

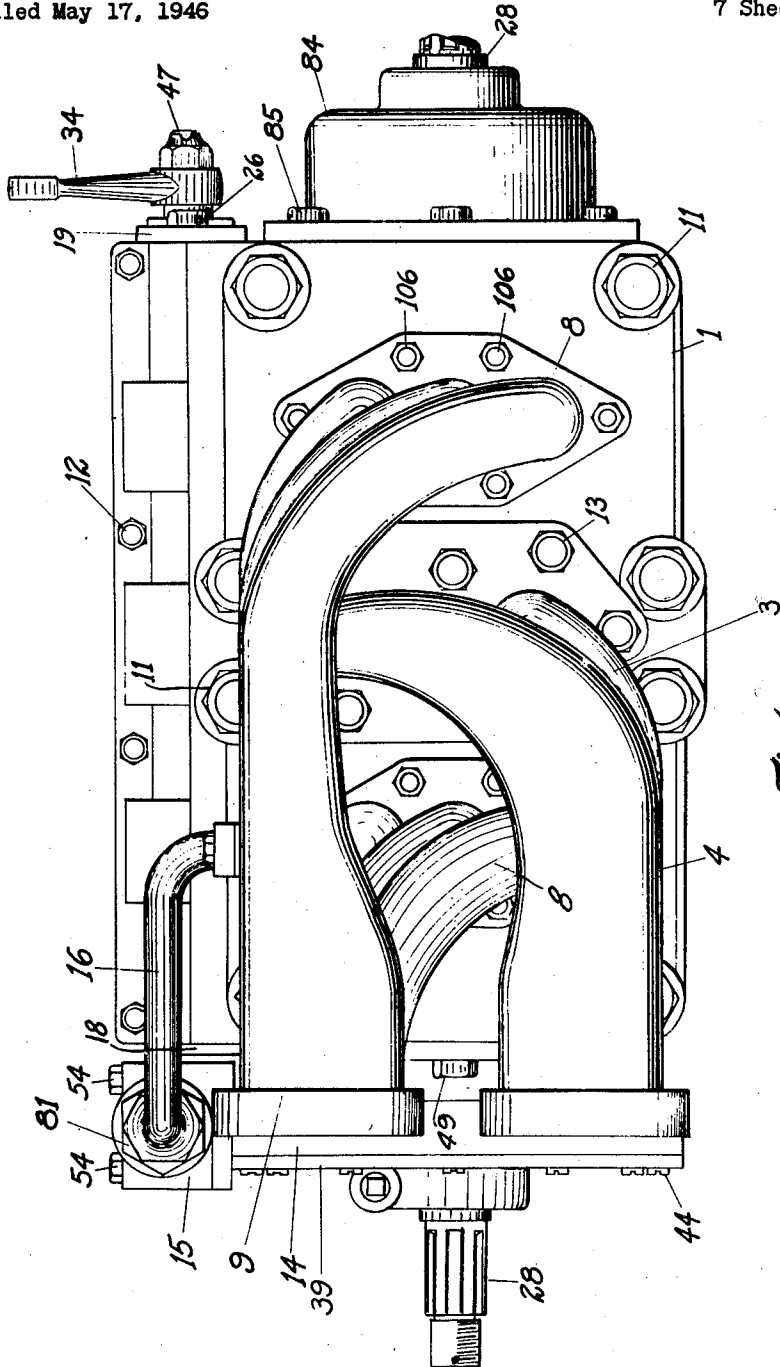
July 4, 1950

W. H. BROWN
PUMP OR MOTOR

2,513,446

Filed May 17, 1946

7 Sheets-Sheet 1



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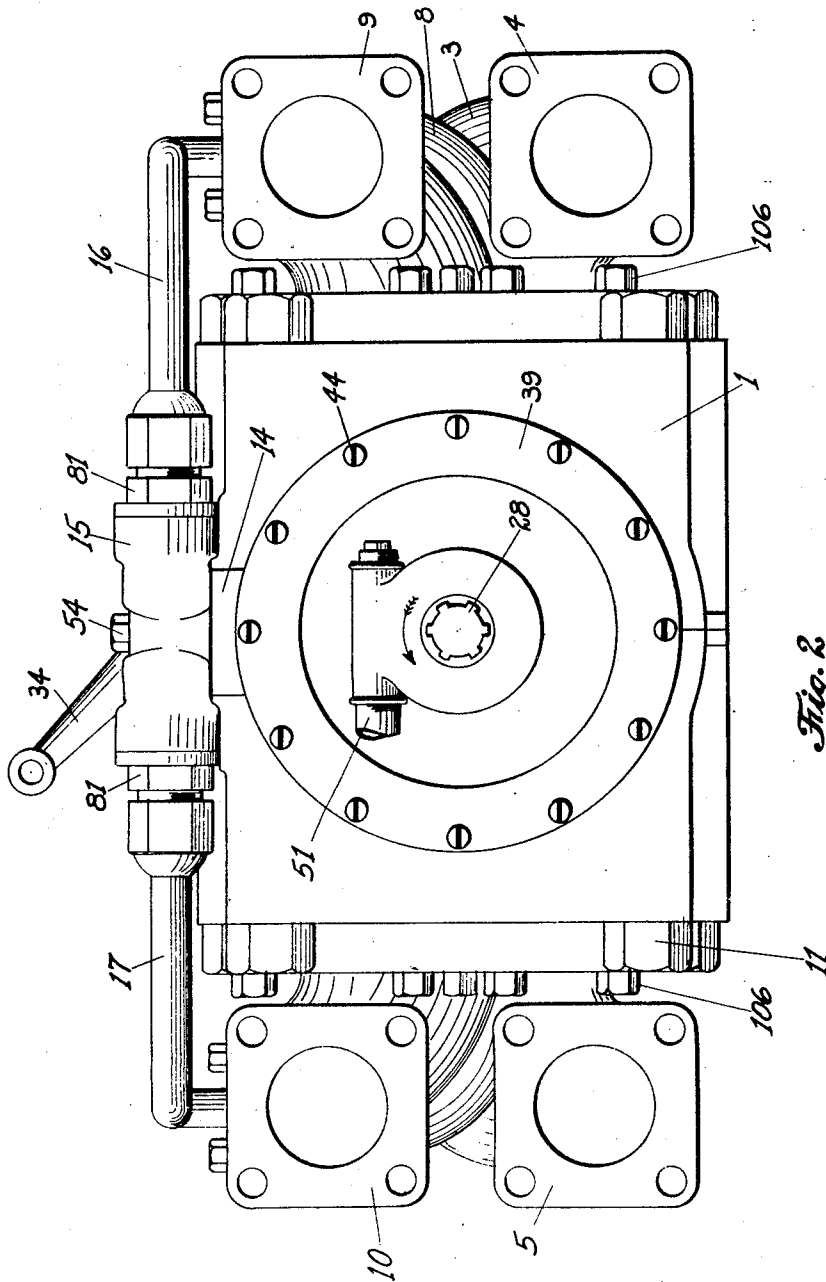
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7 Sheets-Sheet 2



