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Roth

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[54] HYDRAULIC DRIVE

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[73] Assignee: **Deere & Company**, Moline, Ill.

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[52] **U.S. Cl.** **60/489**, 60/462
[51] **Int. Cl.** **F15b 15/18**, F15b 15/24
[58] **Field of Search** .... 60/52 VS, 51, 53 A, 60/53 R

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Attorney—H. Vincent Harsha, Harold M. Knoth, William A. Murray et al.

[57] **ABSTRACT**

A hydraulic drive includes a hydraulic pump and a variable displacement axial piston type hydraulic motor. The swash plate of the motor is adjusted by a hydraulic cylinder having an accumulator connected to the pressurized end of the cylinder so that the motor displacement is at a maximum value when the pressure in the accumulator and the cylinder is below a predetermined value and decreases as the pressure in the accumulator builds up. A pilot-operated valve controls the flow of pressurized fluid from the pump to the motor, the pressure to open the pilot valve being supplied through a manually shiftable valve which also directs fluid pressure to the accumulator through an orifice, which retards the pressure buildup in the accumulator to gradually decrease the motor displacement after the control valves are shifted to their open positions.

14 Claims, 7 Drawing Figures

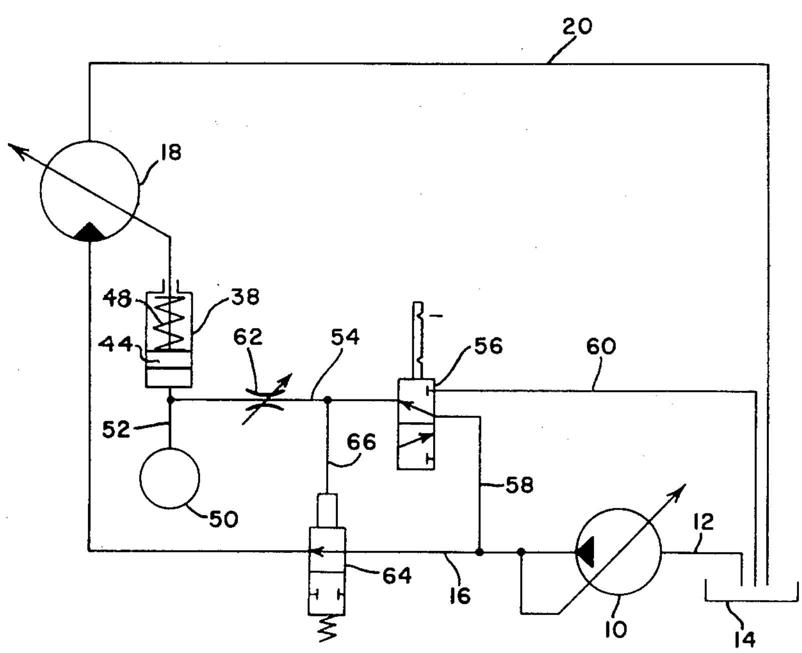
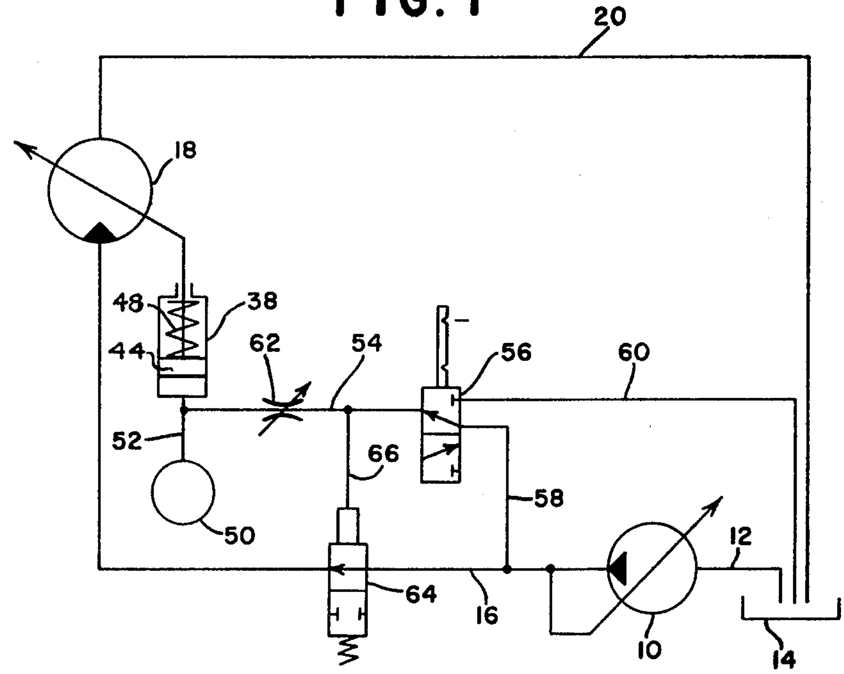


