May 26, 1970 R. C. HARE 3,514,223

HYDRAULIC PUMP

Original Filed April 26, 1966 4 Sheets-Sheet 1

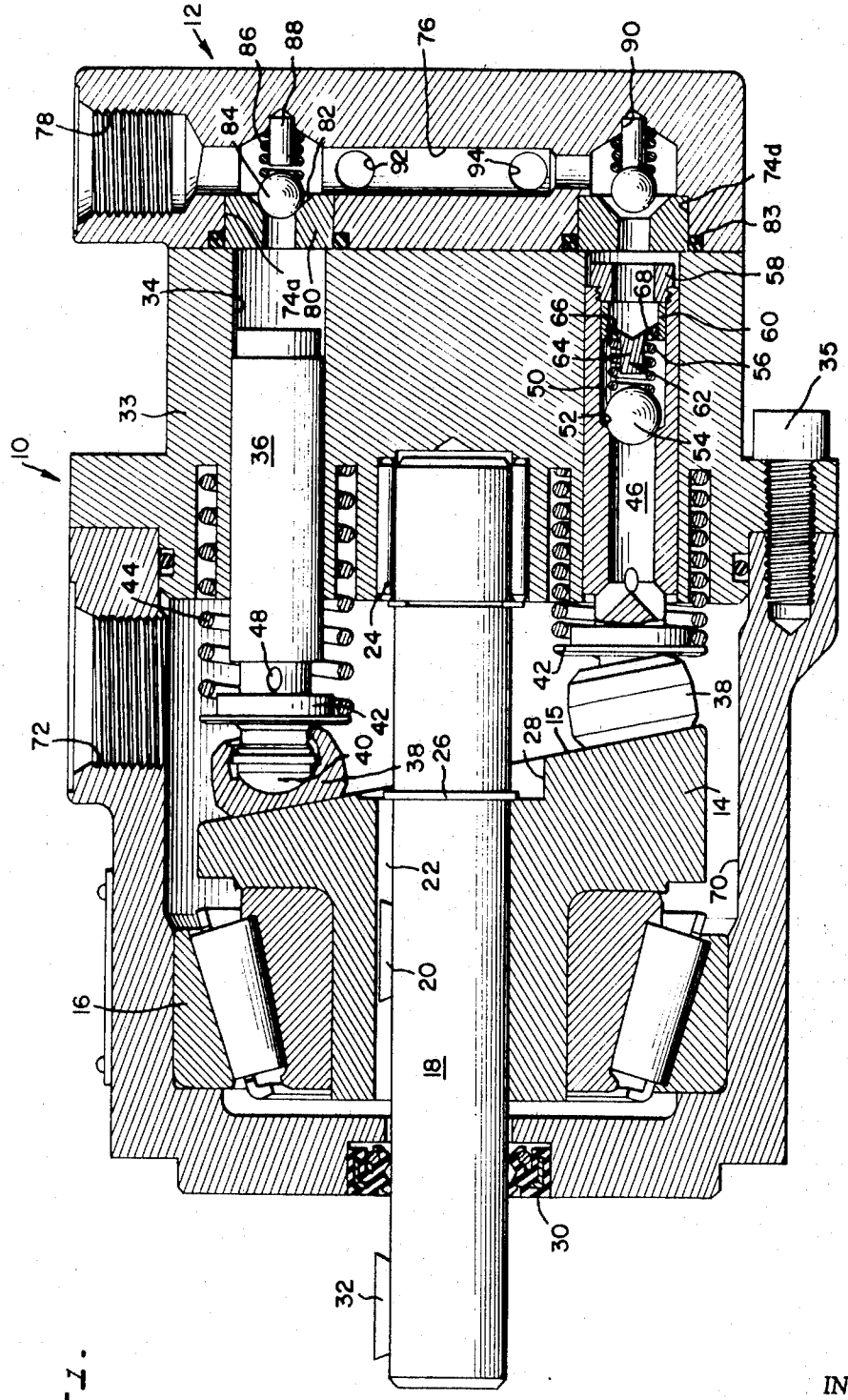


FIG 1.

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Fig 2.

