March 21, 1950 W. FERRIS 2,501,165

HYDRODYNAMIC MACHINE

Filed Aug. 23, 1945 4 Sheets-Sheet 1

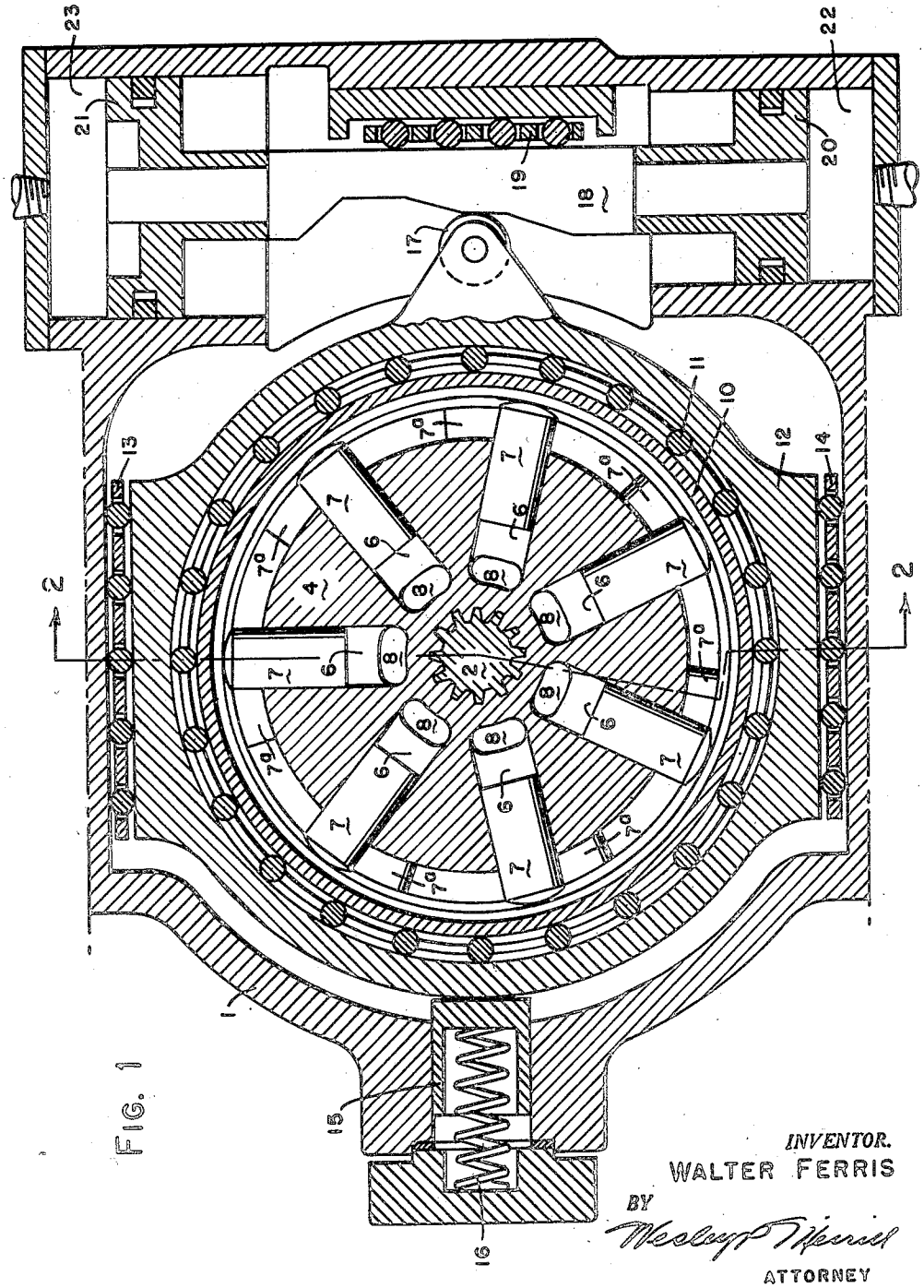


FIG. 1

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HYDRODYNAMIC MACHINE

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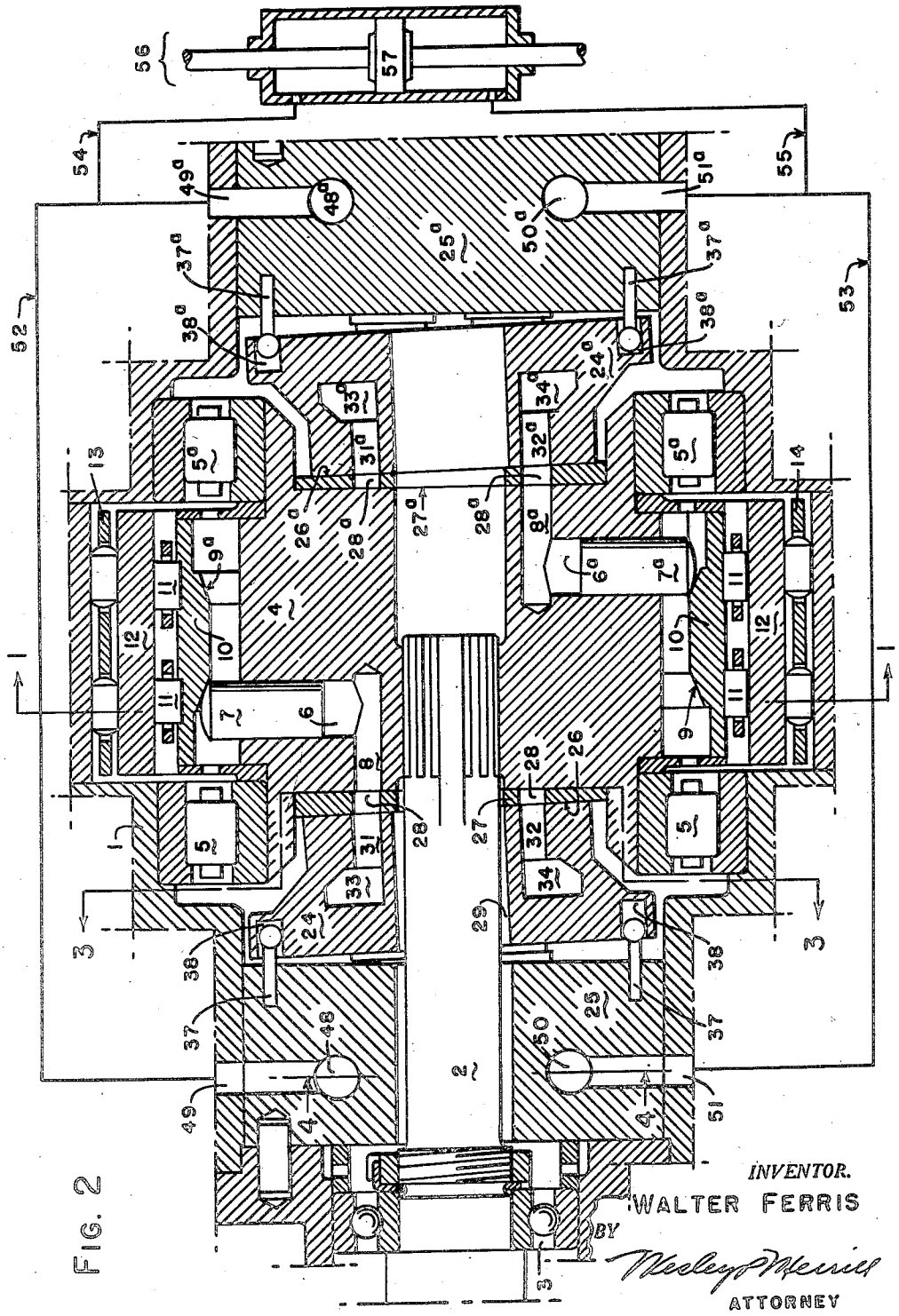


