Nov. 21, 1961 W. T. LIVERMORE ET AL 3,009,420

SLIPPER PUMP

Filed July 11, 1957 2 Sheets-Sheet 1

FIG. 1

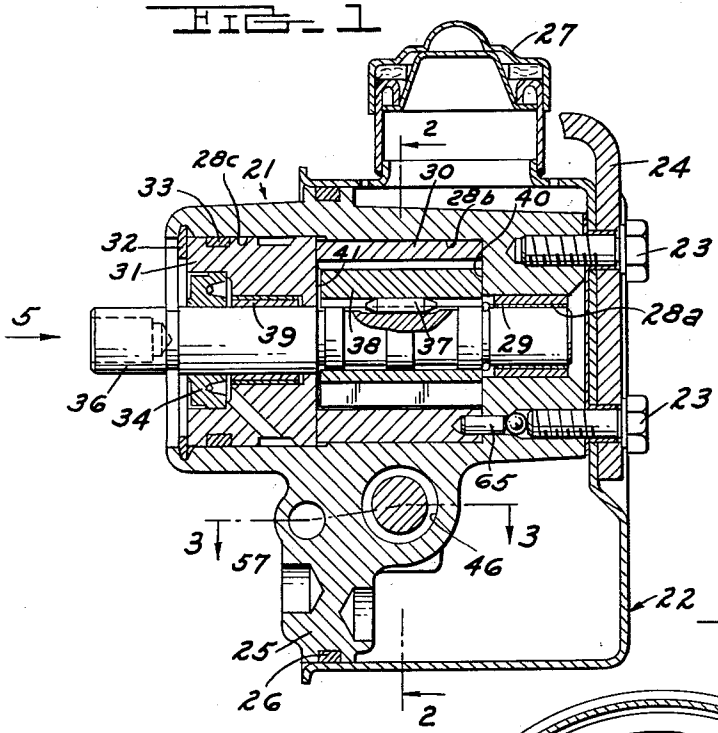


FIG. 2

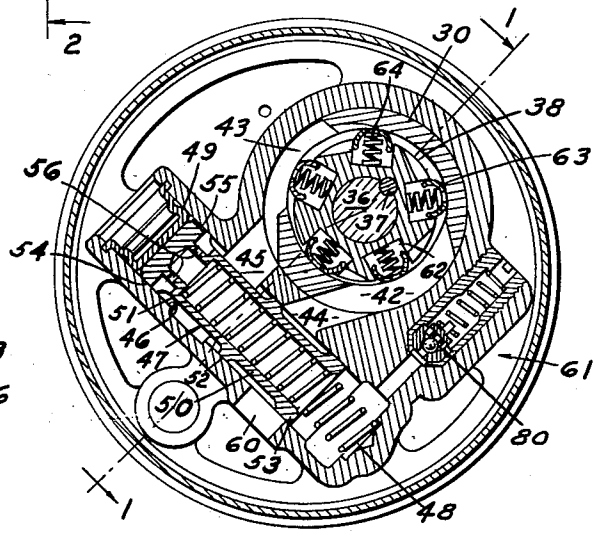
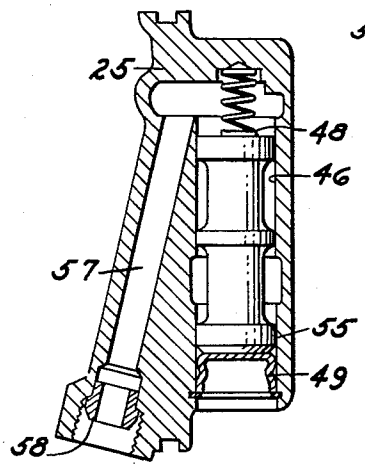


FIG. 3



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Filed July 11, 1957 2 Sheets-Sheet 2

