June 27, 1939. E. K. BENEDEK 2,163,570

PISTON AND REACTANCE COMBINATIONS FOR RADIAL PISTON PUMPS AND MOTORS

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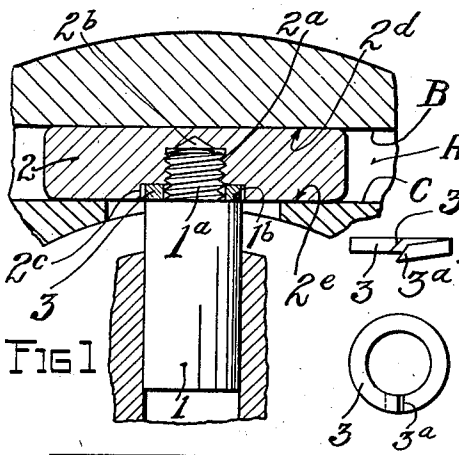


Fig 1

Fig 3

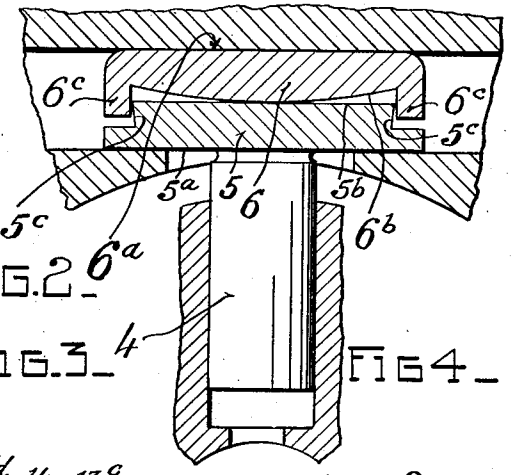


Fig 2

Fig 4

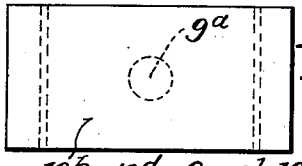


Fig 5

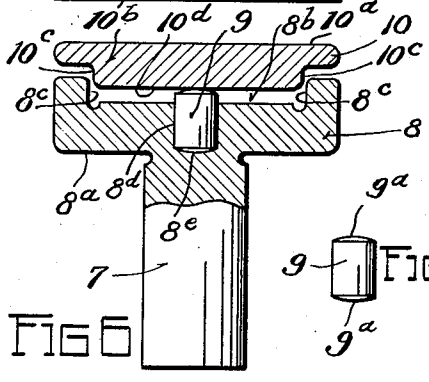


Fig 6

Fig 7

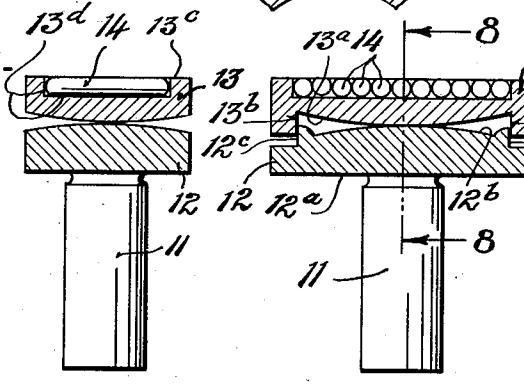


Fig 8

Fig 9

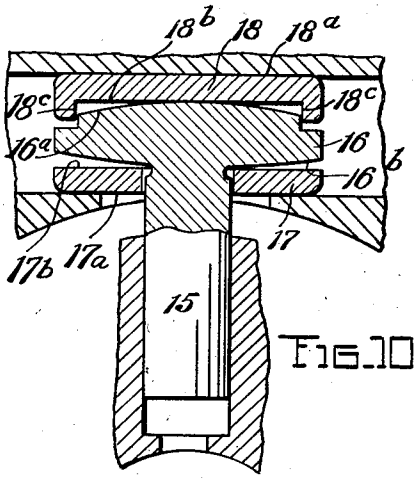


Fig 10

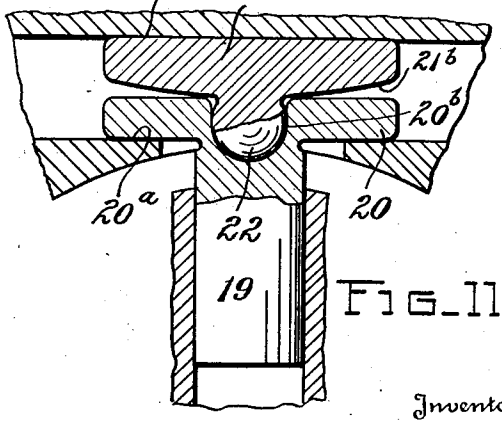


Fig 11

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PISTON AND REACTANCE COMBINATIONS FOR RADIAL PISTON PUMPS AND MOTORS

Elek K. Benedek, Bucyrus, Ohio

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9 Claims. (Cl. 103—161)

This invention relates to piston and reactance combinations and particularly to piston head and reactance guide means for the purpose of providing hydrostatic, hydrodynamic and capillary oil film bearings between the piston heads and the cooperating parts of the reactance guide means so that more efficient combined load and torque transmission is effected.

In the rotary radial piston type of pump or motor of the general character described in my United States patents, No. 1,964,244, issued June 26, 1934, and No. 2,000,271, issued May 7, 1935, it is necessary to compensate for tangential components of eccentricity between the primary and secondary rotors by provision for relative oscillation of the reactance guide means and the piston head.

In the oscillating type of radial piston pump, such as described in my United States Patent No. 1,964,245, issued June 26, 1934, provision must be made for relative tangential oscillation between the reactance guide means and the piston heads.

In either event, this oscillation is in a plane normal to the axis of the piston. As more fully set forth in my co-pending application, Ser. No. 736,550, filed July 23, 1934, the most efficient combined load and torque transmission is effected by combined mechanical and hydrostatic and hydrodynamic oil film bearings between the piston head and the reactance guide means.

Again, in each of these types of pumps or motors, it is necessary to compensate for manufacturing inaccuracies or inaccuracies in adjustment of the guide means and piston automatically, so that misalignment from these causes is eliminated and free operation of the piston head and uniform and efficient application of the load and torque is provided, regardless of the relative positions of oscillation of the guide means and the heads.