FIG. 2

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HYDRODYNAMIC MACHINE

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FIG. 3

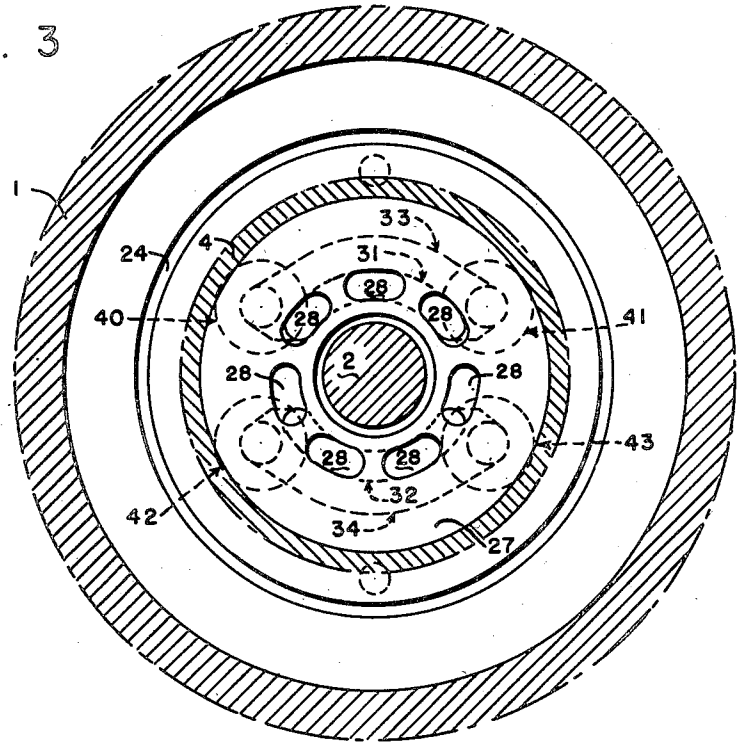
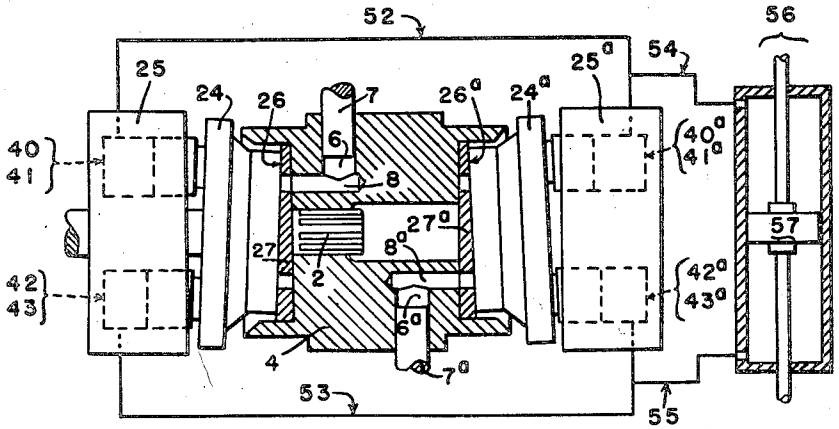


FIG. 6



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HYDRODYNAMIC MACHINE

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FIG. 5

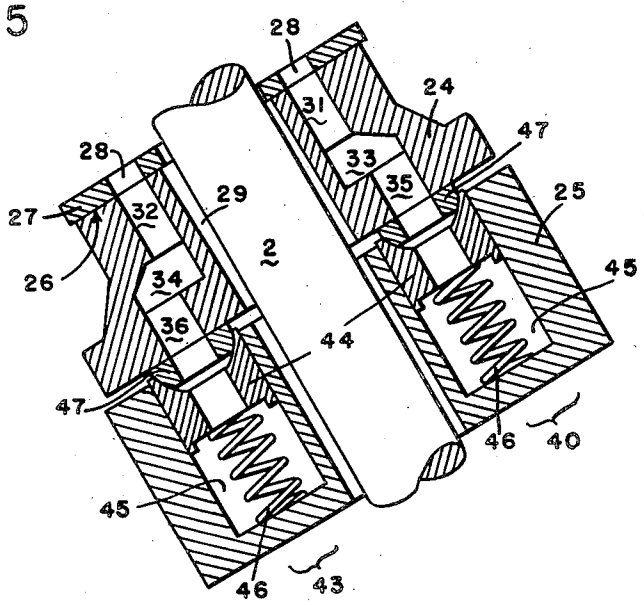
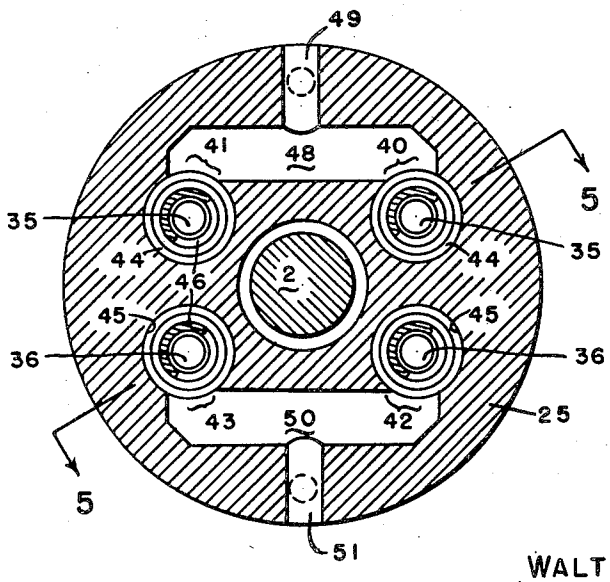