FIG. 4

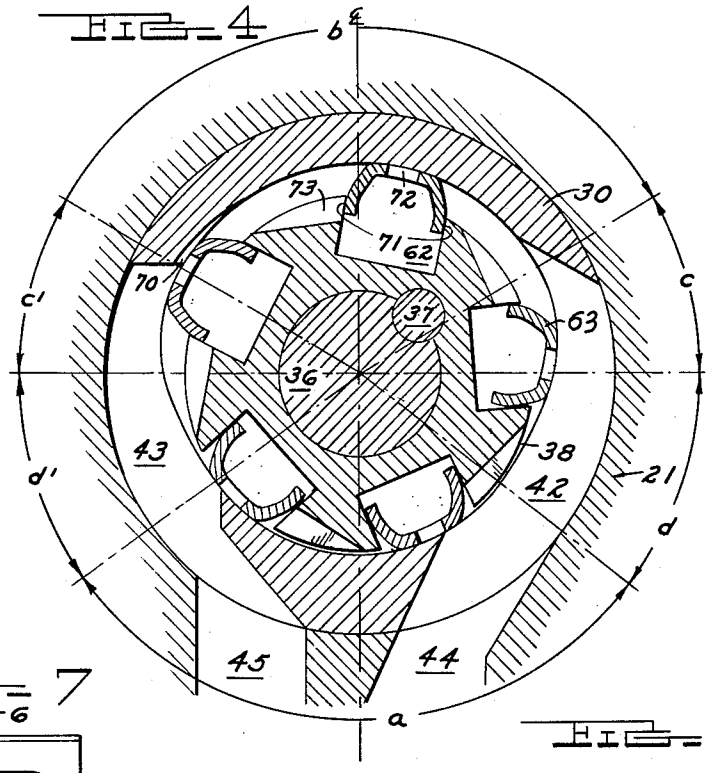


FIG. 7

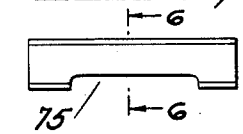


FIG. 6

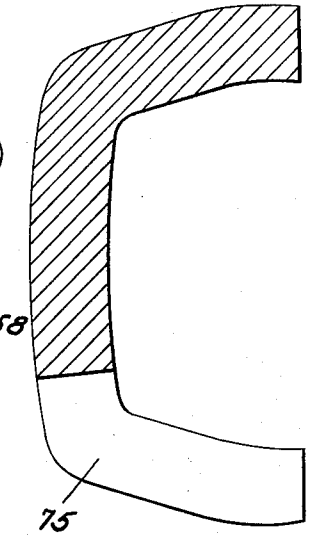
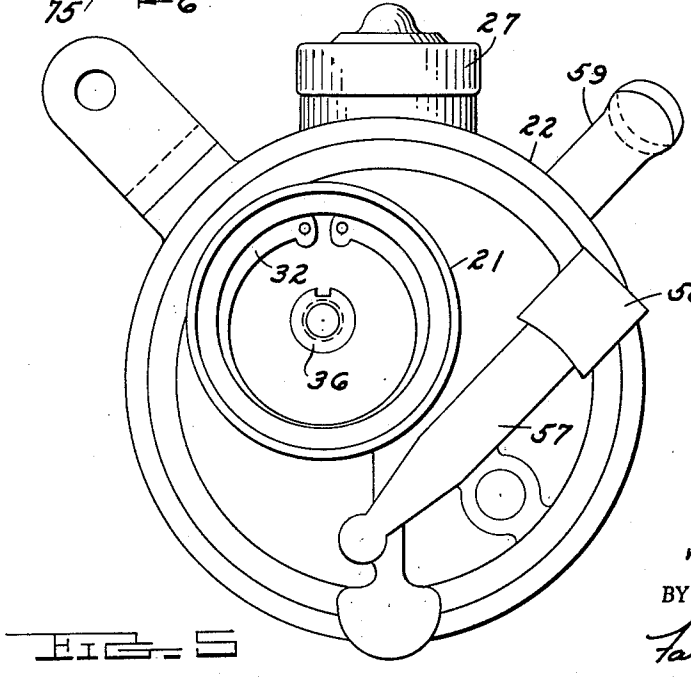


FIG. 5



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United States Patent Office 3,009,420 Patented Nov. 21, 1961

3,009,420

SLIPPER PUMP

William T. Livermore, Fort Lauderdale, Fla., and Hubert M. Clark, Birmingham, and Gilbert H. Drutchas, Detroit, Mich.; said Clark and said Drutchas assignors, by mesne assignments, to Thompson Ramo Wooldridge Inc., Cleveland, Ohio, a corporation of Ohio

Filed July 11, 1957, Ser. No. 671,273
4 Claims. (Cl. 103—135)

This invention relates to a pump assembly and, more particularly, to a slipper pump of the general type disclosed in copending application Serial No. 490,288 of William T. Livermore.

