11 of Fig. 2; Fig. 12 is a front elevation of a coupling disc interposed between the disc shown in Fig. 11 and a fillet of the casing of the driven mechanism, and looking in the direction indicated by the line 12—12 of Fig. 2; Fig. 13 is a greatly enlarged elevation of the fluid bypass controller of the driving mechanism looking in the direction indicated by the line 13—13 in Fig. 2; Fig. 14 is a transverse sectional view of the driven mechanism taken on the line 14—14 of Fig. 3; Fig. 15 is an end view of the casing of the driven mechanism with the header and vanes removed and the casing turned in a direction indicated by the line 15—15 of Fig. 2; and Fig. 16 is a fragmentary sectional view taken on the line 16—16 of Fig. 15.

The drawings illustrate an embodiment of my invention in apparatus comprising a substantially T-shaped housing composed of cylinders 1 and 2 respectively provided with headers 3, 4, and 5, 6.

The flanged cylinder 1 is seated in grooves in the headers 3 and 4 and the cylinder and headers may be held together and connected with the cylinder 2 by bolts 7 which pass through the headers 3 and 4, the cylinder flanges and the discs 8 and 9 into threaded sockets in the fillet 10 formed on the periphery of the cylinder 2. The cylinder 2 may be seated in grooves in the headers 5 and 6 which may be bolted together by bolts 11.

The cylinder 1 and headers 3 and 4 form a cylindrical chamber 12 containing a rotor 13 forming a hub on the driving shaft 14 which is journaled in a bearing 15 of the header 3 and projects outward through a fluid tight packing 16 and follower 16'. The inner end of the rotor 13 is provided with a trunnion 17 journaled in a bearing 18 of the header 4. The rotor 13 is rotatable about an axis of rotation 19 concentric with the inner surface of the cylinder 1.

A cylindrical slotted cage 20 is rotatably journaled in circular grooves 21 and 22 in the inner surfaces of the headers 3 and 4. The circular grooves 21 and 22 have a common axis 23 parallel to but offset from the axis 19 so that the cage 20 encircles the rotor 13 but rotates eccentrically with respect thereto and with respect to the inner cylindrical surface of the cylinder 1.

A series of circularly under-cut grooves 24, 25, 26, 27, and 28 extend longitudinally of the rotor 13 and form cylindrical sockets having flaring mouths for the reception of cylindrical knuckles on the inner ends of vanes 29, 30, 31, 32 and 33. The vanes 29 to 33 are thus hingedly connected with the rotor 13 and are rockable with respect thereto about axes parallel with but offset from the axis of rotation 19 of the rotor 13. The webs of the vanes 29—33 pass freely through equi-distant longitudinal slots 34, 35, 36, 37 and 38 in the cage 20 and the cage may be provided with intermediate openings between the slots to facilitate passage of fluid in the chamber 12 into and out of the cage.

Each vane 29—33 is of such length that its ends make close sliding contact with the inner surface of the headers 3 and 4, and each vane 29—33 is of such width that its outer edge makes close sliding contact with the inner surface of the cylinder 1 when its web is coincident with a diametral plane common to the axis 19 and the axis 23. When the web of a vane is not coincident with a diametral plane common to the axis 19 and the axis 23, the vane is so tilted that the outer edge thereto is spaced from the inner surface of the cylinder 1 to a greater or

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less degree. The clearance between the outer edge of a vane and the inner surface of the cylinder 1 is greatest when the rocking axis of its knuckle in a socket is near a radial plane at right angles to a diametral plane common to the axis 19 and the axis 23.

The inner surface of the header 4 contains a channel 39 concentric with, and lying within the cage 20, and provides a bypass for fluid around the ends of such of the vanes 29—33 as register with open sections of such groove.

The bypassing of fluid around the ends of vanes through the channel 39 may be regulated or prevented by controllers consisting of diametrically disposed blocks or lands 40 and 41 which fill segments of the channel 39 and have surfaces flush with the surface of the header 4 so as to make close sliding contact with the ends of vanes registering with such lands.