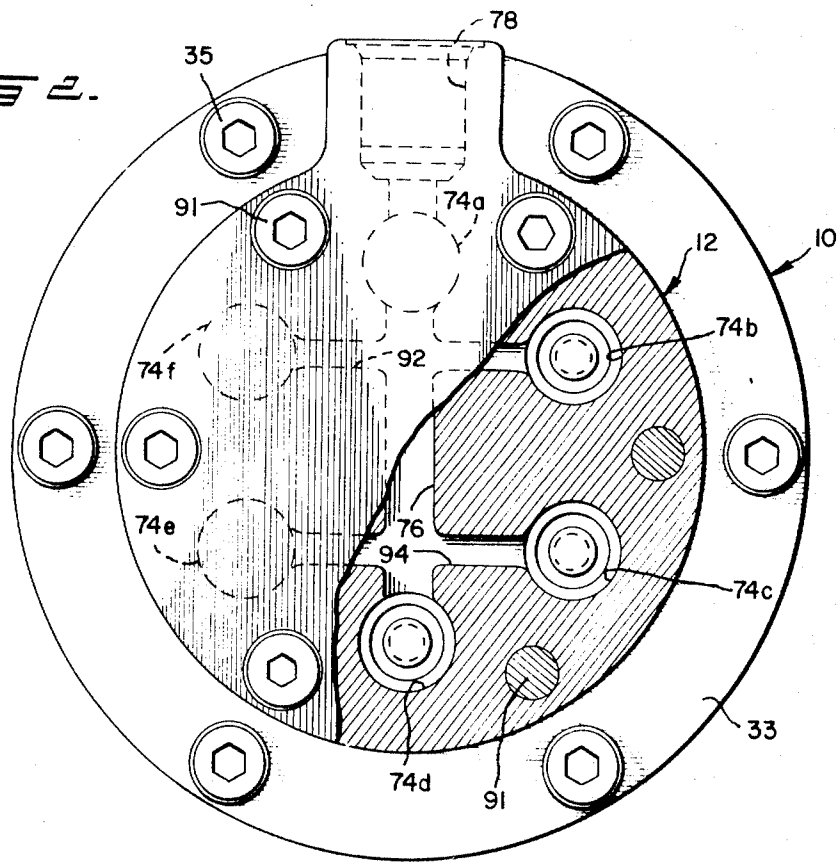


Fig 3.

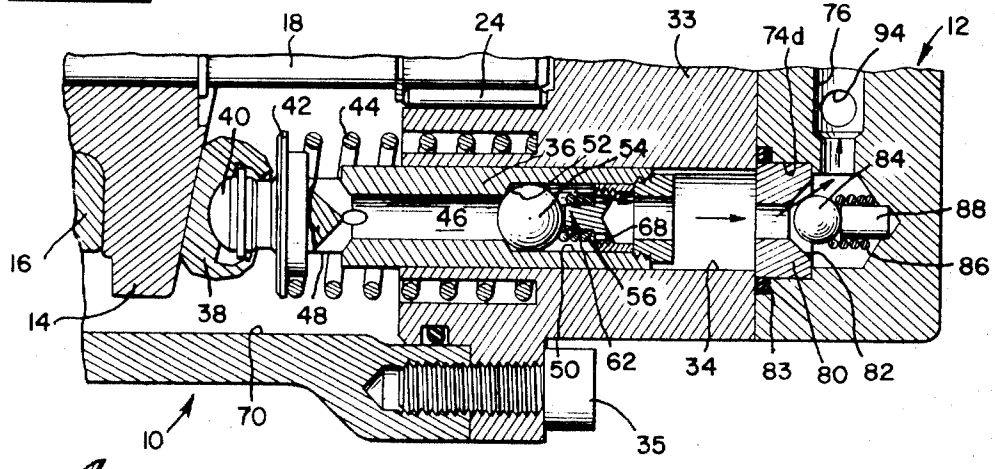
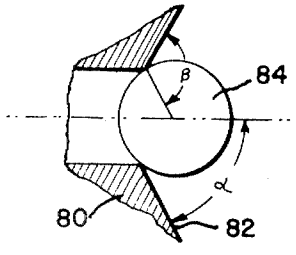


Fig 3a.



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Fig 4.

