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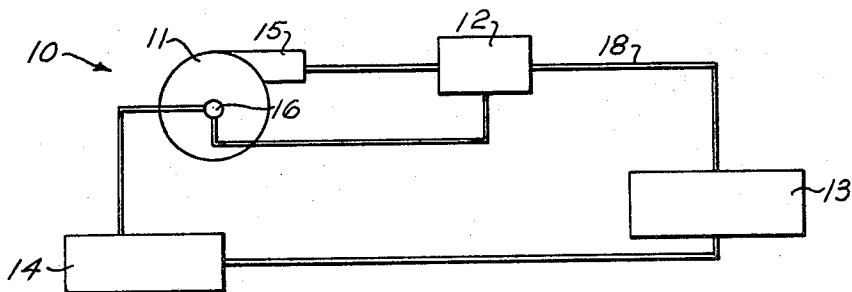


FIG. 1

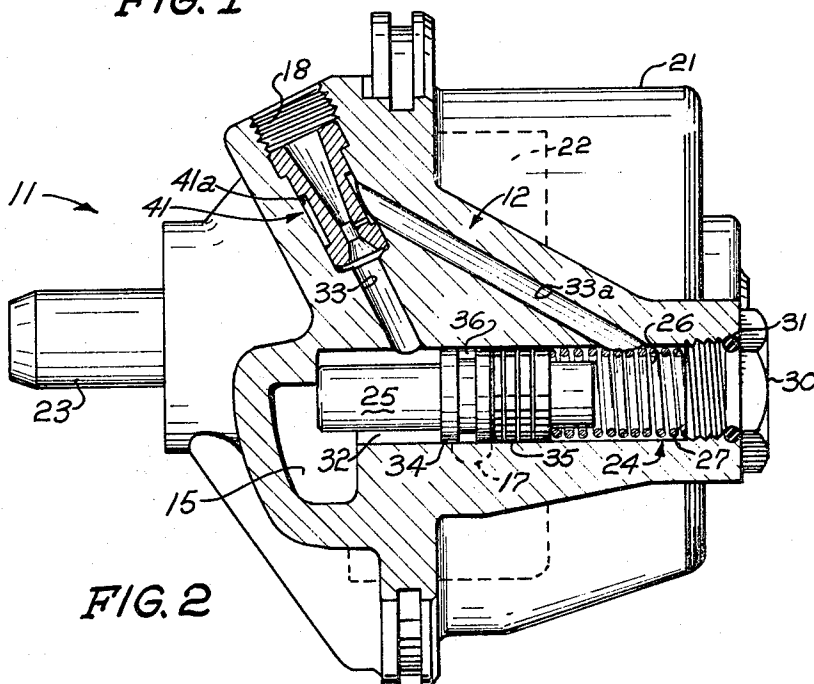


FIG. 2

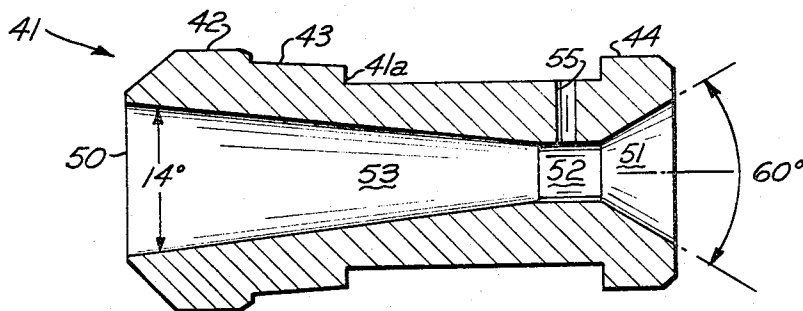


FIG. 3

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ABSTRACT OF THE DISCLOSURE

The present invention relates to a pump and more particularly relates to a pump having flow control means associated therewith for providing a controlled output of fluid therefrom. The flow control means includes a valve for diverting from a hydraulic system a portion of the pump's fluid output and a nozzle for controlling operation of the valve.

