Sept. 4, 1962 G. W. HEAD 3,052,189

PRESSURE BALANCING AND COMPENSATING DEVICE FOR AN HYDRAULIC PUMP

Filed Feb. 23, 1960 2 Sheets-Sheet 1

Fig. 1

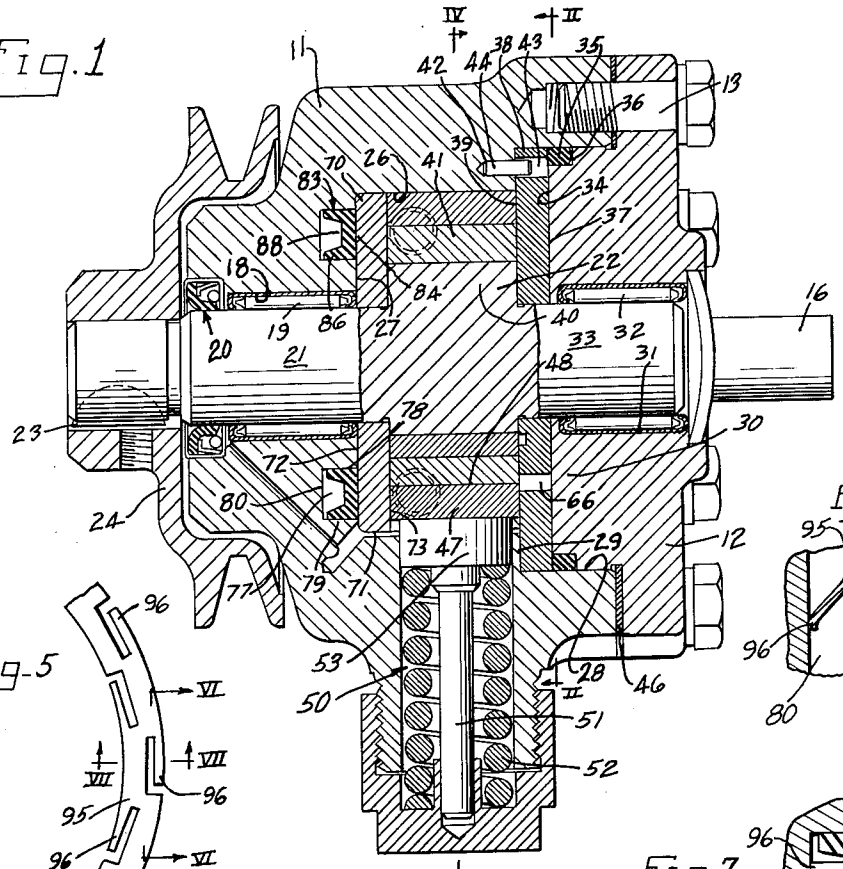


Fig. 6

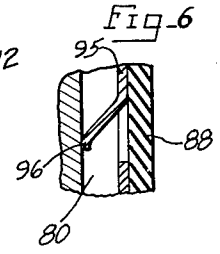


Fig. 5

Fig. 2

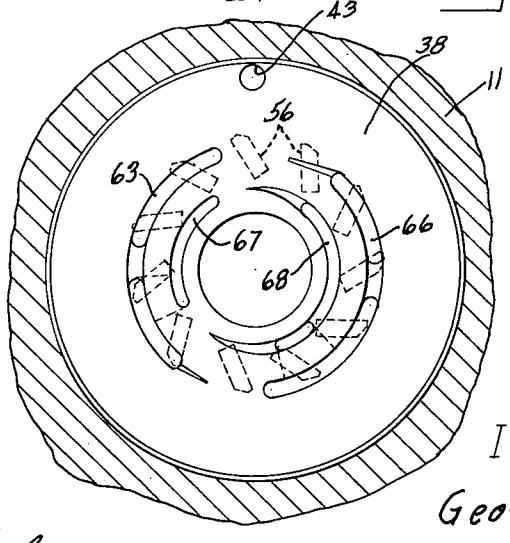
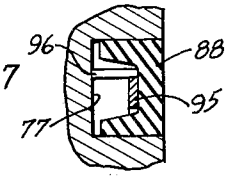