With these facts in mind, it is one of the objects of the present invention to provide pistons, piston heads, and reactance guide means all so cooperated as to assure proper alignment of and formation of hydrostatic and hydrodynamic oil films between the working surfaces of the pistons, piston heads and guide means.

Another object is to provide for a more efficient mechanical bearing between the piston heads and guide means in combination with the hydrodynamic and hydrostatic oil film bearings therebetween.

A more specific object is to effect these results while providing for automatical self adjustment of the coacting parts and resultant compensation for inaccuracies in manufacture or adjustment of the structure by piston and head structures which will be self-adjusting with respect to the reactance surfaces of the reactance guide means and with each other so that the load will be applied axially of the piston at all times.

Another object is to effect these results with structures which may be formed readily and manufactured economically by quantity production methods and from readily available materials.

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

Fig. 1 is an elevation of a piston and piston head structure embodying the principles of the present invention, part thereof being shown in section for clearness in illustration;

Figs. 2 and 3 are an elevation and plan view of a locking and cushioning washer used in connection with the piston and piston head structure in Fig. 1;

Fig. 4 is an elevation of a piston, with a piston head structure and reactance guide means illustrating a modified form of the invention, part thereof being shown in section;

Figs. 5 and 6 are a plan and elevation respectively of a piston and piston head structure embodying the principles of the present invention, part of the structure in Fig. 6 being shown in section for clearness in illustration;

Fig. 7 is an elevation of the load transmitting thrust pin of Fig. 6;

Fig. 8 is an elevation of a piston and head combination, part thereof being shown in section as taken on the line 8—8 of Fig. 9, and illustrating a modification of the invention;

Fig. 9 is an elevation of the structure illustrated in Fig. 8 and is taken at right angles thereto, part being shown in section.

Fig. 10 is a sectional view of a modified piston, head, and reactance guide means combination, part thereof being shown in section for clearness; and

Fig. 11 is an elevation, partly in section, of a modified piston and head combination corresponding in operation to the structures of Figs. 1 and 6.