FIG. 1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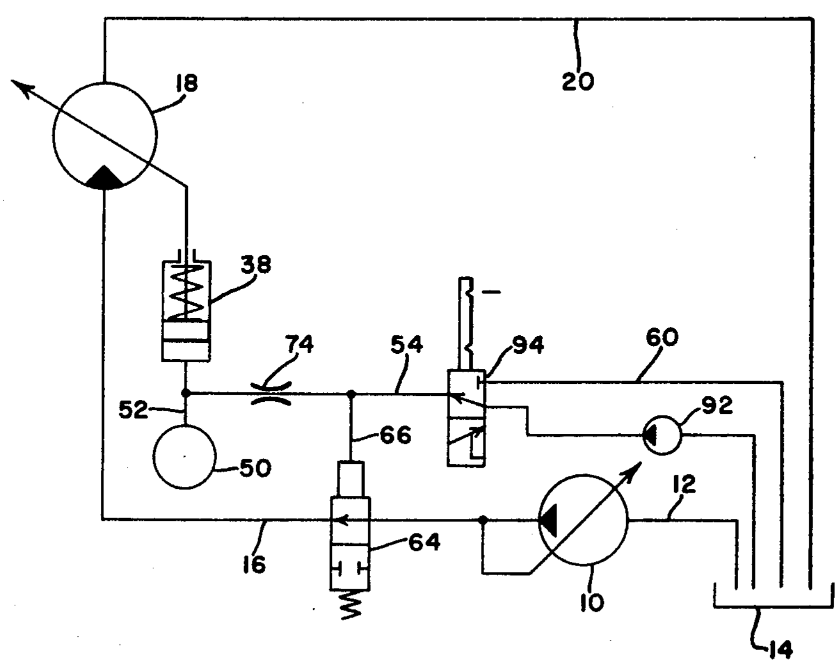
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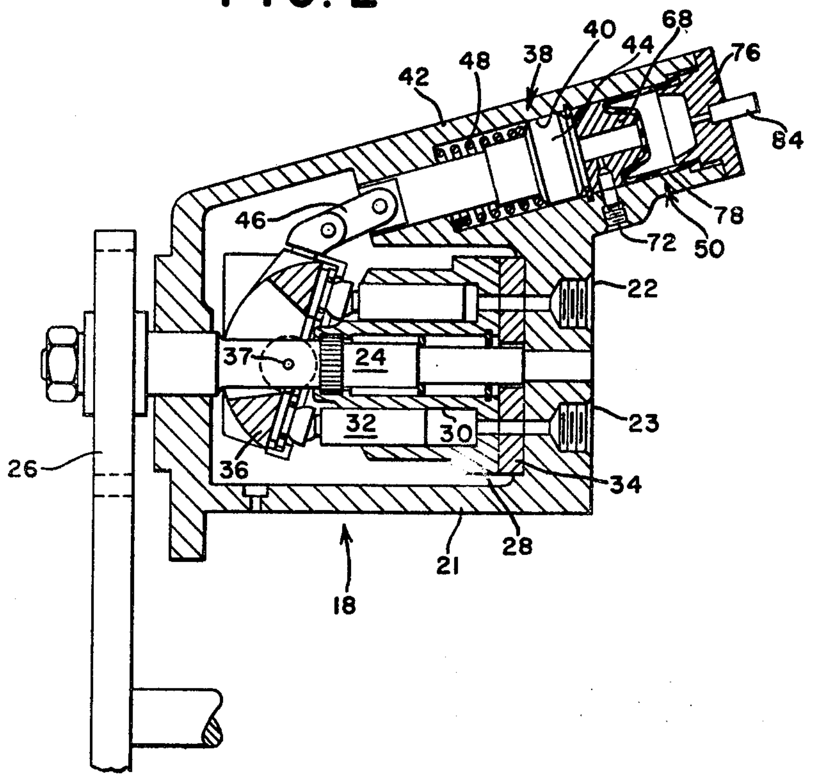
FIG. 6