Fig. 7



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Sept. 4, 1962 G. W. HEAD 3,052,189

PRESSURE BALANCING AND COMPENSATING DEVICE FOR AN HYDRAULIC PUMP

Filed Feb. 23, 1960 2 Sheets-Sheet 2

Fig. 4

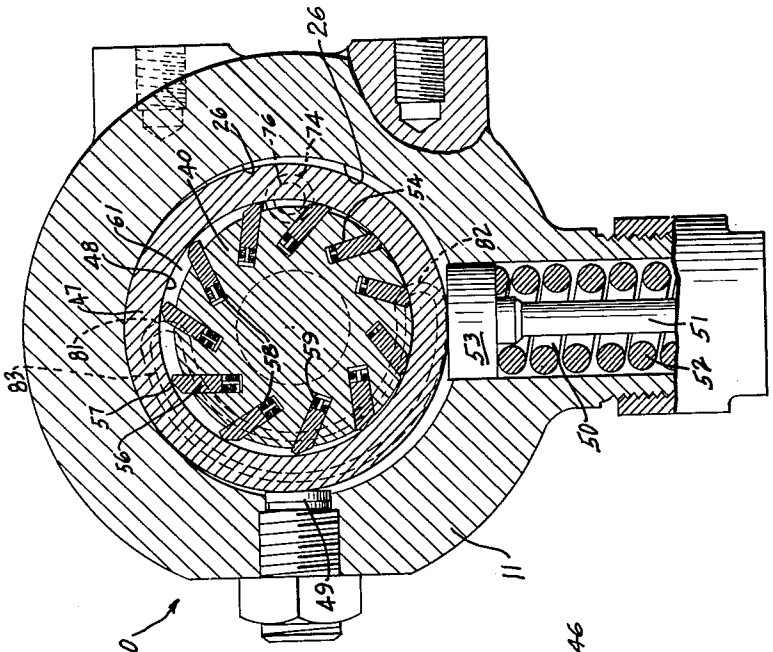
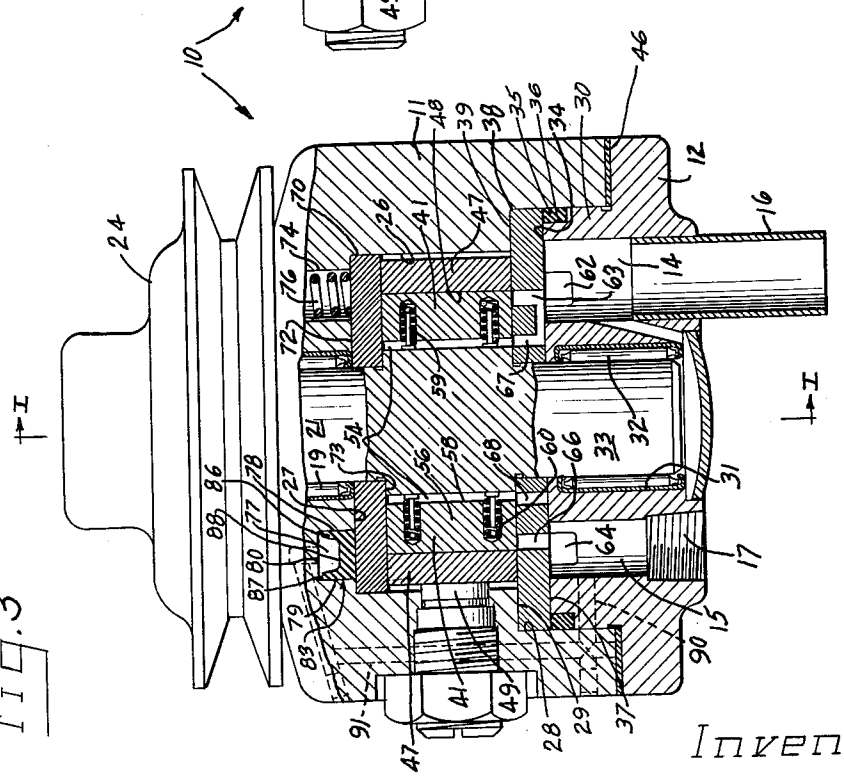


Fig. 3



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3,052,189

PRESSURE BALANCING AND COMPENSATING DEVICE FOR AN HYDRAULIC PUMP

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9 Claims. (Cl. 103—120)

This invention relates generally to pumps and more particularly to an improved means of pressure balancing an hydraulic pump of the sliding vane type so as to maintain desired end or side clearances and specifically through the use of a pressure-sensitive movable hydraulic seal employed as a pressure-balancing device.

