April 1, 1958 L. BRUEHL 2,828,610

PRESSURE BOOSTED HYDRAULIC MOTOR CONTROL SYSTEM

Filed May 5, 1954

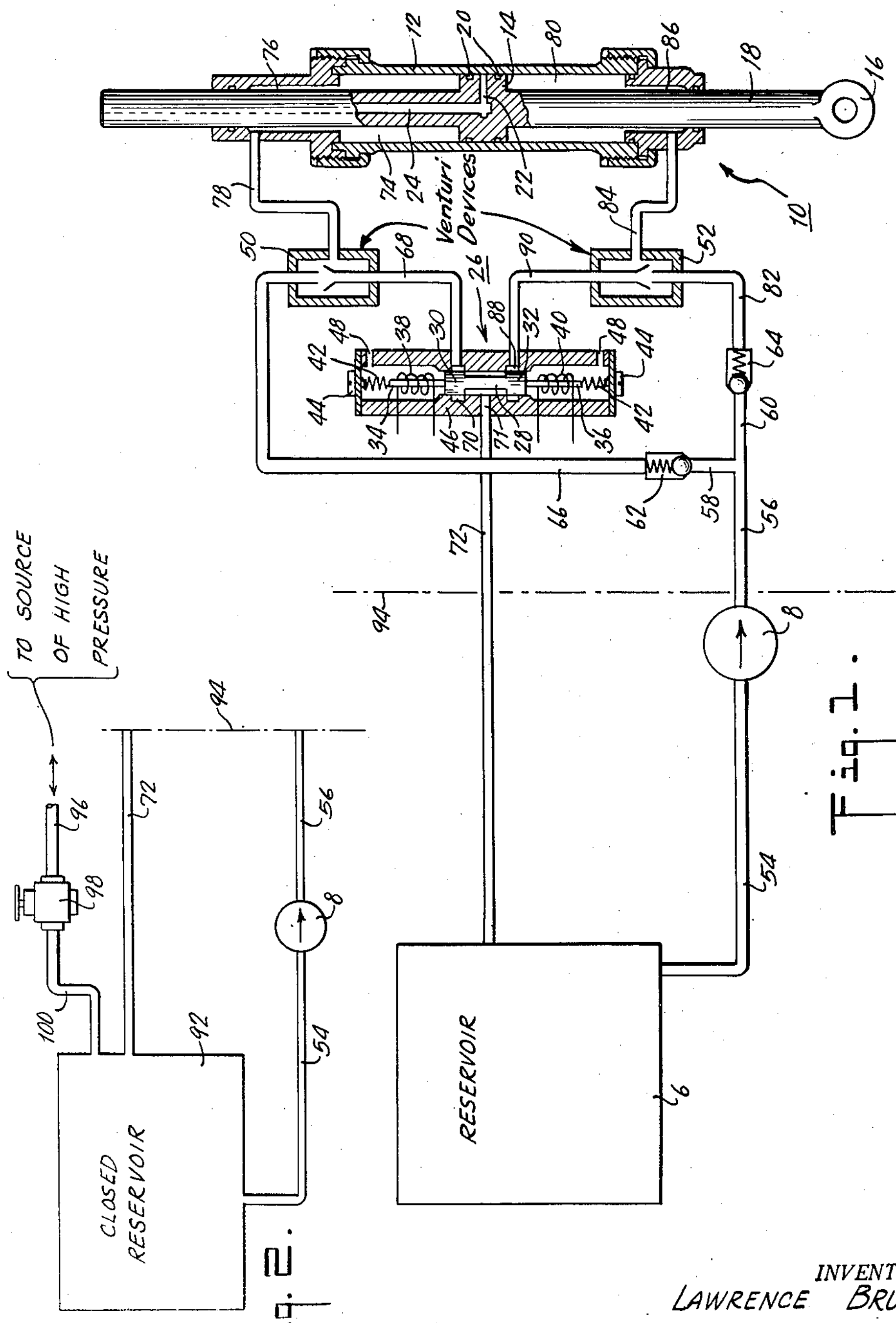

Fig. 1.

Fig. 2.

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2,828,610

Patented Apr. 1, 1958

2,828,610

PRESSURE BOOSTED HYDRAULIC MOTOR CONTROL SYSTEM

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Application May 5, 1954, Serial No. 427,847

4 Claims. (Cl. 60—51)

This invention deals with hydraulic systems in general and more specifically with an improved hydraulic system which employs Venturi means to produce greatly improved operation of a hydraulic system for operating hydraulic motor means.