For the purposes of illustrating the operation of the piston heads, they will be described herein as though associated with rotary radial piston hydraulic pumps and motors, such as described in my above identified patents, Nos. 1,964,244 and 2,000,271, wherein a rotary reactance having

chordal guideways which accommodate the piston heads and actuate the pistons provides the reactance guide means, the use of the present structures in the oscillating type of pump being readily apparent therefrom.

Referring first to Fig. 1, there is illustrated a piston 1 having a threaded reduced diameter portion 1*a* for cooperation with a piston head and forming with the main body of the piston an annular radially extending shoulder 1*b*. A piston head 2, generally in the form of the usual T-head, is provided and has a central bore 2*a* internally threaded to receive the threaded portion 1*a* of the piston 1. The bore 2*a* terminates inwardly of the head 2 in a radial shoulder 2*b*. The head is also provided at the face adjacent the piston with a counterbored recess 2*c* which is of greater diameter than the piston and is coaxial with the bore 2*a*.

Interposed between the shoulder 1*b* of the piston and the base of the recess 2*c* is a resilient cushion 3 which is preferably a steel lock washer, such as illustrated in Figs. 2 and 3. The threads of the piston and head are preferably standard threads so as to fit with a slight yieldability or play. The cushion or washer 3 is such that when unstressed it is of greater length than the depth of the recess 2*c* and it is also of smaller diameter than the recess and substantially the same diameter as the annular shoulder 1*b*. The piston and head are screwed firmly together compressing the spring washer or cushion 3, which, when compressed, substantially fills the recess 2*c*. In this assembled condition the end of the threaded portion 1*a* of the piston is in slightly spaced relation to the shoulder 2*b* of the head.

The cushion or washer 3 is provided with knife edges 3*a* so disposed that when the piston 1 is screwed into the head, the head 2 and piston rotate away from the knife edge, but when the piston and head are rotated in the opposite direction, the knife edges will dig into the shoulder 1*b* and face of the counterbore end wall and thus prevent rotation and separation of the piston 1 and head 2. Since the threaded end of the piston does not engage the shoulder 2*b*, the load transmission is through the medium of the spring and shoulder 1*b* and thus directed parallel to the axis of the piston. Even when compressed in this manner, the elastic effect of the spring and the mating of the threads of the head and piston are such that slight movement of the head relative to the piston occurs. As a result, the head may be moved a slight fraction of 1/1000 of an inch radially of the piston as well as axially and may rock very slightly about the piston axis.

To illustrate the manner in which this structure operates, it is shown in connection with the guide means of a rotary reactance which is assumed to be rotating clockwise. A fragment of a reactance rotor A, such as described in my above identified patents, having usual outer and inner chordal guide surfaces B and C respectively, is illustrated, the piston operating in the usual radial cylinder. The surface B engages the outer or load transmitting face 2*d* of the head 2 and the surface C supports the piston by engagement with the inner or suction working face 2*e*.

Since the head 2 is mounted on the piston 1 for yieldable universal rocking movement and movement radially of the piston, it is self adjusting relative to the surfaces B and C as well as to the piston 1, so that all parts operate in proper relation to each other.

Minor inaccuracies necessarily occur in the manufacture of the reactance and the pistons, as well as in the cylinder rotor, but none of these are so pronounced that the slight resulting misalignment is not compensated. In operation, the head 2 oscillates along the surfaces B and C of the guide means A, as fully described in my above identified patents. During such operation, the head 2 rocks slightly and yieldably about a transverse axis with the result that wedge shape spaces are formed between the surfaces of the head 2 and the cooperating surfaces of the guide means, these spaces being sufficient to maintain capillary oil films so that combined torque and load transmission is through the medium of high pressure oil bearings. Likewise, oil is maintained by capillarity between the coacting surfaces of the head and piston. Consequently all pistons of the pump or motor share evenly in torque transmission, whereas, in the absence of the slight self-aligning movement, the loaded pistons tend to bind in the chordal guideways of the reactance rotor and transmit all of the torque.