The blocks or lands 40 and 41 may be connected with one another to effect concurrent movement thereof by means of a perforated ring 42 which fits in the bottom but does not fill the channel 39. The ring 42, and the blocks 40 and 41 connected therewith may be manually adjusted circumferentially by means of a rod 43 which is rectilinearly moveable through a packed boss 44 and connected through a spring 45 with a pin 46 projecting from the ring 42 through an arcuate slot 47 in the header 4. Preferably the block 40 is of greater radial width than the block 41 so that fluid pressure tends to move the blocks to a neutral position indicated in Fig. 6.

The cylinder 2 has a diameter considerably greater than, and preferably twice, that of the cylinder 1, and contains a pair of discs 48 and 49 containing central apertures surrounded by a collar 50 which is divided by a disc 51 into two concentric bearings coaxial with the bearings 52 and 53 of the headers 5 and 6. A pair of partitions 54 and 55 project radially from the collar 50 outward to the cylinder 2 and divide the space between the discs 48 and 49 into a pair of non-communicating, inner chambers 56 and 57.

The disc 48 contains segmental ports 58 and 59 through which the inner chamber 56 communicates with an outer chamber 60 lying between the disc 48 and the header 5. The disc 48 also contains segmental ports 61 and 62 through which the inner chamber 57 communicates with the outer chamber 60.

The disc 49 contains ports 58' and 59' (corresponding to the ports 58 and 59) through which the inner chamber 56 communicates with an outer chamber 60' lying between the disc 49 and the header 6. The disc 49 also contains segmental ports 61', 62' (corresponding to the ports 61 and 62) through which the inner chamber 57 communicates with the outer chamber 60'.

The chamber 12 communicates with the inner chamber 56 through the openings 63, 64 and 65, and communicates with the inner chamber 57 through the openings 63', 64' and 65'. Hence if fluid in the chamber 12 be placed under pressure adjacent to the port 63 and suction be created in the chamber 12 adjacent to the port 63', fluid will be forced from the chamber 12 through the chamber 56 into the chambers 60, 60' and will return from the latter through the chamber 57 to the chamber 12, and vice versa. Normally the rate of flow through the chambers 60 and 60' will be equal, but should the rate of flow through either chamber 60 or 60' be retarded, the rate of flow through the other chamber will be increased.

The respective cylindrical chambers 60, 60' contain independent rotors 66, 66' forming hubs on the respective shafts 67, 67' which are journaled in the respective bearings 52 and 53 and project outwardly in opposite directions through fluid tight packings 68, 68', and followers 69, 69'. The inner ends of the rotors 66, 66' are provided with trunnions 70, 70', journaled in bearings formed by the collar 50 and partition 51. The rotors 66, 66' are rotatable about a common axis of

rotation 71 concentric with the interior surface of the cylinder 2.

Cylindrical slotted cages 73, 73' are rotatably journaled in circular grooves in the inner faces of the headers 5 and 6 and of the discs 48, 49. The circular grooves in which the cages 73, 73' rotate have a common axis 71' parallel to but offset from the axis 71, so that the respective cages 73, 73' encircle their respective complementary hubs 66, 66' but are rotatable eccentrically with respect thereto and with respect to the inner cylindrical surface of the cylinder 2.

Each rotor 66, 66' has a series of similar, circularly under-cut grooves 74, 75, 76, 77, 78, 79, and 80 extending longitudinally thereof and forming in each rotor cylindrical sockets having flaring mouths for the reception of cylindrical knuckles on the inner ends of respective sets of vanes 81, 82, 83, 84, 85, 86, and 87, and 81', 82', 83', 84', 85', 86', and 87'.

The vanes 81 to 87 are thus hingedly connected with the rotor 66 and are rockable with respect thereto on axes parallel with but preferably offset from the axis of rotation 71 of the rotor 66, and the webs of such vanes 81 to 87 pass freely through equidistant, longitudinal slots 88, 89, 90, 91, 92, 93, and 94 in the cage 73.

Similarly the vanes 81' to 87' are hingedly connected with the rotor 66' and are rockable with respect thereto about axes parallel with but preferably offset from the axis of rotation 71 of the rotor 66'. The webs of the vanes 81' to 87' pass freely through equidistant slots (similar to the slots 88-94) in the cage 73'.