It is an object of this invention to provide the use of one or more venturis in such a way that a hydraulic motor may be securely locked in a given position under full hydraulic pressure on both sides of the motor, while always standing ready to be actuated for movement in either direction by means of a differential in pressure.

A further object of this invention lies in the use of a pair of venturis in the hydraulic control system for a conventional hydraulic motor, in such a way that a greater force may be applied by the hydraulic motor than the normal differential of force obtained by having the system pressure applied to one side of the motor while the other side is connected to return. This is accomplished by proper design of the venturis in such a way that the reduced pressure, at the throat of each venturi, may be carried below atmospheric pressure under certain operating conditions, e. g. when the fluid flow through the venturis is at or near maximum. Therefore, when such maximum flow exists a pressure differential on the motor will be greater than the normal maximum for prior types of hydraulic systems in which the normal pressure of the returns for the hydraulic system is atmospheric pressure.

A further object is to provide a faster acting system which eliminates the delays incidental to the building up of hydraulic pressure on one side or the other of the hydraulic motor. In other words, the energy required for the initial motion is stored right at the spot where it is to be used and not back at some control valve away from the hydraulic motor.

These and other objects and features of this invention will appear below in the detailed description which follows:

In the drawings:

Fig. 1 is a schematic illustration of a hydraulic system according to this invention; and

Fig. 2 is a schematic showing of an alternative form for a portion of the system.

The figure illustrates a hydraulic system according to this invention and shows a hydraulic motor of the cylinder and piston type. Many other types of hydraulic motors might be employed with the hydraulic system disclosed; the type illustrated being chosen for its simplicity and ability to illustrate some of the beneficial features of this invention. The system includes the usual elements among which are a reservoir 6, a hydraulic pump 8, and a hydraulic motor 10, which, in this instance, is shown as a cylinder 12 and piston 14. The cylinder and piston will be attached in a conventional manner to any device where it is desired to obtain relative motion between two elements. The piston 12 may be fastened by any conventional means (not shown) to one of the elements of the device to be actuated while the other movable element may be attached by means of a ring 16 integral with the end of a piston rod 18. It will be noted that piston rod extends an equal distance from the piston 14 out either end of the cylinder 12 so that the cylinder and piston combination is a no-differential type of motor whereby equal fluid pressure on both sides of the piston 14 will produce no relative motion between cylinder 12 and piston 14.

It will be noted that the piston 14 is a type more fully disclosed and claimed in my copending application Serial No. 340,451, filed March 5, 1953, which provides substantially leak-proof sealing of the hydraulic fluid on either side of the piston. This is accomplished by means of a pair of grooves 20 around the periphery of the piston 14 near each of the faces of the piston 14. In these grooves, there is located a pair of pliable O rings (not shown) which may be composed of plastic or other pliable material which is impervious to chemical attack by the hydraulic fluid. Between the grooves 20, there is a radial passage 22 which connects with an axial passage 24 in order to provide access to the atmosphere for the inner side of each of the piston grooves 20. In this way, there is maintained a full differential in pressure upon each of the O rings in the grooves 20, and, under these conditions, such O rings maintain substantially leak-proof seals.

There is a control valve unit 26 which is composed of a spool-shaped valve core 28 having enlarged piston-like lands 30 and 32 and also having extending shafts 34 and 36 which have magnetic members (not shown) to act in cooperation with electric solenoids 38 and 40 respectively. Attached to the ends of the shafts 34 and 36, there are mechanical springs 42 which are fastened to adjustment screws 44. The springs 42 act to center the spool 28 when neither solenoid 38 or 40 are energized. Adjustment screws 44 are to adjust the center position of the spool 28 to neutral upon assembly of the valve unit 26, or, thereafter, should the tension of either spring 42 change relatively to the other. The casing of valve unit 26 is made up of a cylindrical body section 46 having closed ends. There are openings 48 through the body section 46 in order to allow for drainage of the internal end sections within the body section 46, in case hydraulic fluid should leak past either of the lands 30 or 32 of the spool 28. Connected to the control valve unit 26, there is a pair of venturis 50 and 52, which are schematically shown because numerous designs of these elements might be employed.