FIG. 2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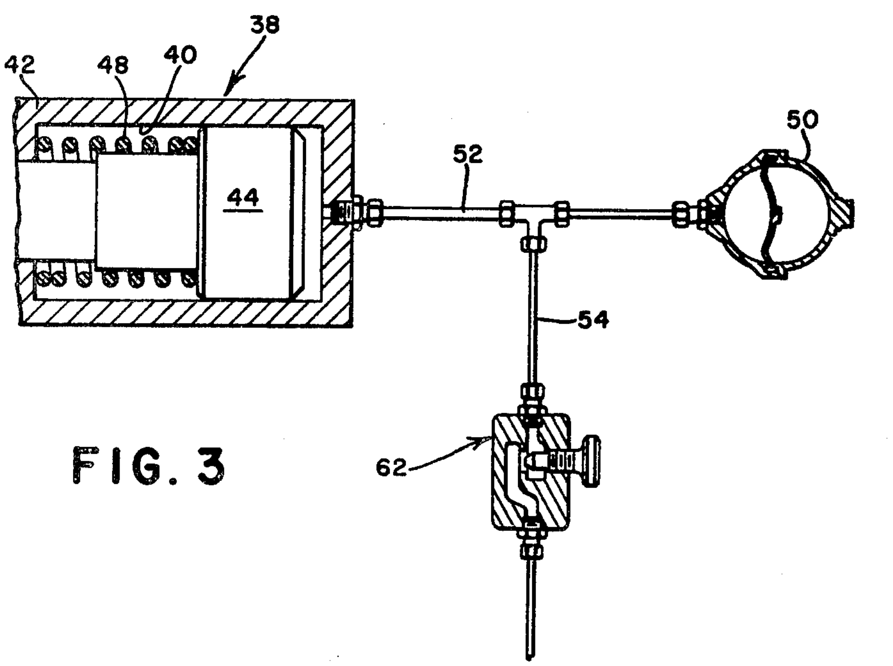
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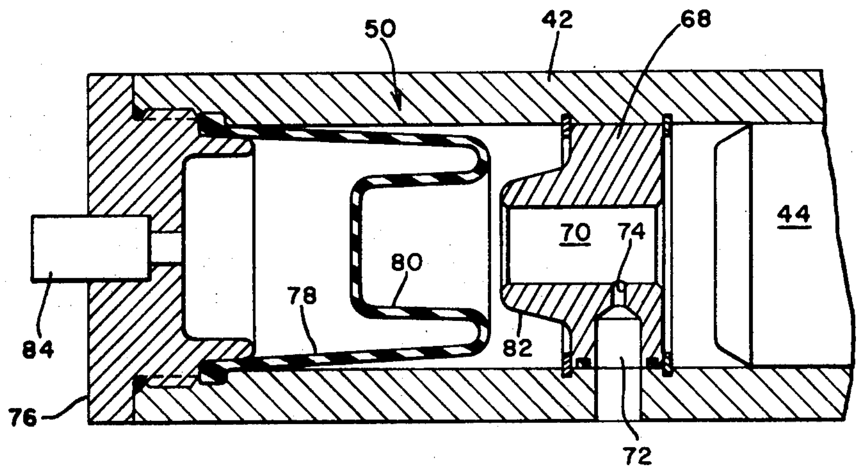
FIG. 3