The cages 73, 73' are devoid of the intermediate openings between slots provided in the cage 20, and the fit of the vanes in the slots of the cages 73, 73' are made as close as possible without interfering with the free rocking of the vanes so as to minimize or prevent the passage of fluid into and out of the respective chambers enclosed by the cages 73, 73'.

Each of the vanes 81 to 87 and 81' to 87' is of such length that its ends make close sliding contact with the inner surfaces of the end members 5, 6, and 48, 49 of the respective chambers 60, 60' in which the respective sets of vanes are rotatable. Each vane 81 to 87 and 81' to 87' is of such width that its outer edge makes close sliding contact with the inner surface of the cylinder 2 when its web is coincident with a diametral plane common to the axis 71 and the axis 71'. When the web of a vane is not coincident with a diametral plane common to the axis 71 and the axis 71', the vane is so tilted that the outer edge thereof is spaced from the inner surface of the cylinder 2 to a greater or less degree. The clearance between the outer edge of a vane and the inner surface of the cylinder 2 is greatest when the web of a vane is rocked to a maximum angle to a rotor axis intersecting the rocking axis of its knuckle. When using dimensions of desirable relative proportions the maximum rocking of each vane occurs on one side of the diametral plane intersecting the axes 19, 23 when its knuckle axis is approaching the rotor axes perpendicular to such plane. The maximum rocking of such vane on the opposite side of such plane occurs when the knuckle axis is leaving the rotor axes perpendicular to such plane.

The disc 48 contains tapering shallow arcuate channels 58a, 58b, 59a, 59b, 61a, 61b, and 62a, 62b projecting from the ends of the respective ports 58, 59, 61, 62 and forming by-passes for the passage of fluid around the ends of vanes 81-87 during the registration of the respective vanes with the respective by-passes. Similarly, the disc 49 contains tapering, shallow, arcuate channels 58a', 58b', 59a', 59b', 61a', 61b', and 62a', 62b' projecting from the ends of the respective ports 58', 59', 61', 62' and forming by-passes for the passage of fluid around the ends of vanes 81'-87' during the registration of the respective vanes with the respective by-passes. The by-passes do not permit the passage of fluid around the ends of the vanes when the latter are in or near a dia-

metral plane intersecting the axes 71, 71'; in which positions the outer edges of the vanes are closest to the inner surface of the cylinder 2 and passage of liquid around such outer edges is minimized or prevented.

Operation

The respective sets of vanes couple each rotor 13, 60, 60' with its complementary cage 20, 73, 73' so that the rotor and cage rotate in unison. Due to the eccentricity or offset of the cage axis, e.g. 23, from the rotor axis, e.g. 19, the concurrent rotation of the rotor and cage in unison causes the periphery of the cage to move with different angular velocities (relatively to the rotor axis) in different zones of the orbit of the cage. Consequently a vane hinged to the rotor and slidable through the cage oscillates or rocks back and forth through a rotor radius intersecting the rocking axis, (viz. the center line of the knuckle) of the vane during each rotation of the rotor and cage. The vane registers with such rotor radius on opposite sides of the rotor axis when such rocking axis is aligned with a diametral plane intersecting both the axis of the rotor and the axis of the cage. Such plane may be referred to as the common diametral plane. A plane perpendicular to the common diametral plane and intersecting the axis of the rotor only may be referred to as the transverse plane.

The amplitude of the angle through which a vane rocks and its rate of oscillation when its knuckle is approaching and receding from the common diametral plane is greater than the amplitude of the angle through which the vane rocks and its rate of oscillation when its knuckle is approaching and receding from said transverse plane. Further the amplitude and rate of oscillation through which a vane rocks are greater when the cage is relatively close to the knuckle approaching or receding from the common diametral plane than when the cage is relatively remote from the knuckle approaching or receding from the diametral plane. If the rotor and cage are coupled together by such number of vanes having equidistantly positioned knuckles that several knuckles may be simultaneously on the side of the transverse plane where the cage is relatively close to the knuckles, one or more such vanes may rock oppositely to one another and at different rates. The vanes whose knuckles are on the opposite side of the transverse plane (viz. where the cage is more remote from the knuckles) will all rock in the same direction (relatively to their respective rotor axes) but may rock through angles of different amplitudes per unit of rotation of the rotor.