Such prior application discloses a pump and valve assembly adapted to meet the requirements of an automotive power steering pump wherein a pump rotor operates in a noncircular eccentric bore having concentric circular sealing and working arcs tangentially joined by additional circular arcs of different radii extending through the areas of the inlet and outlet ports. The rotor of such pump is provided with rectangular slots in which solid slipper-type pumping elements are free to move radially and to rock angularly when following the contour of the bore throughout the pumping operation. Such rotor is required to be closely assembled to the sealing arc of the bore in order to provide a seal between the inlet and outlet port. End plates having bearings for the rotor shaft are bolted and doweled to a center housing enclosing the pump rotor, slippers and pump bore, and in order to effect a satisfactory sealing relation between the rotor and pump bore, notwithstanding commercial tolerances, a procedure is disclosed for machining the dowel holes at assembly.

The present improved construction eliminates the necessity for any direct sealing relationship between the rotor and bore by employing the slippers as sealing elements in the sealing arc as well as the working arc of the pump, thereby eliminating the necessity for highly accurate radial location of the rotor in the pump bore. It further employs a "blind-ended bore" housing construction with an insert sleeve containing the pump bore and ports together with a header insert containing one of the rotor shaft bearings. With this construction, it is possible to machine all primary locating surfaces for the rotor shaft bearings and bore insert as concentric cylindrical surfaces in a single setup as well as one of the header walls for the inner end of the rotor.

In addition, the present pump incorporates simple U-channel-shaped sheet metal slippers which may be readily formed by stamping or roll-forming operations in place of previous solid metal slippers. In addition to cost advantages, such slipper construction materially decreases the weight of the slippers and resulting centrifugal forces contributing to bore wear, as well as providing somewhat flexible pumping elements capable of utilizing internal pressures to reduce sealing clearances with the rotor notches, and thus facilitate slipper sealing in the sealing arc. The present construction further provides auxiliary passages for filling the rotor slots under the slippers, minmizing any tendency for the slippers to "hang up" in the slots out of contact with the bore due to restrictions in the speed of filling during slipper travel in the intake arc.

From the above brief description it will be understood that one of the objects of the present invention is to provide a simplified, one-piece "blind bore" housing construction materially reducing and simplifying machining operations.

Another object is to provide a construction eliminating the necessity for assembling the rotor in direct sealing relation with the pump bore.

Another object is to adapt slippers to provide a seal between inlet and outlet ports in the sealing arc, as well as working arc of the pump.

Another object is to provide an improved U-shaped-channel slipper construction adapted for construction by sheet metal stamping or roll-forming operations.

Another object is to provide a pump bore insert construction incorporating inlet and outlet ports, a noncircular eccentric pump bore surface and a circular outer surface.

Another object is to provide U-channel-shaped slippers having radial slots for passage of oil from the ports to the space between the slipper and the rotor slots.

Another object is to provide auxiliary passages for filling the rotor slots under the slippers during the intake cycle.

Another object is to provide channel-shaped slippers flexible enough to be expanded by oil pressure within the channel to reduce sealing clearances between both "legs" of the channel and the sides of the rotor slots.

Another object is to provide notches in the leading edge of the rotor slots deep enough to conduct pressure to the space inside the slippers after initial outward radial displacement, but not deep enough to break the seal between the leading slipper legs and the rotor slots during their travel in the sealing arc.

