Sept. 19, 1939. E. K. BENEDEK 2,173,432

HYDRAULIC PUMP OR MOTOR

Filed Oct. 9, 1935 3 Sheets-Sheet 1

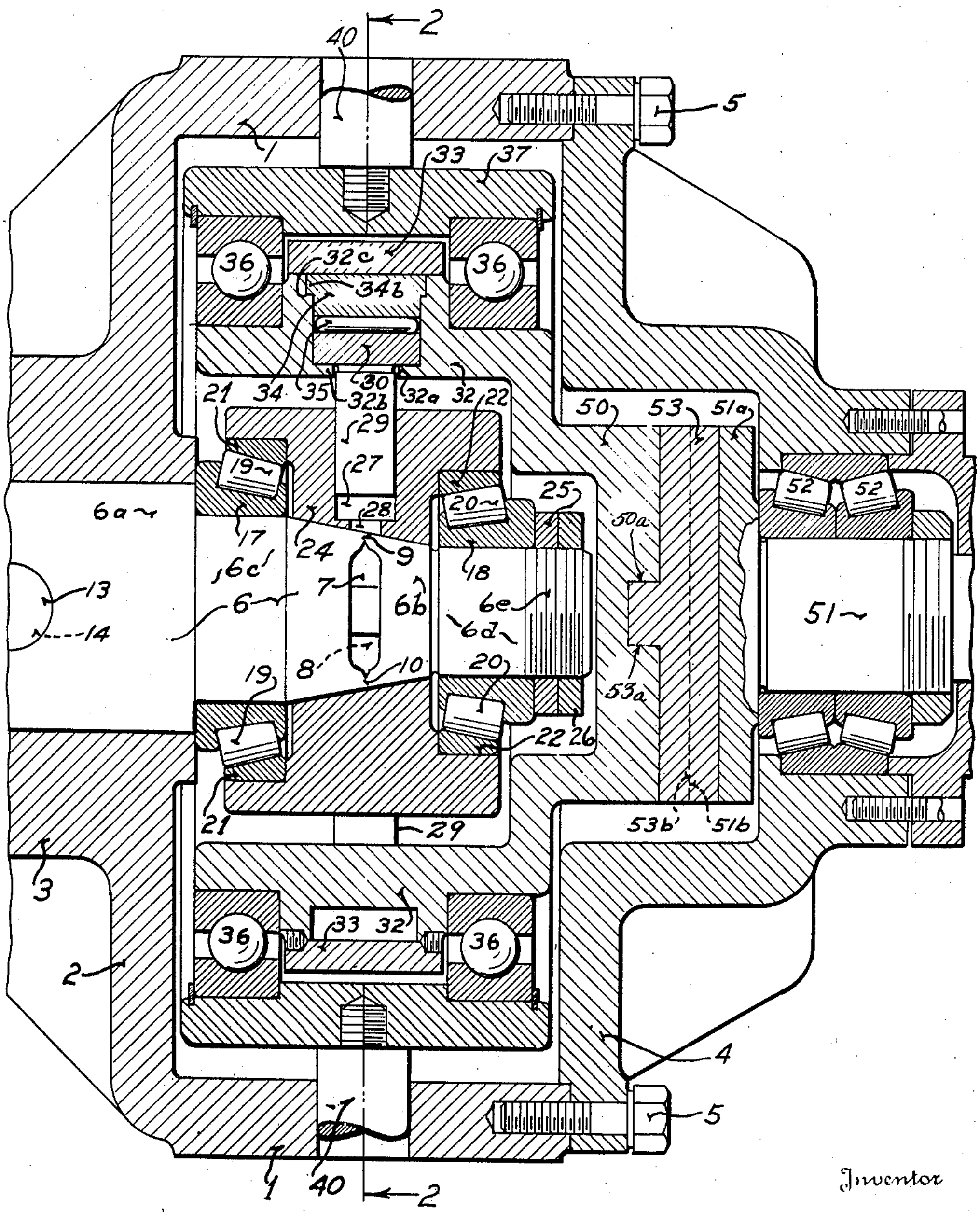

FIG. 1.

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HYDRAULIC PUMP OR MOTOR

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FIG. 2.