FIG. 4



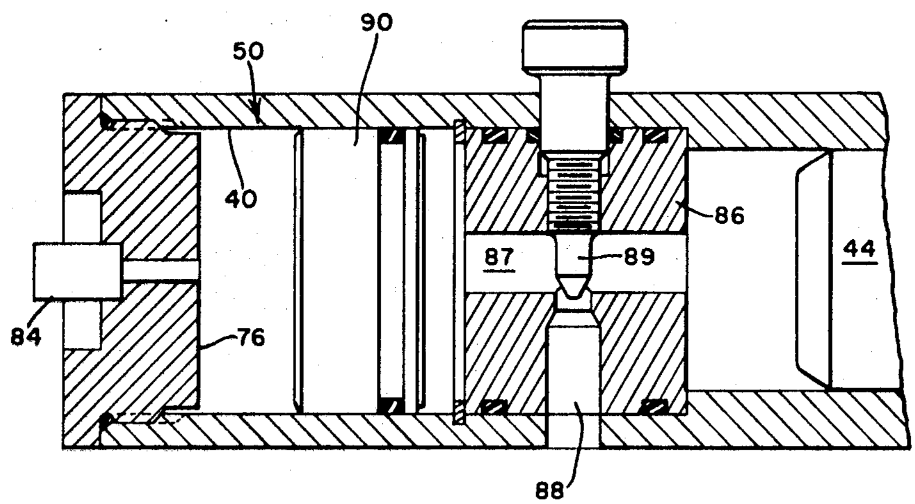


FIG. 5

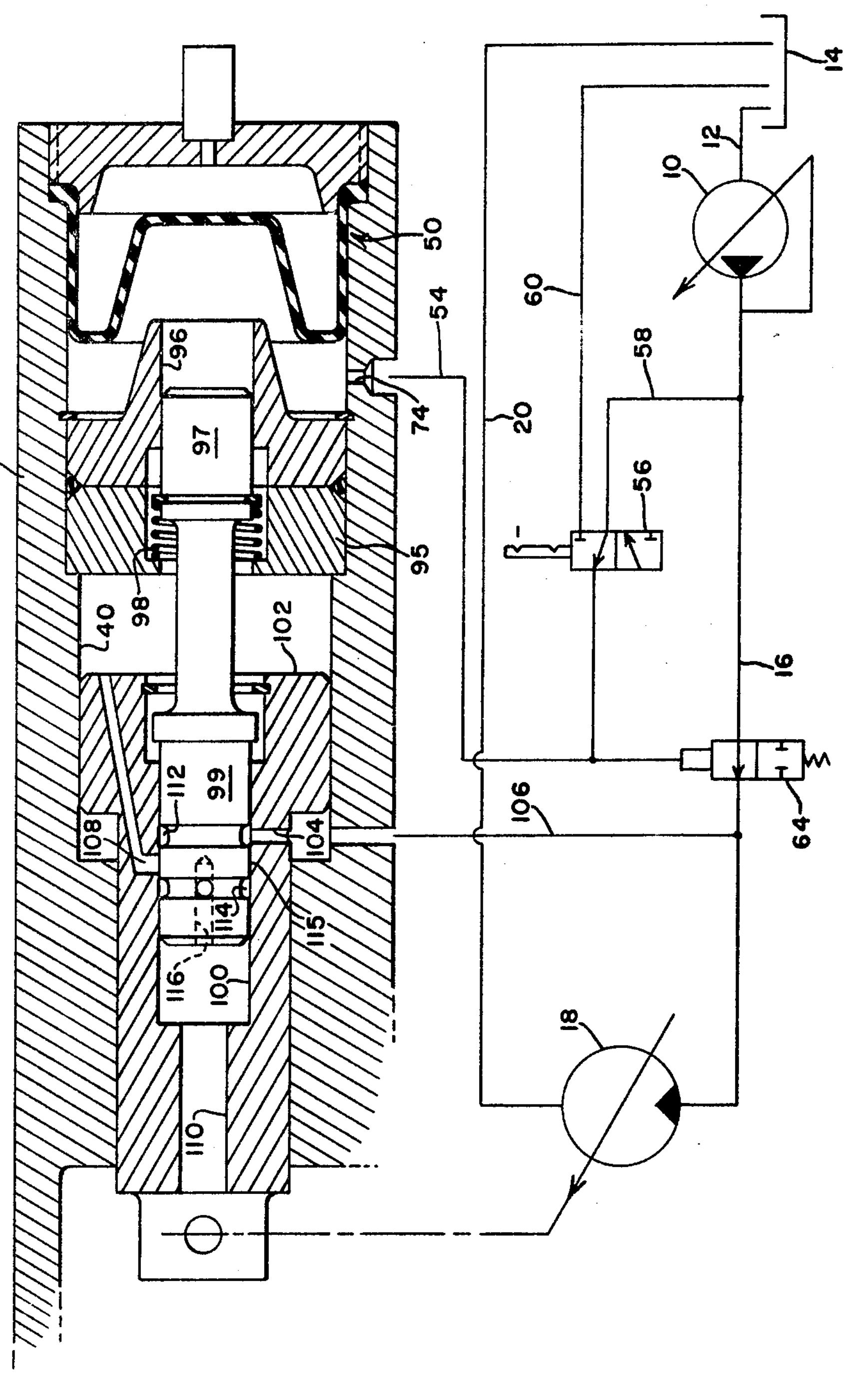

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FIG. 7

HYDRAULIC DRIVE

BACKGROUND OF THE INVENTION

This invention relates to a hydraulic drive and more particularly to a hydraulic drive having an automatic speed and torque control.