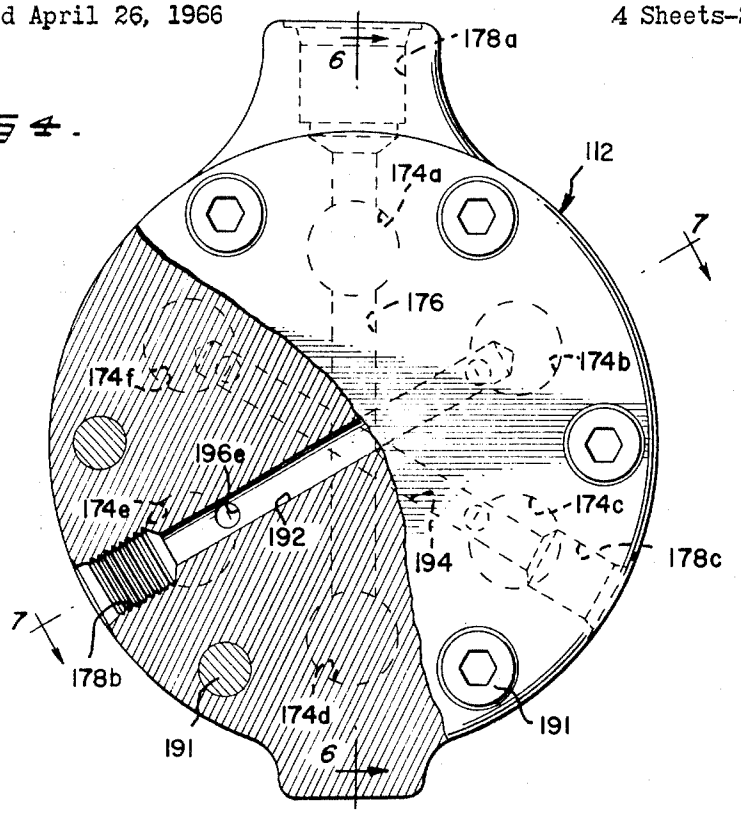
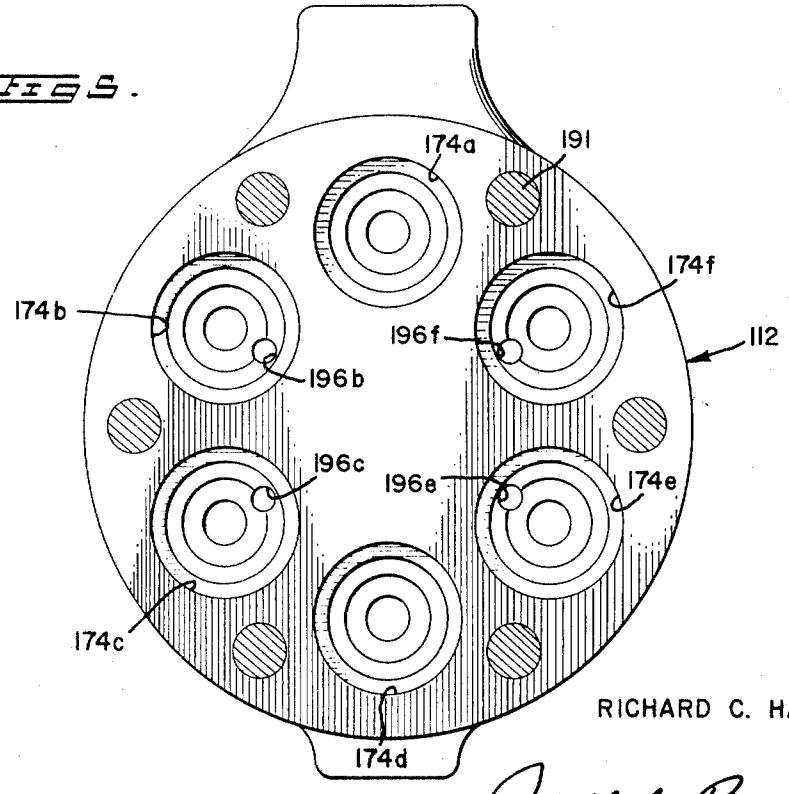


Fig 5.



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Fig 6.