Briefly described, the inventive subject matter consists of a pressure-balancing device sized and shaped so that an imposed pressure results in a balancing force in a direction opposite the distributed loading exerted by the resultant pressure in the pumping envelope on a movable end plate or thrust plate.

It is an object of this invention to eliminate the need for a shim material which may be required to control final stack up tolerances.

Yet another object of the present invention is to provide a means of automatically compensating for wear or erosion on the side or end plates of an hydraulic pump in a new and improved manner.

Yet another object of the present invention is to provide a pump wherein manufacturing tolerances required in stack-up clearances are reduced due to the compensating feature of the pressure-balancing device employed.

Still another object of the present invention is to provide a pump which can be manufactured at reduced cost since the pump decreases manufacturing tolerances and reduces the need for selective assembly.

Many other advantages, features and additional objects of the present invention will become manifest to those versed in the art upon making reference to the detailed description which follows and the accompanying sheet of drawings in which a preferred structural embodiment of a pump incorporating the principles of the present invention is shown by way of illustrative example.

On the drawings:

FIGURE 1 is a cross-sectional view of a pump incorporating the principles of the present invention and taken on line I—I of FIGURE 3;

FIGURE 2 is a cross-sectional view taken generally on line II—II of FIGURE 1;

FIGURE 3 is a plan elevational view of the pump of FIGURE 1 with parts broken away and shown in cross-section to illustrate additional details of construction;

FIGURE 4 is a cross-sectional view taken generally on line IV—IV of FIGURE 1;

FIGURE 5 is a fragmentary view of an auxiliary spring which may be combined with the sealing member; and

FIGURES 6 and 7 are cross-sectional views taken generally on lines VI—VI and VII—VII, respectively, of FIGURE 5.

As shown on the drawings:

The pump of the present invention is shown generally at 10 and comprises a housing formed by a casing member 11 closed at one end by a cover 12 fastened to the casing member by a plurality of fasteners 13.

The cover has formed therein an inlet 14 and an outlet 15. An inlet conduit 16 is shown fastened in the inlet 14 to assist in conducting fluid from a suitable source to the inlet 14. The outlet 15 is provided with a threaded coupling portion 17 by means of which a suitable discharge conduit may be connected to the outlet 15 for carrying the fluid discharged by the pump to a point of utilization.

The casing member 11 is formed with a first bore 18 receiving a bearing assembly 19 and also a seal assembly 20, thereby to journal and seal a shaft extension 21 of a rotor indicated generally at 22. The end of the shaft section 21 is keyed as at 23 to a pulley 24 by means of which the rotor 22 may be rotatably driven off of a suitable power source.

The bore 18 in the casing member 11 is successively counterbored, first at a central portion forming a pumping chamber recess 26 separated from the bore 18 by a radially extending annular wall 27, and next at an end portion to form a counterbore 28 separated from the pumping chamber recess 26 by a radial annular wall 29.

The cover member 12 has an axially extending boss portion 30 apertured as at 31 to receive a bearing assembly 32 journaling a shaft extension 33 on the opposite side of the rotor 22.

The cover 12 further provides a radially extending end wall 34 notched as at 36 to retain an O ring sealing member 35, thereby effecting a seal against the adjoining wall of the counterbore 28 and also sealing against a radial face 37 formed on one side of a port plate 38 received within the counterbore 28 and formed with a radial sealing face 39 adapted to engage and seal against an adjoining side face of a hub portion 40 provided on the rotor 22, as well as against one end of a plurality of vanes 41 carried by the rotor hub 40.