Referring next to Fig. 4, a piston 4 is illustrated, the piston having a head 5 which may be formed integrally therewith and which is elongated fore and aft in the direction of oscillation of the head relative to the reactance rotor. The piston head has inner working surface 5*a* for engagement with the inner guide surfaces of the associated guideway. Interposed between the outer reactance guideway and the head 5 is a reactance and torque transmitting interponent 6, which, in effect, is part of the piston head structure and has a guideway engaging, or working, face 6*a* for engagement with the guideway. In order to transmit load from the reactance means to the piston at a single point or area at the axis of the piston, the face 5*b* of the head portion 5 and the inner face 6*b* of the interponent 6 are formed with divergent surfaces, one of the faces being cylindrical and the other being tangential thereto. In the form illustrated, the inner face 6*b* of the interponent is cylindrical about an axis parallel to the axis of rotation and outer face 5*b* is flat and tangential thereto. Thus the interponent 6 may rock slightly about a constantly shifting axis which is at all times parallel to the axis of rotation and thereby effect a slight rolling engagement with the outer surface 5*b*. This rolling is so slight that the theoretical point of tangency of the cylindrical face 6*b* and the face 5*b* is at all times very close to the axis of the piston. Due to the rolling oscillation, oil films are formed between all working faces.

In order to transmit torque through the medium of the head structure, the interponent 6 is provided at each end of its cylindrical surface with depending transverse shoulders 6*c*. Correspondingly, the head 5 is provided with cooperating shoulders 5*c*, the shoulders 6*c* and 5*c* engaging each other for transmitting torque while permitting slight rolling oscillation of the interponent relative to the head 5*c*. To prevent binding between the shoulders 5*c* and 6*c*, the shoulders 5*c* are slightly undercut so that only the edges thereof in the plane of the face 5*b* engage the shoulders 6*c*.

Thus, assuming the interponent 6 as a part of the piston head structure, it is apparent that hydraulic load is applied at the axis of the piston with slight rocking or rolling oscillation for com-

pensating for inaccuracies and maintaining proper oil films both in the structures of Fig. 1 and Fig. 4.

Another manner of accomplishing this same result is illustrated in Figs. 5 to 7 inclusive, wherein is illustrated a piston 7 having a head portion 8 which may be formed integrally therewith and which is elongated in the direction of oscillation of the head in the reactance means. The head has the usual inner working or suction face 8a. At its outer, or load, face the head 8 is recessed, as indicated at 8b, the recess 8b extending in the direction of oscillation of the head and terminating short of the ends thereof. The end walls 8c of the recess provide torque transmitting abutments. The head portion is also provided with an axial bore 8d extending from the base of the recess inwardly and having a generally spherical end wall 8e. Disposed within the bore 8d and fitting the same with only slight operating clearance is a thrust pin 9 having spherical end walls 9a, one of which cooperates with the spherical wall 8e of the bore. The thrust pin 9 terminates at its outer end inwardly of the head portion 8 from the plane of the outer face so that its outer end lies within the limits of the recess 8b. An interponent 10 forming the remainder of the head structure and having an outer working or load face 10a for cooperation with the reactance guideways is provided, the interponent 10 having a thickened central portion 10b defining with the end portions transversely extending torque transmitting shoulders 10c. The inner face 10d of the interponent engages the outer end of the pin 9 and when so engaged the shoulders 10c are in position to abut the shoulders 8c for torque transmission. Slight clearance in the direction of travel is provided between the shoulders 10c and 8c so that the interponent 10 can become self aligning. Thus the load is transmitted through the spherical end surfaces of the pin 9 and axially of the piston 7 regardless of the rocking action of the interponent 10 which necessarily oscillates by rolling action about the outer end of the spherical pin 9. Oil is retained in the recess 8b so that combination oil and mechanical bearing is obtained.