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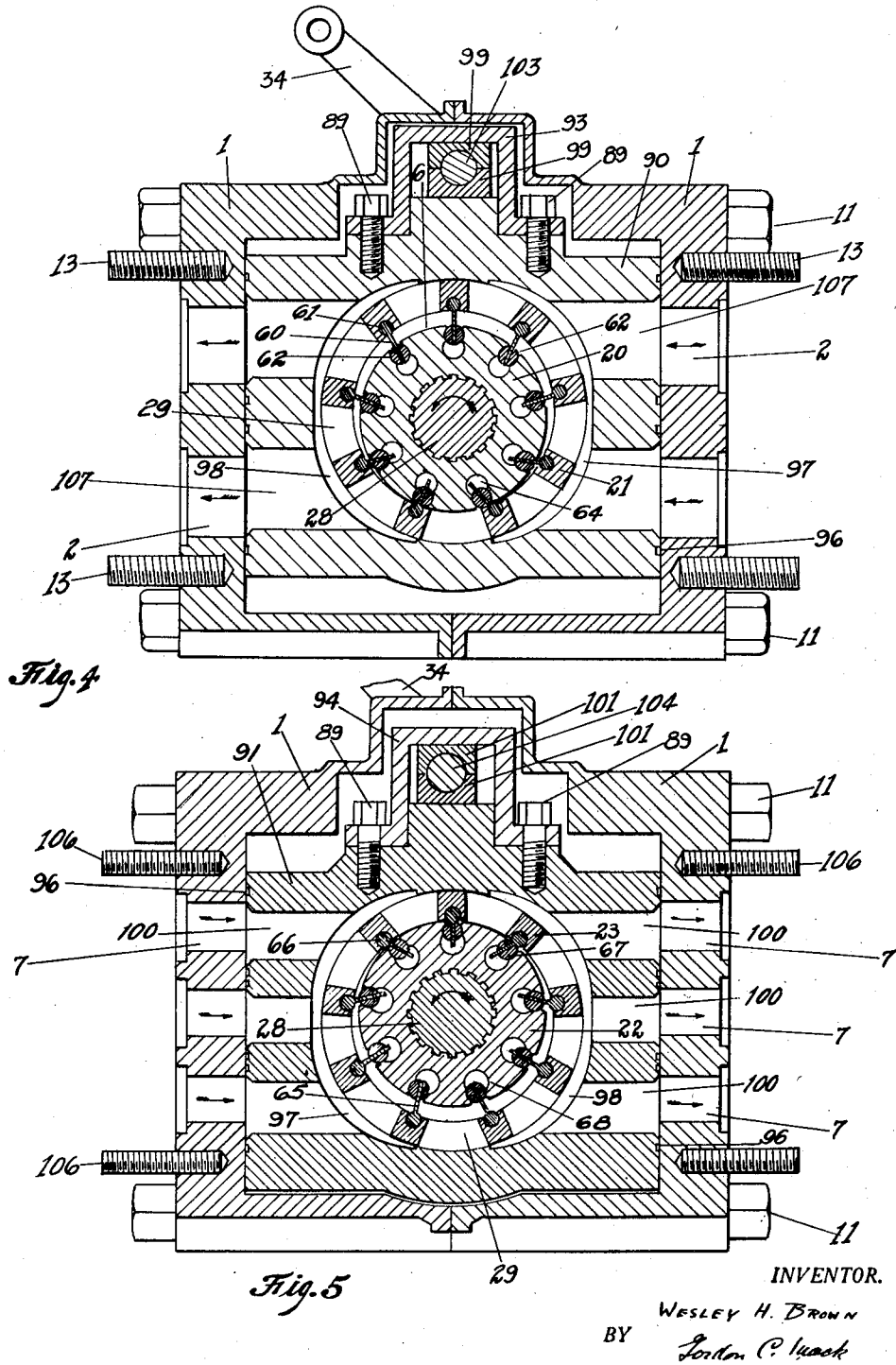
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7 Sheets-Sheet 4