FIG. 4



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Patented Mar. 21, 1950 2,501,165

UNITED STATES PATENT OFFICE

2,501,165

HYDRODYNAMIC MACHINE

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Application August 23, 1945, Serial No. 612,252

12 Claims. (Cl. 60—52)

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This invention relates to hydrodynamic machines of the type which will function as pumps when driven mechanically and will function as hydraulic motors when supplied with liquid under pressure. The machine to which the invention relates in particular has its pistons and cylinders arranged in a rotatable cylinder barrel, a valve seat arranged upon an end of the cylinder barrel, and a flat valve engaging the seat to control the flow of motive liquid to and from the cylinders.

The motive liquid, which is ordinarily oil, forms a lubricating film between the valve and its seat and the pressure in the valve and in the film tends to move the valve away from its seat but is prevented from doing so by a plurality of hold-up motors which are energized by the motive liquid and each of which ordinarily includes a stationary cylinder and a piston fitted in the cylinder. The hold-up pistons remain stationary for long intervals of time and never move more than the very slight amount necessary to compensate for varying deflections in the supporting structure and variations in the thickness of the lubricating film caused by variations in the viscosity of the liquid due to variations in temperature.

Hydrodynamic machines of this type are in extensive use and operate successfully if the motive liquid is relatively clean but after an extended period of use the motive liquid often becomes contaminated with particles of solid and semisolid matter some of which lodge between the pistons and the cylinder walls of hold-up motors. Since the hold-up pistons have such limited movements, they are unable to eject the particles of matter from between their outer walls and the walls of their cylinders with the result that the particles accumulate therein until they cause the hold-up pistons to stick in their cylinders, thereby impairing the efficiency of the machine and sometimes rendering it inoperative until the hold-up pistons are removed and cleaned.

The present invention has as an object to provide a hydrodynamic machine in which the danger of the hold-up pistons sticking in their cylinders is substantially eliminated.

In certain situations it is desirable that the motor of a hydraulic transmission should start under load simultaneously with the operation of the element which controls the flow of liquid thereto but, when a pump is adjusted from zero displacement to a positive displacement, it must compress the liquid in the motor and in the connecting channels before the motor can start to operate.

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Another object of the present invention is to provide a pump which when at zero displacement will create rapid intermittent pulsations of pressure and thereby enable a motor connected thereto to start substantially simultaneously with the adjustment of the pump to a positive displacement.

These and other objects and advantages will be apparent from the following description of an embodiment of the invention shown somewhat diagrammatically in the accompanying drawing in which the views are as follows:

Fig. 1 is a transverse section through a hydrodynamic machine in which the invention is embodied, the section being taken on the line 1—1 of Fig. 2.

Fig. 2 is in part a longitudinal section taken on the irregular line 2—2 of Fig. 1 and in part a circuit diagram showing the machine connected to a hydraulic motor.

Fig. 3 is a transverse section taken on the irregular line 3—3 of Fig. 2.

Fig. 4 is a transverse section through a distributing block through which liquid flows to and from the cylinder barrel, the view being taken in the plane of the line 4—4 of Fig. 2.

Fig. 5 is a section through the distributing block and the adjacent valve, the section being taken on the line 5—5 of Fig. 4.

Fig. 6 is a diagram illustrating a modification of the arrangement shown in Fig. 2.

The machine chosen for illustration is of the type illustrated and described in application Serial No. 485,279 filed May 1, 1943, now Patent No. 2,484,337, to which reference may be had for details of construction not fully illustrated herein. This machine will function either as a pump or as a motor but, in order to simplify the description, it will be referred to herein as a pump. It is to be understood however that the invention is equally applicable to a motor and that the invention is in no way limited to a pump nor to a pump having flat valves at both ends of its cylinder barrel.

As shown, the pump has its mechanism arranged within and carried by a casing 1 which consists of a plurality of parts and in practice has a plurality of passages formed therein but, in order to simplify the drawings, only fragments of the casing have been shown and certain of the passages have been represented by external channels.

Power is transmitted to the pump through a

shaft 2 which is journaled in a bearing 3 carried by casing 1. Shaft 2 has its inner end splined or otherwise suitably connected to a cylinder barrel 4 which is rotatably supported within casing 1 by bearings 5 and 5a carried thereby. Cylinder barrel 4 has a plurality of cylinders formed therein and shown arranged in two circular rows, each cylinder in one row being indicated by the reference numeral 6 and each cylinder in the other row being indicated by the reference numeral 6a. Each cylinder 6 has a piston 7 fitted therein and its inner end connected to a passage 8 which is formed in cylinder barrel 4 and extends through the left end thereof. Each cylinder 6a has a piston 7a fitted therein and it has its inner end connected to a passage 8a which is formed in cylinder barrel 4 and extends through the right end thereof.

The cylinders have been shown as being radial and the pistons have been shown as having the outer ends or heads thereof in contact with conical reaction surfaces 9 and 9a arranged upon the inside of an annular thrust member 10 which extends around cylinder barrel 4, the outer end of each piston being so shaped that the reaction surface makes contact therewith upon a single spot which is offset far enough from the piston axis to cause the piston to rotate in its cylinder as it is reciprocated therein during rotation of cylinder barrel 4 and thrust member 10 as fully explained in Patent No. 2,074,068.