Referring next to Figs. 8 and 9, a similar operation is obtained with a piston 11 having a head 12 elongated in a direction of oscillation. The head portion 12 is preferably formed integral with the piston 11 and has an inner chordal working face 12a for engagement with the reactance guideways. The outer working face 12b of the head portion 12 is preferably spherical or spheroidal, the working surface thus being arcuate in cross section in every direction from the axis of the piston. At the ends of the spherical surface 12b, forwardly and rearwardly in the direction of oscillation, are abutment shoulders 12c for transmitting torque. An interponent 13 forming a part of the piston head structure and having a spherical inner working face 13a for engagement with the face 12b of the head is provided. At the ends of the spherical face 13a, in the direction of oscillation of the head in the reactance rotor, are depending transverse shoulders 13b which cooperate respectively with the shoulders 12c for effecting torque transmission. The outer face 13c of the interponent is arranged to cooperate with the outer chordal guideway of the rotary reactance. For reducing frictional resistance to oscillation, the face 13c may be recessed, as indicated at 13d, for accommodating a plurality of capillary cageless needle rollers 14. Thus limited universal rocking of the interponent 13 by rolling action to provide the necessary self-adjustment for full cooperation with the chordal guideways of the reactance means is provided, and oil films are maintained between all coacting surfaces.

Referring next to Fig. 10, a piston 15 is illustrated, the piston 15 having a head portion 16 which may be formed integral therewith. The head portion 16 is elongated in the direction of oscillation relative to the reactance means, and has an outer cylindrical or spherical working face 16a and an inner cylindrical or spherical working face 16b, the faces being cylindrical or spherical about axes parallel to the axis of rotation. In this structure a pair of interponents complete the head structure. The interponents include an inner interponent 17 having a central passage for accommodating the piston. The interponent 17 has an inner working face 17a adapted for engagement with the inner chordal guide surface of the reactance guideway. The outer working face 17b of the interponent 17 is preferably flat so as to define with the face 16b wedge-shaped spaces for receiving lubricant. An outer interponent 18, having a flat outer working face 18a for cooperation with the outer chordal guide surface of the reactance guideway is also provided. The inner face 18b of the interponent 18 is likewise flat so as to provide theoretical line contact between the outer face 16a of the piston head portion 16 and the inner face of the interponent 18. In this head structure, the interponent 18 rocks about an axis parallel to the axis of rotation and about a transverse axis. Suitable end shoulders 18c are formed on the interponent 18 for engagement with complementary shoulders 16c at the leading and trailing edges of the head 16 for effecting proper torque transmission. Due to the rocking action, oil films are positively maintained by hydrodynamic action as well as by capillary action.

Another structure for accomplishing this result is illustrated in Fig. 11 wherein a piston 19 is illustrated. The piston has a longitudinally elongated head portion 20, the head 20 having an inner working face 20a for engagement with the chordal guideways of the reactance means, as illustrated. The head 20 has an axial bore 20b, the bottom of which is spherical. An interponent 21, forming the other part of the head structure cooperates with the head portion 20, the interponent having an outer working face 21a for engagement with the outer chordal guideway of the reactance means. The interponent likewise has an inner face 21b which preferably is slightly cylindrical about an axis parallel to the axis of rotation or is slightly tapered from the central portion toward each end. At its central portion, the interponent 21 has a depending ball portion 22 which may be formed integral therewith, the portion 22 being snugly received in the bore 20b of the piston so as to form a ball and socket load transmission connection. In this structure the interponent 21 may rock with universal rolling action due to the ball and socket connection and is also effective for torque transmission. By making the bore 20b of slightly larger radius than the ball portion, rolling action instead of sliding may be obtained.

In all of the structures illustrated, the various wedge-shaped surfaces between the curved and flat surfaces receive slip fluid from the pump or motor so that oil films are maintained therein.

Slight capillary clearance is also provided between the shoulders of the various structures so as to permit the entrance of slip fluid and the formation of capillary oil films. The various parts of each structure are preferably accurately and smoothly finished and polished and hardened to such a degree that they will resist wear and scratching by foreign matter.

Referring next to the manner in which the present head structures are self-aligning with respect to the various reactances, attention is first directed to the reactance structure of my United States Patent No. 1,964,244. Therein the piston head members operate in chordal reaction ways having parallel inner and outer reaction surfaces which are positively fixed in parallel relation to each other and to the reactance ring. Further, the reactance ring is formed in one piece so that each chordal way is fixed circumferentially and angularly relative to the other chordal ways. In connection with such a reactance any misalignment of the reactance surfaces and piston head structures must be remedied in the piston head structures or by actual re-cutting of the reactance ways.