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7 Sheets-Sheet 5

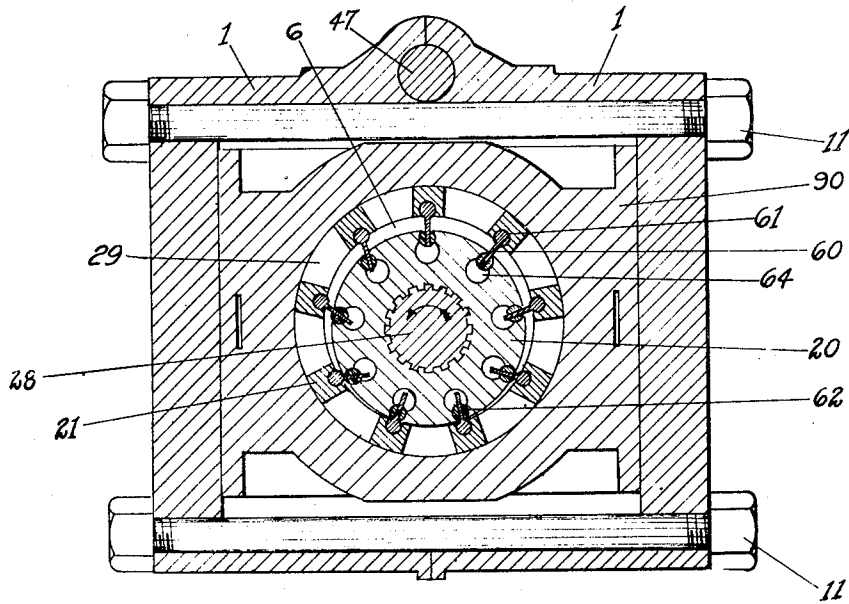


Fig. 6

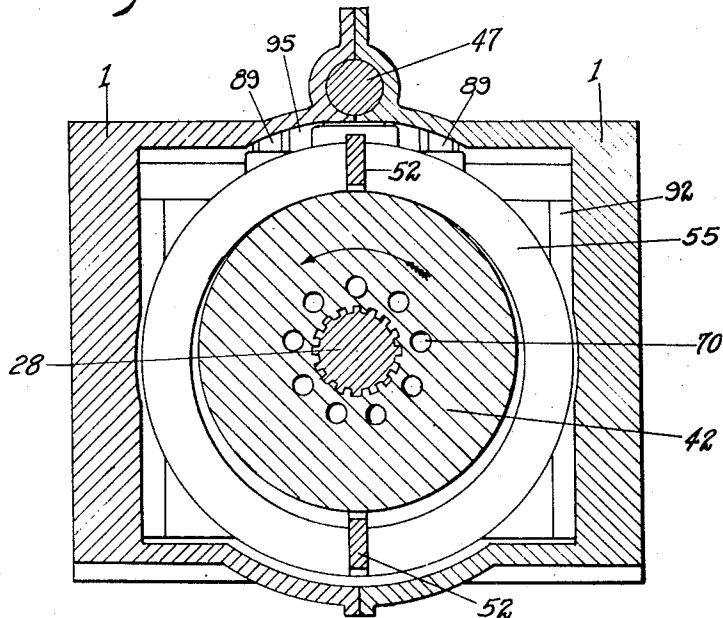


Fig. 7

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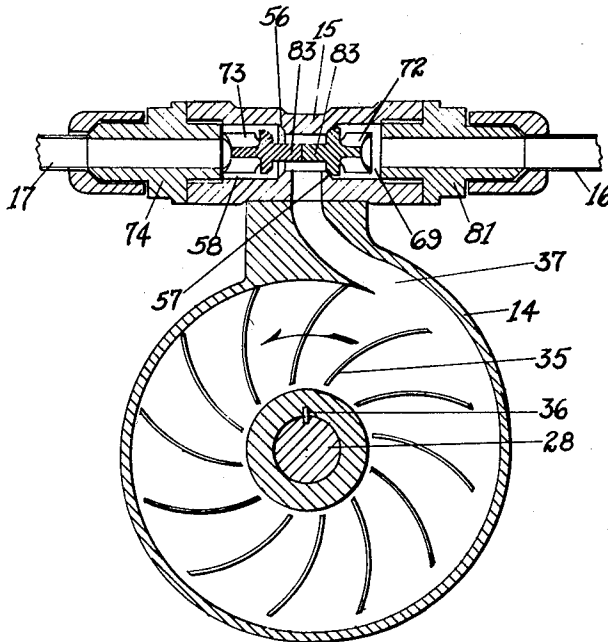


Fig. 8

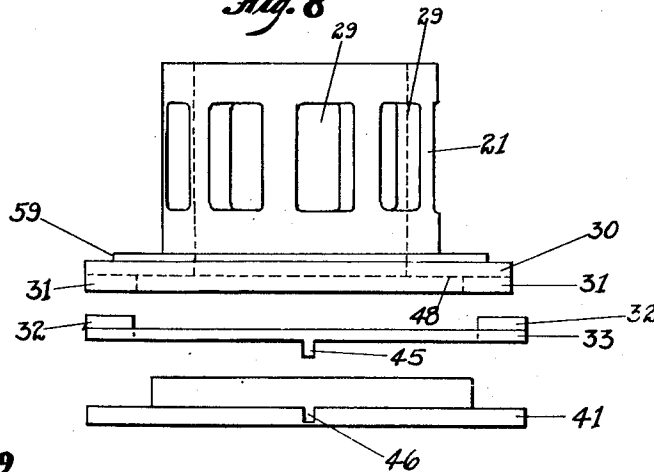


Fig. 9

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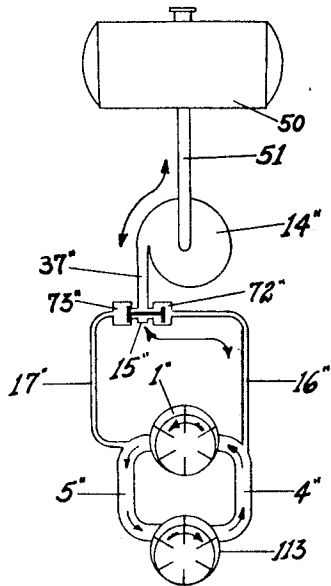