The radial wall 29 is recessed as at 42, while the port plate 38 is recessed as at 43, thereby to accommodate a dowel pin 44 retaining the port plate 38 against rotary displacement.

A sealing gasket 46 is interposed between the casing member 11 and the cover 12.

As will be noted from the drawings, the pumping chamber recess 26 is generally circular in configuration and is disposed to be relatively concentric with respect to the axis of rotation of the rotor 22.

Disposed within the pumping chamber recess 26 is a header ring 47 having an outer circular peripheral surface of lesser diameter than the diameter of the pumping chamber recess 26 and including an inner peripheral surface 48 forming a vane track. Relative side displacement of the header ring 47 within the pumping chamber recess 26 is restrained by an adjustable stop 49 carried by the casing member 11 and the relative eccentricity of the header ring 47 within the pumping chamber recess 26 is controlled by an adjustment means shown generally at 50 and including an adjustment member having a stem 51 extending through the coils of a spring 52 and carrying on the end thereof a head member 53 which engages against the outside surface of the header ring 47.

The hub portion 40 of the rotor 22 is particularly characterized by the formation in the peripheral surface thereof of a plurality of notches 54, each of which extends generally radially inwardly of the hub portion 40, but which is offset in such a manner as to extend somewhat tangentially. Slidingly received within each notch 54 for reciprocation therein, is a vane 56 having a chamfered end portion 57 slidingly engaged against the vane track 48. Each vane 56 has an inner end wall 58 engaged against a spring means. To facilitate retention and seating of the spring means, herein shown at 59, each respective vane 56 may have the end wall 58 formed with a pair of spring recesses 60.

By virtue of the relative eccentricity between the rotor hub 40 and the vane track 48 prescribed by the header ring 47, there is provided a crescent-shaped working area 61 extending from the inlet to the outlet sides of the pump so that upon rotation of the rotor 22 the spaces between adjoining vanes 56 will increase on the inlet side of the pump and will decrease on the outlet side of the

pump, thereby to develop a positive displacement pumping action.

In order to conduct fluid to and from the spaces between the vanes in the crescent-shaped working area **61**, the cover member is provided with an arcuate inlet slot **62** which is formed in the wall **34** to extend through a sector of arc on the inlet side of the pump in register with an inlet port **63** formed in the porting plate **38**.

On the discharge side of the pump, the cover member **12** is formed with a discharge slot **64** which is arcuate in configuration and which extends through a sector of arc on the discharge side of the pump in register with a discharge port **66** formed in the porting plate **38**. Using the orientation of FIGURE 2, as the vanes **56** sweep through the crescent-shaped working area **61**, fluid is drawn in through the inlet port **63** and is discharged via the outlet port **66**.

The particular form of pump described by way of exemplary construction herein also includes vane loading means. Accordingly, in the porting plate **38** there is provided radially inwardly of the inlet port **63** and the outlet port **66** additional recess means including a recess **67** on the inlet side of the pump and a recess **68** on the outlet side of the pump axially opposite the inner ends of the vanes **56** and specifically the inner ends of the slots or notches **54**, thereby to communicate fluid at pump generated pressure to the inner ends of the vanes and urging the vanes into sealing engagement with the vane track **48**.

It will be appreciated that the pressure arc or working area **61** is subjected to changing pressure conditions which vary considerably from the inlet to the outlet side of the pump. At higher pump operating speeds, the center of pressure of the pressure arc is likely to be displaced considerably in the direction of the discharge side of the pump. It is contemplated by the present invention, therefore, to provide a means of pressure-balancing the pump to maintain desired end or side clearances regardless of the unbalanced forces which may occur within the pumping chamber prescribed by the vane track **48** and regardless of the shifting of the center of pressure of the pressure arc or working area **48**.

In accordance with the invention, therefore, there is provided a pressure plate or thrust plate **70** having an outer peripheral surface **71** sized to be complementary to the bore **26** prescribing the pumping chamber recess, the thrust plate **70** having a back face **72** adjoining the radial wall **27** and a front sealing face **73** for engaging and sealing against the adjoining side face of the rotor hub **40**, as well as the ends of the blades **41** and the end of the header ring **47**.

