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VARIABLE FLOW HYDRAULIC SYSTEM WITH RESERVE FLUID EDUCTOR

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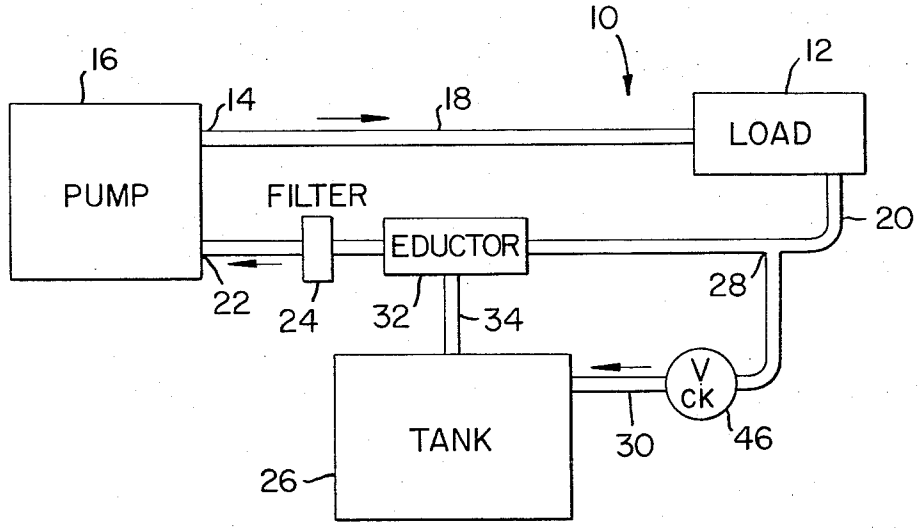


FIG_1

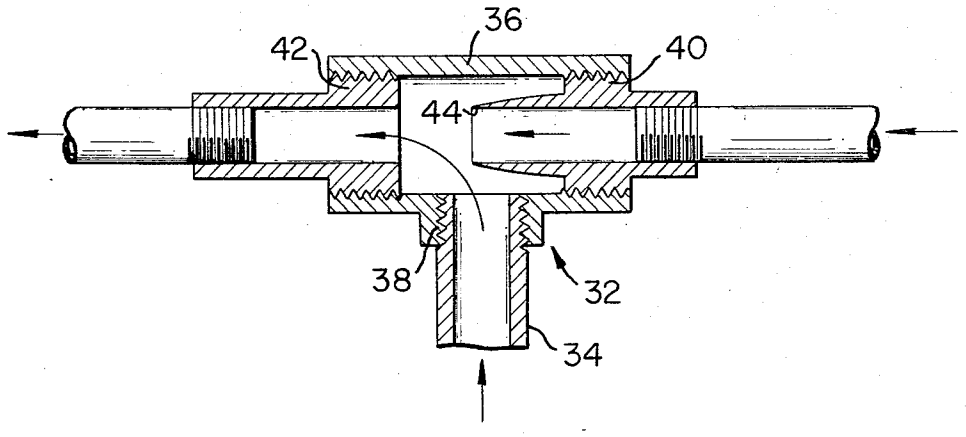


FIG_2

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VARIABLE FLOW HYDRAULIC SYSTEM WITH RESERVE FLUID EDUCTOR

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This invention relates to improvements in hydraulic systems, and more particularly, to hydraulic circuitry utilizing a hydraulic pump.

The present invention resides in the provision of improved fluid supply apparatus for the inlet or suction side of a hydraulic pump to prevent its inlet fluid pressure from decreasing beyond a lower limit. Below such limit, the efficiency of the pump begins to decrease. Also, structural damage may occur from excessive component vibrations caused by opposed positive and negative pressures on such components. This invention permits additional hydraulic fluid to be directed into the pump inlet as the inlet fluid pressure starts to decrease. Thus, the aforesaid lower limit is not reached. The invention is suitable for use with a constant flow pump as well as a variable flow pump.