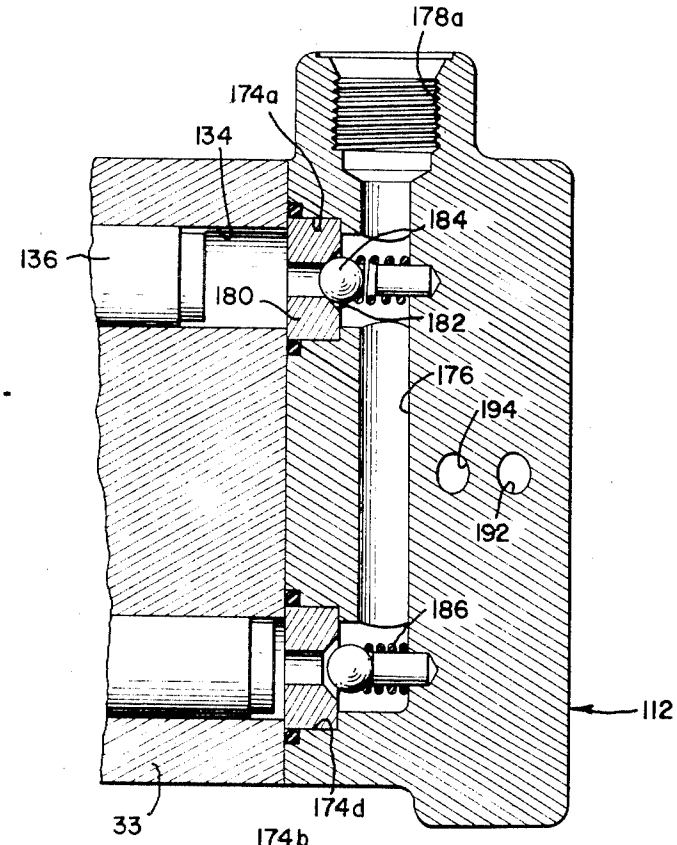
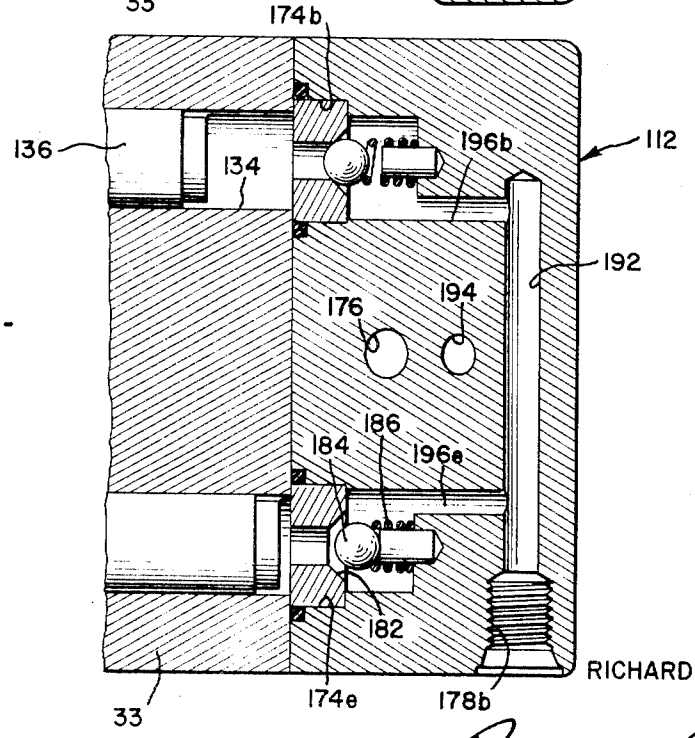


Fig 7.



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3,514,223

HYDRAULIC PUMP

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Continuation of application Ser. No. 545,321, Apr. 26, 1966. This application Aug. 19, 1968, Ser. No. 757,519
Int. Cl. F04b 9/00, 1/14, 7/00
U.S. Cl. 417—269 4 Claims

ABSTRACT OF THE DISCLOSURE

A hydraulic pump of the type having a plurality of parallel cylinders with pistons therein driven by a rotating wobble plate. The pump includes a removable and plate assembly having a plurality of outlet bores communicating with the cylinders and further having check valve units wholly disposed within the end plate between the cylinders and the outlet bores, whereby said end plate is removeable as a unit.

This application is a streamlined continuation of 545,321 filed Apr. 26, 1966, now abandoned.

This invention relate generally to pumps and more particularly to hydraulic pumps of the type that incorporates a plurality of reciprocating pistons driven by a rotating wobble plate.

Prior art pumps of the type to which this invention generally relates are, on the whole, rather expensive in that they require parts which are machined to high degrees of tolerance and require rather complicated means for reducing the friction between stationary and relatively rotating parts thereof. For example, the reciprocating pistons require at least two spring-biased check valves associated with each piston unit. In each of these check valves the prior art pumps require seats machined to a high degree of accuracy to maintain leakage between the valving member and the seat to a minimum.