Some applications for hydraulic drives require a relatively high starting torque and also a relatively high speed after the drive has started. An example of such an application would be a drive for the grain tank discharge auger on a combine. To provide the necessary high starting torque and ultimate speed with a fixed displacement drive necessitates relatively large units, and to reduce the size in cost of such units, it has been found desirable to provide variable displacement drives which can be controlled to provide maximum displacement and minimum speed upon starting and a higher speed when lesser torque is required. Heretofore, the displacement has been manually adjusted or has been responsive to the operating pressure in the drive. The manual adjustment, of course, requires the attention of an operator, while the adjustment in response to pressure has caused a speed fluctuation responsive to fluctuations in the working pressure.

SUMMARY OF THE INVENTION

According to the present invention, an improved hydraulic drive is provided, having a variable displacement motor with means for automatically placing the displacement of the motor at maximum value initially to provide maximum torque and minimum speed and gradually decreasing the motor displacement at a controlled rate to gradually increase the motor speed.

An important feature of the invention resides in the provision of hydraulic means for automatically decreasing the motor displacement in response to increasing fluid pressure supplied to the hydraulic means. More specifically, a hydraulic cylinder is provided for decreasing the motor displacement in response to increasing pressure supplied to the cylinder and an accumulator is provided in parallel with the cylinder to control the pressure buildup therein. Also according to the invention, orifice means are provided for controlling the rate of pressure buildup in the accumulator and cylinder.

Another feature of the invention resides in the provision of the accumulator as an integral part of the hydraulic cylinder and further providing the cylinder and the accumulator integrally with the variable displacement motor.

Still another feature of the invention resides in the provision of valve means for automatically directing fluid pressure to the accumulator and cylinder for controlling the motor displacement when pressurized fluid is delivered from the pump to the motor.

Another feature of the invention resides in the provision of a gas-type accumulator and in providing means for varying the quantity of the trapped gas to thereby vary the initial pressure in the accumulator.

Also according to the invention, there is provided a servo piston between the motor control cylinder and the accumulator, so that the accumulator pressure acts on the piston, which has associated valve means for controlling the fluid pressure supplied to the motor control cylinder, thereby reducing the size of the spring required in the displacement control means.

Also according to the invention, a novel accumulator design is provided in association with the motor displacement control means.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic illustration of one embodiment of the hydraulic drive system.

FIG. 2 is an axial section view of the variable displacement motor and the displacement control cylinder and accumulator associated therewith.

FIG. 3 is a section view of an alternate arrangement of the displacement control cylinder and accumulator with a variable orifice for controlling the flow rate to the accumulator.

FIG. 4 is an enlarged section view of the accumulator shown in FIG. 2.

FIG. 5 is an enlarged section view of another embodiment of the accumulator.

FIG. 6 is a schematic view, similar to FIG. 1, showing a slightly different embodiment of the hydraulic drive.

FIG. 7 is a partly schematic view of a third embodiment of the hydraulic drive utilizing servo means between the accumulator and motor displacement control cylinder, the cylinder, servo piston, and accumulator being shown in section.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in FIG. 1, the hydraulic drive system includes a variable displacement hydraulic pump 10 having an inlet line 12 connected to a reservoir and an outlet conduit 16 connected to the end of a variable displacement motor 18 having a conventional return or outlet line 20.

The motor 18 is of the conventional axial piston type, and, as shown in FIG. 2, it includes a housing 21 having inlet and outlet ports 22 and 23, respectively, and an axial shaft 24 journaled in the housing. The output shaft 24 is shown connected to output gearing, which, as an illustrative environment, can be connected to the drive shaft of a combine grain discharge auger. A cylinder barrel 28 is mounted on and connected to the shaft 24 and includes a plurality of cylinders 30 parallel to the shaft 24. A piston 32 reciprocates in each cylinder 30 in response to fluid pressure therein, and, as is conventional, a radial valve plate 34 controls the flow of pressurized fluid to and from the cylinders from the inlet and outlet ports 22 and 23. The pistons 32 act against a swash plate 36, the angle of which is adjustable about a pivot 37 normal to the motor shaft 24. When the swash plate 36 is at its maximum angle, as illustrated in FIG. 2, the motor displacement is at its maximum to provide a minimum motor output speed for a given fluid flow. Of course, as the angle of the swash plate decreases, the motor displacement decreases to increase the motor speed.