The volumetric capacity of the pump may be increased by increasing the number of rows of cylinders, or it may be increased by increasing the number of cylinders in each row and inclining alternate cylinders in each row in opposite directions and having the outer ends of the pistons in contact with a circular reaction surface as shown in Patent No. 2,406,138. If the pump is to operate at a high pressure, such as 2500 p. s. i., the pistons are reduced in diameter and provided on their outer ends with enlarged heads as shown in Patent No. 2,074,068.

Thrust member 10 is rotatably supported as by means of a roller bearing 11. In a constant displacement pump or motor, thrust member 10 is adapted to rotate upon a stationary axis but it has been shown supported by bearing 11 within a displacement varying member or slide block 12 which is slidably supported within casing 1 as by means of two roller bearings 13 and 14 so that when functioning as a pump it will deliver liquid in a direction and at a rate dependent upon the direction and the distance that the axis of slide block 12 is offset from the axis of cylinder barrel 4.

Slide block 12 may be shifted in response to operation of a suitable control such as the control illustrated and described in Patent No. 2,406,138. As shown in Fig. 1, slide block 12 is constantly urged toward the right by a servo-motor 15 which engages the left side thereof and includes a spring 16. A roller 17 carried by slide block 12 at the right side thereof is urged by servo-motor 15 against the face of a cam 18 which is guided by a roller bearing 19 and has its ends connected to pistons 20 and 21 fitted, respectively, in cylinders 22 and 23 carried by casing 1, roller bearing 19 preventing cam 18 from being deflected by the thrust of servo-motor 15.

Cylinder 22 is continuously supplied with liquid at a substantially constant pressure and cylinder 23 is larger than cylinder 22 so that, when it is supplied with liquid at the same pressure, piston 21 will move cam 18 downward and permit servo-motor 15 to move slide block 12 toward the right and, when cylinder 23 is opened to drain, piston 20 will move cam 18 upward and cause it to move slide block 12 toward the left.

The flow of liquid to and from cylinders 6 and 6a is controlled by two flat valves 24 and 24a which are arranged, respectively, between opposite ends of cylinder barrel 4 and two identical distributing blocks 25 and 25a which are fixed to or formed integral with casing 1. In order to maintain the overall length of the pump at a minimum, cylinder barrel 4 has been shown as having its ends recessed and valves 24 and 24a extending into the recesses.

Prior pumps of the flat valve type have a valve seat formed directly upon the recessed end of the cylinder barrel and arranged parallel to the plane of rotation of the cylinder barrel but in the present invention the valve seat is inclined to the plane of rotation to cause the flat valve to wabble during rotation of the cylinder barrel for reasons to be presently explained.

Inclined valve seats may be formed directly upon opposite ends of cylinder barrel 4 but preferably two inclined valve seats 26 and 26a are formed, respectively, upon the outer faces of two beveled wear plates 27 and 27a which are arranged upon opposite ends of cylinder barrel 4 and fixed for rotation therewith. Wear plate 27 has extending therethrough a plurality of cylinder ports 28 each of which registers with a passage 8, and wear plate 27a has extending therethrough a plurality of cylinder ports 28a each of which registers with a passage 8a.

Valve 24 is provided at its center with an opening 29 which is larger than shaft 2 so that, during rotation of cylinder barrel 4, valve 24 may wabble without engaging shaft 2. The inner end or face of valve 24 has formed therein two diametrically opposed substantially crescent shaped ports 31 and 32 (Figs. 2 and 3) with which each cylinder port 8 communicates alternately as cylinder barrel 4 rotates. Ports 31 and 32 communicate, respectively, with two chambers 33 and 34 (Figs. 2 and 5) which are formed within valve 24 and have passages 35 and 36 leading therefrom respectively through the outer end of the valve.

Valve 24 may be supported and prevented from rotating in any suitable manner. As shown, two pins 37 are fixed in distributing block 25 at opposite sides of shaft 2 and extend, respectively, into two sockets 38 formed in valve 24. Pins 37 fit loosely in sockets 38 to permit valve 24 to wabble while preventing any substantial rotation or radial movement thereof.

When the machine is performing work either as a pump or as a motor, liquid in one port of valve 24 is under a high pressure, the liquid in the other port of valve 24 is under a low, zero or negative pressure, and minute quantities of liquid will escape from the high pressure port and spread over valve seat 26 and the face of valve 24 to form a lubricating film therebetween. The pressure prevailing in the high pressure port will extend into the lubricating film and the pressure prevailing in one or both ports and in the film will tend to move the valve away from its seat 26.

Due to the pressure being very high in one valve port and very low or absent in the other valve port, the film pressure varies from a high pressure at the edge of the high pressure port to a low or zero pressure at the edge of the other port and to zero at the edges of the valve seat. Consequently, the center of pressure is not on the

center of the valve but, if the pressure in the low pressure port is zero or negative, the center of pressure is near the center of a high pressure area which extends around the high pressure port or, if there is pressure in the low pressure port, there will be one center of pressure near the center of the high pressure area which extends around the high pressure port and another center of pressure near the center of a low pressure area which extends around the low pressure port.

However, the force exerted by the liquid in the low pressure area is ordinarily so small that it may be disregarded in the present explanation and only the high pressure area considered, it being understood that the center of high pressure is on one side of the cylinder barrel axis when one port is the high pressure port and on the other side of the cylinder barrel axis when the other port is the high pressure port.

Since an area of the valve equal to the area of the high pressure port is under full working pressure and since a film of liquid leaks from the high pressure port to the nearest low pressure areas so that the film is under full working pressure at the edges of the high pressure port and has low or zero pressure at the edges of the nearest low pressure area, the pressure area may be considered as being equal to the area of the high pressure port plus one half the valve face area across which the liquid passes. This pressure area will be referred to herein as the "blow-off area." The force which tends to move the valve away from its seat, hereinafter referred to as the "blow-off force," is determined by multiplying the blow-off area by the unit working pressure.

The cylinder barrel is always provided with an odd number of cylinder ports so that an odd number of cylinder ports communicate alternately with the high pressure valve port during rotation of the cylinder barrel. For example, if each end of cylinder barrel **4** is provided with seven cylinder ports **28** as shown, three cylinder ports **28** will communicate with the high pressure port during a part of a revolution of cylinder barrel **4** and four cylinder ports **28** will communicate with the same valve port during the preceding and succeeding parts of the revolution. Consequently, the blow-off area will vary as the cylinder ports move into and out of communication with the high pressure valve port, and the center of the blow-off force will shift both radially and circumferentially but it is always near the vertical center line of the valve and is always spaced a short distance radially inward from the inner edge of the high pressure valve port.