If lands 40, 41 are positioned to obstruct the channel 39 adjacent to the transverse plane, as indicated in Fig. 6, vanes concurrently moved over such lands by clockwise movement of the rotor 13 are both rocked in the same direction (viz. anti-clockwise) at approximately the same rates and approximately the same amplitude of rocking so that there is substantially no pressure or suction created between such vanes. The by-passing of fluid through the channel 39 around the ends of intermediate vanes between the vanes registering with the lands 40, 41 prevents the development of pressure or suction by unequal or opposite movements of such intermediate vanes. The rotor, vanes and cage therefore rotate freely and idly in the casing 1 when the lands are positioned in a neutral position where they are centrally intersected by the transverse plane above referred to.

The movement of the lands 40, 41 (clockwise) toward the common diametral plane, e.g. toward the position shown in Figs. 4, 5, and clockwise rotation of the rotor 13 results in the development of increasing pressure in a zone including the port 63 and of increasing suction in a zone including the port 63'. This is due to the increase in the rate and amplitude of the rocking in opposite directions (clockwise and anti-clockwise) of complementary vanes during their passage over the surfaces of the lands in the various positions of the latter. For example, as

shown in Fig. 4, the vane 34 while passing over the land 40 is being rocked clockwise through an angle of maximum amplitude per unit of rotation of the rotor and the vane 31 while passing over the land 41 is being rocked anti-clockwise through an angle of major amplitude per unit of rotation of the rotor. Since the fluid between the converging faces of the vanes 34 and 31 cannot escape through the channel 39 and leakage is de minimis, such fluid is subjected to pressure and forced through the port 63. Since the increasing space between the diverging faces of the vanes 34 and 31 cannot be supplied with fluid through the channel 39 and leakage is de minimis, suction is created which draws fluid through the port 63'.

To maintain any desired pressure at the port 63 and suction at port 63' and a desired speed ratio of the driven mechanism to the driving mechanism, the lands 40, 41 are held stationary at the proper positions to generate such pressure and suction. To increase or decrease the speed ratio of the driven mechanism to the driving mechanism, the lands are moved away from or toward their neutral positions.

To reverse the direction of rotation of the driven mechanism relative to the direction of rotation of the driving mechanism, the lands may be moved counterclockwise from their neutral positions toward the common diametral plane, as indicated, for example in Fig. 7. When the lands are so positioned, the vanes moved thereover by the clockwise movement of the rotor 13 are rocked on their knuckles toward one another, and fluid is thereby subjected to pressure in a zone communicating with the port 63'. For example with the lands positioned as in Fig. 7, the web of a vane whose knuckle is being rotated to the dashline position of Fig. 9 is being rocked clockwise through an angle of major amplitude relatively to the rotor radius intersecting its knuckle, and the web of a vane whose knuckle is being rotated toward the dotted line position of Fig. 9 is being rocked anticlockwise through an angle of considerable amplitude. The fluid thereby forced through the port 63' operates the driven mechanism in a direction opposite to that effected by fluid forced through the port 63.

The rocking of the vanes as above described results in an increase in the space between the diverging faces of such vanes, thereby creating suction tending to draw fluid through the port 63 between such diverging faces.

The pressure and suction created by the rocking of fulcrumed vanes of the driving mechanism may be transmitted through fluid, such as oil, to rock similar vanes of driven mechanism by introducing such pressure fluid between certain vanes and withdrawing fluid from between other vanes of the driven mechanism having a rotor, cage and vane construction similar to that of the driving mechanism. In other words, the principles of my rotor, cage and vane mechanism are applicable to either a pump, in which a shaft is rotated to rock vanes and create pressure and suction, or to a motor in which pressure and suction are applied to fulcrumed vanes to rock them and rotate a shaft to which they are hinged.

My invention contemplates the unidirectional rotation of the shaft 14 by any suitable prime mover to drive either or both of the shafts 67, 67' in either a forward or reverse direction and at variable rates of speed relative to the speed of the shaft 14.