These and other objects will be more apparent from the following detailed description of a preferred embodiment of the present pump and by reference to the drawings, in which:

FIG. 1 is a sectional side elevation of the pump, control valve, and reservoir assembly taken along the line 1—1 of FIG. 2;

FIG. 2 is a sectional end elevation taken along the line 2—2 of FIG. 1;

FIG. 3 is a fragmentary sectional view of the control valve taken along the line 3—3 of FIG. 1;

FIG. 4 is an enlarged fragmentary view of the pump rotor, slippers and bore with the rotor and slippers displaced to a different position from that shown in FIG. 2;

FIG. 5 is an end elevation of the pump assembly taken along the line 5—5 of FIG. 1;

FIG. 6 is an enlarged sectional view of a modified slipper form; and

FIG. 7 is a face view of such modified slipper form.

With reference to FIG. 1 of the drawings, the preferred embodiment of the present invention includes a pump housing **21** mounted inside of a fluid reservoir **22** and secured thereto by bolts **23** passing through mounting bracket **24**, the pump housing being adapted with an annular flange **25** and sealing ring **26** to form a fluid-tight closure for the reservoir which is filled with hydraulic fluid through cap **27**.

The pump housing is provided with three concentric cylindrical bores **28***a*, **28***b* and **28***c* forming the seats, respectively, for rotor shaft bearing **29**, a pump bore insert **30**, and a front bearing insert **31**, the latter being held in position by snap ring **32** and sealed by ring **33** and shaft seal **34** against any pump leakage from within the pump housing. A rotor drive shaft **36** is drivingly connected by key **37** to the pump rotor **38**, the rotor shaft being straddle mounted in bearings **29** and **39** for rotation about an axis coinciding with that of bores **28***a*, **28***b* and **28***c*.

Header surfaces for the pump rotor **38** are provided by the end **40** of the housing bore **28***b* and the end **41** of the bearing insert **31**, respectively. The pump bore insert **30** is in the form of a sleeve having a cylindrical outer surface adapted for press fit within the housing bore **28***b*, an eccentric inner surface forming the pump bore per se (later described in detail), an inlet port **42** and an outlet port **43**, as shown in FIGS. 2 and 4, said inlet and outlet ports extending through the sleeve wall

for respective communication with an inlet port 44 and outlet port 45 in the pump housing 21.

A cylindrical valve bore 46 in the housing intersects ports 44 and 45. A spool-type flow control valve 47 is axially movable in the valve bore and is urged by spring 48 against a plug stop 49. The valve is provided with necked portions 50 and 51, communicating respectively at all times with inlet and outlet ports 44 and 45, an intermediate sealing land 52, an end sealing land 53, and an end land 54, the latter being provided with a slight groove or flat 55 providing communication between the outlet port 45 and the corresponding end of the valve. Flow control orifices 56 provide communication from the outlet port 45 to the interior hollow end of the valve and the outlet passage 57 leading to power steering hose fitting 58. As shown in FIG. 5, a power steering return line hose fitting 59 leads directly into the side wall of the reservoir 22 from which free passage into the inlet port 44 is provided through passage 60 in the housing extending between the reservoir and valve bore 46.

A maximum pressure relief valve 61, later described in detail, is adapted to by-pass the power steering pump circuit.

As best shown in FIGS. 2 and 4, the rotor 38 is provided with a plurality of rectangular slots 62 in which U-shaped sheet metal slipper pumping elements 63 are carried and driven by the rotor to provide a pumping action between the inlet port 42 and outlet port 43, such slippers being urged by springs 64 into face engagement with the pump bore provided by the inner surface of the insert sleeve 30. Such sleeve is locked in correct angular position relative to the housing inlet and outlet ports 44 and 45 by pin 65. as shown in FIG. 1. It will, of course, be understood that the rotor slots 62 and slippers 63 extend across the entire width of the rotor and that the rotor and slippers are dimensioned to provide a running pressure sealing fit with the header surfaces 40, 41.