In order to understand the operation of this invention, flow of hydraulic fluid will be traced for a given direction of operation of the hydraulic motor 10. Fluid flows from the reservoir 6 through a hydraulic pipe 54 to the pump 8 and from there through a hydraulic pipe 56 to a branch where the flow may be directed through either a pipe 58 or a pipe 60 to a check valve 62 or another check valve 64 respectively. It will be observed at this point that when control valve 26 is in its neutral position as illustrated, each of the lands 30 and 32 seals off its respective valve port and no flow of hydraulic fluid will take place. However, assuming that solenoid 38 is energized and valve core is pulled up (as viewed in the figure of the drawing (a path for hydraulic fluid to flow will be completed, and fluid will flow as follows: Beginning at check valve 62, fluid flow will take place through a hydraulic pipe 66 which leads to venturi 50. The fluid flow will continue through venturi 50 and a hydraulic pipe 68 to an annular groove 70 in the valve unit 26. From there fluid may flow past the lower edge of land 30 into the space around the center of spool 28 and out through a passage 71 connected to a return hydraulic pipe 72 which is connected to the reservoir 6.

When the flow of hydraulic fluid takes place, the upper face of the piston 14 will be subjected to a reduced hydraulic pressure since the chamber 74 above the piston 14 is connected by means of a passage 76 (surrounding the piston rod 18 above the piston 14) and a hydraulic pipe 78, to the throat section of venturi 50. Therefore, at this time, piston 14 will be subjected to a differential of pressures upon its two faces and there will be a tendency for relative motion between piston 14 and its cylinder 12. Such differential of pressure will be applied, because at the same time the chamber 74 is subjected to a reduced pressure (by being connected to the throat section of venturi 50) a lower chamber 80 will continue to be subjected to system pressure. In other words, when valve spool 28 is in a raised position for allowing fluid to flow through venturi 50 and to return via hydraulic pipe 68, internal passages of control valve unit 26, and return pipe 72; system pressure is continuously applied to lower chamber 80 via pressure pipes 56 and 60, check valve 64, a pipe 82, the throat connection of venturi 52, a pipe 84, and a passage 86 which adjoins chamber 80. Therefore, piston 14 will be forced upward in the cylinder 12 as previously described.

It will be noted that when the valve spool 28 is moved up as described above, land 32 also will be moved upward within its chamber in the body section 46 on the valve unit 26, and will maintain an annular space 88 sealed off from the space around the undercut section of spool 28 so that fluid may not flow from a hydraulic pipe 90 to return. This means that no hydraulic fluid flow will take place directly through venturi 52, and, therefore, the fluid pressure at the throat section of venturi 52 will be maintained substantially at system pressure.

Of course, some fluid must flow into the chamber 80 of the hydraulic motor 10 when piston 14 moves upward in cylinder 12. However, such fluid flow may take place from hydraulic pipe 60 through check valve 64, hydraulic pipe 82 to the throat section of venturi 52. Then this fluid will flow out from throat section of venturi 52 through hydraulic pipe 84 to passage 86 around piston rod 18 and thence to chamber 80 below piston 14.

It will now be evident that one of the benefits of this invention lies in the fact that when no control is being exercised over the hydraulic motor 10 by the control valve unit 26, there is being applied full system pressure to both faces of the piston 14 and therefore the piston 14 will be securely locked into a given position within its cylinder 12. Under these conditions, any play within the hydraulic system is removed. Such play may be caused by the movement of the various seals as they react to the increase of fluid pressure in the ordinary hydraulic system, because in the ordinary system, fluid under pressure is only applied when the motor is to be actuated. For the same reason, any softness or play caused by air bubbles in the hydraulic fluid will be substantially reduced, because the fluid pressure is maintained and therefore, the bubbles will be maintained in a compressed state so that no energy will be absorbed in compressing them before applying full power to the hydraulic motor (in the illustrated system, motor 10). Check valves 62 and 64 are provided in order to prevent the movement of piston 14 within its cylinder 12 which could be effected if there were an unrestricted passage for fluid to flow from chamber 74 to chamber 80, or the reverse.

Another feature of this invention lies in the fact that, by properly designing the venturis 50 and 52, there may be applied a greater differential pressure to the piston 14 than that which would be possible in a conventional hydraulic system. This is because, in a conventional hydraulic system, the maximum pressure differential is the system pressure itself; since the return of such a system is at zero pressure with respect to the measured system pressure. But, by proper design of the venturis 50 and 52 of this invention, a pressure of less than atmospheric or zero system pressure may be obtained at the throat section of each venturi under maximum flow conditions. For this reason, a reduced pressure which is below the return, or atmospheric, pressure may be applied to one of the chambers 74 or 80 while the full system pressure is continuously applied to the other. Therefore, it will be readily observed that with system pressure applied to one face of the piston 14 while less than atmospheric pressure is applied to the other face, a greater force will be created than would be possible where atmospheric pressure is applied to one face and the full system pressure is applied to the other face, as is true in the ordinary system.