The general principles of my invention are the same whether used as a pump or as a motor, but the detailed embodiment thereof in a motor preferably differ somewhat from the embodiment thereof in a pump, as hereinbefore set forth. For instance, the ports of the vane chambers of the driven mechanism differ in position and shape from the ports of the vane chamber of the driving mechanism; the cages 73, 73' are imperforate except for the slots with which the vanes make relatively tight joints so that there is a minimum of communication between the chambers within and without the cages except through the ports, whereas there is free communication through

the cage 20 between the chambers within and without such cage; the channels in the disks 48 and 49 differ from the channel 39 in the header 4, and the segments of the former channels are separated from one another by fixed lands constituting integral parts of the disks 48, 49 instead of by movable lands 40, 41; and the cage axis 71' lies above the rotor axis 71, instead of having the cage axis below and to the right of the rotor axis as is the case with the axes 23 and 19. As shown, each of the driven rotors 66, 66' has a greater number of vanes than the driving rotor 13 but the number of vanes on each rotor may be varied to provide the relative ratios desired.

By increasing the number of vanes capable of co-acting as complementary pairs, the number of pulsations per revolution of the vane-carrying rotor may be increased. The number of vanes may be odd or even and I have shown five vanes on the driving rotor and seven on each driven rotor merely by way of example.

Fluid discharged under pressure from the chamber 12, through the chamber 56 and ports 58, 58' into the chambers 60, 60' exerts pressure tending to diverge faces of certain pairs of vanes projecting through the cages 73, 73' on one side of the common diametral plane and so positioned that the rocking of such vanes applies thrusts to the rotors 66, 66' tending to rotate them. Simultaneously fluid is drawn from between, and suction is applied to, the inner ends of such vanes within the cages 73, 73' through the ports 62, 62', chamber 57, etc. to facilitate and augment the rocking of such vanes. Fluid is likewise drawn from between, and suction applied to, the outer ends of vanes projecting through cages on the opposite sides of the common diametral planes, and pressure fluid is simultaneously discharged through the ports 59, 59' between the inner ends of such vanes within the cages 73, 73'. The vanes subjected to such stresses are so positioned as to be rocked thereby and exert thrusts against the rotors 66, 66' tending to rotate the rotor in the same direction as the pairs of vanes first referred to.

If the direction of circulation of the fluid through the chambers and ports is reversed by moving the lands 40, 41, the stresses will be so applied to portions of the vanes inside and outside of the cages 73, 73' that the direction of rotation of the rotors 66, 66' will be opposite to that above described.

It will thus be seen that my invention not only permits variation of the speed ratio between the driving and driven mechanisms and the elimination of gear shift and differential mechanisms, but provides a power transmission apparatus of general utility, simple construction and low cost.

Having described my invention I claim:

1. In apparatus of the character described, the combination of a housing defining a chamber, said housing including a circular wall and two end headers, a rotor within said chamber and spaced from said circular wall, a drive shaft for rotating said rotor, vanes within said chamber, said rotor being concentric with said circular wall and having grooves for receiving end portions of said vanes, said vanes being rotated by said rotor about a common axis, said vanes being rockably positioned in said grooves, said vanes making close slidable contact with the inner surface of said circular wall during each rotation, inlet fluid means and outlet fluid means in communication with said chamber, cage means operatively connected to said vanes for eccentric rotation relative to said rotor and for rocking said vanes so that the space between certain vanes decreases in volume and the space between certain other vanes increases in volume, one of said headers containing a channel interconnecting the spaces between vanes and forming a fluid bypass around lateral ends of said vanes for bypassing fluid from said spaces of decreasing volume to said spaces of increasing volume, and adjustable means obstructing said channel and variably hindering the bypassing of fluid around said vanes in different positions thereof.

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2. In apparatus of the character described, the combination with a housing containing a chamber, said housing including a cylindrical wall and two end walls, a rotor in said chamber spaced from said cylindrical wall and rotatable about an axis concentric with said cylindrical wall, inlet fluid means and outlet fluid means in communication with said chamber, a drive shaft for rotating said rotor, said rotor having grooves, vanes in said chamber having portions rockably mounted in said grooves, said vanes making close slidable contact with the inner surface of said cylindrical wall during each rotation, cage means positioned about said rotor and operatively connected with said vanes and rotor for eccentric rotation relative to said rotor and for rocking said vanes about axes that are offset from the axis of rotation of said rotor; portions of said vanes opposed to each other defining, during the rocking, zones of decreasing volume relative to other opposed portions of said vanes defining, simultaneously, zones of increasing volume; said inlet fluid means being in fluid communication with said zones of decreasing volume, said outlet fluid means being in fluid communication with zones of increasing volume, one of said end walls including a channel for bypassing fluid around lateral edges of each vane, and lands for closing the bypass around said vanes in different circumferential positions thereof.