On the inlet side of the pump, the wall **27** is particularly characterized by the formation therein of a recess **74** receiving and bottoming a coil spring **76**, the opposite end of spring **76** engaging against the rear surface **72** of the thrust plate **70**, thereby to initially counterbalance the plate **70** and to preload the plate **70** into sealing relation relative to the rotor **22**.

On the discharge side of the pump, the wall **27** is particularly characterized by the formation therein of a kidney-shaped recess indicated generally at **77** and including more specifically spaced inner and outer parallel walls **78** and **79**, respectively, and a bottom wall **80**. The kidney-shaped recess **77** extends substantially circumferentially over the entire discharge side of the pump and, as shown in FIGURE 4, extends more specifically from a point indicated at **81** radially opposite the maximum dimension of the working area **61** to a point **82** which is slightly in advance of the normal point of seal between the rotor hub **40** and the vane track **48**, or, in other words, slightly into the beginning of the working area **61**.

Received within the recess **77** is a pressure-sensitive movable hydraulic seal indicated at **83** and comprising a flat face **84** engaging against the adjoining surface **72** of the plate **70** and extending across the open portion of the recess **77** between the spaced side walls **78** and **79**.

Extending inwardly into the recess **77** and away from the flat face **84** is a pair of legs indicated at **86** and **87**, respectively, the legs **86** and **87** being initially disposed in somewhat divergent position. The seal member **83** is preferably made of a suitably resilient and elastic material such as rubber or a rubber substitute so that the somewhat divergent legs **86** and **87** when confined within the recess **77** will elastically engage and seal against the adjoining side walls **79** and **78** of the recess **77**.

The seal member **83** is somewhat trough-shaped in cross-section and includes a rear portion which is dished out as at **88**, thereby to form a pressure pocket or pressure-receiving pocket. The legs **86** and **87** are preferably of such a length as to be less than the axial dimension of the adjoining side walls **78** and **79** and, therefore, terminate short of the bottom wall **80**.

The cover **12** is formed with a passage **90** forming an extension of a passage provided in the casing member **11** and shown at **91**, thereby establishing communication between the outlet port **15** and intersecting the bottom wall **80** of the recess **77** to communicate fluid at pump-generated pressure into the pressure receiving pocket formed at the rear of the seal member as at **88**. Thus, the legs **86** and **87** are pressure-biased outwardly into good sealing engagement with the adjoining walls **78** and **79** and the pressure-sensitive movable hydraulic seal **83** also operates to deliver an axial thrust to the plate **70** which is so located by virtue of the construction and arrangement of the recess **77** as to oppose the center of pressure of the pressure arc. Thus, the recess **77** normally located under the center of pressure of the pressure arc, confines the hydraulic sealing device **83** and provides a sealing and sliding surface via the walls **78** and **79**.

In operation, as the pressure in the pumping envelope increases, the hydraulic loading on the plate **70** is increased on the pressure arc and is simultaneously balanced by pressure supplied at pumping envelope pressure through the passage **90**, **91** into the pocket **88** of the seal member **83**. The pressure confined within the recess **77** moves the seal member **83** against the plate **70** which then retains its position in contact with the header ring **47** to maintain the required clearance, thereby counterbalancing the plate **70**.

As a means of initiating pressure under the sealing member **88** at low speed, continuous biasing means may be provided as shown in FIGURES 5, 6 and 7 wherein a spring **95** has a plurality of tangs **96** struck out from the marginal edges thereof to engage against the sealing member **88**, the spring **95** being sized and shaped to be received in the recess **77**.

Although various minor modifications might be suggested by those versed in the art, it should be understood that I wish to embody within the scope of the patent warranted hereon all such modifications as reasonably and properly come within the scope of my contribution to the art.