Fig. 11

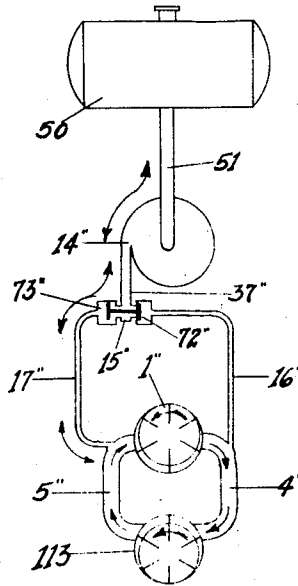


Fig. 12

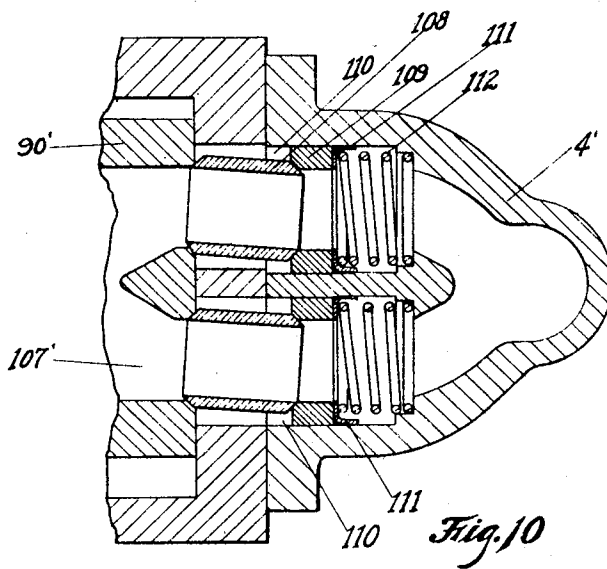


Fig. 10

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2,513,446

PUMP OR MOTOR

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Application May 17, 1946, Serial No. 670,592

8 Claims. (Cl. 103—3)

1

This invention relates to an improved type of variable-discharge pump to be used in combination with suitable hydraulic motors to produce a torque converter or variable-speed power transmission unit or for other purposes requiring a variable-discharge or reversible-flow pump. When used in combination with a hydraulic motor to form a torque converter, the speed of the motor may be varied while that of the pump remains constant, and the direction of rotation of the motor may be reversed while that of the pump is unchanged. Either or both of these features make it a particularly desirable unit for many different types of operations.

If the pump is to be used for driving a vehicle, a single motor may drive all wheels, or each wheel may be driven by a separate motor; or two pumps may be used, one for driving one or more of the wheels on one side of the vehicle and the other for driving one or more of the wheels on the other side of the vehicle. When the last-mentioned arrangement is used in crawler-type or track-laying vehicles, such as farm or industrial tractors, military tanks, and the like, the relative speeds of the wheels on the two sides of the vehicle will control the direction of its movement; and conventional steering equipment, clutches, brake bands, etc., may be omitted.

With a Diesel engine or other suitable source of power as a prime mover, the unit of this invention may be used in combination with a motor or motors for driving vehicles, such as tractors, trains, busses, trucks, etc. In such vehicles a separate motor may be attached to each wheel, all of the motors being driven from the same Diesel engine or other prime mover. By using individual wheel motors connected in parallel to a single pump, multiple-wheel drives may be obtained without the use of mechanical balance or differential gears. The maximum speed of vehicles driven by means of a pump of the type here described is fixed by the maximum speed of the source of power, but speeds below the maximum are infinitely variable and under the operator's control.

Motors for use in connection with these pumps may be identical with the pumps or may be modified by the elimination of the variable-displacement feature of the pumps or may be of a different type.

Pumps of this invention, when installed in motorboats and smaller ships, make possible the use of light, high-speed, nonreversing, constant-speed engines. Variable speeds, both forward

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and reverse, will be easily obtained by the pilot. Used on power shovels and the like, much of the gear now required for the boom, dipper, and travel may be omitted.

A preliminary study indicates that units of the type here described may be useful in the operation of helicopters, thereby eliminating the use of variable-pitch lifters and propellers.

In fact, the pumps of this invention are valuable wherever power transmission is required. They may be used for operating rotary- and piston-type hydraulic motors and hydraulic plunger devices. The pump may be placed a considerable distance from the motor or other hydraulically driven unit and the power transmitted thereto through tubes which may be bent to clear obstructions.

The pump comprises inner and outer vane-driving members and connecting vanes, but the outer vane-driving member of this invention is perforate and may be cage-like, with means for conducting the operating liquid through the passages therein. Both driving members are driven positively, the vanes being subject only to strains caused by the fluid pressure. The outer vane-driving members are preferably driven from flanges which form the end walls of the compartments for driving fluid.

According to one preferred design of this invention, several such pumps are arranged in tandem with a single drive shaft passing through all of them and with the various outer driving members offset from the shaft at different angles so that when the pump is in operation, the sum of the components of force produced by the liquid on the different inner driving members is practically zero. The volume of the fluid delivered by the pump and its direction of flow are determined by the relative positions of the several outer driving members with respect to the drive shaft.

A pump of this type is advantageously operated in combination with a priming pump or other suitable means for providing sufficient pressure on the liquid at the openings in the outer driving member to overcome the tendency of the centrifugal force of the liquid contained by this member to prevent the flow of liquid into the openings therein. The invention includes such a combination and the method of operating therewith.