The angle of the swash plate is controlled by a hydraulic cylinder, indicated in its entirety by the numeral 38. The cylinder 38 is formed by an elongated bore 40 in a housing 42 integral with the motor housing 21, and a piston 44 mounted for reciprocation within the bore 40. The lower end of the piston 44 is connected to the swash plate 36 by a linkage 46, so that extension of the cylinder 38 in response to fluid pressure supplied thereto rocks the swash plate to decrease the motor displacement. A spring 48 acts between the housing 42 and the piston 44 to bias the piston toward its retracted position, wherein it places the motor in its maximum displacement condition, as shown in FIG. 2.

The hydraulic control cylinder 38 is schematically illustrated in FIG. 1 and the upper or working end of the cylinder 38 is connected to an accumulator 50 by a hydraulic conduit 52. The conduit 52 between the cylinder and accumulator is, in turn, connected to a conduit 54, which is connected to a manually actuatable valve 56, which is operative to either connect the conduit 54 to the pump outlet conduit 16 through a line 58, as shown in FIG. 1, or to the reservoir 14 via a hydraulic line 60.

A variable orifice 62 is disposed in the conduit 54 between the valve 56 and the conduit 52 to control the flow rate of pressurized fluid to the accumulator 50 and cylinder 38. As shown in FIG. 3, a manually adjustable needle-type valve of conventional construction can serve as the variable orifice 62. Also, the accumulator 50 can be in the form of a conventional gas-type accumulator.

A pilot-operated on-off type valve 64 is disposed in the pump outlet conduit 16 between the pump 10 and the motor 18 and is shifted to its open position, as illustrated in FIG. 1, in response to fluid pressure in the conduit 54, which is connected to the valve 64 by a pilot line 66.

In the embodiment illustrated in FIG. 2, the accumulator 50 is also formed as an integral part of the hydraulic motor 18, the control housing 42 being extended and the bore 40 extending the length of the housing. As best seen in FIG. 4, an annular member 68 is secured in the bore 40 opposite the piston 44 and includes an axial passage 70, which serves the function of the schematically illustrated conduit 52 in FIG. 1. A radial passage 72 through the housing wall and the annular member 68 is connected to the axial passage 70 through an orifice 74. Unlike the orifice 62, the orifice 74 is a fixed orifice, although it performs the same function. The end of the bore 40 is closed by an end cap 76 and a flexible membrane 78 spans the bore 40 between the end cap 76 and the annular member 68. The flexible membrane is provided with a cup-shaped recess 80 which mates with an axial projection 82 in the shape of a frustum of a cone on the axial member 68, when there is no hydraulic pressure in the passage 70, as illustrated in FIG. 2. The volume between the flexible membrane and the end cap is filled with gas, the quantity of which can be varied through a valve 84 in the end cap, this type valve in a gas accumulator being well known. When pressurized fluid is delivered through the orifice 74 to the space between the flexible membrane 78 and the member 68, the membrane shifts toward the end cap, as shown in FIG. 4, to compress the gas therebetween, thus forming a gas-type accumulator.

A slightly different version of the accumulator and orifice is shown in FIG. 5, wherein an annular member 86 is again mounted in the bore 40 between the piston 44 and the end cap 76. The member 86 again has an axial passage 87 connected to a radial passage 88, and a manually adjustable needle-type valve 89 extends radially through the member 86 opposite to and in alignment with the passage 88 to restrict the flow of fluid from the passage 88 to the passage 87 and thereby provide a variable orifice. Also, a solid piston 90 is interposed between the gas and the fluid rather than the flexible membrane illustrated in FIG. 4.