For certain applications, it is desirable to provide a pump which maintains a relatively constant fluid output regardless of pump speed. Such an application is in automotive power steering pumps. In previously known hydraulic pumps, means for providing a relatively constant flow of output fluid have been provided. In some instances a valve has been provided to bypass fluid from the discharge of the pump to the intake thereof in response to pressure differentials created across the valve. Flow restricting orifices have sometimes been used to provide the aforementioned pressure differential but the use of these orifices has resulted in unrecoverable pressure losses as fluid from the pump passes therethrough. Since pressure is dissipated in the form of heat in the fluid, such orifices have contributed to undesirable high temperatures of the pumped fluid in the hydraulic system supplied by the pump. Moreover pressure losses caused by the use of such orifices have resulted in increased power requirements for the pump when it supplies fluid at a given pressure. It is important to reduce power steering system temperatures since high speed engines, increased traveling speeds and the added heat load of air conditioning have led to increases in fluid temperatures in such systems. Minimizing the power required to operate the pump of the power steering system is also desirable for obvious reasons.

Accordingly, an important object of the present invention is the provision of a new and improved pump having a valve controlling the flow of discharge from the pump in response to a pressure differential across the valve and wherein the pressure differential is controlled by a flow restriction which is associated with the valve and pump mechanism so as to minimize increases in the temperature of the pumped fluid and to minimize power requirements for the pump.

Another object of the present invention is the provision of a new and improved flow control means for a pump which includes a valve movable in response to differential pressures acting on portions thereof to provide a regulated flow of fluid from the pump and a converging-diverging nozzle having a throat section with a pressure tap communicating the low pressure of the fluid at the throat with a portion of the valve and wherein the pressure drop across the nozzle is minimized and less than the pressure drop between the pumping chamber and the throat so that

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the power requirements for the pump in supplying fluid at a given pressure are minimized.

A further object of the present invention is the provision of a new and improved flow control means for a pump, as set forth in the next preceding paragraph wherein the pressure of the fluid is lowest at the nozzle throat section and the pressure of the fluid is increased as the fluid flows through the diverging section of the nozzle so that total pressure drop across the nozzle is minimized.

Other objects and advantages of the present invention will become apparent from a consideration of the following detailed description of a preferred embodiment thereof as well as from the drawings in which:

FIG. 1 is a schematic view of a fluid system embodying the present invention;

FIG. 2 is an elevational view of a portion of the fluid system of FIG. 1 with parts in section; and

FIG. 3 is a sectional view of a portion of FIG. 2.

The present invention provides an improved pump having a flow controlling means associated therewith for providing a substantially constant flow of discharge fluid from the pump to a hydraulic system. A pump embodying the present invention is particularly useful for providing motive fluid to a power steering actuating mechanism for use in automotive vehicles and is described herein in reference to such a use. However, it should be apparent that a flow controlling means of the type described herein is adapted for use in any fluid system having a variable source of fluid and requiring a substantially constant supply of fluid to be delivered from the source.

As representing the present invention, FIG. 1 illustrates a hydraulic system 10 embodying the present invention. The system 10 includes a pump 11 and flow controlling apparatus 12 for supplying a substantially constant flow of fluid to a hydraulically operated mechanism 13 forming a part of a power steering mechanism. The mechanism 13 utilizes the energy of the pumped fluid to turn the wheels of the vehicle, not shown, and exhaust the fluid to a reservoir 14 from which the fluid is recirculated through the system.

The pump 11 is preferably a rotary pump having a discharge 15 and an inlet 16. The flow controlling apparatus 12 is shown schematically as situated between the pump discharge 15 and the mechanism 13 and communicates with the pump inlet 16. The apparatus 12 is operative to provide a substantially constant flow of fluid to the mechanism 13 through a discharge passageway 18 by diverting quantities of the pumped fluid from the discharge 15 back to the pump inlet 16 through a port 17, see FIG. 2. The pump 11 is a rotary pump having a housing 21 which supports a pump rotor 22 therein and which is driven by an input shaft 23 which is connected to the vehicle engine by suitable means such as a belt and pulley arrangement, not shown.

The flow control apparatus 12 includes a cylindrical valve chamber 24 having openings therein communicating with the discharge 15 of the pump and the pump inlet 16. A cylindrical valve member 25 is snugly and slidably received in the chamber 24 and is biased toward the discharge 15 by a coil spring 26. The chamber 24 is closed at an end 27 thereof opposite the discharge 15 by a threaded plug 30 which forms a seat for the spring 26. The plug 30 includes an arcuate portion adjacent a head thereof for receiving an O-ring 31 which is effective to

form a seal between the plug 30 and the wall of the chamber 24.