Four points of misalignment must be considered. The first two are that the outer or inner reactance surfaces, or both, of each way may not be exactly 90° to the associated piston axis, due to inequalities in spacing the cylinders exactly the same distance apart circumferentially of the barrel or due to inaccuracies in forming the cylinders truly radial. The third point is that the inner and outer reactance surfaces of a given chordal way may not be truly parallel with each other. A fourth point is that either the inner reactance surfaces or the outer reactance surfaces may not be in the same plane with each other or in a plane transversely normal to the piston axis.

The cooperation of the present head structures with the reactance of Patent No. 1,964,244 should be noted briefly. If the structure of Fig. 1 is utilized, obviously, if the inner and outer reactance surface C and B are parallel, the surfaces 2*d* and 2*e* can align therewith whether they define planes normal to the piston axis or not as the head can rock both fore and aft and transversely. If, however, the coacting inner and outer surfaces of any way are not parallel, they must be reformed for parallelism. If one way is at a slightly different distance radially of the reactance from its laterally-aligned coacting way, the head can rock about a longitudinal axis and largely correct this inaccuracy. If the cylinder is slightly out of position circumferentially, the head can rock about a transverse axis to compensate.

If the structure of Fig. 4 is utilized, since the head 5 is rigid with the piston, positive alignment must be made between its surface 5*a* and the inner reactance surfaces of the chordal way, even if reforming the reactance surface is required, and regardless of the cause of inaccuracy. This being done, the head portion 6 rocks to permit alignment of face 6*a* with the outer reactance surfaces. If the laterally aligned chordal ways for the particular piston head are not truly in a plane normal to the piston axis, the surfaces thereof which coact with the fixed portion of the piston must be reformed to eliminate this inaccuracy. Such an inaccuracy in the reactance surfaces cooperating with the movable head portion may be compensated, however, by structures such as illustrated in Figs. 6, 8 and 9, and Fig. 10, wherein the movable head portions 10, 13 and 21, respectively, can rock universally to effect self-alignment.

The structure of Fig. 10 has very special advantages in connection with this particular type of reactance structure. It will be noted that both the head portions 17 and 18 are independently self-adjusting so that, regardless of the inaccuracies in the ways, as above described, no portion of the ways needs to be reformed. Instead, each head portion readily adjusts itself to its particular reactance surfaces of the ways and of the head.

Referring next to the type of reactance illustrated in my United States Patent No. 2,000,271, the reactance is comprised of segments which are circumferentially adjustable with respect to each other, but the inner and outer reactance surfaces of the chordal way of each block or fixed with respect to each other. If these surfaces of each block are parallel with each other, obviously all of the head structures herein can be utilized therewith to the same extent as heretofore mentioned with respect to the reactance of Patent 1,964,244 but with additional advantages. For example, inaccuracies of circumferential position of the cylinders or true radial position thereof can be compensated by circumferential adjustment of the segments forming the reactance instead of reformation of the reactance surfaces of the ways. Thus fore and aft, the ways can be adjusted to 90° to the cylinder axes and properly lined up in this respect with the rigid piston head portions. The movable head portions can then compensate for inaccuracies in the outer reactance surfaces of the ways. The structure of Fig. 10, when used in this reactance, is very beneficial also, if most extremely small inaccuracies are to be compensated, though ordinarily, the circumferential adjustment of the reactance segments render unnecessary the joint use of the head members 17 and 18.