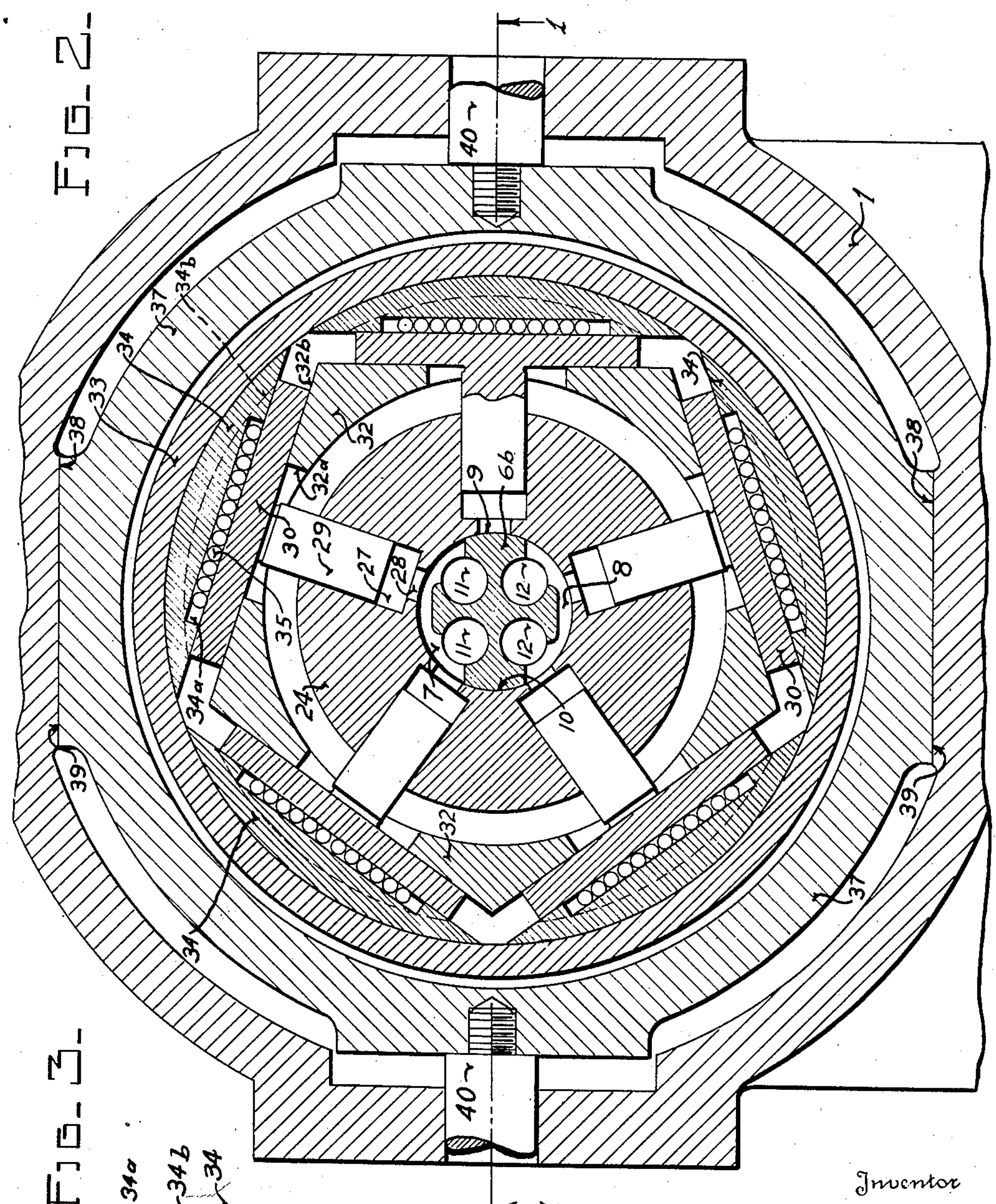
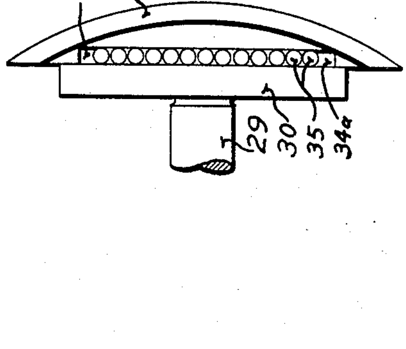


FIG. 3.