I claim as my invention:

1. A pump comprising a housing having a bore formed therein, a diametrically adjustable header ring in said housing bore forming a pumping chamber, a notched sliding vane carrying rotary fluid displacement means in said pumping chamber, said displacement means being relatively offset with respect to the pumping chamber upon adjustment of said header ring to form a crescent-shaped working area constituting a pressure arc, a porting plate at one side of said pumping chamber formed with inlet and outlet ports on different sides of said eccentric working area and having a sealing surface engaging an adjoining side face of said rotary fluid displacement means, an axially movable thrust plate on the other side of said header ring sized to be complementary to the housing bore and having a sealing surface on one side thereof engaging and sealing against an adjoining side face of the rotary fluid displacement means, and a back face on said thrust plate engaging an adjoining wall of

said housing, said wall of said housing having a kidney-shaped pocket formed therein behind said thrust plate on the discharge side of the pump and located axially opposite the center of pressure of the pressure arc, said pocket comprising a notched recess having parallel side walls forming a sealing and sliding surface, and a bottom wall, said wall of said housing having a spring pocket formed on the inlet side of the pump, spring means bottomed in said spring pocket and biasing said thrust plate axially, said casing having an outlet and an inlet communicating with said inlet and outlet ports of said porting plate, means forming a passage between said bottom wall of said notched recess and said outlet to communicate fluid at pump-generated pressure to said kidney-shaped pocket, and a pressure-sensitive movable hydraulic seal of an outside size and dimension to fit within said kidney-shaped pocket and being essentially trough-shaped in cross-sectional configuration so that the external portions of the legs thereof will snugly engage said housing at the sealing and sliding surface of said side walls, the internal portions of the legs and the bight portion of said seal being subject to the fluid at pump-generated pressure to transmit a thrust to said back face of said thrust plate counterbalancing the forces acting on said sealing face.

2. In a vane-type pump,

a vane-carrying rotor,

an axially movable thrust plate having a sealing face for engaging and sealing against the adjoining side face of the rotor and the ends of the vanes,

a header ring encircling the rotor and forming a vane track for the vanes radially inwardly of the periphery of said thrust plate,

said header ring being eccentrically offset to form a crescent-shaped working area constituting a pressure arc acting against said sealing face during operation of the pump,

a pump casing having a pumping chamber formed therein receiving said thrust plate and said header ring and including a wall adjacent a rear face of said thrust plate notched to form a kidney-shaped recess behind said thrust plate,

said kidney-shaped recess being offset on the outlet side of the pump opposite the center of pressure of said pressure arc,

an hydraulic seal in said kidney-shaped recess,

and means communicating fluid at pump-generated pressure into said kidney-shaped recess behind said seal,

thereby to load said thrust plate as a function of pump discharge and pump casing pressure,

and a porting plate on the other side of said rotor having a sealing face for engaging and sealing the opposite side face of the rotor and the ends of the vanes while channeling fluid displaced by said rotor.

3. In a pump, a casing member having formed therein a bore, a rotor having a shaft portion journaled in said bore, said casing member being successively counterbored to form a pumping chamber recess separated from said bore by a first radially extending annular wall and a porting plate recess separated from said pumping chamber recess by a second radially extending annular wall, a movable thrust plate received in and sized to be complementary to said pumping chamber recess having a back surface adjoining said first wall and a front surface sealing against the adjoining rotor side face, said rotor having a vane-carrying portion in said pumping chamber recess and providing oppositely disposed rotor side faces, a header ring in said pumping chamber recess adjustable diametrically and providing a vane track for said rotor, a porting plate in said porting plate recess and having inlet and outlet ports formed therein positioned adjacent one of said rotor side faces, said first wall having a kidney-shaped recess generally rectangular in cross-section formed therein on the discharge side of the pump, said recess having parallel side walls and a bottom wall, a pressure-sensitive movable hydraulic seal in said recess comprising a flexible member made of elastic material and having a flat front surface extending between said parallel side walls and being generally trough-shaped in cross-section to provide spaced legs extending into said recess from said flat front surface, said legs being initially spread wider than said recess and elastically engaging said side walls, said legs terminating short of said bottom wall, the rear of said flexible member being relieved between said legs to form a pressure-receiving pocket, and means in said casing member forming a passage intersecting said bottom wall of said recess and communicating with the discharge side of the pump, thereby to supply fluid at pump-generated pressure into said pocket-receiving recess and loading said flexible member into sealed relation with said casing member and said flexible member delivering a selectively applied axially loading thrust to said thrust plate on the discharge side of the pump, said recess being constructed and arranged to be disposed axially opposite the center of pressure in said pumping chamber recess.