If shaft **2** did not extend through valve **24**, the blow-off force could be opposed by a single hold-up motor arranged within distributing block **25** and engaging valve **24** upon its vertical center line a short distance inward from the inner edge of the high pressure valve port but in that location it would occupy a part of the space required by shaft **2**. Therefore, the blow-off force is opposed by two spaced apart hold-up motors which are arranged in distributing block **25** and engage valve **24** at equal distances from the vertical center line. The two hold-up motors are the equivalent of and function in the same manner as a single hold-up motor arranged upon the vertical center line of the valve.

As shown in Figs. 3 and 4, two hold-up motors **40** and **41** are arranged in distributing block **25** above its horizontal center line and two hold-up motors **42** and **43** are arranged in distributing

block **25** below its horizontal center line. All four hold-up motors are equidistant from the horizontal center line and are equidistant from the vertical center line. Also, auxiliary hold-up motors are ordinarily provided to compensate for variations in the blow-off area as explained in Patent No. 2,484,337 but such auxiliary motors have been omitted from the drawings to avoid complicating the views.

The four hold-up motors are identical and each has a hollow piston **44** fitted in a cylinder **45** which is formed in distributing block **25**. Each piston **44** is urged by a spring **46** against an annular sealing member **47** which is urged by spring **46** against the outer end of valve **24**, the contacting surfaces of member **47** and valve **24** being ground flat and the contacting surfaces of piston **44** and member **47** being ground spherical to provide self-aligning liquid tight seals therebetween.

The openings through the pistons **44** and sealing members **47** of motors **40** and **41** communicate through passages **35** and chamber **33** with port **31** in valve **24** and the openings through the pistons **44** and sealing members **47** of motors **42** and **43** communicate through passages **36** and chamber **34** with port **32** in valve **24**. The cylinders of motors **40** and **41** are connected by a passage **48** (Fig. 4) to each other and to a passage **49** which extends outward through distributing block **25** for connection to one side of an external circuit. The cylinders **45** of motors **42** and **43** are connected by a passage **50** to each other and to a passage **51** which extends outward through distributing block **25** for connection to the other side of an external circuit.

The force exerted upon pistons **44** by springs **46** is transmitted to valve **24** and any pressure prevailing in the hold-up motor cylinders acts upon the ends of pistons **44** and is transmitted therethrough to valve **24**. Consequently, valve **24** is urged against its seat **26** by the constant force supplied by the four springs **44** and by a force which varies in accordance with variations in the pressure of the motive liquid.

Valve **24ª** is identical to valve **24** and distributing block **25ª** is identical to distributing block **25**. Consequently, they have not been fully illustrated and a description thereof is deemed unnecessary, like parts and passages as far as shown being indicated by like reference numerals with the exponent *"a"* added to the reference numerals applied to valve **24ª** and distributing block **25ª**.

Passage **49** in block **25** and passage **49ª** in block **25ª** are connected to each other by a channel **52**. Passage **51** in block **25** and passage **51ª** in block **25ª** are connected to each other by a channel **53**. Channels **52** and **53** have been shown as external channels and as being connected, respectively, by channels **54** and **55** to opposite ends of a hydraulic motor **56** but in practice they may be formed in the casing of the machine and connected to a different device.

Passages **8** and **8ª** are equally spaced in the cylinder barrel **4** and valves **24** and **24ª** are symmetrical about their horizontal center lines so that, when cylinder barrel **4** is rotated, the machine will function as a pump and will deliver liquid in a direction and at a rate dependent upon the direction and rate of rotation of cylinder barrel **4** and upon the direction and distance slide block **12** is offset from its neutral position, it being understood that, when slide block **12** is in its neutral position so that thrust member **10** is concentric with cylinder barrel **4**, pistons **7**

and 7ª will not be reciprocated and no liquid will be delivered by the pump.

Assuming that cylinder barrel 4 is being rotated in a clockwise direction in respect to Fig. 1 and that slide block 12 is offset to the left of its neutral position in respect to that figure, the pistons in the lower half of cylinder barrel 4 will move progressively outward and the pistons in the upper half of cylinder barrel 4 will be forced progressively inward by thrust member 10. The cylinders of the outward moving pistons will be filled with liquid which flows thereto through the passages 8 and 8ª connected thereto, the lower parts of valves 24 and 24ª and the lower parts of distributing blocks 25 and 25ª from channel 53, the liquid being supplied to channel 53 from the external circuit and/or from an auxiliary pump according to common practice. The inward moving pistons will eject liquid from their cylinders through passages 8 and 8ª connected thereto, the upper parts of valves 24 and 24ª, the upper parts of distributing blocks 25 and 25ª, channel 52 and channel 54 to the external circuit and the resistance encountered by the liquid in the external circuit will cause pressure to rise and act upon the pistons 44 of motors 40, 41, 40ª and 41ª and cause them to urge valves 24 and 24ª inward with a force proportional to pump pressure, thereby firmly holding valves 24 and 24ª against their seats 26 and 26ª.

If cylinder barrel 4 is rotated in the opposite direction or if slide block 12 is shifted to the other side of its neutral position, the pump will deliver liquid into channel 53, ports 32 and 32ª will then be the high pressure ports, ports 31 and 31ª will then be the low pressure ports, and the pressure in ports 32 and 32ª will cause the pistons 44 of motors 42, 43, 42ª and 43ª to firmly hold valves 24 and 24ª against their seats 26 and 26ª.

During rotation of cylinder barrel 4, inclined valve seats 26 and 26ª cause valves 24 and 24ª to wabble and continuously reciprocate pistons 44 which are thus enabled to dislodge particles of matter which tend to accumulate between the walls of cylinders and pistons, thereby reducing to a minimum all danger of the hold-up pistons sticking in their cylinders.

Each piston 44 alternately draws liquid into and ejects liquid from its cylinder as it reciprocates therein. That is, pistons 44 pump liquid so that limited volumes of liquid are alternately subtracted from and added to the liquid discharged from pump cylinders 6 and 6ª and also the liquid supplied to pump cylinders 6 and 6ª.