Prior art pumps of the type referred to also require friction reducing means between their rotating wobble plate and the portion of the rotationally stationary pistons which engage the surface of the wobble plate. One such means comprises a roller bearing structure positioned between the portion of the piston against which the wobble plate drives and the wobble plate driving surface. Another means for reducing this friction consists of hydraulic channeling to provide a hydraulic film or hydrostatic balance between the relatively moving surfaces.

Prior art pumps have furthermore been limited to a designed in hydraulic fluid output configuration thereby limiting the adaptability of the pump to a single design use.

It is an object of this invention to provide a novel hydraulic pump which is less expensive than heretofore available by providing means to minimize the need for high tolerance machined ball check valve seats in the pump structure.

It is another object of this invention to furnish a novel hydraulic pump which requires fewer parts than heretofore necessary by providing means to overcome friction between the portions of the reciprocating pistons engaging the wobble plate without resorting to anti-friction roller bearings or hydrostatic balance techniques.

It is still another object of this invention to furnish a new hydraulic pump in which the hydraulic output configuration can be readily altered according to the use requirements of the pump.

These and other objets of the invention will become more apparent to those skilled in the art by reference to the following detailed description when viewed in light

of the accompanying drawings, wherein like elements throughout the figures thereof are indicated by like numerals and wherein:

FIG. 1 is a sectional view, in elevation, of a pump embodying features in accordance with this invention;

FIG. 2 is an end view, partly in section, of the pump of FIG. 1 showing the detail of an end plate controlling the hydraulic output configuration of the pump;

FIG. 3 is a sectional view of a portion of the pump of FIG. 1 illustrating, in detail, a reciprocating piston and the resultant hydraulic flow;

FIG. 3*a* is an enlarged and broken away sectional view of a portion of the detail illustrated in FIG. 3;

FIG. 4 is a view similar to that of FIG. 2 showing another end plate controlling the hydraulic output configuration of the pump in accordance with the invention;

FIG. 5 is a view of the obverse side of the end plate of FIG. 4;

FIG. 6 is a sectional view of the end plate of FIG. 4, taken along the lines **6**—**6** thereof, installed on a pump in accordance with the invention; and

FIG. 7 is a sectional view of the end plate of FIG. 4 similar to the view in FIG. 6 taken along the lines **7**—**7** of FIG. 4.

Turning now to FIG. 1 of the drawings, a pump comprising a housing, shown generally at **10**, a barrel section **33** and an end plate shown generally at **12** is provided with a wobble plate **14** having a slanted or non radially extending flat transverse cam surface **15**. The plate **14** is rotatably mounted in the housing on a tapered roller bearing assembly **16** and a rotatable shaft **18** fixed to the wobble plate by means of a key **20** disposed in a keyway **22**. The inner end of the shaft **18** is rotatably mounted in the housing by means of a needle bearing assembly **24** and is axially fixed with respect to the wobble plate **14** by means of a radially extending ring **26** which engages the transverse surface of a recess **28** coaxially disposed in the surface **15** of the wobble plate. An annular elastomeric seal **30** engages the peripheral surface of the shaft **18** proximate the point where the shaft traverses the housing **10**. A second key **32** is disposed in the outer end of the shaft **18** to serve as a point of attachment for a driving means (not shown).

A barrel section **33** defining a plurality of axially disposed cylindrical bores **34** is mounted to the end plate end of the housing **10** by a plurality of bolts **35**. A piston **36** is disposed in each of the bores **34** for reciprocation therein. Each of the pistons **36** is provided with a wobble-plate-engaging shoe **38** swivelly connected thereto through a ball joint **40**. The shoes **38** are formed of bronze (Mueller '602) while the wobble plate **14** is composed of a cast-iron alloy (spec H 511.850). The combination of the piston shoe design and the materials used permits a high velocity under high loadings with a minimum of friction thereby obviating a requirement for anti-friction bearings or hydrostatic balance between the contacting surfaces. An annular collar **42**, fixed to each of the pistons **36** proximate the ball joint **40**, engages a compression spring **44** coaxially disposed around the piston. The compression spring **44** is disposed between the collar **42** into an annular recess coaxially disposed around the cylindrical bores **34** to bias the pistons **36** and the shoes **38** toward the surface **15** of the wobble plate.