4. In a pump, a casing member having formed therein a bore, a rotor having a shaft portion journaled in said bore, said casing member being successively counterbored to form a pumping chamber recess separated from said bore by a first radially extending annular wall and a porting plate recess separated from said pumping chamber recess by a second radially extending annular wall, a movable thrust plate received in and sized to be complementary to said pumping chamber recess having a back surface adjoining said first wall and a front surface sealing against the adjoining rotor side face, said rotor having a vane-carrying portion in said pumping chamber recess and providing oppositely disposed rotor side faces, a header ring in said pumping chamber recess adjustable diametrically and providing a vane track for said rotor, a porting plate in said porting plate recess and having inlet and outlet ports formed therein positioned adjacent one of said rotor side faces, said first wall having a kidney-shaped recess generally rectangular in cross-section formed therein on the discharge side of the pump, said recess having parallel side walls and a bottom wall, a pressure-sensitive movable hydraulic seal in said recess comprising a flexible member made of elastic material and having a flat front surface extending between said parallel side walls and being generally trough-shaped in cross-section to provide spaced legs extending into said recess from said flat front surface, said legs being initially spread wider than said recess and elastically engaging said side walls, said legs terminating short of said bottom wall, the rear of said flexible member being relieved between said legs to form a pressure-receiving pocket, and means in said casing member forming a passage intersecting said bottom wall of said recess and communicating with the discharge side of the pump, thereby to supply fluid at pump-generated pressure into said pocket-receiving recess and loading said flexible member into sealed relation with said casing member and said flexible member delivering a selectively applied axially loading thrust to said thrust plate on the discharge side of the pump, said recess being constructed and arranged to be disposed axially opposite the center of pressure in said pumping chamber recess, said first wall having additional recess means formed therein on the inlet side of the pump receiving and bottoming a spring to initially counterbalance and preload the thrust plate axially.

5. In a pump, a casing having a bore formed therein, a pumping header ring in said bore of a smaller diameter than said bore and being adjustably eccentrically displaceable in said bore, said ring having an inner peripheral surface forming a vane track, a vane-carrying rotor rotatable within said ring, and a movable end plate in said bore, said end plate having a front sealing surface for engaging against the end of said ring and against the adjoining side face of said rotor and a back surface adjoining an adjacent casing wall, said casing wall having formed therein

on the discharge side of the pump a pocket offset towards the discharge side of the pump to be located axially opposite the center of pressure of a pressure arc within said ring and a movable hydraulic sealing member confined within said pocket, said pump including means to supply fluid at pump-generated pressure to the rear side of the hydraulic sealing member, thereby to move the sealing member against the plate which then retains its position in contact with the ring to maintain the required clearance while counterbalancing the forces acting on the end plate.

6. In a pump, a housing having a bore formed therein, a pumping ring in said bore adjustable diametrically, said pumping ring having a vane track formed on its inner surface, a vane-carrying rotor having a plurality of vanes engaging said vane track, means to move said pumping ring thereby to maintain a crescent-shaped working area between said rotor and said vane track, a porting plate on one side of said rotor having inlet and outlet ports in communication with said crescent-shaped working area, and a movable end plate on the other side of said rotor sized to be complementary to said bore having a front sealing face engaging against the end of said pumping ring and for sealing against the adjoining side face of the rotor, said end plate having a rear motive surface, and means including said housing forming a pocket offset towards the discharge side of the pump and being opposite the center of pressure of the crescent-shaped working area, an hydraulic sealing member in said pocket, said pocket having means forming a sealing and sliding surface for said sealing member, and means for supplying pump-generated pressure behind said sealing member in said pocket, thereby to bias said sealing member into sealing engagement with said sealing and sliding surface, said pressure further operating to move said sealing member against said end plate which then retains its position in contact with said pumping ring to maintain required clearance while counter-balancing the end plate.