The general operation of the pump may best be understood by reference to FIG. 2. When the rotor 38 is driven in a counterclockwise direction, hydraulic fluid from the reservoir passes through the passage 60 around the necked portion 50 of the valve 47 through the housing inlet port 44 and the sleeve inlet port 42 where it is pumped by slipper elements 63 to the outlet port 43 and 45 in the sleeve and housing and through the orifices 56 and outlet passage 57 to the power steering circuit. Pressure in the outlet port 45 communicates through flat 55 in the valve end land 54 to the end of the valve exerting pressure against the spring 48. Fluid pressure reduced by flow through the orifices 56 operates on the other end of the valve to assist spring 48 in urging the valve to the position shown. When a predetermined flow rate through the orifices corresponding to the maximum flow rate demand of the power steering system is exceeded, the pressure differential across the orifices applied to equal valve end areas overcomes spring 48 causing the valve to shift to a position where direct flow from outlet port 45 at the edge of land 52 to the inlet port 44 occurs, providing a direct bypass and injection filling of the inlet port 42. Any pressure demand in the power steering circuit will be met at the same flow rate up to the maximum pressure established by pressure relief valve 61.

Referring to FIG. 4, the preferred pump bore disclosed is symmetrical about the center line CL and includes concentric circular arcs *a* and *b* tangentially joined by tangential circular arcs *c*, *d*, *c'*, and *d'*. Typical values for such arcs are *a*—108°, *b*—120°, *c*—30°, and *d*—36°, where, as in the present case, the radius of arc *a* is approximately 85% of the radius of arc *b*. The terminal points of the inlet and outlet ports at the bore surface coincide generally with the ends of the arcs *a* and *b* with the exception that the inlet port extends into the arc *a* a distance approximately equal to the face contact width of one slipper, and into arc *b* a distance approximately equal to one half of such face contact width, while the outlet port includes a narrow precompression notch or groove 70 which extends into arc *b* to a position just short of establishing direct communication from outlet to inlet port between adjacent slipper sealing edges, thereby providing for gradual pressurizing of the fluid column between adjacent slippers in the working arc.

The slippers are preferably constructed as U-shaped sheet metal elements formed with an outer central face arc having a radius substantially equal to the radius of the working bore arc *b* with tangential segments on either side of the central arc having a radius substantially equal to that of the minimum radius bore arc *c*, so that each slipper is positioned angularly as well as radially during their travel in both working and sealing arcs by the contact or spanning of a substantial peripheral arc of the bore, while the end 71 of the slipper legs are formed as segments of a common circle having a diameter substantially equal to the width of the rotor slot 62 less a slight working clearance which will permit the slipper to rock within the slot as required to follow the contour of the pump bore. A radial slot 72 in the face of each slipper provides direct communication between the rotor slot and the inlet or outlet ports during the slipper travel therethrough and an auxiliary flow passage is provided by a rotor notch 73 extending part way across the leading edge of each rotor slot. Such notch may be limited to the width of the port in the insert sleeves 30, which are centrally located and less than the width of the rotor, leaving a contact surface for the leg of the slipper on either end or, for manufacturing convenience, the notch 73 may start at one side face of the rotor and extend part way across, for example, approximately half way, leaving the remaining half of the rotor slot rectangular for confining contact with the slipper leg. In either case, it is preferred to limit the notch 73 to a depth such that the leading edge of the slipper leg will not uncover such notch during its travel in the sealing arc *a* but will begin to uncover such notch as it moves radially outwardly in the intake arc. This auxiliary filling path, it will be seen provides in combination with the radial slot 72 substantially unrestricted flow to the rotor slot under the slipper, thus overcoming any tendency for the slipper to leave the bore during high speed operation as the result of restrictive filling, while not interfering with the seal developed between the leading legs of each slipper and its slot during travel in the sealing arc. It will be observed from an examination of the adjacent slippers in the sealing arc, as shown in FIG. 4, that at least one full slipper or equivalent portions of two adjacent slippers will be in sealing engagement with the bore face between the inlet and outlet ports at all times, making it unnecessary for the rotor itself to form a seal with the bore surface. Such "slipper seal" construction greatly facilitates manufacturing by eliminating high precision tolerances for all component dimensions affecting the clearance between the rotor and the rotor bore, selective fitting or other costly alternatives, and also contributes to the feasibility of the present "blind bore" housing construction wherein the concentric cylindrical surfaces 28*a*, 28*b* and 28*c* as well as the header face 40 may all be finish machined in a single setup, greatly reducing the cost over previous construction methods.