Referring next to the reactance structure of my copending application 736,550, there is illustrated a reactance formed of circumferentially adjustable segments such as that of my United States Patent No. 2,000,271 with the additional feature that one reactance surface of each guideway is provided by a circumferentially movable block such that the reactance surfaces of each way are self-adjusting into parallelism with respect to each other or to the piston heads. This latter reactance may be used with each structure herein illustrated, and is particularly useful for great precision. Since, in each chordal way, inaccuracies in parallelism of the inner reactance surface with the outer are compensated, it is especially useful in connection with the structure of Fig. 1 herein, wherein the outer and inner faces of the head 2 are fixed in relation to each other. Thus by circumferential adjustment of the reactance segments, the inner surfaces of the ways can be brought into accurate coaction with the inner surfaces of the head 2, and the circumferentially movable blocks can adjust themselves to the outer faces of the heads. The use of this reactance which has dual adjustment features in connection with the other head structures herein disclosed provides for extreme accuracy in cooperation. By use of the various combinations of the reactance herein described with the piston head structure, it is apparent that almost any specific self-adjusting problem can be solved and any degree of precision of cooperation obtained.

The reactance portions herein shown diagrammatically may be each of the types of reactances

described in the above identified patents and application, or other types employing chordal reactance ways. It is apparent that in each structure, the load is transmitted substantially at and parallel to the axis of the piston, the point of application of the load being automatically maintained by the self-adjustment and self-alignment of the pistons, head structures, and guideways. Since proper alignment of the head structures with the reactance rotor guideways is effected, each piston may transmit its proportionate part of the torque.

As heretofore pointed out, the terms "inner" and "outer" are merely relative terms for convenience in description, as obviously the same operative relation can be maintained when the piston heads are connected to the inner rotor, or when the cylinders are the reciprocating members.

Having thus described my invention, I claim:

1. A piston and head structure for a radial piston pump or motor having a pair of rotors corotatable about parallel axes, one rotor having a radial cylinder, a piston therein, inner and outer guideways respectively in the other rotor extending normal to the cylinder axis for accommodating the piston head structure for oscillation therealong and for cooperating therewith to transmit hydraulic load and torque, a head portion on the piston extending normal to the piston axis and having a working face for cooperation with one of said guideways, a separate head portion having an oppositely disposed working face for cooperation with the other of said guideways, said head portions having space-defining faces contiguous to each other between said inner and outer guideways, and said contiguous faces conjointly being so formed as to provide substantially wedge-shaped spaces extending inwardly from the edges of the head portions toward the piston axis, one of said head portions having a bore centrally disposed therein coaxial with the piston and extending into said head portion well below the space-defining face thereof, and an axial thrust element received in said bore and operatively connected to the other one of said head portions for load transmission between said portions and for compensating for misalignment of said cylinder bore and guideway.

2. A piston and head structure for a radial piston pump or motor having a pair of rotors corotatable about parallel axes, one rotor having a radial cylinder, a piston therein, guideways in the other rotor extending normal to the cylinder axis for accommodating the piston head structure for oscillation therealong and for cooperating therewith to transmit hydraulic load and torque, comprising a head portion on the piston extending normal to the piston axis, another head portion movable relative to the piston, said head portions having space-defining faces contiguous to each other between said guideways and being conjointly formed to provide space between at least the marginal portions of the contiguous faces and one head portion having a socket of less diameter than the piston and coaxial therewith, a ball on the other head portion and seated in the socket, the center of curvature of the ball and socket lying in the piston axis and said portions having normally parallel working faces for engagement and cooperation with said guideways, the connection between said portions compensating for misalignment of said cylinder bore and guideways, whereby free reciprocation of the piston, oscillation of the head structure and uniform load transmission is effected.

3. A piston and head structure for a radial piston pump or motor having a pair of rotors corotatable about parallel axes, one rotor having a radial cylinder, a piston therein, guideways in the other rotor extending normal to the cylinder axis for accommodating the piston head structure for oscillation therealong and for cooperating therewith to transmit hydraulic load and torque, comprising an elongated head portion rigid with the piston and extending normal to the piston axis, a cooperating head portion generally normal to the piston axis and movably relative to the piston, said portions having coacting surfaces in rolling engagement with each other and working faces respectively in cooperation with said guideways, means carried by the head portions in addition to said rolling surfaces and operatively engaging each other for constraining the head portions to limited relative movement endwise of the head portions.