The chamber 24 communicates directly with the discharge 15, and fluid flows into the chamber 24 from the discharge 15. This fluid flows into a portion 32 of the chamber 24 and exerts pressure on an end of the valve member 25 before flowing from the chamber to a flow passage 33 through which it is conducted to the mechanism 13. Fluid entering the chamber portion 32 from the discharge 15 is prevented from passing around the valve body 25 by lands 34, 35 formed on the valve member which are snugly engaged with the cylindrical wall of the chamber. The lands 34, 35 of the valve member 25 are spaced apart to define an annular channel 36 in the periphery of the valve body 25 which, in the position of the valve shown in FIG. 2, communicates with the inlet 17. The land portion 35 includes a plurality of annular grooves extending therearound which are operative to decrease the amount of sliding friction between the valve body and the chamber 24, as well as to provide a tortuous path seal along the periphery of valve member. The annular grooves extending around the land portion 35 additionally act to balance the fluid pressure around the valve member allowing it to float centrally in the chamber 24.

In accordance with the present invention the flow control means 12 includes flow restricting means between the pump discharge and the system for providing a pressure differential across the valve member 24 and a minimum pressure loss in fluid flowing therethrough to the system. The flow restricting means includes a flow restrictor member or nozzle 41 operable to decrease the pressure of fluid flowing thereto and to increase the pressure of the fluid as it flows therefrom. The operation of the restrictor member 41 is effective to minimize temperature rises in the system fluid due to pressure losses and to reduce the power required by the pump 10 to supply fluid to the system at a given pressure.

As shown in the drawings, the pumped fluid flowing from the chamber portion 32 of the chamber 24 into the passage 33 flows through the flow restrictor member or nozzle 41 and to the mechanism 13 through the discharge passageway 18. The flow restrictor member 41 is an annular generally cylindrical member having a head portion 42 and a pair of spaced lands 43, 44 which are sealingly engaged with walls of the passageway 33. The land 43 is formed with a slight taper on its periphery with the small end of the taper remote from the head portion 42 so that the restrictor member 41 may be forced into the passage 33 and tightly seated therein by wedging engagement between the wall of the passageway and the land 43. The restrictor member also has an annular groove 41a around the periphery thereof. When the restrictor member 41 is seated in the passage 33 an annular chamber is formed on the outer periphery of the restrictor member 41, which chamber is defined by the groove 41a and the wall of the passage 33.

A fluid passage 50 extends axially through the restrictor member 41 and forms a converging-diverging nozzle having a frusto-conical or converging inlet section 51, a throat section 52, and a frusto-conical or diverging outlet section 53. Fluid flowing through the passage 50 is accelerated as it flows through the converging section 51 toward the throat 52. The velocity of the fluid is maximum and the pressure thereof is a minimum as the fluid passes through the throat section 52. As the discharge fluid flows through the diverging section 53 of the passage 50, the velocity thereof is gradually decreased and its pressure correspondingly increased.

The included angle of the converging section is preferably approximately 60 degrees as indicated in FIG. 3 and the included angle of the diverging section is preferably approximately 14 degrees. In the preferred embodiment the axial length of the converging section 51 is approximately the same as the axial length of the throat section 52 while the diverging section 53 has an axial length

preferably approximately seven times longer than the throat section 52. This nozzle configuration is effective to reduce internal pressures in the pump by reducing pressure losses in the restriction.

The throat section 52 at which the pressure of the fluid is at a minimum communicates with the end 27 of the chamber 24 by means of a passageway 33a connecting the end 27 of the valve chamber 24 with the groove 41a and by a port 55 formed in the member 41 and connecting the throat section 52 to the groove 41a. The port 55, the groove 41a and the passage 33a are operative to communicate the static pressure of the fluid in the throat 52 of the restrictor member 41 with the end 27 of the valve chamber 24.