Various improvements and advantages in the design and operation of the pump of this invention will be apparent from consideration of the drawings and the following description. The

drawings relate more particularly to a small unit for a tractor or the like. In larger units the flexible couplings shown for rotating the cage-like outer member from the adjoining flanges may be replaced by toothed gearing. Other modifications and changes in design may be made as desired. In the drawings:

Fig. 1 is an elevational side view of the pump or motor;

Fig. 2 is an end view of the pump or motor shown in Fig. 1;

Fig. 3 is a longitudinal quarter-sectional view of the pump shown in Figs. 1 and 2;

Fig. 4 is a sectional view of the mechanism shown in Figs. 1, 2, and 3, taken on the line 4—4 of Fig. 3 but with the manifolds removed;

Fig. 5 is a sectional view taken on the line 5—5 of Fig. 3;

Fig. 6 is a sectional view taken on the line 6—6 of Fig. 3;

Fig. 7 is a sectional view taken on the line 7—7 of Fig. 3;

Fig. 8 is a sectional view of the centrifugal priming pump, taken on the line 8—8 of Fig. 3;

Fig. 9 is a view of the center outer driving member, its driving coupling ring, and the adjacent intermediate rotor disk with the parts separated to illustrate how they cooperate;

Fig. 10 is a fragmentary sectional view of modified apparatus;

Fig. 11 is a diagrammatic view showing the flow of fluid through the pump and a motor connected thereto, also the connections between the centrifugal pump, the main pump circuits, and an expansion tank; and

Fig. 12 is similar to Fig. 11 but shows the flow through the pump and motor reversed.

The pump illustrated in the drawings is formed of a central driving unit and two end units, each of which is identical in size except that the central unit is twice the length of each end unit. All three units are enclosed in the housing 1. The liquid is pumped through the central unit and the end units in opposite directions. It is, therefore, advantageous to provide two manifolds on each side of the pump, one of which connects with the ports of the central unit and the other of which connects with the ports of the end units. Thus, the two ports 2 (Figs. 3 and 4) of the central unit are connected by the pipes 3 with the manifolds 4 and 5 (Fig. 2) on opposite sides of the pump. The ports 7 (Figs. 3 and 5) of the two end units are connected by the pipes 8 with manifolds 9 and 10 (Fig. 2) on opposite sides of the pump. Fig. 1 clearly illustrates how the pipes connect the various ports with the manifolds. The parts of the housing are held together by bolts 11 and 12, and the manifolds are bolted to the housing by studs 13 and 106.

The flow of liquid in the manifold 4 is always in the same direction as in manifold 10, and the flow in manifold 5 is always in the same direction as in manifold 9. These pairs of manifolds (4, 10 and 5, 9) may, therefore, advantageously be connected into two larger manifolds when the motor is located at considerable distance from the pump, or uses single intake and exhaust ports. If the four manifolds are used to connect the pump with a motor of the same type, small pressure-balancing tubes connecting manifolds 4, 10 and 5, 9 will ordinarily be used to insure equal fluid pressure on the center and end rotors. Then when a centrifugal pump is used for placing the entrance ports under pres-

sure (as will be explained in more detail in what follows), it is necessary to connect the centrifugal pump with but one manifold on each side of the main pump. Figs. 1, 2, 3, and 8 show the centrifugal pump housing 14. It is connected through the selector valve 15 (Figs. 1, 2, and 8) and pipes 16 and 17 with the manifolds 9 and 10.

The pump is preferably a multi-unit pump with the units so arranged around the drive shaft that the thrust produced on the shaft by one unit is counterbalanced by the thrust produced by the one or more other units. In the preferred form illustrated in the drawing the central unit has twice the capacity of each end unit, and the end units act together and oppositely to the central unit. The central unit is formed of the inner and outer members 20 and 21 (Figs. 3, 4, and 6); one end unit is formed of the inner and outer members 22 and 23 (Figs. 3 and 5); and the other end unit is composed of the inner and outer members 24 and 25. The inner driving members are mounted directly on the splined drive shaft 28 and are driven by it. The outer driving members 21, 23, and 25 are perforated and are preferably cage-like with openings 29 between the bars of the cage-like portions to permit the liquid to pass through them, as will be explained. In the drawings each of these outer members is of the same size and similar construction except that the center member 21 is twice the length of each of the other members 23 and 25.

A side view of the outer driving member 21 is shown in Fig. 9. It is provided at one end with the flange 30 in which are radial slots 31 one hundred eighty degrees apart, in which feathers 32 on the annular coupling ring 33 engage.

Each of the three pump units is flanked by two disks. Thus, there are four disks 40, 41, 42, and 43. The outer member 21 of the central unit is driven by the disk 41 (Figs. 3 and 9), and the outer members 23 and 25 of the two end units are similarly driven by the disks 40 and 42. Feathers 45 on the coupling ring 33 fit slidably in the notches 46 of the disk 41. The inside diameter of the ring 33 is larger than, and encircles, the main portion of disk 41, which is also encircled at one edge by the counterbore 48 of the flange 30 on the outer vane driving member 21. (The slots 31 are merely relatively narrow openings in the annular ring which surrounds the counterbore 48.)

Fig. 9 shows that the coupling ring 33 is larger in internal diameter than the projection on the disk 41, which it surrounds, and the feathers 32 are free to slide radially in the slots 31. The notches 46 are at right angles to the slots 31, and the feathers 45 are free to slide radially in these. This combined radial movement allows the disk 41 and vane driving member 21 to be moved radially with respect to one another in any direction. Thus, the cage-like unit 21 is driven by the disk 41 regardless of whether it is positioned nearer or farther from the driving shaft 28.

This is most easily explained by comparing the positions (Fig. 3) of the three outer driving members 21, 23, and 25 and the disks 41, 40, and 42 which drive them. The central driving unit 21 is lifted upward away from the shaft 28, and the end units 23 and 25 are lowered diametrically opposite 21 away from it. The feather 32 of the coupling ring 33 of the central unit is lifted so that it comes almost to the outer edge

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of the flange 30. The corresponding feathers 52 of the coupling rings 53 which drive the end units are the same distance from the drive shaft as the feather 32 although the flanges 55 of the driving members 23 and 25 are much nearer the driving shaft. This flexible coupling arrangement permits the disks 40, 41, and 42 to drive the outer driving members 21, 23, and 25 regardless of their position relative to the shaft 28.

The flange 30 of the central driving member is relieved around one edge of its circumference at 59 to prevent interference with the adjacent bolt 11. There is no comparable relief in the end driving units.