Each of the pistons **36** is provided with an internal coaxially disposed bore **46** which extends from an inlet **48** in the peripheral surface thereof proximate the collar **42** to the free end of the piston proximate the end plate **12**. The bore **46** is provided with an enlarged portion **50**, the intersection therebetween being defined by a tapered, generally transversely extending seat **52**. A ball valving member **54** is disposed in the enlarged portion **50** and is biased against the seat **52** by a check valve compression

spring **56**. An annular collar **58** is threaded into the open end of the enlarged portion **50** and, on its inner transverse surface, abuts an annular spacer **60** which, in turn, supports a ball stop member **62** threaded in the open end thereof. The ball stop member **62** comprises an axially extending cylinder portion **64**, which engages the ball valving member **54**, to limit axial movement thereof, and a transversely extending flange **66** which is provided with a plurality of axially extending bores **68** to provide passage of the fluid being pumped thereby. The aforedescribed piston structure is similar to those known in the art and it should be understood that suitable structures other than that specifically described can be utilized in this portion of the pump.

The housing **10** is formed to define an inlet chamber **70** which encompasses the wobble plate **14** and a portion of the shaft **18**. A threaded inlet fitting **72** is provided through the housing to furnish communication between the inlet chamber **70** and a source of hydraulic fluid (not shown).

The end plate **12** is formed, to encompass an outlet manifold system consisting of end plate inlet bores **74***a* through **74***f* (FIG. 2) extending axially into said end plate and disposed in registration with each of the cylindrical bores **34** and communicating with a main outlet bore **76** disposed transversely to the axis of the end plate. This latter-described bore communicates with a threaded outlet fitting **78** which fitting furnishes means for connecting the pump to a pressure sink (not shown) to which the pressurized hydraulic output of the pump is directed.

An annular bushing insert **80** is disposed in each of the end plate inlet bores **74***a* through **74***f*, sealing being effected therebetween by an O ring **83** disposed in a cylindrical recess coaxially formed around each of the bores. A tapered annular seat **82** is coaxially disposed on the inner transverse face of the bushing **80** and is engaged by a ball valving member **84** which is biased thereagainst by a compression spring **86**.

Referring specifically to FIG. 3*a*, the ball valving member **84** is formed of a hardened steel as is usual in the art. By configuring the seat **82** so that the angle is approximately 36° and by providing a bore-to-ball diameter ratio of 5 to 6, it is possible to provide a "self seating" capability for the valve by forming the seat of a soft steel. With this configuration and these materials, the ball **84** will deform the seat **82** during the initial operation of the pump to form a suitable seal therebetween. The above-described seat angle and diameter ratio will result in an angle β between a radius drawn to the point of tangency and the seat of approximately 92.5° prior to deformation of the seat by initial operation of the pump. This feature of the invention permits the use of check valve seats machined to lower tolerances than heretofore necessary thereby resulting in savings of cost and fabrication time for the pump.

A cylindrical ball stop pin **88** is mounted in a recess **90** behind the ball **84** and serves to provide means to limit the axial movement of the ball **84** as well as a guide for the spring **86**.

Turning now to FIG. 2 of the drawings, an end view of the pump of FIG. 1 showing the transverse details of the end plate **12** is illustrated. Bolts **91** suitably disposed around the periphery of the end plate **12**, attach the end plate to the barrel section **33**. As is better seen in this figure, the end plate inlet bores **74***a* through **74***f* are symmetrically disposed in the inlet with the bores **74***a* and **74***d* directly communicative with the outlet fitting **78** through the main transverse bore **76**. Inlet bores **74***b* and **74***f* are interconnected by a first lateral bore **92** which intersects the main bore **76** to provide communication with the outlet fitting **78**. The inlet bores **74***c* and **74***e* are similarly connected by a second lateral bore **94** which also intersects the main bore **76** to provide intercommunication between the outlet fitting **78** and the latter-mentioned bores.

In operation, the pump, suitably hooked to a source of hydraulic fluid through the inlet fitting **72** and a sink for pressurized fluid through the outlet fitting **78** by means of hydraulic conduits, is energized by rotation of the shaft **18**. Rotation of the shaft **18** causes rotation of the wobble plate **14** which, because of the configuration of the slanted cam surface **15**, causes alternate reciprocation of each of the pistons **36**. Referring to FIG. 1, the uppermost piston is illustrated substantially at its maximum point of intake stroke while the lowermost piston is at the opposite extreme substantially at its maximum displacement in the compression stroke. The remaining pistons are at intermediate stages between these extremes. In the compression stroke, the piston is driven by the slanted surface **15** of the wobble plate **14** and the shoe **38** while, during the intake stroke, the piston is displaced in the opposite direction in contact with the wobble plate **14** by bias of the spring **44**. Because of the composition of the shoe and wobble plate as set forth above, there is no requirement for friction reducing means between the members and pump operates efficiently with the members in direct contact.