In insuring adequate "slipper sealing" between the inlet and outlet ports, the U-shaped sheet metal slipper construction has also been found to provide an important contributing factor inasmuch as the slippers may be constructed with sufficient flexibility to permit a slight spreading of the legs from internal pressure within the notch as the slipper leaves the outlet port, thereby reducing the sealing clearances between the slipper legs and the rotor slot during each slipper's travel through the sealing arc. In addition, the relative lightness of weight of this form of slipper compared to previous solid slipper

forms greatly reduces the centrifugal forces contributing to bore wear.

An alternative slipper construction is shown in FIGS. 6 and 7 wherein a notch **75** is provided in the leading leg of each slipper instead of the radial slot **72**. It is preferable in such alternative construction for the notch to extend all the way up to the contact face as shown in order to provide a "scoop" action in filling the slot during travel through the intake arc. A tangent seal between the rotor and bore is used with this slipper.

Referring again to FIG. 2, in order to insure quietness of relief valve operation, the ball check valve **61** is provided with a washer plunger **80** which fits closely within the cylindrical bore adjacent the ball seat, the edge of such washer being provided with flats or grooves to limit and control the return rate of the ball to its seat after opening. The closely fitting washer bore is limited in depth to permit substantially unrestricted outflow when the ball is raised from its seat, thereby operating only to limit the return rate of the ball to its seat and dampen out "hunting" action contributing to noisy relief valve operation.

While a preferred embodiment of the present pump has been described above in detail, it will be understood that numerous modifications might be resorted to without departing from the scope of our invention as defined in the following claims.

We claim:

1. A slipper type pump having a pump bore, a rotor mounted eccentrically in said bore providing a chamber therebetween, slots in said rotor, slippers carried in said slots adapted to engage said bore throughout successive portions of said chamber corresponding to a sealing arc including minimum spacing between rotor and bore, an inlet arc of increasing spacing, a working arc including maximum spacing, and an outlet arc of decreasing spacing, and radial inlet and outlet ports communicating with said bore respectively at said inlet and outlet arc portions of said chamber; characterized by each slipper being formed with a uniform channel cross section extending throughout its entire length providing fully open channel ends and a circumferential bore arc spanning outer base face adapted to control the angular as well as radial position of said slipper in its rotor slot, the radially inwardly extending channel legs of each slipper having outer surfaces dimensioned relative to the rotor slot with working clearance providing freedom of angular adjustment and being flexibly spreadable when the effective pressure internally of said slipper exceeds the effective external pressure to effectively reduce said clearance, and said slipper being slotted in its bore arc spanning face for registration with said radial inlet and outlet ports.

2. A slipper type pump as set forth in claim 1 wherein the spacing of said slippers relative to said sealing arc is such that at least one slipper is interposed in sealing relation with said bore and rotor in the sealing arc between said inlet and outlet ports as well as in the working arc between said inlet and outlet ports at all times, said higher internal pressure being effective to reduce clearance when a slipper is within said sealing arc with the outer surface of the leading leg exposed to inlet pressure.

3. A slipper type pump as set forth in claim 1 wherein the leading edge of each rotor slot is notched to provide open flow to the underside of said slipper when it moves radially outward.

4. A pump as set forth in claim 1 wherein said working and sealing arcs are concentric with said rotor, and said inlet and outlet arcs are smoothly curved to tangentially join adjacent ends of said working and sealing arcs.

References Cited in the file of this patent

UNITED STATES PATENTS

319,093	Hassinger	June 2, 1885
892,443	Ostrander	July 7, 1908
2,165,963	Curtis	July 11, 1939
2,192,588	Heckert	Mar. 5, 1940
2,312,886	Ellinwood	Mar. 2, 1943
2,455,303	Grate	Nov. 30, 1948
2,499,763	Livermore	Mar. 7, 1950
2,525,619	Roth et al.	Oct. 10, 1950
2,846,138	Racklyeft	Aug. 5, 1958

FOREIGN PATENTS

8,123	Great Britain	of 1910
31,237	France	Sept. 21, 1926
110,165	Switzerland	May 16, 1925
139,905	Switzerland	July 16, 1930
286,240	Great Britain	Aug. 27, 1927
414,965	Germany	June 16, 1925
636,513	Great Britain	May 3, 1950