In operation, the hydraulic drive is started by manually shifting the valve 56 to its open condition, as illustrated in FIG. 1, wherein the pump outlet conduit 16 is connected to the conduit 54. The fluid pressure in the conduit 54 then actuates the pilot-operated valve 64 through the pilot line 66 into its open condition, as also illustrated in FIG. 1, wherein the pump outlet is connected to the inlet of the motor 18 via the conduit 16 to supply pressurized fluid to the motor. Prior to the conduit 54 being connected to the pressurized line 16, it was connected to the reservoir 14 to drain the hydraulic cylinder 38 and the accumulator 50. In the absence of fluid pressure in the cylinder 38, the spring 48 shifts the piston 44 to its retracted position, as shown in FIG. 2, wherein it maintains the swash plate 36 in its maximum displacement position. The orifice 62 controls the rate at which the pressurized fluid in the conduit 54 is delivered to the accumulator 50 and thereby controls the rate that the pressure builds up in the accumulator and the cylinder 38. When the motor is in its maximum displacement condition, as illustrated in FIG. 2, the motor output speed for a given flow rate between the pump 10 and the motor 18 is at its minimum and the torque is at its maximum. Thus, the motor is able to provide the high initial torques necessary in many applications, such as in the previously mentioned combine grain discharge auger.

After the pressure in the accumulator 50 and the cylinder 38 reaches a point sufficient to overcome the preload on the spring 48, the piston 44 starts to extend to reduce the motor displacement and consequently increase the output speed. As the pressure gradually builds up in the accumulator 50, the piston 44 will gradually shift the motor swash plate 56 until the motor reaches its maximum speed, which may be established by stops engaged by the swash plate, as is well known in the art. The minimum displacement can also be established by the pressure in the accumulator 50 reaching its maximum value to establish the maximum extension of the piston 44 and thereby the minimum motor displacement. As is apparent, the variable orifice 62 provides a means for controlling the rate at which the pressure builds up in the accumulator and consequently the rate at which the motor speed changes. The above described control of the starting torque and speed is completely automatic after the operator shifts the valve 56 to engage the drive. The provision of the accumulator as an integral part of the motor control cylinder and the motor provides a compact and inexpensive control system.

In the embodiment shown in FIG. 6, the control system is substantially identical to that shown in FIG. 1 with the exception that the pressure for the control system is provided by a separate pump 92, which delivers fluid under pressure to the conduit 54 through a manually shiftable valve 94, which is illustrated in its open position in FIG. 6 wherein it delivers fluid under pressure to the pilot line 66 and the accumulator 50 and control cylinder 38. When the system is not operating and the valve 94 is shifted to its closed position, the output of the pump 92 is returned to the reservoir via the line 60 while the pressure in the accumulator is allowed to bleed off. The use of the separate pump 92 for the control pressure provides a more precise regulation of the motor, since the control system is not subject to the pressure variations in the main pump output.

In the embodiment in FIG. 7, a servo type control system is used for controlling the motor displacement. As in the previous described embodiments, when the valve 56 is actuated to start the hydraulic drive, pressurized fluid is delivered to the accumulator 50 through an orifice 74 to control the pressure buildup in the accumulator 50, which is again mounted in the housing 42 integral with the motor housing. However, rather than the annular member 68, a similar annular member 95 is mounted in the bore 40 in the housing 42. The annular member 95 has an axially extending bore 96 in which a servo piston 97 is mounted. As before, pressure in the accumulator 50 moves the piston 97 toward the motor swash plate against the bias of a compression spring 98. However, the end of the piston 97 is not connected drectly to the motor swash plate, but is rather provided with a spool-type valve member 99, which is slidable in an axial bore 100 in a motor control piston 102, the end of which is connected to the motor swash plate. The bore 100 is connected to a radial passage 104 through the piston shaft via a hydraulic line 106, which is connected to the pump outlet conduit 16 and is pressurized when the valve 64 is opened. A second radial passage 108 intersects the bore 100 adjacent to the passage 104 and extends to the head end of the piston 102. The end of the bore 100 is connected to the interior of the motor housing by an axial passage 110, the interior of the housing being connected to the reservoir. The valve member 99 is provided with a pair of annular grooves 112 and 114 separated by a valve land 115. The groove 114 is connected to the lower end of the valve member via a passage 116, so that the groove 114 is in fluid communication with the reservoir.

In operation, when the fluid pressure in the accumulator 50 is sufficient to overcome the preload of the spring 98, it shifts the piston 97 toward the piston 102. The shifting of the piston 97 causes the valve member 99 to shift relative to the piston 102, so that the annular groove 112 connects the pressurized passage 104 to the passage 108, thereby delivering fluid pressure to the head end of the piston 102 between the member 95 and the piston. This, of course, causes the piston to extend, shifting the swash plate to which it is connected. Fluid pressure is supplied to the upper end of the piston 102 until the position of the piston 102 corresponds to the position of the piston 97, at which time the valve land 115 covers the passage 108, as illustrated in FIG. 7. Obviously, as the pressure builds up in the accumulator 50, the piston 97 compresses the spring further and shifts toward the piston 102, which follows the movement of the piston 97. When the fluid pressure in the accumulator reaches its maximum value, or when the piston 97 is mechanically stopped, the piston 102 will also not extend any further. When pressure is reduced in the accumulator, the spring 98 shifts the piston 97 toward the accumulator, so that the passage 108 communicates with the annular groove 114 and consequently the reservoir, draining the pressurized fluid at the upper end of the piston 102 until the piston again reaches its equilibrium condition, as illustrated in FIG. 7.