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HYDRAULIC PUMP OR MOTOR

Filed Oct. 9, 1935

3 Sheets-Sheet 3

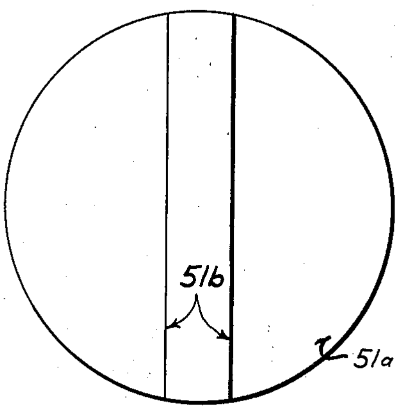

FIG. 4

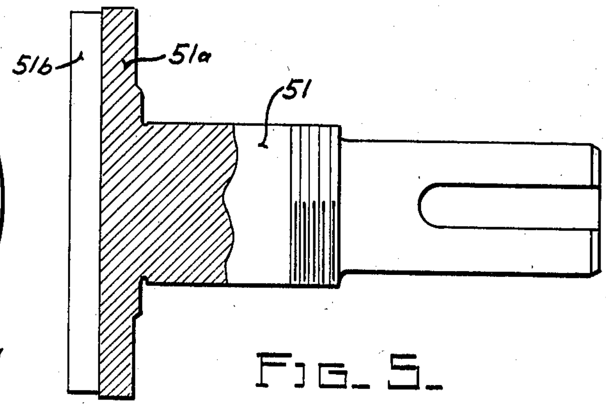

FIG. 5

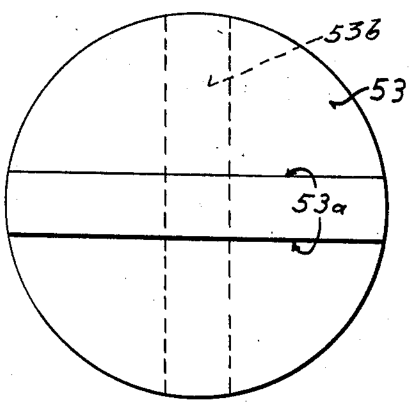

FIG. 6

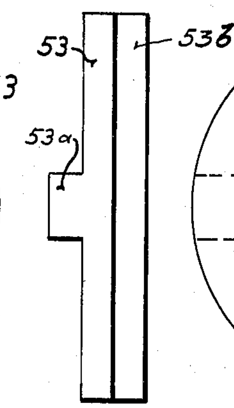

FIG. 7

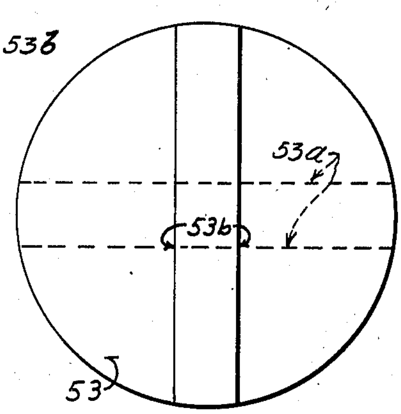

FIG. 8

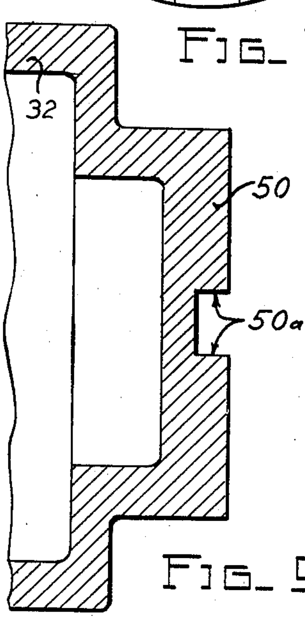

FIG. 9

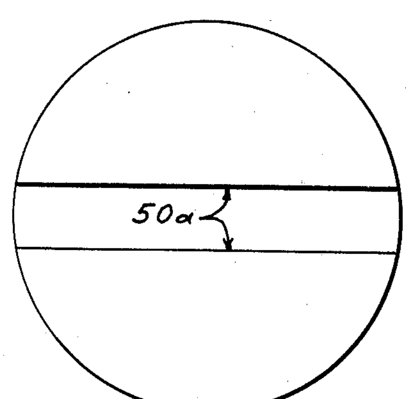

FIG. 10

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Patented Sept. 19, 1939

2,173,432

UNITED STATES PATENT OFFICE

2,173,432

HYDRAULIC PUMP OR MOTOR

Elek K. Benedek, Bucyrus, Ohio

Application October 9, 1935, Serial No. 44,225

11 Claims. (Cl. 103—161)

This invention relates to variable displacement, reversible, positive delivery pumps and motors and particularly for use in connection with high pressure fluid power transmission systems. The present pump or motor is of the general type comprising a rotary cylinder barrel and a surrounding rotary piston actuating reactance which are interconnected for synchronous rotation about their respective parallel axes through the medium of rigid torque transmitting T-head pistons mounted in cylinders of the barrel and connected to the rotary reactance.

One of the principal objects of the present invention is to provide a pump or motor of this character wherein driving power from a suitable prime mover is applied to the piston actuating rotary reactance instead of to the cylinder barrel so that the pistons are relieved from transmitting the torques of the rotary reactance and the large anti-friction bearings thereof.

A correlative and more specific object is to support the barrel rotatably solely upon a stationary valve pintle instead of directly in the casing; to provide, for cooperation with the pistons of the barrel, an adjustable rotary reactance mounted in the casing and positively and accurately guided so that its axis is at all times coincident with or parallel to the pintle axis and in a fixed plane through the pintle axis; and to fixedly support the pintle in the casing in a nonrotative position in which the plane defined by the axis of the pintle and the dead center line of the pintle valve bridges is at all times coincident with the said fixed plane through the pintle axis.

An equally important object is to provide a structural relation in which, in the dead center positions of each piston, its axis coincides with the dead center line pintle valve bridges during adjustment of and in all adjusted positions of the reactance whereby no changes in timing and valving cooperation result, restriction and entrapment of the operating fluid are eliminated, and accurate and positive fluid flow are assured.

Another object is to provide a pump wherein are combined a directly driven adjustable reactance rotor, a driving means for the rotor supported independently of the rotor and cylinder barrel, and a stationary pintle accurately and fixedly mounted for proper timing, tapered for uniform stress and for providing accurate adjustment of radial clearance between the pintle and barrel, and constrained to absolute rigid coaxial relation in the barrel.

Another object is to provide a valve pintle, barrel, and rotary reactance combination of this character, in which the reactance rotor may be positively driven by an impeller while in any adjusted position and in which the barrel and pistons are relieved from all torque except that necessary for rotating the barrel itself.

Another specific object is to provide for rotating the reactance rotor by an impeller shaft in any of its adjusted positions, through the medium of a planetating coupling means.

Other objects are to provide a more compact and efficient piston actuating means, and a barrel mounting by which accurate and positive hydraulic clearance between the pintle and barrel may be obtained and wear may be compensated by adjusting the barrel on the pintle.

Other objects and advantages will become apparent from the following specification wherein reference is made to the drawings in which

Fig. 1 is a longitudinal, horizontal axial sectional view of a pump or motor embodying the principles of the present invention, and is taken on a plane indicated by the line 1—1 in Fig. 2;

Fig. 2 is a vertical cross sectional view taken on the plane indicated by the line 2—2 in Fig. 1;

Fig. 3 is a fragmentary side elevation of a piston illustrating a piston reactance block and an anti-friction roller bearing assembly showing the cylindrical load transmitting shoulders of the block;

Fig. 4 is a end elevation of the driving element of the impeller means for driving one end of the planetating coupling disc;

Fig. 5 is a front elevation, partly in section, of the element illustrated in Fig. 4;

Figs. 6, 7 and 8 are, respectively, a left end elevation, a front elevation, and a right end elevation of the planetating disc member of the planetating coupling mechanism;

Fig. 9 is a fragmentary sectional view of the reactance rotor;

Fig. 10 is a right end elevation of a portion of the reactance rotor illustrated in Fig. 9, Figs. 9 and 10 showing the means on the reactance rotor for connecting the planetating disc and the reactance rotor at one end of the disc.

Referring to the drawings, the working parts of the structure are mounted in a liquid tight casing 1 which is in the form of an annular body portion open at one end and having at the opposite end an integral radial wall portion 2, the wall portion terminating in a rigid hub portion 3 which forms the valve head of the pump. The open end of the body 1 is closed by a suitable end cover 4 secured to the end of the body 1 by suitable bolts 5 and forming therewith a substantially rigid unitary closed housing structure. Mounted in the hub 3 of the body is a shank portion 6*a* of a pintle 6 which pintle extends into and in coaxial relation with the body 1 and has a tapered valve portion 6*b*.