To accomplish this end, the return flow conduit coupled to the inlet of the pump is tapped upstream of this inlet to allow a certain portion of the return fluid flow to be diverted into a closed tank containing a supply of the fluid. A suction device coupled to the tank and disposed in the return conduit downstream of the tap is responsive to the inlet fluid pressure of the pump to draw make-up fluid out of the tank and into the fluid moving toward the pump inlet. Thus, as the fluid demand placed on the pump by the external circuit increases, the inlet pressure of the pump tends to decrease to, in turn, cause the suction device to draw a proportionately greater volume of fluid out of the tank and into the return flow to the pump. Conversely, as the fluid demand of the pump decreases, a smaller volume is drawn out of the tank and into the fluid line of the return flow conduit. The fluid flow into the tank from the tap increases and decreases proportionately in accordance with the fluid flow increase and decrease out of the tank. This tapped flow thus maintains the tank at essentially constant volume within the operating range of the pump. This invention is, therefore, highly sensitive to variations in the fluid demand of the external circuit due to changing load conditions and assures that the pump will immediately provide the fluid necessary to sustain the system in operation notwithstanding sudden changes in this demand.

In the past, fluid volume changes in an external hydraulic circuit have been provided for by a precharge pump coupled with the main pump to direct a constant volume of hydraulic fluid to the inlet side of the pump regardless of the demand. Any excess flow out of the main pump is diverted back to the precharge pump before the fluid flow passes into the load of the circuit. Since the precharge pump is restricted to the constant volume of fluid which it pumps, its use is limited because it cannot provide for fluid demands above this constant volume. To increase the capacity of the precharge pump might cause excessive fluid to be delivered to the main pump, resulting in increased power required to operate the same. The precharge pump also requires an external power source. Thus, equipment costs could be quite high and, since a precharge pump has moving parts, maintenance always remains a problem.

Another problem in a hydraulic system is the filtering action that must be relied upon to maintain the hydraulic fluid substantially free of impurities as it passes through the main pump. In most systems, it is necessary to drive the fluid through a filter in order to prevent the inlet pressure mentioned above from decreasing to the danger limit. To permit the use of precharge pumps of small capacity for this purpose, the effective area of this filter must be relatively large.

The present invention avoids the problems mentioned above by providing a reserve fluid supply operated in response to changes in the inlet fluid pressure of the main pump. In this way, a greater or lesser amount of fluid can be added to the return flow to the pump according to the fluid demand of the external circuit connected to the pump. The supply is thus able to meet the required demands of the main pump such that, as these demands increase and decrease, the flow from the tank toward the pump inlet also increases and decreases proportionately.

The suction device used in the present invention has no moving parts inasmuch as it operates on the Bernoulli principle. Thus, it requires substantially no maintenance. Fatigue and wear problems are of no consequence. Hence, it has an indefinite operating life.

The invention is highly efficient when the fluid demand of the main pump is high whereas a conventional precharge pump, because of its fixed volume output, has a low efficiency at high volume demands. Moreover, the efficiency of the precharge pump progressively decreases as the volume demands increase. The present invention, however, becomes more efficient as the demand increases since greater suction action of the suction device more readily draws fluid from the supply tank and into the return flow to the pump inlet.

The size of the filter required for use with the present invention can be smaller than the filter size required for a conventional precharge pump. This is because instead of the constant volume of fluid delivered by a conventional precharge pump the suction device will deliver a variable volume of fluid depending on the demand from the main pump. Since the device is sensitive to the full range of maximum to minimum demands of the main pump, the average volume of fluid there will be substantially smaller than the volume of the constant flow delivered by a conventional precharge pump. Hence, the size of the filter can also be smaller.

The present invention also avoids fluid losses due to system leakage. There is always a certain amount of leakage occurring in system components operated under pressure. Such leakage fluid can readily be recovered by collecting it and returning it to the supply tank.

It is, therefore, the primary object of this invention to provide improved fluid supply apparatus for use with a hydraulic pump as a reserve source of fluid operated by the pump itself so that a sufficient amount of fluid will always be available for delivery to the pump inlet to meet the fluid demands placed on the pump outlet by the external hydraulic circuit connected thereto.

A further object of the present invention is the provision of fluid supply apparatus of the type described which is responsive to the inlet fluid pressure of the pump so that a decrease or increase of this pressure will immediately cause the apparatus to provide a proportionate increase or decrease respectively, in the fluid supplied to the pump inlet.