The outer driving members are so connected that when one of them is concentric with its inner driving member, all three of them are concentric with their respective inner driving members. If one of them is moved to an eccentric position, all are. In Fig. 3 the central outer driving member 21 is moved up from the concentric position (see Fig. 4), and the end outer driving members 23 and 25 are moved down from the concentric position (see Fig. 5).

The vanes 60 (Fig. 4) are mounted in the bars of the central cage-like outer member 21 by an enlarged cylindrical edge 61, with sliding engagement of the vanes in rockers 62 in the inner driving member 20, and the provision of vane clearance counterbores 64 through the member 20 for radial oscillatory movement of the vanes. It is possible to reverse the vanes, placing the rockers and vane clearances in the outer vane driving member 21. The mounting of the vanes 65 (Fig. 5) with cylindrical edges 66 in the end outer driving members 23 and 25, rockers 67, and counterbores 68 in the inner members 22 and 24 is the same. Fig. 3 shows the full width of all the vanes, with the bottom edge of the upper vane 60 coming just to the edge of the counterbore 64, and the lower edge of the vanes 65 coming almost to the bottom of the counterbores 68.

The holes 70 through the intermediate disks and the annular grooves 71 in their faces (Fig. 3) permit the exchange of liquid axially and circumferentially between the counterbores 64 and 68 as the vanes move in and out.

The inner driving members 20, 22, and 24, the intermediate disks 41, 42 and the end disks 40, 43 are fixed longitudinally on the shaft 28 by means of nuts 75, 76, lock nuts 77, 78, and nut locks 79, 80. The shaft 28 and attached parts operate as a unit on bearing 82 (retained in housing 1 by bearing cap 84 affixed to the housing by cap screws or studs 85) and bearing 86 (which is covered by the centrifugal pump housing 14). Seals 87 and 88 are enclosed in the cap 84 and in the centrifugal pump cover (to be described later).

The outer vane-driving members 21, 23, and 25 are rotatably fitted in casings 90, 91, and 92 which enclose the cage-like portions thereof and are coextensive therewith. These have perpendicular walls (Figs. 4 and 5) which prevent their rotation but permit up and down vertical movement within the housing 1. The casing 90 (shown in section in Fig. 4) includes the two ports 107 in each wall which register with the ports 2 in the casing 1 regardless of whether the eccentric driving member is raised or lowered. Packing may be fitted in the grooves 96 to make liquid-tight seals. The cylindrical bore of eccentric casing 90 has channels 97 and 98

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(Fig. 4) of a width corresponding to the length of openings 29 in outer vane-driving member 21 and connecting with ports 2 to permit passage of fluid to and from spaces 6 between the vanes. Thus, the expanding spaces on one side of the rotor can induct fluid while the contracting spaces on the opposite side expel the fluid. Channels 97 and 98 are of such length that at least one bar of the outer vane driver 21 is always between the upper and lower ends, preventing the flow between them of any fluid except that contained in the space 6 between the vanes.

The end casings 91 and 92 (Fig. 5) surrounding the cage-like portions of the driving members 23 and 25 are similarly constructed but are provided with three openings 100 in each side wall to register with the ports 7. Three openings are required to allow the passage at the same velocity of half the volume that passes through the two openings in center casing 90, as the width of casings 91 and 92 restricts the diameter of the openings 100. Pumps operating at low speed may have only one opening on each side of each casing without producing excessively high velocities.

The vertical position of the three outer driving members with respect to the shaft 28 is controlled by the central crank pin 103 and the two end crank pins 104 and 105 of the control shaft 47 acting through split bearings 99, 101, and 102, respectively. These bearings are free to slide horizontally in the spaces between the tops of the respective casings 90, 91, and 92 and the yokes 93, 94, and 95 attached thereto by means of studs or cap screws 89.

Control shaft 47 is rotatably mounted in housing 1 and is located longitudinally by thrust washers 63, end plate 18, and cap 19 which are secured to the housing by cap screws 26. Seal 27 in cap 19 prevents leakage of liquid around control shaft 47. This shaft is actuated by control arm 34. The angular movement permitted this arm is limited. It may be replaced by gears, and these may be operated by automatic control devices or in any manner desired.

The end crank pins 104 and 105 are placed diametrically opposite center crank pin 103. When these crank pins are in the same horizontal plane, the outer driving members 21, 23, and 25 are concentric with the inner driving members 20, 22, and 24, and the exposed area of each of the vanes in each of the units remains constant as it rotates. The pump then idles. There is no flow of liquid through it. When the position of the crank pins is such as to make one of the outer driving members eccentric with respect to its inner member, then all are eccentric with respect to their respective inner members; and this causes positive movement of the liquid through the units, in one direction or the other.

When the several rotors are operating at high speed, they generate considerable centrifugal force. This force may become so great that it is difficult to force liquid through the ports into the openings 29 between the bars of the outer driving members. To direct the liquid into the openings 29 on one side of the outer driving members, a small differential pressure is induced on the first side from some outside source, such as a centrifugal pump which may advantageously be mounted on the shaft 28, as in the drawings.

The centrifugal pump housing 14 is secured to the housing 1 by cap screws or studs 49. This housing contains the impeller 35 keyed to the shaft 28 by key 36 and discharges through passage 37 into the selector valve body 15. The inlet 38 of the pump is formed in the cover 39 and is in communication with supply and expansion tank 50 (Figs. 11 and 12) by means of pipe 51. The cover is held in place by screws 44. (Seals 88 are included in the cover 39 as previously mentioned).

The selector valve body 15, affixed to the centrifugal pump housing 14 by cap screws 54, is made with oppositely facing seats 56 and 57 at the inner end of the cylindrical bores 58 and 69 which act as guides for the valves 72 and 73. These bores are enclosed at their outer ends by the plugs 81 and 74 through which liquid is conducted to the pipes 17 and 16 connecting with the manifolds. The valves 72 and 73 are provided with the abutting valve stems 83.