In the valve portion 6*b* of the pintle are diametrically opposite reversible valve ports 7 and 8 respectively, separated from each other by circumferentially extending bridges 9 and 10, one of the ports being a fluid pressure port and the other a suction port concurrently. The port 7 is in communication with longitudinal ducts 11 in the pintle and the port 8 is in communication with longitudinal ducts 12. The ducts 11, in turn, communicate with a main port 13 in the shank 6*a* of the pintle and the ducts 12 communicate with the other main port 14 in the shank of the pintle. The main ports 13 and 14 are diametrically opposite with respect to each other and are connected respectively through suitable ducts formed in the hub portion 3 of the casing with a pressure conduit and a suction conduit, in a well known manner, the pressure conduit leading to a suitable hydraulic machine to be operated and the suction conduit leading to a suitable sump or to the exhaust of the machine.

On the pintle 6, at the ends of the tapered valve portion 6*b*, are cylindrical bearing surfaces 6*c* and 6*d*, respectively, on which are supported the inner races 17 and 18 respectively of tapered radial load and axial thrust bearings 19 and 20, having outer races 21 and 22 respectively.

The valve portion 6*b* of the pintle is tapered from the portion 6*c* to the portion 6*d* at a very pronounced taper so that the pintle approximates as nearly as may be a constant strength end-supported beam whereby substantially uniform stress results thereon and deflection of the pintle is eliminated even in the absence of end support at the free end because of the extra strength at the mounted or shank portion.

Mounted on the pintle is a cylinder barrel 24 having at each end an internal axially extending annular shoulder and an intersecting radial shoulder, which shoulders receive and fixedly accommodate outer races 21 and 22 respectively of the bearings 19 and 20, for supporting the barrel in coaxial relation to the pintle. The barrel is provided with a valving bore which is tapered complementary to the valve portion 6*b* of the pintle and which, when the barrel is mounted on the bearings 19 and 20, receives and fits the tapered valve portion 6*b* of the pintle. A slight but very positive adjustable clearance is provided between the wall of the barrel bore and the complementary tapered valve portion 6*b* of the pintle, the roller elements 19 and 20 having sufficient capacity to maintain this clearance under all pressure conditions so that an oil film may be formed between the pintle and barrel bore wall for effecting a seal between the barrel and pintle, for preventing seizure and heating, and hydraulically balancing the pintle to eliminate unbalanced hydraulic load.

Due to this high capacity dual bearing mounting of the barrel directly on the fixed and rigid pintle instead of in the housing of the pump, an accurately determined mounting of the barrel in relation to the pintle is provided in which concentricity of the pintle and barrel, with proper positive clearance between the pintle and barrel is absolutely assured. This mounting, therefore, whereby the proper radial and axial relations of the pintle and barrel are maintained may be referred to as a "positive mounting". Among its advantages are the facts that eccentricity of the pintle and barrel and inaccuracies in radial clearance, due to separately pressing the pintle in the casing and separately supporting the barrel in the casing, are entirely eliminated. Consequently, the pintle cannot seize in the barrel due to inaccuracy in alignment with the barrel or to eccentricity of the pintle and barrel.

To provide for axial adjustment of the barrel on the pintle, in case it becomes necessary due to wear of the bearings 19 and 20, or for other reasons, the outer or free end portion 6*e* of the pintle is threaded and receives an adjusting nut 25, which engages the end of the inner bearing race 18 so that by operation of the nut 25, the race 18 can be adjusted axially toward the valve portion 6*b*, and through the medium of the tapered bearing elements and races can positively move the barrel axially toward the shank of the pintle for decreasing the radial clearance between the bore wall and portion 6*b* of the pintle. Very slight movement of the barrel in this manner will positively adjust and maintain the radial clearance between the pintle and barrel bore after which an outer lock nut 26 may be tightened for retaining the adjustment. In order to permit such adjustment, slight clearance, not shown, axially of the rotary reactance is provided between the lateral faces of the piston T-head and guide ways of the rotary reactance, as will later be described.

The race 17 is stationary with respect to the pintle while the race 18 is movable axially thereon. Thus for adjustment for wear the bearing assembly including the bearings 20, the race 18, and the race or cone 22 may be shifted bodily axially and, when so shifted, effects a corresponding axial shifting of the barrel, which necessarily carries with it the race or cone 21 of the bearings 19. Since the race 17 is fixed with respect to the pintle, this movement causes tightening of the bearings 19 to eliminate radial clearance in the bearing itself. At the same time, this movement permits a reduction in radial clearance between the barrel bore and the tapered portion of the pintle. If the wear on the bearings 19 is so great that movement of the barrel axially theretoward to effect the proper reduction of radial clearance of the bearings 19 reduces too greatly the radial clearance between the pintle and barrel, the bearings 19 must be replaced or shims must be placed between the race 17 and the cooperating radial abutment shoulder of the pintle.

For effecting the adjustment, the adjusting nut 25 is tightened until the barrel is difficult to rotate. The nut 25 is then backed away on the screw portion 6*e* of the pintle a definite fraction of one revolution, the amount of turning of the nut 25 depending upon the taper per inch of the barrel bore and pintle portion 6*b* and the pitch of the threads on the portion 6*e* of the pintle. For example, if the taper is one eighth of an inch per each inch of length of the pintle, and a total radial clearance of .001 inch is required, this can be obtained by adjusting the barrel .008 inch axially. Knowing the pitch of the particular threads on the pintle portion 63, the amount of rotation of the nut 25 to effect an exact amount of clearance between the barrel bore and tapered portion of the pintle is readily determined.

For permitting the axial adjustment of the race 18, a small clearance recess 20*a* is provided between the portions 6*b* and 6*d* of the pintle, this recess being coextensive axially of the pintle with the normal clearance space between the race 18 and the corresponding end of the barrel. It should be noted, however, that due to the taper of the pintle and the positive radial clearance between it and the barrel, the hydrostatic pressure urges the barrel toward the bearings 20 so that the bearings 20 are subjected to appreciable thrust and resultant wear, whereas the bearings 19 are subjected to substantially no axial thrust. Furthermore, since the tapered portion of the pintle is axially short, the pressure film is coextensive axially therewith, and substantially no wear occurs on the pintle portion 6b, the bearings 19, or bearings 20 due to unbalanced load. Consequently, misadjustment of the barrel on the pintle results primarily from wear of the bearings 20 and resultant travel of the barrel toward that end of the pintle. The adjustment above described, therefore is effective for maintaining the proper clearances.