Another object of the invention is to provide apparatus of the type described which has no moving parts by virtue of its reliance only on the flow of fluid, so that it requires substantially no maintenance and has a relatively long operating life.

Another object of the present invention is to provide fluid supply apparatus for a hydraulic pump of either the variable flow type or constant flow type wherein the apparatus is responsive only to the inlet fluid pressure of the pump so that a relatively small fluid filter can be employed.

In the drawings:

FIG. 1 is a schematic view of a hydraulic system using the structure of the invention; and

FIG. 2 is a cross sectional view of the suction device forming a part of the invention.

To illustrate the invention, it is shown in FIG. 1 with a hydraulic circuit 10 having a fluid-actuated load 12 coupled by a conduit 18 to the fluid outlet 14 of a hydraulic pump 16. A conduit 20 extends from load 12 to the fluid inlet 22 of pump 16 to complete the circuit. A filter 24 is disposed across the return fluid flow through conduit 20 to assure the removal of impurities from the hydraulic fluid before it flows into pump 16.

The reserve fluid supply apparatus includes a fluid tank 26 in fluid communication with conduit 20 at location 28 thereon by a conduit 30. Tank 26 is also coupled by fluid passage means to conduit 20 between filter 24 and location 28. Such fluid passage means includes a suction device 32 connected across conduit 20 and a conduit 34 interconnecting tank 26 and device 32, the latter preferably having the configuration shown in FIG. 2.

Device 32 can be of any construction but, for purposes of illustrating the invention, is comprised of a tube 36 having an internally threaded side opening 38 for threadably receiving conduit 34. The ends of tube 36 are threaded to threadably receive, respectively, a pair of fittings 40 and 42.

Since device 32 is positioned across the fluid flow path through conduit 20, this conduit is divided into two sections, the section upstream of device 32 being removably coupled to fitting 40 and the downstream section being removably coupled to fitting 42. Filter 24 is coupled across the downstream section in order to be between the pump and device 32.

Fitting 40 provides a fixed orifice for device 32 and has an innermost portion 44 located with respect to the proximal end of conduit 34 to educe a flow through this conduit from tank 26. Thus, device 32 comprises an eductor which operates on the Bernoulli principle to create an area of reduced fluid pressure at the proximal end of conduit 34.

Conduit 30 is provided with a restriction to limit the flow therethrough. In a preferred form, this restriction comprises a check valve 46 responsive to fluid pressure, such as a ball valve member biased against a valve seat by a suitable spring. Check valve 46 thus provides a variable orifice for conduit 30, the orifice size being dependent upon the fluid pressure in conduit 20 adjacent to location 28.

Valve 46 is preferably of the type which remains closed until a predetermined fluid pressure is developed in conduit 20 upstream of device 32. After this pressure is reached, valve 46 will open and its orifice will progressively be greater as fluid flow out of load 12 increases. Thus, this predetermined pressure is maintained in conduit 20 at least between location 28 and portion 44.

While valve 46 is closed and as the pressure builds up in conduit 20, the velocity of the fluid issuing from portion 44 within device 32 will increase and thereby progressively decrease the fluid pressure on the upper end of conduit 34. This will cause additional fluid to be drawn out of tank 26 and into the return flow moving out of device 32. The fluid drawn out of tank 26 will generally be replenished by leakage fluid of the system directed by gravity or other means into the tank.

After valve 46 has opened, it will direct a certain amount of fluid into the tank depending upon its orifice size. The constant pressure in conduit 20 will provide for a constant velocity of fluid issuing from portion 44. Thus, the suction action from the fluid flow through fitting 40 will remain the same. However, the suction action at pump inlet 22 will be sensed by the upper end of conduit 34 so that additional fluid will be supplied to the return flow. In this way, not only will the fluid pressure in conduit 20 remain constant but also the fluid demand at pump inlet 22 will be supplied.

In operation, tank 26 is initially provided with a supply of hydraulic fluid and conduit 34 extends into this fluid supply to assure fluid flow into device 32 in response to the reduced pressure therewithin. The top of the tank is open to the atmosphere. Pump 16 is actuated in the usual manner, such as by the use of an electric motor or the like.