The valve member 25 is axially movable in the chamber 24 in response to differential forces acting thereon. These differential forces are produced by the pressure of the fluid from the pump discharge acting on the valve member at the chamber portion 32 and the combined forces of the spring 26 and the pressure of the fluid at the throat 52 of the restrictor 41 exerted on the valve member at the end 27 of the chamber. When the valve member 25 is in its position shown in FIG. 2, the pump is stopped, or rotating very slowly, and the force of the spring 26 is effective to hold the valve member 25 in its far left position with an end thereof in abutment with a wall of the chamber 24. When the pump rotor 22 rotates faster, the pressure in the discharge chamber 15 increases and produces a force tending to move the valve to the right, as viewed in the drawings, against the bias of the spring 26 and the fluid pressure of the throat 52 of the restrictor member 41.

When the pressure differential and resulting force acting on the valve member 25 has increased to a value sufficient to overcome the force exerted by the spring 26, the valve member 25 moves to the right as viewed in the drawings. As the valve member moves to the right in response to the differential force acting thereon, the land 34 of the valve member 25 moves across the port 17 which is located between the chamber 24 and the inlet 16, causing a quantity of the discharge fluid in the chamber portion 32 to be bypassed from the chamber portion 32 to the pump inlet 16.

As the pump fluid is bypassed as described, the amount of fluid which will be directed through the restrictor 41 and on to the discharge passageway 18 will be reduced and as a result, the pressure difference between the chamber 15 and the end 27 of the chamber 24 will also be reduced. Therefore, when the quantity of bypassed fluid is such that the pressure in the end 32 of the chamber 24 is balanced by the spring force and the fluid pressure acting on the valve member 25 at the end 27 of the chamber, the valve ceases to move in the chamber. Since the flow of the fluid in the discharge 15 is increased and decreased in response to rotational speed of the rotor 22, the valve moves longitudinally back and forth in the chamber 24 in response to such changes in speed, to bypass greater or lesser quantities of pumped fluid. This action of the valve member 25 is effective to maintain the flow of discharge fluid constant through the operating range of the pump.

From the above, it should be apparent that the flow restrictor nozzle 41 reduces the pressure of the discharge fluid from the pump as the fluid passes through the throat portion of the restrictor to provide a pressure differential across the valve member 25. Further, due to the construction of the gently diverging nozzle section 53, the pressure of the fluid which has flowed through the throat portion is increased with the result that the pressure at the discharge passageway 18 is only slightly reduced in relationship to the fluid pressure in the passageway 33. Flow restricting orifices which have been utilized in previously known pumps to provide a pressure differential across a control valve have no means for replenishing the pressure losses thereacross. To provide a given pressure at the discharge passageway of such known pumps, increased

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power must be supplied to the pump to provide a higher pressure at the discharge 15 of the pump. Due to the increased power requirement of the pump and the pressure losses across such orifices, undesirable increases in temperatures of the system result.

It can now be seen that an improved pump having a flow controlling valve movable in response to differential pressure forces acting on portions thereof has been provided, and in which a converging-diverging nozzle provides a pressure at one side of the valve, and the pump discharge fluid provides pressure at the other side of the valve. It should further be appreciated that in a pump embodying the present invention the flow restricting nozzle is effective to produce a minimum drop in fluid pressure between the pump discharge and the fluid system so that fluid pressure in the pumping chamber is minimized to reduce power requirements of the pump, while the nozzle is effective to provide a flow dependent pressure differential across a flow controlling valve of the pump. Such a pump when used in conjunction with a fluid system such as an automotive power steering system is extremely effective in maintaining generally low fluid temperatures in the system as a result of the low pressure losses and decreased power required by the pump.

While a preferred embodiment of the present invention has been illustrated and described in considerable detail, the invention is not to be considered to be limited to the precise construction shown. It is my intention to cover hereby all adaptations, modifications and uses of the present invention which come within the scope of the appended claims.

Having described my invention, I claim:

1. A pump for supplying fluid to an external fluid system comprising, pumping means operable to provide a flow of fluid, a discharge passage communicating with said pumping means for directing fluid flow to the system, and flow control means operably associated with said discharge passage of said pump for maintaining a substantially constant flow of pumped fluid to said system, said flow control means including a valve member movable in response to differentials in fluid pressure acting thereon to divert discharge fluid of the pump from the system, a flow restricting means for creating a differential pressure on said valve member, said flow restricting means including a fluid passageway conducting pumped fluid from said discharge passage to said system, said fluid passageway including a portion of reduced flow area providing a high fluid velocity for a given flow rate of fluid passing therethrough and a corresponding decrease in pressure of said fluid flowing therethrough, a frusto-conical portion diverging at an included angle of approximately 14 degrees from said reduced flow area portion in the direction of fluid flow and operable to reduce the velocity of fluid flowing therethrough and thereby increasing the pressure thereof to provide a minimum pressure drop across said flow restricting means, and a second frusto-conical portion converging toward said reduced flow area portion for increasing the velocity of fluid flowing therethrough, and pressure tap means communicating with said reduced area portion of said passageway and communicating the pressure of said fluid therein to said valve member.