Thus with the barrel mounted on the pintle as described, instead of in the casing, arcuate clearance and relationship between the pintle and barrel is maintained at all times and the barrel and pintle form a substantially self-contained unit. Since the valve portion is very short and the taper very pronounced, and the radial clearance is positively maintained, an effective oil film is maintained between the barrel and pintle coextensive with the valve portion 6b. Substantially hydrostatic balance of the barrel and pintle results and the only torque necessary for rotating the barrel is that to overcome the slight and negligible frictional resistance of the barrel itself and viscuous friction of the fluid.

The barrel is provided, in the zone of the pintle valve portion 6b, with a plurality of circumferentially spaced radial cylinders 27, each of which has a cylinder port 28 cooperable successively with the ports 7 and 8 of the pintle as the barrel rotates. Mounted one in each cylinder are radial pistons 29, each of which has a rigid T-head 30, later to be described, for effecting load transmission between the pintle and rotary reactance, and torque transmission between the rotary reactance and barrel.

The rotary reactance comprises a generally annular member 32 surrounding the barrel and having a cooperating annular ring 33 which forms the circumferentially closed wall of the member 32, the member 32 and ring 33 thus providing a series of generally chordal recesses in which are received, respectively, the T-heads 30 of the pistons. The members 32 has a series of openings 32a for accommodating the pistons and has shoulders 32b engaging the radially inward faces of the piston T-heads for actuating the pistons on the radially outward strokes.

Mounted within the recesses are reactance blocks or interponents 34, each of which has an inwardly disposed chordal face and an outwardly disposed cylindrical face, the cylindrical face being coaxial with the ring 33 and slidably abutting the inner wall of the ring so that the block 34 may shift slightly circumferentially therein. The inner or chordal face of each block 34 engages the outwardly exposed face of the associated T-head 30. By this arrangement wedge-shaped oil films form between the T-heads and blocks 34 and self-alignment and uniform load transmission is effected during concurrent rotation of the barrel and rotor.

In order to provide anti-friction cooperation between the T-heads 30 and the blocks 34, each of the blocks 34 is provided, at its inner face, with a trough 34a in which are received a plurality of elongated hydralically caged rollers 35, the rollers being either true capillary cageless needle rollers or larger rollers but, in any event, so spaced that the total clearance therebetween in the directions of rolling movement is such that only capillary spacing of each roller from the others and from the ends of the trough 34a is permitted. By this arrangement, slip fluid may enter the trough 34a and the centrifugal pressure fluid will maintain the proper pressure and capillary oil films between the T-heads and the blocks 34 and capillary films between the rollers 35, so that combination, high pressure, oil and capillary and anti-friction bearings are provided.

As better illustrated in Figs. 1 and 3, each of the blocks 34 has laterally extending shoulders 34b, both the inner and outer surfaces of the shoulders being cylindrical and coaxial with each other about an axis parallel to or coincident with the axis of the reactance rotor or barrel. Complementary cylindrical shoulders are formed on the radial walls of the member 32, as indicated at 32c, and engage the inner cylindrical walls of the shoulders 34b. The outer walls of the shoulders 34b engage and are complementary to the inner cylindrical wall surface of the rings 33. Consequently, on the suction strokes of the pistons, the clearance between each T-head and its associated block 34 will be coextensive with the T-head and positively formed for admitting slip fluid therebetween.

As hereinbefore mentioned, clearance axially of the reactance rotor is provided between the lateral faces of the T-heads 30 and aligned radial wall portions of the recesses so that, upon axial adjustment of the barrel, the T-heads may accommodate themselves properly.

Since the ring 33 is separately made, it is apparent that both it and the member 32 may be machined and hardened and polished where desired both accurately and economically. Furthermore, the blocks 34 are suspended and doubly guided by the shoulders 32c and inner cylindrical surface of the ring 33, so that they may shift circumferentially of the reactance rotor for self-alignment in operating position and for creating oil films on all of their surfaces.

The reactance rotor is mounted through the medium of heavy anti-friction bearings 36 in and coaxial with an adjustable reactance stator 37, the reactance stator and reactance rotor being constrained to coaxial relation with respect to each other at all times. The stator 37, in turn, is provided at its outer surface with diametrically opposite flat slide bearing surfaces 38 which cooperate with complementary surfaces 39 formed on the interior of the casing 1 so that the stator 37 may be adjusted in either direction from coaxial relation with the pintle to an eccentric relation therewith. It is important to note, however, that at all times the reactance stator, and consequently the reactance rotor, maintains a position in which its axis of rotation is either coincident with or parallel to the pintle axis and lies at all times in a fixed plane defined by the dead centerline of the bridges 9 and 10 of the pintle and the axis of the pintle. Thus the reactance rotor moves, during adjustment, with its axis always in a plane through the axis of the pintle and the dead center of the bridges while remaining parallel to the pintle axis. Consequently in any adjusted position of the reactance rotor, the pistons are at their extreme outward or inward position in the cylinders when aligned with and centered on the dead centers of the respective bridges. For adjusting the reactance housing and rotor from the outside of the casing, suitable control rods 40 are provided.