As pump 16 operates, it pumps hydraulic fluid through conduit 18 to load 12, following which the fluid passes out of the load, through conduit 20 and is returned to inlet 22. At location 28, the fluid flow divides only if the fluid pressure is great enough to open valve 46. When this occurs, a portion of the fluid flows into conduit 30 while the remainder continues on through conduit 20. The portion flowing through conduit 30 will pass check valve 46 and continue on until it is received in tank 26.

The fluid flow axially through device 32 causes fluid from tank 26 to be drawn into the device so as to combine with the axial flow thereof. Leakage fluid of the system will be directed into tank 26 and this fluid will generally be sufficient to replenish the fluid drawn out of the tank by device 32 so long as valve 46 remains closed.

As the volume demand of load 12 increases, the fluid pressure at the inlet 22 of pump 16 will decrease and this decrease will be sensed at device 32. This decreased inlet pressure will tend to draw an increased volume of fluid through device 32. However, the fixed orifice defined by fitting 40 presents a restriction limiting the volume rate of fluid therethrough. As the fluid demand increases, the pressure on the upstream side of fitting 40 will also increase to the pressure determined by check valve 46. The velocity of the fluid through fitting 40 will thereby increase, to create a greater reduced pressure at the upper end of conduit 34 until this pressure is reached. A greater amount of fluid will be drawn out of tank 26 and added to the return fluid flow to pump 16.

After the predetermined pressure is reached, further fluid demand by pump inlet 22 will be sensed by the upper end of conduit 34 and additional fluid will be drawn out of tank 26. The pump is thus provided with the necessary fluid so that its inlet pressure wil lnot drop to a negative value. The efficiency of the pump is thus maintained and the possibility of structural damage of the pump components caused by negative inlet pressures is substantially eliminated.

Filter 24 is matched in size to the maximum volume of pump 16 and is disposed to effectively remove impurities from the fluid in the return flow.

If the fluid demand of load 12 decreases, the inlet pressure of pump 16 increases and this increase is sensed by device 32. The fluid flowing axially through device 32 is then decreased in velocity so that there is less suction on the upper end of conduit 34. Thus, less fluid will be drawn out of the tank and into device 32 and the fluid pressure at the fixed orifice defined by fitting 40 will decrease, thus decreasing the fluid flow into the tank through conduit 30.

As described above, the invention provides a reserve fluid supply unit to permit pump 16 to operate efficiently over a wide range of volume rates of flow. Since the structure of the invention utilizes no moving parts substantially no maintenance is required.

For a maximum volume output of a particular pump 16, fitting 40 and check valve 46 are selected to assure a predetermined minimum pressure at the pump inlet. If it is desired to change pumps to obtain a different maximum output, fitting 40 can be replaced in accordance with the desired minimum inlet pressure of the replacement pump. In this way, the invention is suitable for use with pumps of different capacities. If the pump is replaced by one with a different capacity, the remaining components of circuit 10 need not be replaced. It is only necessary to replace fitting 40.

The present invention provides a simple and rugged means of pressurizing the inlet of a variable flow or constant flow hydraulic pump to avoid the problems caused

by the presence of negative inlet pressures. The invention also provides a means of driving fluid through a relatively small filter to assure filtered fluid for the main pump. It eliminates booster pump circuits while meeting all demands of the main pump due to changing load conditions of the hydraulic system of which the pump forms a part.

While one emobdiment of this invention has been shown and described, it will be apparent that other adaptations and modifications can be made without departing from the true spirit and scope of the invention.

What is claimed is:

1. In a hydraulic fluid flow system: a hydraulic pump having a fluid inlet; a first conduit coupled to said inlet and extending outwardly from said pump for directing a return flow of hydraulic fluid thereto; a tank adapted to contain a supply of said fluid; a second conduit placing said tank in fluid communication with said first conduit at a location thereon spaced from said inlet, whereby a portion of said return flow will be directed into and retained within said tank; and fluid passage means interconnecting said tank and said first conduit at a second location on the latter between the pump and said first location and being disposed for drawing said fluid into said first conduit from said tank in response to the fluid pressure at said inlet, whereby variations in the volume rate of flow of said fluid to said inlet can be effected to permit said pump to satisfy changing load conditions of said system.