2. A pump as defined in claim 1 wherein said converging frusto-conical portion has included angle of approximately 60 degrees.

3. A pump as defined in claim 1 wherein said diverging frusto-conical portion is of substantially greater longitudinal dimension than said portion of reduced flow areas.

4. In a flow control apparatus for providing a substantially constant flow of fluid to a hydraulic system from a source having a variable fluid output, a valve member movable in response to pressure differentials acting thereon to divert said fluid output from said system in quantities to maintain said substantially constant flow and flow restriction means between said valve member and said system, said flow restriction means including a nozzle

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having a converging inlet section and a diverging outlet section connected by a reduced flow throat portion, pressure tap means communicating fluid pressure from said throat portion to a portion of said valve, said converging section having an included angle of approximately 60 degrees, said diverging section having a frusto-conical portion diverging away from said converging portion and having an included angle of approximately 14 degrees and being of substantially greater length than said converging section and operable to decrease the velocity of fluid flowing therethrough to provide a minimum pressure drop across said restriction means.

5. An apparatus of the type defined in claim 4 wherein said flow restricting means includes an annular channel communicating with said pressure tap and said valve.

6. An apparatus of the type defined in claim 5 wherein said diverging section is approximately seven times the length of said throat section.

7. A pump for providing a predetermined rate of flow of fluid to a hydraulic system, said pump comprising a housing, pump means in said housing and operable to provide a variable flow of fluid, said housing having a bore formed therein, valve means located in said bore for maintaining said predetermined flow rate by diverting from said hydraulic system a portion of said fluid output when said fluid output exceeds said predetermined rate of flow, a nozzle through which fluid flows at said predetermined rate to said system said nozzle being mounted in said housing and having a converging inlet portion connected in fluid communication with said source of fluid through one passage formed in said housing, a diverging outlet portion of substantially greater length than said converging inlet portion and operable to decrease the velocity of fluid flowing therethrough to provide a minimum pressure drop across said nozzle, and a throat portion interconnecting said converging inlet portion and said diverging outlet portion to provide a source of varying pressure which varies as a function of variations in the output of fluid from said source of fluid, said valve means having one side connected in fluid communication with said source of fluid and another side connected in fluid communication with said throat by another passage formed in said housing whereby said valve means is movable in said bore to vary said diverting of fluid as a function of the variations in the output of fluid from said source of fluid to thereby maintain said predetermined rate of flow of fluid through said nozzle to said hydraulic system.

8. A pump as set forth in claim 7 wherein said valve means includes a valve member slidably mounted in said bore, said bore having one end portion separated from another end portion by an intermediate portion connected to a by-pass passage formed in said housing and through which fluid is diverted from said hydraulic system, said one end portion of said bore being connected in fluid communication with both said sources of fluid and said converging inlet portion of said nozzle, said other end portion of said bore being connected in fluid communication with said throat portion of said nozzle by said other passage, said valve member being slidable in said bore between a first position blocking a flow of fluid from said source of fluid to said intermediate portion of said bore and a second position enabling fluid to flow from said source of fluid to said intermediate portion of said bore to thereby divert fluid from said hydraulic system through said by-pass passage, and spring means located in said bore and engaging said valve member and said housing to urge said valve member toward said first position, said valve member being moved from said first position to said second position by fluid pressure on said one side of said valve member when said fluid output exceeds said predetermined rate of flow to maintain said predetermined rate of fluid flow through said nozzle to said hydraulic system, said valve member being moved from said second position to said first position by said spring means and fluid pressure con-

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ducted through said other passage from said throat portion of said nozzle and applied against said other side of said valve member when said fluid output is substantially the same as said predetermined rate of flow.

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