Heretofore, in pumps and motors in which both a driven rotary reactance was to be utilized, and variable displacement was to be effected the practice was to provide a driven means coaxial with the reactance rotor and to effect the variable displacement by shifting the pintle and the barrel. Two manners of effecting this relative shifting of the barrel and pintle are now utilized. The first is to mount the pintle at the end of a pendulum or swinging arm and provide flexible joints or connections between the ducts of the pintle and the remainder of the hydraulic circuit so that the pintle can be swung to different positions during operation of the pump. In this type of structure, however, when the pintle is thus swung about a fixed point eccentric to its axis, there necessarily occurs a partial rotation of the pintle about its own axis. The eccentric disposition of the rotary reactance, on the contrary, is fixed in position circumferentially of the pintle. Therefore, when the pintle is concentric with the rotary reactance, a condition occurring only at zero stroke, the bridges of the pintle are in a normal circumferential position relative to the reactance rotor, in which the dead center plane of the bridges and eccentric plane of the barrel and reactance are identical. Upon swinging the pintle, however, the bridges are rotated out of the proper dead center with respect to the plane of eccentricity so that they are either slightly in advance of or to the rear of the cylinder ports when the piston are at their dead center strokes, either in extreme radially inward or outward positions. Consequently, the proper timing between the pintle ports and cylinders is prevented and undue precompression and expansion of the pressure fluid results in dynamic unbalance of the pintle with the accompanying disadvantages of extreme hammering, wear, vibration and destruction of the pump structure.

Again the pintle of such structures necessarily must be shiftable for adjusting the stroke in the very plane in which the greatest hydraulic load occurs, that is, in the plane of the dead center positions of the pistons. Necessarily, therefore, the pintle cannot be permanently secured against movement in these directions.

Here is should be noted that the pump of the present invention is for extremely high pressures, in which the eccentricity must be accurately maintained, and for such use the prior structures would be inoperable.

First, in the swinging pintle pump, when operated at high pressures, the pintle gradually creeps to zero stroke position, the stroke continuously varying until this position is reached. Again, it is impossible to support the swinging arm on a pivot and the pintle on the arm at a position remote from the pivot with sufficient rigidity to prevent deflection or tipping of the pintle and deflection of the arm itself. These deflections change the relation between the pintle and other operating parts of the pump. This disadvantage cannot be overcome by shortening the supporting arm, as this in turn would result in greater rotation of the pintle about its own axis for a given eccentric setting.

The present pintle, as explained, is supported fixedly in the casing with the dead center line of the pintle bridges lying in a fixed plane defined by the axes of the pintle and reactance rotor, later to be described, in all adjusted positions of the rotor, so that the dead center position of the pistons is always in the same plane as the dead center of the bridges. Thus accurate timing is assured. As a result, proper pre-compression and expansion of the working fluid in the cylinders is obtained and smooth, silent operation provided. Were accurate timing not provided, as is the case with prior structures, undue precompression of the fluid and only partial filling of the cylinders would result and cause excessive noise, hammering and vibration. At high pressures, the vibrations due to this mistiming between the pintle and cylinders are transmitted to the swinging arm, causing periodic oscillation thereof which disturbs the relation of the pintle, barrel and reactance and causes dangerous vibrations throughout the structure.

Another attempt has been made to maintain proper valving relation and variable delivery by mounting the pintle for straight line adjustment between ways extending parallel to the dead center plane of the pintle bridges, the reactance rotor having its axis fixed in the said dead center plane. This structure also requires a telescoping or flexible connection between the pintle and external fluid circuit. Aside from this disadvantage, it also fails to maintain the accuracy of setting required, due, primarily, to the fact that the slot or support in which the pintle is mounted for sliding to and fro in a straight line must necessarily extend parallel to the plane through the axis of the pintle and dead center of the bridges. Thus, at dead center piston positions, the directions of greatest forces applied to the pintle, there is no resisting support and the pintle tends to rock in the eccentric plane through the bridges and gradually works toward concentric position with respect to the reactance rotor.

Attempts were made to support the opposite end of the pintle in suitable bearings in the barrel with a corresponding slot. However, when the pintle is disposed eccentrically in the bearing at such end, forces transversely of the slot are translated into both tangential and radial force components which, in turn, tend to twist or subject the pintle to torque.

Thus five conditions must be met concurrently if successful operation is to be obtained, namely: (*a*) a directly driven rotary reactance is to be utilized; (*b*) variable displacement is to be provided; (*c*) accurate timing must be maintained; (*d*) the pintle must be fixedly and rigidly fixed in position; and (*e*) adjustment of stroke must be in the plane of the dead center line of the bridges and dead center plane of the pistons.

Obviously, the first type of prior structure fails to meet, among others, conditions *c*, *d*, and *e*; the second, conditions *c* and *d*, and others various ones of these conditions. None of the prior structures meets all of the requirements.

In the present structure, however, the dead center plane of the bridges and the plane of eccentricity are always identical and conform to the section plane 1—1 of Fig. 2, and all of the other conditions above enumerated are met.

Referring next to the direct driving means for the reactance rotor, the reactance rotor carries at the end adjacent the free end of the pintle, a hub portion having a radial end wall 58, closing the entire end of the rotor. The end wall 58, in turn, has at its outer surface a diametral slot 58*a* for effecting a driving connection between it and a suitable planetating disc, to be described. An impeller shaft 51 is mounted on suitable sets of tapered bearings 52 in the end cover 4, the bearings cooperating to constrain the shaft to fixed axial position. Carried on the inner end of the shaft 51 is a face plate 51*a* on which is provided a diametral slot 51*b*. For connecting the reactance rotor and shaft 51 through the medium of the slots 50*a* and 51*b*, a planetating interponent or disc 53 is provided. As better illustrated in Figs. 6 to 8 inclusive, the disc has at the face adjacent the reactance rotor a diametral tongue 53*a* which is slidably received in the slot 50*a*, and has at its opposite face a tongue 53*b* which is slidably and snugly accommodated in the slot 51*b* of the plate 51*a*. The tongues 53*a* and 53*b* are both diametral and extend at right angles to each other, and the disc or interponent is snugly received between the end wall 50 of the reactance rotor and the face plate 51*a* of the shaft 51. Consequently, in any eccentric position of the reactance rotor, one component of eccentricity may be compensated by travel of the tongue 53*a* along the slot 50*a* and the complementary component of eccentricity may be simultaneously compensated by travel of the tongue 53*b* along the slot 51*b*. If desired, suitable anti-friction means may be provided for effecting better anti-friction cooperation between the respective tongues and slots.