Referring specifically now to FIG. 3 of the drawings, one of the pistons **36** is shown during the compression stroke thereof. During the intake stroke, the cylinder **34** and the bore portions **46** and **50** have been filled with hydraulic fluid from the inlet chamber **70** through the bore inlet **48**. As the direction of reciprocation of the piston changes and the piston travels towards the end plate end of the pump, the ball valving member **54** is moved against the tapered seat **52** under the influence of the compression spring **56** and the hydraulic fluid trapped downstream of the ball **54** thereby sealing hydraulic fluid in the cylinder **34**. As the volume of the cylinder is decreased by movement of the piston **36**, pressure is built up in the cylinder and the ball valving member **84** in the end plate **12** is displaced from the tapered seat **82** thereby opening communication between the cylinder **34** and the main transverse bore **76** for expulsion of hydraulic fluid under pressure through the outlet fitting **78** (FIG. 1). The compression stroke is identical for each of the pistons and, in the case of the pistons communicating with the inlet bores **74***b* and **74***f* and inlet bores **74***c* and **74***e* (FIG. 2), fluid is exhausted therefrom by way of the first and second lateral bores **92** (FIG. 2) and **94** respectively through the main transverse bore **76** and ultimately through the outlet fitting **78**. In the embodiment of FIGS. 1 through 3 then, the output from each of the cylinders **34** is manifolded and exhausted at a single point, the outlet fitting **78**.

In the inlet stroke, the above-described components function essentially in a reverse sequence with the piston changing direction and moving toward the wobble plate **14** from the position of the lowermost piston in FIG. 1 under the influence of the compression spring **44**. Under these conditions, the pressure drops in the cylinder **34** and the end plate ball valving member **84** returns into sealing engagement with the seat **82** under the influence of the bias of the compression spring **86**. As the piston moves away from the end plate end of the pump, the pressure in the cylinder **34** drops causing the ball valving member **54** to unseat due to the pressure differential thereacross. Hydraulic fluid then flows from the inlet chamber **70** through the bore inlet **48** into the cylinder through the bore portions **46** and **50** to again fill the cylinder.

In FIGS. 4 through 7, a variation in the pump in accordance with the invention is illustrated. In these figures, portions thereof corresponding to like portions in the pump shown in FIGS. 1 through 3 are indicated by like numerals only of the next highest order. The primary distinction between the pump of the embodiment of FIGS. 4 through 7 over the aforedescribed embodiment lies in the manifolding of the end plate **112**. By fabricating a pump in accordance with the teachings of this invention, the manifolding and valving of the end plate is completely self-contained and utilized so that,

by substitution of end plates, the outlet manifolding configuration thereof may be practically and readily changed without requiring modification to the pump body or mechanism itself. Furthermore, the components making up the end plate valving mechanism of both of the illustrated embodiments are identical so that the end plate may be manifolded as desired by simply altering the coring pattern thereof, the other components making up the valving elements in the end plates being interchangeable.

As will be seen by reference to the figures, the end plate is provided with a plurality of end plate inlet bores **174***a* through **174***f* disposed in a manner similar to those in the end plate of FIG. 1.

A main transverse bore **176** connects end plate inlet bores **174***a* and **174***d* to an outlet fitting **178***a*. A first diagonal bore **192**, spaced axially from the main transverse bore **176**, connects inlet bores **174***b* and **174***e* to a second outlet fitting **178***b* while a second diagonal bore **194**, axially disposed between the main transverse bore **176** and the aforementioned diagonal bore, connects inlet bores **174***c* and **174***f* to a third outlet fitting **178***c*. Due to the axial offset of the first and second diagonal bores **192** and **194**, it is necessary to provide axial passageways therefrom to communicate with the inlet bores **174***b*, **174***c*, **174***e* and **174***f*. This is accomplished by providing axially extending transfer bores **196***b*, **196***c*, **196***e* and **196***f* to communicate with bores **174***b*, **174***c*, **174***e* and **174***f* respectively. This manifold arrangement affords connection of the end plate inlet bores, in pairs, to separate outlet fittings thereby providing for a split or division of the output of the hydraulic fluid. Obviously, other variations may be readily made in the manifolding of the end plate to meet other contingencies if required. For example, inlet bores **174***a* through **174***d* could be manifolded into a common outlet while inlet bores **174***e* and **174***f* could be connected to a second common outlet thereby providing split flow output of different volumes. Any variation or combination of multiple flow outlets, up to and including a separate outlet for each of the pistons, can obviously be provided by proper design of the end plate manifolding systems. The pump itself could also have any desired number of pistons as the use to which it is to be put or the design requirements dictate.