If valve seats 26 and 26ª are inclined in the same direction as shown in Fig. 2, each piston 44 at one end of the pump will draw liquid into its cylinder 45 at the same time and at the same rate that the corresponding piston 44 at the other end of the pump ejects liquid from its cylinder 45. Consquently, there will be no flow from hold-up cylinders 45 to an external circuit so that, if the pump were connected as shown in Fig. 2, piston 57 of motor 56 would be moved at a uniform rate when the pump had a positive displacement and it would remain stationary when the pump was at zero displacement.

Figure 6

When a prior pump which is connected in circuit with a hydraulic motor is adjusted from zero displacement to a positive displacement, the pump will start to deliver liquid at a limited rate but the motor will not start until after the pump has discharged enough liquid to compress the liquid between it and the motor piston and thereby create sufficient pressure in the motor to start it. There is thus a time lag between the adjustment of the pump and the starting of the motor, particularly if the motor is to be operated at slow speed in which case the pump is adjusted to deliver liquid at such a low rate that an appreciable length of time is required for the pump to deliver sufficient liquid to compress the liquid between it and the motor piston to the pressure required to start the motor. When the motor is employed for certain purposes, it is important that the motor starts substantially at the instant that the pump is adjusted to a positive displacement.

Substantially instantaneous starting of the motor in response to adjustment of the pump to a positive displacement in either direction, or to reversal of pump discharge by moving the slide block across neutral position, may be effected by inclining the pump valve seats 26 and 26ª in opposite directions as shown in Fig. 6. With the valve seats inclined in opposite directions, rotation of cylinder barrel 4 will cause corresponding pistons 44 at opposite ends of the pump to be moved alternately toward and from each other.

During one half of each revolution of cylinder barrel 4, the pistons 44 above the horizontal center line of the pump will move outward and eject liquid from their cylinders and the pistons 44 below the horizontal center line of the pump will move inward and draw liquid into their cylinders. During the other half of each revolution of cylinder barrel 4, the pistons 44 below the horizontal center line of the pump will move outward and eject liquid from their cylinders and the pistons 44 above the horizontal center line of the pump will move inward and draw liquid into their cylinders. A limited volume of liquid is thus alternately supplied to and subtracted from each side of the circuit in which the pump is connected but, when the pump is adjusted to a positive displacement, the net volumetric delivery of the pump is unaffected by the pumping action of hold-up pistons 44.

When the pump is ajusted to zero displacement and cylinder barrel 4 is rotated, pistons 7 and 7ª wil not be reciprocated and no liquid will be discharged thereby but hold-up pistons 44 will be reciprocated in their cylinders. The outward moving pistons 44 will expel liquid from their cylinders into one side of the hydraulic circuit and the cylinders containing the inward moving pistons will be filled with liquid from the other side of the circuit.

If the pump and the motor are connected into a closed circuit and the parts are so proportioned that the volume of liquid discharged by the outward moving pistons 44 into one side of the circuit is great enough to compress the liquid in that side of the circuit to create pressure therein but is not great enough to effect operation of the motor, the previously compressed liquid in the other side of the circuit will expand and fill the cylinders containing the inward moving pistons 44, it being understood that means are provided to make up leakage losses such as by connecting each side of the circuit to a low pressure auxiliary pump through check valves according to common practice and as shown in Patent No. 2,406,138 and in Patent No. 2,484,337. In this case, there will be no actual flow in the circuit.

If the pump is connected into a closed hydraulic circuit with a reciprocating hydraulic

motor as shown in Fig. 6 and the parts are so proportioned that the volume of liquid discharged by the outward moving pistons 44 into one side of the circuit is sufficient to compress the liquid therein and to cause the piston 57 of the motor to move slightly, the cylinders containing the inward moving pistons 44 will be filled with liquid by the expansion of the liquid in the other side of the circuit and by the liquid expelled by piston 57 from the motor cylinder. In this case there will be a slight flow of liquid in opposite directions alternately and piston 57 will be vibrated rapidly, making one complete reciprocation during each revolution of cylinder barel 4.

In either case, the pulsations of pressure will follow each other very rapidly for the reason that cylinder barrel 4 is ordinarily rotated at high speed. For example, if cylinder barrel 4 is rotated at 1200 R. P. M. which is an ordinary speed, pressure will be created in both sides of the circuit alternately every 1/20 of a second.

If at the instant that the pump is adjusted to deliver liquid into one side of the circuit the outward moving pistons are creating presure in the same side of the circuit, the motor will start at the same instant but, if at that instant the outward moving pistons 44 are creating pressure in the opposite side of the circuit, the motor will start as soon as cylinder barrel 4 has made one-half or less of a revolution which in the above example would be 1/20 of a second or less and that amount of time probably would be required to adjust the pump from zero to a positive displacement so that in any event the motor would start substantaneously instantaneously in response to adjustment of the pump.

The hydrodynamic machine disclosed herein is susceptible of various modifications and adaptations without departing from the scope of the invention which is hereby claimed as follows:

1. In a hydrodynamic machine, the combination of a rotatable cylinder barrel having pistons and cylinders arranged therein, a valve seat arranged upon an end thereof and inclined to the plane of rotation thereof and passages extending from said cylinders through said valve seat, a flat valve engaging said seat to control the flow of liquid to and from said cylinders, hold-up motors for urging said valve against said seat and each including a piston and a cylinder, and means providing a reactance for said hold-up motors the inclined valve seat causing said valve during rotation of said cylinder barrel to wabble and effect relative reciprocation of said hold-up motor pistons and cylinders.

2. In a hydrodynamic machine, the combination of a rotatable cylinder barrel having pistons and cylinders arranged therein, a beveled wear plate fixed upon an end thereof and providing a valve seat which is inclined to the plane of rotation thereof and passages extending from said cylinders through said valve seat, a flat valve engaging said seat to control the flow of liquid to and from said cylinders, hold-up motors for urging said valve against said seat and each including a piston and a cylinder, and means providing a reactance for said hold-up motors, the inclined valve seat causing said valve during rotation of said cylinder barrel to wabble and effect relative reciprocation of said hold-up motor pistons and cylinders.