The rapidity of the response of this system is especially good in comparison to the ordinary hydraulic system where the hydraulic fluid pressure is admitted by a control valve to the motor. This means that in the ordinary system there will be a pressure drop in the orifice of the control valve before the pressure will build up at the motor. In the system of this invention, one-half of this drop is non-existent because no fluid need be moved initially to build the pressure on one side of the motor.

A practical embodiment of a system making use of the reduction in pressure at the throats of the venturis to a magnitude of less than system datum pressure, is shown in Fig. 2. Only that part of the system to the left of dashed line 94 is in any way changed by this embodiment so only the additional elements and their relation to the system are shown.

A closed reservoir 92 is used in this system in order to make possible the introduction of a booster pressure. From any suitable source of additional pressure, as indicated on the drawing, an additional or booster pressure is introduced via a pipe 96, a reducing valve 98, and a pipe 100, into the closed reservoir 92. This added pressure may be applied via a suitably pressurized gas or may be a liquid under pressure. So long as the hydraulic fluid in the venturi system is pressurized or boosted to a datum pressure on the reservoir side of pump 8 which is substantially above atmospheric, e. g. in the range of about two hundred pounds per square inch, the desired effect may be created. The reducing valve 98 permits adjustment of the amount of the added pressure to a desired magnitude, which will be less than that of the high pressure source, of course.

It is pointed out that because, with proper design of the venturis, the throat pressure may be reduced to something below the datum level, by raising the datum level sufficiently, a substantial increase in the effective difference of pressure applied to the piston 14 may be obtained. For example, assume that pump 8 can deliver one hundred and fifty pounds per square inch of pressure, and that two hundred pounds per square inch of additional pressure is applied to the closed reservoir 92 via pipe 100. Then, assume the throat of the venturi in use can drop the pressure at this point to one hundred pounds per square inch below the datum pressure of two hundred pounds per square inch, the total effective pressure delivered to the piston 14 will be one hundred and fifty pounds (pump pressure) plus one hundred (below datum) or two hundred and fify pounds per square inch. It will be clear that no such increase would be possible with only atmospheric pressure as the datum because atmospheric pressure is only about fifteen pounds per square inch.

While I have disclosed my invention in detail in accordance with the applicable statutes, this disclosure is to be taken as descriptive only and in no way as limiting my invention.

I claim:

1. An improved hydraulic control system, comprising a source of hydraulic fluid under pressure, return means for completing a hydraulic circuit, a reversible hydraulic motor having at least two hydraulic lines, two separate venturi means each having an input, an output and a throat connection, means for connecting said inputs to said source and including means to prevent reverse flow, means for alternatively connecting said outputs to said return means to create a reduced pressure in one of said

throats, and means for connecting said hydraulic lines to said throats for causing said hydraulic motor to be actuated in a given direction when one of said outputs is connected to the return means.

2. In a hydraulic system having a source of hydraulic fluid under pressure, a reversible hydraulic fluid operated motor, means for maintaining said motor locked against movement when stationary comprising a pair of check valves connected between said source and said motor, a pair of venturi means having throats and each being connected between one of said check valves and the return for said source, means for alternatively controlling the flow of fluid through said venturi means, said throats being connected to said motor to transmit the static and the dynamic pressures from the throats of said venturi means.

3. An improved hydraulic control system comprising a source of hydraulic fluid under pressure, return means for completing a hydraulic circuit, a reversible hydraulic motor having at least two hydraulic lines, two venturi means each having an input, an output and a throat connection, means for connecting said inputs to said source and including check valves to prevent reverse flow, a selector valve for alternatively connecting said outputs to said return means to create a reduced pressure in one of said throats, and means for connecting said hydraulic lines to said throats for causing said hydraulic motor to be actuated in a given direction when one of said outputs is connected to the return means.

4. In a hydraulic system having a source of hydraulic fluid under pressure, a reversible hydraulic fluid operated motor, means for maintaining said motor locked against movement when stationary comprising a pair of check valves connected between said source and said motor, a pair of venturi means having throats and being connected between said check valves and the return for said source, a selector valve for alternatively connecting the flow of fluid through said venturi means, said throats being connected to opposite sides of said motor to transmit the static and the dynamic pressures from the throats of said venturi means alternately.

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