What has been set forth above is intended primarily as exemplary to enable those skilled in the art in the practice of the invention and it should, therefore, be understood that, within the scope of the appended claims, the invention may be practiced in other ways than as specifically described.

What is new and, therefore, desired to be protected by Letters Patent of the United States is:

1. A hydraulic pump comprising a housing defining an inlet chamber therein, means connecting said chamber to a source of hydraulic fluid, a shaft rotatably disposed through said chamber and extending through one end of said housing, a wobble plate having a slanted transverse cam surface thereto mounted on said shaft for rotation thereby at least the cam surface of said wobble plate being formed of cast iron alloy, a barrel section connected to said housing, said barrel section defining a plurality of axially aligned cylinders communicative at one end thereof with said chamber, a piston slidably disposed in each of said cylinders, each of said pistons having an axial bore therethrough communicating with said chamber, check valve means in each of said pistons to block flow of fluid therethrough in the direction of said chamber, a bronze shoe swivelly mounted on the chamber end of each of said pistons to engage the cam surface of said wobble plate, means to bias each of said pistons towards said wobble plate to maintain continuous contact between the cam surface and said shoe, an end plate removably connected to the free end of said barrel section, said end plate defining a plurality of outlet bores therein, at least one outlet fitting on said end plate, each of the outlet bores disposed to provide communication between one of said cylinders and an outlet fitting, and ball check valve means disposed in each of said outlet bores to block the flow therethrough in the direction of said cylinders, said check valve means including an annular soft steel bushing having a seat tapered approximately 36° to the center line coaxially formed in one end thereof, and a hard steel ball resiliently biased against said seat, the ratio of the diameter of the bore in said bushing to said ball being approximately 5 to 6 whereby initial operation of the check valve deforms said seat to conform to the contacted portion of said ball to thereby provide suitable sealing therebetween.

2. A pump in accordance with claim **1** wherein said end plate is provided with a single outlet fitting.

3. A pump in accordance with claim **1** wherein said end plate is provided with three outlet fittings axially and circumferentially spaced from one another and communicating with said outlet bores, inlet bores extending substantially transversely of said outlet bores into said end plate, and wherein said housing defines six symmetrically disposed cylinders in communication with said inlet bores, each of said inlet bores communicating with the outlet bores corresponding to a different pair of cylinders in said housing thereby manifolding each pair of cylinders to a different outlet fitting.

4. In a pump for hydraulic fluid of the type in which pistons operating in parallel cylinders within a barrel section connected to a pump housing are operated in their pumping stroke by a drive shaft carrying a non-radially extending flat cam plate portion positioned opposite the ends of the cylinders, the improvement which comprises:

a shoe swivelly mounted on each of said pistons to engage said flat plate portion;

a single end plate having a plurality of outlet bores therein and a plurality of outlet fittings each communicating with at least one of said outlet bores, means connecting said end plate to said barrel section, at least one of said outlet bores being disposed to communicate with at least two of said cylinders, a check valve wholly within said end plate in each of said outlet conduits to block flow therethrough in the direction of said cylinders, said check valves comprising an annular soft steel bushing having a seat tapered approximately 36° to the center line coaxially formed in one end thereof, and a hard steel ball resiliently biased against said seat, the ratio of the diameter of the bore in said bushing to said ball being approximately 5 to 6 whereby initial operation of the check valve deforms said seat to conform to the contacted portion of said ball to thereby provide suitable sealing therebetween, said end plate being removable to enable substitution of an end plate having a different arrangement of outlet fittings and bores communicating with different combinations of cylinders.

References Cited

UNITED STATES PATENTS

1,757,139	5/1930	Platenberg.	
2,455,289	11/1948	Baierlein	103—73
2,940,323	6/1960	Cousins et al.	74—60
3,148,707	9/1964	Smyklo.	
2,941,475	6/1960	Blair.	
3,178,888	4/1965	Hampton	103—9
3,236,189	2/1966	Pasker.	

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U.S. Cl. X.R.

91—499; 417—554