The operation of the three units and the centrifugal pump is not complicated. The drive shaft 28 operated by a Diesel engine or other suitable prime mover may be rotated in either direction. For the purpose of illustration we assume it is operating in a counterclockwise direction as indicated by the arrows in the various views. When the control arm 34 is thrown to the position indicated so that the casing 90 is raised (Fig. 4) and raises with it the circular outer driving member 21, the liquid will be pumped through the central compartment from right to left. This naturally follows because the compartments formed between the vanes and the unbroken bore of casing 90 between the upper ends of channels 97 and 98 in the casing are larger than the compartments formed between these same vanes and the unbroken bore between the lower ends of channels 97 and 98. The volume of liquid carried in the compartments formed by the vanes increases as the outer driving member 21 separates from the inner driving member 20 in passing from the lower to the upper end of channel 97. Conversely, the volume of liquid carried by these compartments decreases as the outer driving member 21 approaches the inner driving member 20 in returning from the upper to the lower end of channel 98. The expanding compartments receive the liquid on the right side of the pump in the view shown in Fig. 4 and on contraction discharge it on the left side.

The flow of liquid in the end compartments (Fig. 5) is just the reverse. Here the compartments formed by the vanes expand in traveling from the upper end of the channel to the lower end of the channel and take in liquid on the left side of the pump, and in returning to the top of the chamber, the compartments contract and discharge the liquid on the right side of the pump. The liquid in the end compartments thus flows in the opposite direction from that in the middle compartment.

If it is desired to change the direction of flow of the liquid, it is only necessary to move the control arm 122 and thus reverse the position of the crank pins. This will throw the central outer driving member down with respect to its inner driving member, and in the end units the outer driving members will be raised with respect to the inner driving members. This will force the liquid in the reverse direction in all three compartments.

This operation is illustrated schematically in Figs. 11 and 12. In Fig. 11 the pump 1" is operat-

ing in one direction; in Fig. 12 it is operating in the reverse direction. In Fig. 11 the pump drives the liquid through the manifold 5" to drive the motor 113 in the clockwise direction, and the liquid is then returned through the manifold 4" and recirculated. In Fig. 12 the position of the outer driving member with respect to the driving shaft is reversed so that the pump 1" drives the liquid in the opposite direction even though the rotors of the pump 1" still continue to operate in a counterclockwise direction as indicated by the arrow. The liquid flowing through the manifold 4" (Fig. 12) drives the motor 113 in a clockwise direction and is returned through the manifold 10 to the pump for reuse.

These Figs. 11 and 12 illustrate the operation of the centrifugal pump 14" which is connected on one side through the pipe 51 to the storage tank 50 and on the other side through the pipe 14" with the selector valve 15. One or more safety valves may be provided as desired to serve as a relief to prevent damage in the event excessive pressure develops for any reason.

At high rotative speeds the vanes and the outer driving members may develop centrifugal forces great enough to prevent the entry of fluid into the openings 29 between the bars of the cage-like outer driving members. To provide a pressure in excess of that produced by the centrifugal action of the revolving pump parts on the incoming fluid, the centrifugal priming pump is provided. The peripheral speed of its impeller is greater than that of the outer driving members. By keeping it in communication with the low pressure side of the several units, the pressure on this side is increased to the point where the centrifugal force of the main pump rotating parts is overcome and a constant supply of liquid is provided. This is accomplished by means of the selector valve 15 previously described. The valve 72 or 73, whichever is under the greater pressure, is held on its seat 56 or 57. This prevents the flow of liquid through the manifold to which this valve is connected. In Fig. 11 the valve 73 is held on its seat. The abutting stems 83 raise the valve 72 so that the centrifugal pump is connected through the pipe 16 through the manifold which is supplying liquid to the pump. In Fig. 12 the reverse condition is shown. The pressure of the pump through the pipe 16 holds the valve 72 on its seat, and this raises the valve 73 so that the centrifugal pump is connected through the pipe 17 with the intake side of the pump. Thus, the low pressure manifold of the pump is connected with the centrifugal priming pump which receives its fluid from the supply and expansion tank 50 which feeds the entire system. Any expansion of the fluid in the system from increased temperature, displacement by piston rods, etc., will be relieved through the selector valve 15 against the pressure produced by the centrifugal priming pump, and the excess fluid will flow through the pump into the tank 50.

The priming pump is not essential and is used only when the rotors are operated at sufficient speed to produce centrifugal force which interferes with the supply of liquid under the pressure otherwise employed. By movement of the control arm 34 the crank pins may be placed in dead center, in which case no liquid will flow through the manifolds to the motor 113. By movement of the control arm in one direction or the other, the liquid will be caused to flow in either direction without reversing the direction of the drive shaft

28, and the motor 113 may thus be driven forward or backward and at any desired speed, depending upon how far the outer driving members are thrown off center. By the use of a plurality of opposed driving units as explained, this may all be accomplished while the drive shaft and the inner vane drivers are maintained in balance.

Fig. 10 illustrates a modified structure in which the manifold 4' is connected with the central driving unit. Transfer tubes 108 having spherically ground ends are held on spherical seats at the outer edge of the ports 107' in the eccentric casing 90' by fluid pressure on the manifold spherical seat rings 109 which are slidably fitted in cylindrical bores 110 of the manifold 4'. The leakage of fluid between the spherical seat rings 109 and the bores 110 is prevented by packing cups 111 retained by springs 112.

Other modifications of the design may be made within the scope of this invention without departing from the appended claims.

What I claim is:

1. A variable-discharge, rotary, hydraulic pump or motor formed of an outer hollow rotor, an inner rotor within it, means for varying the distance between the axes of the inner and outer rotors and means for rotating the inner and outer rotors at the same number of revolutions per minute, vanes connecting the rotor through liquidtight seals and adapted to penetrate and emerge from at least one of the said rotors as the distance between the contacted surfaces of the rotors is altered, a drive shaft, and disks abutting the ends of the rotors and forming compartments with the vanes and rotor surfaces, the disks and inner rotor being mounted on said shaft and fastened to the shaft so that they turn as a unit with the shaft.