Since the impeller shaft is maintained at all times in concentric relation to the pintle and in fixed axial position by its independent mounting in the bearings 52, no vibrations or axial thrusts due to the driving connection are transferred by it to the reactance rotor, all such vibrations and forces being taken by the bearings 52, as also are all axial thrusts on the shaft. Therefore, the reactance rotor is subjected only to radial hydraulic load and the actual torque forces developed for rotating the barrel. The pistons themselves are relieved from any rocking movement and stresses tending to rock them as they need only transfer to the barrel the negligible torque required to rotate the barrel itself. All forces and vibrations, therefore, are segregated to the independent sub-assemblies.

Since the reactance rotor is directly driven by the impeller, the power required to rotate the reactance rotor and its large supporting bearings, is directly applied to the rotor and does not have to be transmitted by the pistons, as in the case wherein the barrel itself is driven directly by an impeller shaft. Instead, the only torque which must be transmitted by the pistons is that necessary for rotating the free barrel, the relatively small pitch diameter bearings 19 and 20 for which the power required is negligible due to the pintle being hydrostatically balanced, the bearings generally under no unbalanced load, and to overcome the viscuous friction between the barrel and pintle. Since in any eccentric position of the rotor, the planetating interponent assumes a given axis of rotation of its own and is in any event relatively light in comparison with the power transmitted, substantially no unbalanced forces result therefrom which might cause vibration of any of the other parts.

The present structure also lends itself to cooperation with a prime mover having its impeller shaft coaxial at all times with and directly connected to the reactance rotor, the prime mover being mounted for adjustment concurrently with the reactance rotor to different eccentric positions.

Another advantage of the present structure is that the adjustment is by adjustment of the rotary reactance and hence in the plane of the pistons instead of spaced from the piston plane, as in the case of adjustable pintles.

Again, since the reactance rotor is sealed at one end by the wall 50, slip fluid may be retained readily on all the working parts by provision of a shield at the open end of the reactance rotor.

It is apparent from the foregoing description that a simple, compact and highly efficient variable displacement type of rotary, radial piston, pump or motor is provided in which the rotary reactance is directly driven so as to relieve the pistons from the torque necessary to rotate heavy, large pitch diameter supporting bearings and at the same time, the disadvantages inherent in the shifting pintle type of structure are eliminated. What appears at first glance to be a reversal of parts, in that the pintle is stationary and the reactance is shifted, whereas in prior structures the rotary reactance is fixed and the pintle is shifted, is found, upon closer consideration to result in operations which cannot be produced by the prior structures and in elimination of disadvantageous effects inherent in the prior structures.

Having thus described my invention,

I claim:

1. In a rotary, radial piston pump or motor, a casing, a rotatable barrel having a set of radial cylinders, valve means for the cylinders, pistons in the cylinders respectively, a rotary reactance for actuating the pistons, means supporting the reactance for rotation about its axis and for adjustment and constraining the reactance to adjusted positions wherein its axis is parallel to and in a fixed plane through the axis of the pintle, an impeller rotatably supported independently of the barrel and reactance in fixed position radially of the casing and in axial alignment with the pintle, and planetating means operatively connecting the impeller and rotary reactance for effecting driving relation therebetween, and rotation of the reactance and impeller about their respective axes concurrently.

2. In a rotary, radial piston pump or motor, a rotatable barrel having a set of radial cylinders, a stationary valve pintle coaxial with the barrel and having valve ports in valving cooperation with the cylinders, pistons in the cylinders, a reactance rotor for actuating the pistons, means mounting the reactance rotor for adjustment into different positions of eccentricity with respect to the pintle while constraining the axis of the reactance to positions wherein its axis is in a fixed plane through the pintle axis, an impeller coaxial with the pintle and mounted in the casing independently of the barrel and in fixed position radially, planetating means drivingly connecting the impeller and reactance rotor in all adjusted positions of the reactance, and means for adjusting the reactance to vary the stroke.

3. In a rotary, radial piston pump or motor, a casing, a pintle fixedly mounted therein, a barrel supported on the pintle and constrained to concentricity and positive radial clearance with respect thereto, and having a plurality of radial cylinders, pistons in the cylinders respectively, said pintle having ports in valving cooperation with the cylinders, a reactance rotor for actuating the pistons and disposed in surrounding relation to the barrel, an adjustable stator in surrounding relation to the reactance for supporting the reactance, bearing means interposed between the reactance and stator and supporting the reac-

tance for rotation about the reactance axis, means mounting the stator for adjustment to different eccentric positions with respect to the pintle wherein the axis of the reactance is in a fixed plane through the pintle axis, an impeller means mounted independently of the barrel and reactance and in fixed position radially in the casing, and planetating means drivingly connecting the impeller means to the reactance, for concurrent rotation of the impeller means and reactance about their respective axes.

4. In a rotary, radial piston pump or motor, a casing, a pintle mounted by one end therein, bearing means positively mounting the barrel on the pintle with fixed radial clearance space therebetween, said barrel having radial cylinders, pistons in the cylinders respectively, said pintle having ports in valving cooperation with the cylinders, rotary reactance means adjustably mounted in the casing in surrounding relation to the barrel for adjustment to different eccentric positions relative thereto and being connected to the pistons for actuating the same, said reactance means having a transverse disc portion spaced axially of the pintle beyond the free end of the pintle and adjacent the end of the barrel, an impeller rotatably mounted in fixed radial position in the casing and having a disc portion spaced axially from and being parallel to the transverse disc portion of the reactance means, and planetating means interposed between said disc portions of the reactance means and impeller and drivingly connecting the same to relieve the pistons and cylinders from the driving torque necessary to rotate said reactance means.