3. In apparatus of the character described, the combination of a housing defining a cylindrical chamber and a rotor having an axis of rotation concentric with the axis of said cylindrical chamber, said rotor being disposed within said chamber and spaced from said cylindrical wall, inlet fluid means and outlet fluid means in communication with said chamber, said housing including two headers for the ends of said chamber and a cylindrical wall, a drive shaft for rotating said rotor, a cage within said chamber, said cage being operatively connected with and rotatable about said rotor about an axis offset from the axis of rotation of said rotor, said cage having slots and openings, vanes connected to said rotor, said vanes extending through the slots in said cages, the connections and slots allowing oscillation of said vanes, oscillatory movement of two vanes toward each other defining a first zone of decreasing entrapped volume therebetween for pressurizing fluid and, simultaneously, two vanes defining a second zone of increasing volume to create a vacuum for fluid, said first zone of decreasing volume being in communication with said outlet fluid means and said second zone of increasing volume being in communication with the inlet fluid means, said vanes making close slidable contact with the inner surfaces of said cylindrical wall during each rotation, said openings in said cage allowing the space within said chamber radially inwardly of said cage to be utilized as zones of increasing or decreasing volume, and means for varying the pressure of fluid from said chamber independently of the speed of said vanes, said means including a channel forming a fluid bypass permitting passage of fluid around ends of certain vanes within said chamber and obstructing means for permitting fluid bypass when in certain positions only.

4. In apparatus of the character described, the combination of a housing defining a cylindrical chamber, said housing including a cylindrical wall and two opposed end walls, a rotor disposed within said chamber, said rotor having an axis of rotation concentric with the axis of said cylindrical chamber, said rotor being spaced from said cylindrical wall, a drive shaft for rotating said rotor, means defining a first port and a second port in communication with said chamber, a cage within said chamber and rotatable about said rotor about an

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axis offset from the axis of rotation of said shaft, said cage having slots and openings, said rotor having grooves, vanes having portions mounted in said grooves, said vanes and said cage being rotated by said rotor, said vanes extending through slots in said cages; the grooves and slots allowing said cage to oscillate said vanes during rotation of said vanes, said rotor, and said cage; said vanes having outer ends making close slidable contact with the inner surface of said cylindrical wall, said vanes having lateral edge portions making close slidable contact with the inner surfaces of said opposed end walls; and a channel in one of said headers communicating with said chamber and interconnecting the spaces formed between adjacent vanes, said rotor, said end walls and said cylindrical wall; lands movable in said channel for obstructing portions thereof, said lands being in close slidable relation with said lateral edge portions, certain complementary vanes when rotated oscillating so that the space therebetween increases in volume and simultaneously other complementary vanes when rotated oscillating so that the space therebetween decreases in volume, the first port being in fluid communication with said space that increases in volume and the second port being in fluid communication with said space that decreases in volume, one of said lands being positioned in said channel with respect to said complementary vanes defining the increasing volume space to restrict communication between said channel and said increasing volume space, and another of said lands being positioned in said channel with respect to said complementary vanes defining the decreasing volume space to restrict communication between said channel and said decreasing volume space.

5. The structure recited in claim 4, and, in addition, said lands being jointly movable incrementally between a first position in which said first port provides an outlet from said chamber for high pressure fluid and said second port provides an inlet to said chamber for low pressure fluid, relative to said high pressure fluid, and a second position in which said first port provides an inlet to said chamber for low pressure fluid and said second port provides an outlet for high pressure fluid; said rotor being rotated in the same direction when said lands are in said first position or said second position, said first position of said lands being one in which a first land cooperates with a first space between vanes of decreasing volume and a second land cooperates with a diametrically opposite space between vanes that is increasing in volume relative to said first space, and said second position of said lands being one in which said second land cooperates with a third space between vanes of decreasing volume and said first land cooperates with a diametrically opposite fourth space between vanes that is increasing in volume.

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