7. In a pump, a housing having a bore formed therein, a pumping ring in said bore adjustable diametrically, said pumping ring having a vane track formed on its inner surface, a vane-carrying rotor having a plurality of vanes engaging said vane track, means to move said pumping ring thereby to maintain a crescent-shaped working area between said rotor and said vane track, a porting plate on one side of said rotor having inlet and outlet ports in communication with said crescent-shaped working area, and a movable end plate on the other side of said rotor sized to be complementary to said bore having a front sealing face engaging against the end of said pumping ring and for sealing against the adjoining side face of the rotor, said end plate having a rear motive surface, and means including said housing forming a pocket offset towards the discharge side of the pump and opposite the center of pressure of the crescent-shaped working area, an hydraulic sealing member in said pocket, said pocket having means forming a sealing and sliding surface for said sealing member, and means for supplying pump-generated pressure behind said sealing member in said pocket, thereby to bias said sealing member into sealing engagement with said sealing and sliding surface, said pressure further operating to move said sealing member against said end plate which then retains its position in contact with said pumping ring to maintain required clearance while counter-balancing the end plate, and spring means engaging said motive surface of said end plate on the inlet side of the pump to initially counterbalance the end plate and to preload the end plate against the pumping ring.

8. In a pump, a housing having a pumping ring adjustable in diametrical direction and forming a vane track, said pump including a vaned rotor rotatable within said ring, a porting plate providing inlet and outlet ports axially adjacent the vaned rotor, there being a crescent-shaped working area formed between the vane track and the rotor in communication with the inlet and outlet ports, a movable end plate in said housing on the side of the rotor opposite the porting plate, said end plate having a front sealing surface engaging against the end of the pumping ring and the adjoining side face of the rotor and further including a rear motive surface, means including said housing forming a kidney-shaped recess behind said end plate extending from a first point in radial alignment with the maximum width dimension of the crescent-shaped working area to a second circumferentially spaced point around the discharge side of the pump to the beginning of the crescent-shaped working space, thereby to be disposed in offset relation on the discharge side of the pump opposite the center of pressure of the working area, a movable hydraulic seal in said recess, and means communicating fluid at pump-generated pressure to said recess, thereby to load said seal against said end plate which then retains its position in contact with the pumping ring and maintains required clearance while counter-balancing the end plate.

9. In a pump, a housing having a pumping ring adjustable in diametral direction and forming a vane track, said pump including a vaned rotor rotatable within said ring, a porting plate providing inlet and outlet ports axially adjacent the vaned rotor, there being a crescent-shaped working area formed between the vane track and the rotor in communication with the inlet and outlet ports, a movable end plate on the side of the rotor opposite the porting plate, said end plate having a front sealing surface engaging against the end of the pumping ring and the adjoining side face of the rotor and further including a rear motive surface and means including said housing forming a kidney-shaped recess behind said end plate extending from a first point in radial alignment with the maximum width dimension of the crescent-shaped working area to a second circumferentially spaced point around the discharge side of the pump to the beginning of the crescent-shaped working space, thereby to be disposed opposite the center of pressure of the working area, a movable hydraulic seal in said recess, and means communicating fluid at pump-generated pressure to said recess, thereby to load said seal against said end plate which then retains its position in contact with the pumping ring and maintains required clearance while counter-balancing the end plate, said sealing member comprising an elastic material and shaped to provide a flat face engaging said end plate and axially extending normally divergent legs for engaging said housing at the sealing and sliding surface provided by the adjoining walls of the recess, the rear portion of said sealing member being recessed to form a pocket so that the legs are pressure-loaded into sealing engagement with the housing while the sealing member delivers an axial thrust to the end plate.

References Cited in the file of this patent

UNITED STATES PATENTS

2,044,873	Beust	June 23, 1936
2,312,891	Ferris	Mar. 2, 1943
2,631,544	Wilcox	Mar. 17, 1953
2,642,802	Gardiner	June 23, 1953
2,682,836	Orr	July 6, 1954
2,764,941	Miller et al.	Oct. 2, 1956
2,782,724	Humphreys	Feb. 26, 1957
2,809,588	Stewart	Oct. 15, 1957
2,809,592	Miller et al.	Oct. 15, 1957
2,842,064	Wahlmark	July 8, 1958
2,880,674	Klessig et al.	Apr. 7, 1959