2. In a hydraulic system as set forth in claim 1, wherein said fluid passage means includes a suction device responsive to the fluid flow through said first conduit.

3. In a hydraulic system as set forth in claim 1, wherein said first conduit has a fixed orifice adjacent to said fluid passage means, said second conduit having an orifice for restricting the fluid flow therethrough.

4. In a hydraulic system as set forth in claim 1, wherein said fluid passage means includes a suction device disposed across the path of fluid flow through said first conduit, the latter having a fixed orifice at its junction with said device, said second conduit having a variable orifice responsive to the fluid pressure in said first conduit adjacent to said first location.

5. In a hydraulic system as set forth in claim 1, wherein said fluid passage means includes a tubular suction device having an inlet, and including structure defining a fixed orifice removably coupled to said device at said inlet, said first conduit having an extremity releasably connected to said structure, whereby said structure can be replaced if the operating range of the pump is to be changed.

6. In a hydraulic system as set forth in claim 1, wherein is provided a fluid filter across the path of said fluid flow through said first conduit between said pump and said second location.

7. In a hydraulic system as set forth in claim 1, wherein said fluid passage means includes a suction device disposed across the path of fluid flow through said first conduit and a third conduit interconnecting said device and said tank, said device being responsive to the fluid flow through said first conduit to draw fluid out of said tank, through said third conduit, and into said first conduit.

8. In a hydraulic fluid flow system: a hydraulic pump having a fluid inlet and a fluid outlet; a first fluid conduit coupled to said inlet and extending outwardly from the pump for directing a return flow of hydraulic fluid thereto; a tank having a supply of said fluid therewithin; a

second fluid conduit connected to said tank and said first conduit at a location on the latter in spaced relationship to said inlet, said second conduit being disposed to direct a portion of said return flow into said tank as the remainder flows through said first conduit; means defining a fluid flow restriction in said second conduit; a suction device having a pair of fluid inlet ports and a fluid outlet port, said first conduit having a first section coupled to one of said inlet ports and a second section coupled to said outlet port and to the inlet of said pump, whereby said device is disposed across the fluid flow path of said first conduit, the junction of said one inlet port and said one section defining a fixed orifice; and a third conduit placing said tank in fluid communication with the other inlet port of said device, whereby variations in the volume rate of flow of said fluid to said pump inlet can be effected to permit the pump to satisfy changing load conditions of said system.

9. A closed hydraulic fluid flow system comprising: a hydraulic pump having a fluid input and a fluid output; a fluid actuated device coupled to the output of said pump and defining a load responsive to the flow of hydraulic fluid under pressure outwardly of the pump; a first conduit connecting the device to said input of the pump to permit a return flow of said fluid to said pump; a tank adapted to contain a supply of said fluid; a second conduit placing said tank in fluid communication with said first conduit at a location thereon spaced from said inlet, whereby a portion of said return flow will be directed into and retained within said tank; and fluid passage means interconnecting said tank and said first conduit at a second location on the latter between the pump and said first location and being disposed for drawing said fluid into said first conduit from said tank in response to the fluid pressure at said inlet, whereby variations in the volume rate to flow of said fluid to said inlet can be effected to permit said pump to satisfy changing fluid flow requirements of said device.

10. A closed hydraulic fluid flow system as set forth in claim 9, wherein said fluid passage means comprises a suction device disposed across the fluid flow path defined by said first conduit, there being a fixed fluid-receiving orifice on the upstream side of said device, said second conduit having variable orifice means responsive to the fluid pressure adjacent to said fixed orifice for metering the flow of said fluid to said tank.

11. A closed hydraulic fluid flow system as set forth in claim 9, wherein said fluid passage means comprises a suction device having a fluid inlet portion coupled to said first conduit and being responsive to the fluid flow therethrough, and wherein is included structure removably coupled to said device for defining a fixed orifice at said inlet port.

12. A closed hydraulic fluid flow system as set forth in claim 9, wherein is provided a fluid filter across the path of fluid flow through said first conduit between said pump and said second location.

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