3. In a hydrodynamic machine, the combination of a rotatable cylinder barrel having pistons and cylinders arranged therein, a valve seat arranged upon each of the two opposite ends thereof and inclined to the plane of rotation thereof and passages extending from some of said cylinders through one of said valve seats and other passages extending from the other of said cylinders through the other of said valve seats, two flat valves engaging said seats respectively to control the flow of liquid to and from said cylinders, each of said valves having inlet and outlet ports with which each of said passages registers alternately during rotation of said cylinder barrel, hold-up motors for urging said valves against said seats and each including a piston and a cylinder, means providing reactances for said hold-up motors, the inclined valve seats causing said valves during rotation of said cylinder barrel to wabble and effect relative reciprocation of said hold-up motor pistons and cylinders, means for connecting said inlet ports to each other and to an external circuit, and means for connecting said outlet ports to each other and to an external circuit.

4. In a hydrodynamic machine, the combination of a rotatable cylinder barrel having pistons and cylinders arranged therein, beveled wear plates fixed upon opposite ends thereof and providing valve seats which are inclined to the plane of rotation thereof and passages extending from some of said cylinders through one of said valve seats and other passages extending from the other of said cylinders through the other of said valve seats, two flat valves engaging said seats respectively to control the flow of liquid to and from said cylinders, each of said valves having inlet and outlet ports with which each of said passages registers alternately during rotation of said cylinder barrel, hold-up motors for urging said valves against said seats and each including a piston and a cylinder, means providing reactances for said hold-up motors, the inclined valve seats causing said valves during rotation of said cylinder barrel to wabble and effect relative reciprocation of said hold-up motor pistons and cylinders, means for connecting said inlet ports to each other and to an external circuit, and means for connecting said outlet ports to each other and to an external circuit.

5. In a hydrodynamic machine, the combination of a rotatable cylinder barrel having pistons and cylinders arranged therein, a valve seat arranged upon an end thereof and inclined to the plane of rotation thereof and passages extending from said cylinders through said valve seat, a flat valve engaging said seat to control the flow of liquid to and from said cylinders and provided with inlet and outlet ports in the inner face thereof and with passages extending through the outer face thereof into communication with said ports, a stationary distributing block spaced from the outer face of said valve, and hold-up motors arranged in said block in alignment with said passages, each hold-up motor including a cylinder having a connection for the flow of liquid to and from an external circuit, a hollow piston fitted in said cylinder and a hollow sealing member arranged between said piston and the outer face of said valve so that liquid flows through said hold-up motors to and from said cylinder barrel and any pressure in said liquid causes said pistons to urge said valve against said valve seat, said inclined valve seat during rotation of said cylinder barrel causing said valve to wabble and reciprocate said hold-up pistons to prevent them from sticking in their cylinders.

6. In a hydrodynamic machine, the combina-

tion of a rotatable cylinder barrel having pistons and cylinders arranged therein, a beveled wear plate fixed upon an end thereof and providing a valve seat which is inclined to the plane of rotation thereof and passages extending from said cylinders through said seat, a flat valve engaging said seat to control the flow of liquid to and from said cylinders and provided with inlet and outlet ports in the inner face thereof and with passages extending through the outer face thereof into communication with said ports, a stationary distributing block spaced from the outer face of said valve, and hold-up motors arranged in said block in alignment with said passages, each hold-up motor including a cylinder having a connection for the flow of liquid to and from an external circuit, a hollow piston fitted in said cylinder and a hollow sealing member arranged between said piston and the outer face of said valve so that liquid flows through said hold-up motors to and from said cylinder barrel and any pressure in said liquid causes said pistons to urge said valve against said valve seat, said inclined valve seat during rotation of said cylinder barrel causing said valve to wabble and reciprocate said hold-up pistons to prevent them from sticking in their cylinders.

7. In a hydrodynamic machine, the combination of a rotatable cylinder barrel having a plurality of pistons and cylinders arranged therein, a valve seat arranged upon each of the two ends thereof and inclined to the plane of rotation thereof, passages leading from a part of said cylinders through one of said valve seats and other passages leading from the other cylinders through the other of said valve seats, two flat valves arranged at opposite ends of said cylinder barrel and engaging said seats to control the flow of liquid to and from said cylinders and provided with inlet and outlet ports in the inner faces thereof and with passages extending through the outer faces thereof into communication with said ports, a stationary distributing block spaced from the outer face of each valve, and hold-up motors arranged in said blocks in alignment with said valve passages, each hold-up motor including a cylinder having a connection for the flow of liquid to and from an external circuit, a hollow piston fitted in said cylinder and a hollow sealing member arranged between said piston and the outer face of the adjacent valve so that liquid flows through said hold-up motors to and from said cylinder barrel and any pressure in said liquid causes said pistons to urge said valves against said valve seats and said inclined valve seats during rotation of said cylinder barrel causes said valves to wabble and reciprocate said hold-up pistons to prevent them from sticking in their cylinders.

8. In a hydrodynamic machine, the combination of a rotatable cylinder barrel having a plurality of pistons and cylinders arranged therein, beveled wear plates fixed upon opposite ends thereof and providing valve seats which are inclined to the plane of rotation thereof, passages leading from a part of said cylinders through one of said seats and other passages leading from the other cylinders through the other of said seats, two flat valves arranged at opposite ends of said cylinder barrel and engaging said seats to control the flow of liquid to and from said cylinders and provided with inlet and outlet ports in the inner faces thereof and with passages extending through the outer faces thereof into communication with said ports, a stationary distributing block spaced from the outer face of each valve, and hold-up motors arranged in said blocks in alignment with said valve passages, each hold-up motor including a cylinder having a connection for the flow of liquid to and from an external circuit, a hollow piston fitted in said cylinder and a hollow sealing member arranged between said piston and the outer face of said valve so that liquid flows through said hold-up motors to and from said cylinder barrel and any pressure in said liquid causes said pistons to urge said valves against said valve seat and said inclined valve seats during rotation of said cylinder barrel causes said valves to wabble and reciprocate said hold-up pistons to prevent them from sticking in their cylinders.