4. A piston and head structure for a radial piston pump or motor having a pair of rotors corotatable about parallel axes, one rotor having a radial cylinder, a piston therein, inner and outer guideways in the other rotor extending normal to the cylinder axis for accommodating the piston head structure for oscillation therealong and for cooperating therewith to transmit hydraulic load and torque, comprising a piston having a head portion fixed to the piston and extending normal to the piston axis, said head portion having a working face for cooperation with one of said guideways, another head portion having an oppositely disposed working face for cooperation with the other of said guideways and being movable relative to the piston, one of said head portions having a central bore coaxial with the piston, an axial thrust pin received in said bore and operatively connected to the other one of said head portions for load transmission between said head portions and for connecting the portions for universal relative rolling rocking movement, cooperating abutment means carried by the head portions in addition to said pin for constraining the movable head portion within certain limits endwise of the fixed head portion while permitting rocking of one of the head portions relative to the piston to effect self-alignment of the last mentioned head portion with the guideways.

5. A piston and head structure for a radial piston pump or motor having a pair of rotors corotatable about parallel axes, one rotor having a radial cylinder, a piston therein, inner and outer guideways in the other rotor extending normal to the cylinder axis for accommodating the piston head structure for oscillation therealong and for cooperating therewith to transmit hydraulic load and torque, comprising a head portion fixed in relation to the piston and in engagement with one of said guideways, a movable head portion in load transmitting cooperation with the fixed head portion and rockable relative thereto with a rolling motion for self-alignment thereof with the other of said guideways, and cooperating shoulders on said portions extending transversely relative to the path of oscillation and engageable with each other and constraining the portions within certain limits of movement parallel to the guideways with respect to each other.

6. A piston and head structure for a radial piston pump or motor having a pair of rotors corotatable about parallel axes, one rotor having

a radial cylinder, a piston therein, inner and outer guideways in the other rotor extending normal to the cylinder axis for accommodating the piston head structure for oscillation therealong and for cooperating therewith to transmit hydraulic load and torque, comprising a head portion fixed in relation to the piston, a movable head portion in load transmitting cooperation with the fixed head portion and rockable relative thereto with rolling motion for self-alignment thereof with the guideways, and cooperating shoulders on said portions extending transversely relative to the path of oscillation and engageable with each other and limiting the rocking movement of the movable head portion and movement thereof relative to each other parallel to the guideways.

7. A piston and head structure for a radial piston pump or motor having a pair of rotors corotatable about parallel axes, one rotor having a radial cylinder, a piston therein, guideways in the other rotor extending normal to the cylinder axis for accommodating the piston head structure for oscillation therealong and for cooperating therewith to transmit hydraulic load and torque, comprising a head portion fixed in relation to the piston, a movable head portion in load transmitting cooperation with the fixed head portion and rockable relative thereto for self-alignment thereof with the guideways, and cooperating shoulders on said portions engageable with each other and constraining the portions within certain limits of movement parallel to the guideways with respect to each other while permitting relative rocking of said portions.

8. A piston and head structure for a radial piston pump or motor having a pair of rotors corotatable about parallel axes, one rotor having a radial cylinder, a piston therein, guideways in the other rotor extending normal to the cylinder axis for accommodating the piston head structure for oscillation therealong and for cooperating therewith to transmit hydraulic load and torque, comprising a head portion connected to the piston and extending generally normal to the piston axis, a head portion operatively connected to the first head portion for load transmission axially of the piston, said head portions having space-defining faces contiguous to each other between said guideways and being conjointly formed to provide space between at least the marginal portions of the contiguous faces and said head portions being connected for relative rocking with respect to each other for compensating for misalignment of the guideways and cylinder axis, and constrained from appreciable relative bodily movement parallel to the guideways.

9. A pumping unit comprising a pair of corotating guide members, reciprocating elements carried by each of said members respectively and reciprocable relative thereto respectively, means on said members constraining the elements respectively to reciprocation in predetermined directions concurrently respectively, separate means carried by one of the reciprocating elements and guided in one of the guide members, said means including a thrust plate and a central pivotal means projecting from said thrust plate and terminating in inwardly spaced relation from the sides and ends of said last-named element, there being space between the respectively contiguous sides and ends of said element and said thrust plate, said pivotal means being disposed in the axis of the other reciprocating element to transmit force between said other element and thrust plate through substantially point contact, and mounting the elements for rolling rocking movement relative to each other.

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