5. In a high pressure, variable displacement, rotary, radial piston pump or motor, a casing, a rotatable barrel having a plurality of radial cylinders, pistons in the cylinders respectively, a pintle in valving cooperation with the cylinders and fixed in position in the casing, rotary reactance means for the pistons, impeller means mounted in the casing in axial alignment with the pintle for driving the reactance means, planetating means connecting the reactance means and impeller means in all adjusted positions of the reactance means, means mounting the reactance means for adjustment to different positions of eccentric relation with respect to the barrel while constraining the reactance means to adjusted positions wherein its axis is in a fixed plane through the axis of the pintle, and control means engaging the reactance means in the zone of the pistons, and extending radially of the reactance means in said fixed plane, whereby working reactance forces are more efficiently applied.

6. In a high pressure, variable displacement, rotary, radial piston pump or motor, a casing, a rotatable barrel having a plurality of radial cylinders, pistons in the cylinders respectively, a pintle having diametrically opposite ports and bridges therebetween, and being in valving cooperation with the cylinders and fixed in position in the casing, rotary reactance means for the pistons, impeller means mounted in the casing in axial alignment with the pintle for driving the reactance means, planetating means connecting the reactance means and impeller means in all adjusted positions of the reactance means, means anti-frictionally mounting the reactance means for rotation and supporting the reactance means for adjustment to different positions of eccentric relation with respect to the barrel while constraining the reactance means to adjusted positions wherein its axis is in a fixed plane through the axis of the pintle and dead center line of the bridges, and control means for moving the reactance means to different adjusted positions, said control means being connected to the reactance means for applying force thereto radially along said dead center line of the bridges.

7. In a high pressure rotary, radial piston variable delivery pump or motor, a casing, a stationary pintle having a valve portion and fixedly mounted in the casing, a cylinder barrel rotatably supported on the pintle and having a valve bore fitting the valve portion of the pintle and constrained to concentric relation and positive radial clearance with respect to the pintle valve portion, said barrel having a plurality of radial cylinders, pistons in the cylinders respectively, said pintle valve portion having diametrically opposite valve ports for the cylinders and bridges therebetween, a reactance rotor surrounding the barrel in the plane of the pistons and connected to the pistons for actuating the same, impeller means fixedly mounted in the casing in axial alignment with the pintle, planetating means connecting the reactance means and impeller means in all adjusted positions of the reactance means, means in the casing and positioned axially of the reactance means in the zone of the pistons for adjustably supporting the reactance rotor for movement to vary the stroke and constraining the rotor to positions wherein its axis is parallel to or coincident with the pintle axis and in a plane defined by the pintle axis and dead center line of the pintle bridges.

8. In a rotary, radial piston, variable delivery pump or motor, a casing, a stationary pintle mounted in fixed position therein and having a valve portion, a cylinder rotor supported solely by the pintle and having radial cylinders in valving cooperation therewith, pistons in the cylinders respectively, positive mounting bearing means operatively interposed between the cylinder rotor and pintle, an adjustable stator, a reactance rotor connected to the pistons for actuating the same, positive mounting bearing means rotatably supporting the reactance rotor in the stator and entirely independent of the cylinder rotor, an impeller, positive mounting bearing means rotatably supporting the impeller in the casing independently of the rotors and in fixed axial alignment with respect to the pintle, and planetating means drivingly connecting the impeller to the adjustable rotor in all adjusted positions of the adjustable rotor.

9. In a variable delivery, rotary, radial piston pump or motor, an inner and an outer rotor, one of said rotors having radial cylinders, valve means for the cylinders, pistons in the cylinders and connected to the other rotor for operation thereby, means mounting and constraining said rotors to adjustment into positions wherein their axes are coincident or parallel and in a fixed plane, said means being positioned in the plane of the cylinders and piston actuating rotor, and control means operative to move the rotors relatively into different adjusted positions by force applied radially along the dead center positions of the pistons, and impeller means in coaxial relation with the axis of rotation of the cylinder rotor and planetating means operatively connecting the impeller means and the piston actuating rotor for driving the piston actuating rotor in all relatively adjusted positions of said rotors.

10. In a rotary, radial piston, variable delivery

pump or motor, a rigid casing, a pintle fixedly secured therein, a cylinder barrel rotatively positively mounted solely on said pintle and having a plurality of radial cylinders, pistons in the cylinders, said pintle having diametrically opposite valve ports in valving cooperation with the cylinders and bridges between the ports, a reactance stator positioned axially of the casing in the zone of the cylinders, a reactance rotor rotatably mounted in the stator, an impeller means, means rotatably mounting the impeller means in the casing and constraining the impeller means to fixed radial position in the casing, planetating means operatively interposed between the reactance rotor and impeller means for drivingly connecting the same at all times, means in the casing in the said zone of the cylinders supporting the stator for adjustment parallel to a plane defined by the pintle axis and dead center line of the bridges to different eccentric positions, and means operating in said zone of the cylinders for moving the stator to said adjusted positions.

11. In a rotary radial piston reversible pump or motor, a casing, a pintle mounted in the casing and having a valve portion with diametrically opposite ports, valve bridges between said ports, an adjustable stator surrounding the pintle at the valve portion, guide means in fixed position relative to the pintle and having a pair of flat parallel guide surfaces symmetrically arranged with respect to the pintle and diametrically opposite from each other and parallel to the plane defined by the pintle axis and dead center line of the bridges, and positioned in radial alignment with the pintle valve portion, diametrically opposite slide bearing surfaces on the stator in cooperation with said first bearing surfaces respectively for supporting the stator for adjustment to different eccentric positions, a barrel rotatably supported on the pintle, a plurality of radial cylinder and piston assemblies carried by the barrel, a reactance rotor rotatably mounted in the stator and connected to the pistons of said assemblies, the cylinders of said assemblies being in valving cooperation with the pintle, impeller means rotatably mounted in fixed position radially in the casing, planetating means drivingly connecting the reactance rotor and impeller means in all adjusted positions of the reactance rotor, and control means for moving the stator to different adjusted positions to vary the stroke, said control means being positioned at the intersection of the plane defined by the pintle axis and dead center line of the bridges with the plane of the piston axes, and operative along said intersection for moving the stator.

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