9. In a hydraulic transmission comprising a motor, fluid channels, and a pump connected to said motor by said channels to form therewith a hydraulic circuit and including a rotatable cylinder barrel having a plurality of pistons and cylinders arranged therein, the combination of a valve seat arranged upon each end of said cylinder barrel and inclined to the plane of rotation thereof, said cylinder barrel having passages leading from some of said cylinders through one of said valve seats and other passages leading from the other of said cylinders through the other valve seat, two flat valves arranged at opposite ends of said cylinder barrel and engaging said seats to control the flow of liquid to and from said cylinders and provided with inlet and outlet ports in the inner faces thereof and with passages extending through the outer faces thereof into communication with said ports, a stationary distributing block spaced from the outer face of each valve, and hold-up motors arranged in said blocks in alinement with said valve passages, each hold-up motor including a cylinder having a connection for the flow of liquid to and from said circuit, a hollow piston fitted in said cylinder and an annular sealing member arranged between said piston and the outer face of the adjacent valve so that liquid flows through said hold-up motors to and from said cylinder barrel and any pressure in said liquid causes said pistons to urge said valves against said valve seats, said inclined valve seats during rotation of said cylinder barrel causing said valves to wabble and reciprocate said hold-up pistons to prevent them from sticking in their cylinders and to cause each hold-up piston during reciprocation thereof to function as a pump and alternately increase and decrease the flow of liquid therethrough by a limited amount, said valve seats being inclined in opposite directions so that corresponding hold-up pistons at opposite ends of said cylinder barrel pump in the same phase and thereby effect a pulsating flow of liquid to said motor.

10. In a hydraulic transmission comprising a motor, fluid channels, and a pump connected to said motor by said channels to form therewith a hydraulic circuit and including a rotatable cylinder barrel having a plurality of pistons and cylinders arranged therein, the combination of a beveled wear plate fixed upon each end of said cylinder barrel and providing a valve seat which is inclined to the plane of rotation of said cylinder barrel, said cylinder barrel having passages leading from some of said cylinders through one of said valve seats and other passages leading from the other of said cylinders through the other valve seat, two flat valves arranged at opposite ends of said cylinder barrel and engaging said seats to control the flow of liquid to and from

said cylinders and provided with inlet and outlet ports in the inner faces thereof and with passages extending through the outer faces thereof into communication with said ports, a stationary distributing block spaced from the outer face of each valve, and hold-up motors arranged in said blocks in alinement with said valve passages, each hold-up motor including a cylinder having a connection for the flow of liquid to and from said circuit, a hollow piston fitted in said cylinder and an annular sealing member arranged between said piston and the outer face of the adjacent valve so that liquid flows through said hold-up motors to and from said cylinder barrel and any pressure in said liquid causes said pistons to urge said valves against said valve seats, said inclined valve seats during rotation of said cylinder barrel causing said valves to wabble and reciprocate said hold-up pistons to prevent them from sticking in their cylinders and to cause each hold-up piston during reciprocation thereof to function as a pump and alternately increase and decrease the flow of liquid therethrough by a limited amount, and said valve seats being inclined in opposite directions so that corresponding hold-up pistons at opposite ends of said cylinder barrel pump in the same phase and thereby effect a pulsating flow of liquid to said motor.

11. In a hydraulic transmission comprising a motor, fluid channels, and a pump connected to said motor by said channels to form therewith a hydraulic circuit and including a rotatable cylinder barrel having a plurality of pistons and cylinders arranged therein, the combination of a valve seat arranged upon each end of said cylinder barrel and inclined to the plane of rotation thereof, said cylinder barrel having passages leading from some of said cylinders through one of said valve seats and other passages leading from the other of said cylinders through the other valve seat, two flat valves arranged at opposite ends of said cylinder barrel and engaging said seats to control the flow of liquid to and from said cylinders and provided with inlet and outlet ports in the inner faces thereof and with passages extending through the outer faces thereof into communication with said ports, a stationary distributing block spaced from the outer face of each valve, and hold-up motors arranged in said blocks in alinement with said passages, each hold-up motor including a cylinder having a connection for the flow of liquid to and from an external circuit, a hollow piston fitted in said cylinder and a hollow sealing member arranged between said piston and the outer face of the adjacent valve so that liquid flows through said hold-up motors to and from said cylinder barrel and any pressure in said liquid causes said pistons to urge said valves against said valve seats, said inclined valve seats during rotation of said cylinder barrel causing said valves to wabble and reciprocate said hold-up pistons to prevent them from sticking in their cylinders and to cause each hold-up piston during reciprocation thereof to function as a pump and alternately increase and decrease the flow of liquid therethrough by a limited amount, and said valve seats being inclined in the same direction to cause corresponding hold-up pistons at opposite ends of said cylinder barrel to pump in opposite phase and thereby neutralize the pumping effects of each other so that the flow of liquid to said motor is unaffected by reciprocation of said hold-up pistons.

12. In a hydraulic transmission comprising a motor, fluid channels, and a pump connected to said motor by said channels to form therewith a hydraulic circuit and including a rotatable cylinder barrel having a plurality of pistons and cylinders arranged therein, the combination of a beveled wear plate fixed upon each end of said cylinder barrel and providing a valve seat which is inclined to the plane of rotation of said cylinder barrel, said cylinder barrel having passages leading from some of said cylinders through one of said valve seats and other passages leading from the other of said cylinders through the other valve seat, two flat valves arranged at opposite ends of said cylinder barrel and engaging said seats to control the flow of liquid to and from said cylinders and provided with inlet and outlet ports in the inner faces thereof and with passages extending through the outer faces thereof into communication with said ports, a stationary distributing block spaced from the outer faces of each valve, and hold-up motors arranged in said blocks in alinement with said valve passages, each hold-up motor including a cylinder having a connection for the flow of liquid to and from said circuit, a hollow piston fitted in said cylinder and an annular sealing member arranged between said piston and the outer face of the adjacent valve so that liquid flows through said hold-up motors to and from said cylinder barrel and any pressure in said liquid causes said pistons to urge said valves against said valve seats, said inclined valve seats during rotation of said cylinder barrel causing said valves to wabble and reciprocate said hold-up pistons to prevent them from sticking in their cylinders and to cause each hold-up piston during reciprocation thereof to function as a pump and alternately increase and decease the flow of liquid therethrough by a limited amount, and said valve seats being inclined in the same direction to cause corresponding hold-up pistons at opposite ends of said cylinder barrel to pump in opposite phase and thereby neutralize the pumping effects of each other so that the flow of liquid to said motor is unaffected by reciprocation of said hold-up pistons.

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