2. A variable-discharge, rotary, hydraulic pump or motor formed of an outer hollow, perforate rotor, an inner rotor within it, means for varying the distance between the axes of the inner and outer rotors and means for rotating the inner and outer rotors at the same number of revolutions per minute, vanes connecting the rotors through liquidtight seals and adapted to penetrate and emerge from at least one of the said rotors as the distance between the contacted surfaces of the rotors is altered, a drive shaft, and substantially imperforate disks abutting the ends of the rotors and forming compartments with the vanes and rotor surfaces, the disks and inner rotor being mounted on said shaft and fastened to the shaft so that they turn as a unit with the shaft.

3. A variable-discharge, rotary, hydraulic pump formed of an outer hollow vane driving member, an inner vane driving member within it, means for varying the distance between the axes of the inner and outer driving members and means for driving the inner and outer driving members at the same number of revolutions per minute, vanes connecting the vane driving members through liquidtight seals and adapted to penetrate and emerge from at least one of the vane driving members as the distance between the contacted surfaces of the vane driving members is altered, a drive shaft, and disks abutting the ends of the vane driving members and forming compartments with the vanes and vane driving members, the inner vane driving member and at least one of the disks being fastened to the shaft and arranged to turn as a unit, and the outer vane driving member being arranged to be turned by said disk or disks so arranged.

4. A variable-discharge, rotary, hydraulic pump formed of an outer hollow perforate vane driving member, an inner vane driving member within it, means for varying the distance between the axes of the inner and outer driving members, vanes connecting the vane driving members through liquidtight seals and adapted to penetrate and emerge from at least one of the driving members as the distance between the contacted surfaces of the vane driving members is altered, substantially imperforate disks abutting the ends of the vane driving members and forming compartments with the vanes and vane driving members, a drive shaft, at least one of the disks and the inner vane driving member being mounted on said shaft passing therethrough and fastened to the shaft so as to turn therewith, and means for driving the outer vane driving member from at least one disk so fastened.

5. A variable-discharge, rotary, hydraulic pump or motor having a plurality of inner vane-driving members mounted on a driving shaft which passes through the center thereof; a like number of outer hollow, cylindrical vane-driving members each encircling an inner vane-driving member, vanes in the spaces between the vane-driving members forming liquidtight seals with the surfaces thereof and being adapted to penetrate and emerge from at least one of the vane-driving members as the distance between the contacted surfaces of the vane-driving members is altered; means for varying radially the relative position of the vane-driving members, and between each two of the outer vane-driving members a substantially imperforate disk of larger diameter than the diameter of the outer vane-driving members, each of said disks being fastened to the shaft so as to rotate therewith; and a flexible connection between each outer vane-driving member and at least one of said disks to drive the outer member synchronously therefrom.

6. A variable-discharge, rotary, hydraulic pump or motor having a plurality of inner rotors concentric with and affixed to a driving shaft, a plurality of outer hollow rotors each encircling one of the inner rotors substantially the same length as itself, means for rotating the inner and outer rotors at the same number of revolutions per minute, vanes connecting the respective inner and outer rotors through liquidtight seals and adapted to penetrate and emerge from at least one of the rotors as the distance between the contacted surfaces of the rotors is altered, a control shaft parallel to the driving shaft which includes a crank pin for each outer rotor to which the outer rotor is fastened, the crank pins being arranged so that as the control shaft is rotated, their axes are changed and thus the position of the axes of the outer rotors with respect to the axis of the driving shaft is altered radially.

7. A variable-discharge, rotary, hydraulic pump or motor having a plurality of inner cylindrical rotors concentric with and affixed to a driving shaft; a plurality of outer hollow, perforate rotors each encircling one of the inner rotors which is substantially the same length as itself, all of which outer rotors are mounted so as to remain parallel to one another at all times; means for rotating the inner and outer rotors at the same number of revolutions per minute; between the respective inner and outer rotors vanes forming contact therewith through liquidtight seals which are adapted to penetrate and emerge from at least one of the rotors as the distance between the contacted surfaces of the rotors is altered;

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substantially imperforate disks abutting the ends of the rotors to form compartments with the vanes and rotors; a control shaft which includes a crank pin for each outer rotor to which the outer rotor is fastened, the axes of adjacent crank pins being out of line but with the axes of alternate crank pins in line and so arranged with respect to the control shaft that as the shaft is rotated, the axes of adjacent crank pins are interchanged and the relative positions of the axes of the adjacent outer rotors with respect to the axis of the driving shaft are interchanged, the diameter of all inner rotors being the same, the inner diameter of all outer rotors being the same, and the lengths of the individual rotors being such that the total of the lengths of every other rotor in the pump is substantially the same regardless of which of the first two rotors at either end of the pump is included in the total.

8. A variable-discharge, rotary, reversible flow hydraulic pump formed of a driving shaft; an inner vane-driving member mounted thereon; a perforate outer vane-driving member encircling the inner vane-driving member; vanes between the vane-driving members and forming contact therewith through liquidtight seals and adapted to penetrate and emerge from at least one of the vane-driving members as the distance between the contacted surfaces of the vane-driving members is altered; a centrifugal pump driven from said driving shaft; means for changing the relative position of the axes of the two vane-driving members to vary the discharge of the pump and

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the direction of flow therethrough; a selective valve on the discharge of the centrifugal pump with one connection from the valve to one side of the reversible flow pump and another connection from the other side of the valve to the other side of the reversible flow pump, the valve being selective so as to close the connection therefrom to the discharge of the reversible flow pump, thereby opening the connection with the intake side of the reversible flow pump so as to maintain pressure on said inlet side.

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