As is apparent, the above embodiment permits the use of a smaller spring than in the previously described embodiments, while still providing the relatively high pressures necessary for the swash plate control cylinder.

I claim:

1. A hydraulic drive comprising: a hydraulic pump means; a variable displacement hydraulic motor hydraulically connected to and driven by the pump means through a first conduit means and having a hydraulically actuated control means responsive to fluid pressure in a second conduit means to maintain the motor at maximem displacement when the pressure in said second conduit means is below a predetermined value and to decrease the displacement in response to increasing pressure in said conduit means above said predetermined value; a valve means operative to selectively control the flow of pressured fluid from the pump means to the motor and the second conduit means; an orifice means in the second conduit means for restricting the flow of pressured fluid to the control means; and an accumulator in the second conduit means downstream of the control valve means and orifice means and operative to gradually build up the pressure in the second conduit means after the valve means is actuated to supply fluid pressure thereto and thereby cause a gradual decrease in the displacement of the motor after the valve means is actuated to supply fluid pressure thereto.

2. The invention defined in claim 1 wherein the orifice means is a variable orifice operative to selectively vary the flow rate in the second conduit means and thereby vary the rate of pressure increase therein and the rate of change of the motor displacement.

3. The invention defined in claim 1 wherein the control means includes a hydraulic cylinder actuatable in response to fluid pressure in the second conduit means to shift the control means in one direction and thereby decrease the motor displacement and a spring means biasing the control means in the opposite direction toward its maximum displacement condition.

4. The invention defined in claim 3 wherein the control means includes a housing having a cylindrical bore with a piston mounted in the bore to form said hydraulic cylinder and the accumulator includes a shiftable member mounted in said bore opposite the piston, the second conduit means being in fluid communication with the bore between said shiftable member and said piston.

5. The invention defined in claim 4 wherein the end of the bore opposite the shiftable member is closed to trap a compressible gas between said end and the shiftable member, the shiftable member shifting to compress the trapped gas in response to fluid pressure in the second conduit means, so that the pressure of the trapped gas establishes the accumulator pressure.

6. The invention defined in claim 5 and including means for varying the quantity of the trapped gas and thereby the initial pressure in the accumulator.

7. The invention defined in claim 5 wherein the shiftable member comprises a second piston slidably mounted in said bore.

8. The invention defined in claim 5 wherein the shiftable member comprises a flexible membrane spanning said bore.

9. The invention defined in claim 8 and including a generally annular member mounted in the bore between the flexible membrane and the piston with its central aperture communicating with the second conduit means, the end of the annular member opposite the membrane having an axial projection which mates with an axially extending recess in the membrane.

10. The invention defined in claim 4 wherein the housing is an integral part of the motor housing.

11. The invention defined in claim 1 wherein the pump means includes a first pump operative to supply fluid pressure to the first conduit means and a second pump operative to supply fluid under pressure to the second conduit means.

12. The invention defined in claim 1 wherein the valve means includes a first valve operative to selectively supply fluid pressure to the second conduit means and a hydraulically actuated valve in the first conduit means responsive to fluid pressure in the second conduit means to direct fluid pressure from the pump means to the motor.

13. The invention defined in claim 1 wherein the control means includes a hydraulic cylinder having a piston shiftable in response to fluid pressure to shift the control means and a servo valve responsive to the fluid pressure in the accumulator and operative to direct fluid to or exhaust fluid from the cylinder so that the position of the piston varies according to the pressure in the accumulator.

14. The invention defined in claim 13 wherein the piston has an axial bore and the servo valve includes a spool-type valve member coaxially slidable in said bore and acted on in one direction by the fluid pressure in the accumulator and in the opposite direction by a spring means, the valve member shifting in said bore to control the flow of pressurized fluid to and from the cylinder so that the position of the cylinder corresponds to the position of the valve member.

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