

[54] **HYDRAULIC CONTROL SYSTEM FOR TWO-SPEED WINCH**

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60/905, 91/412

[51] Int. Cl. **F16h 39/50**

[58] Field of Search 60/53 WW, 53 R, 420,
60/424, 425, 427, 435, 483, 484, 905; 91/412

[56] **References Cited**

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[57]

ABSTRACT

The hoisting winch of a mobile crane is driven by two hydraulic motors connected to a common drive shaft. A control system for the motors includes manually controlled directional and speed control valves. The speed control valve optionally connects the motor hydraulically either in parallel for low-speed, high-torque operation or in series for high-speed, low-torque operation. A speed-limiting feature automatically shifts the speed valve to or maintains it in its low-speed position whenever the load is too heavy to be handled by the system in its high-speed mode. The hydraulic circuit of the control system also provides anticavitation protection for the motors when in its high-speed mode.

10 Claims, 5 Drawing Figures

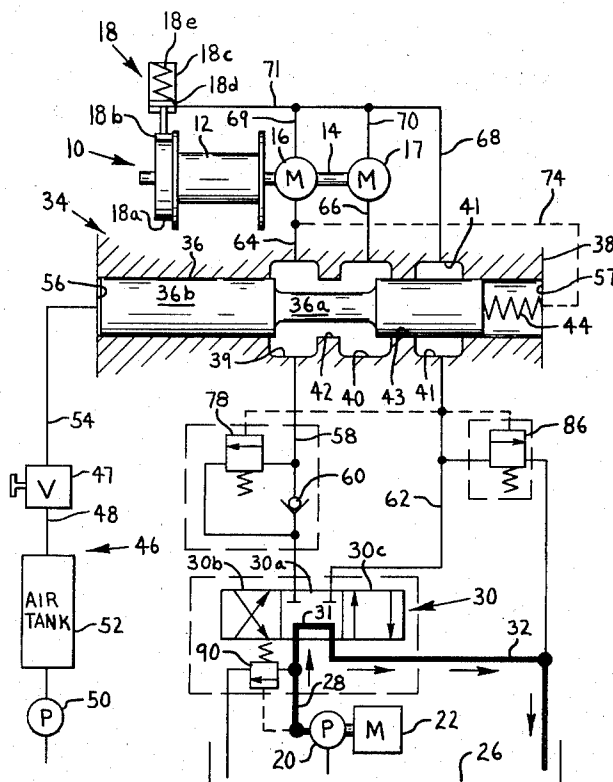


Fig. 2

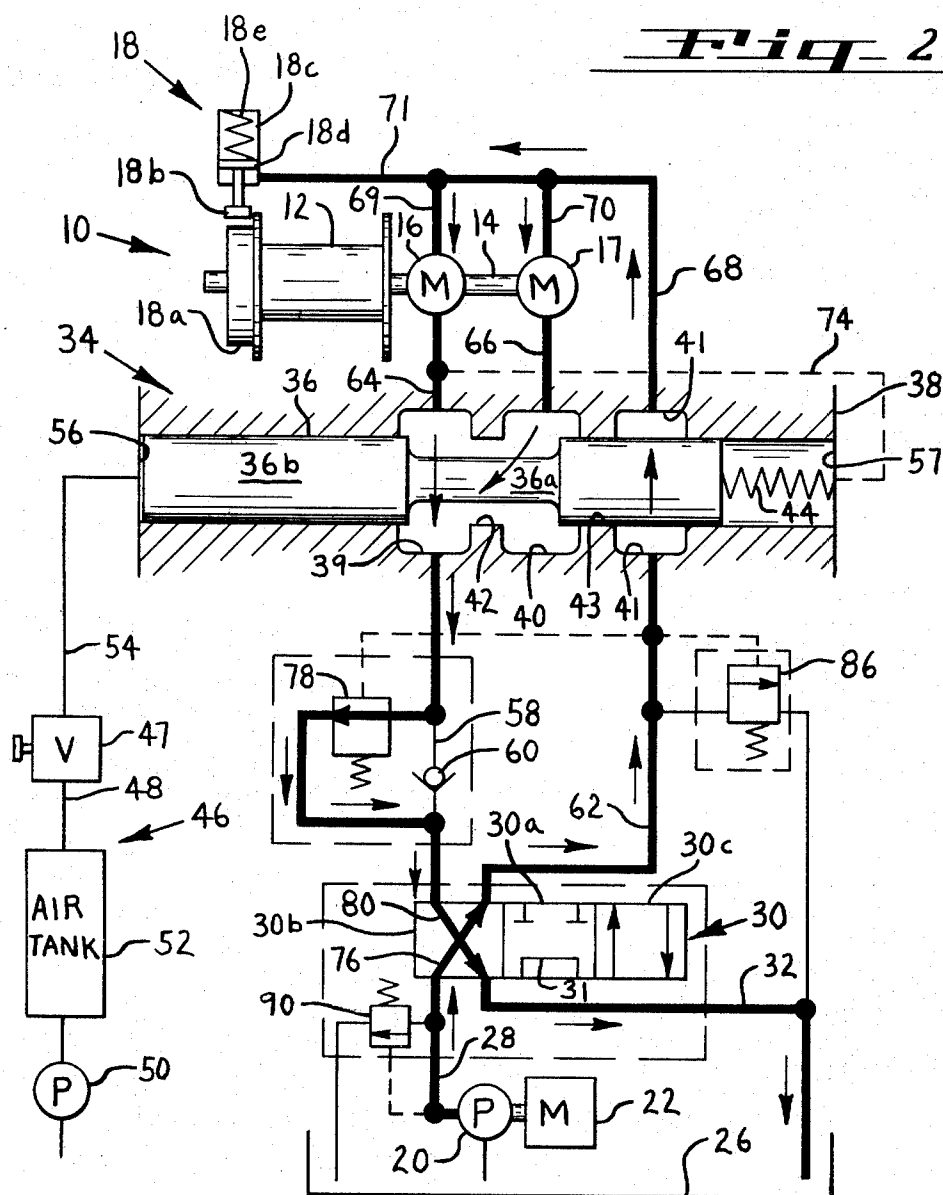


Fig. 3

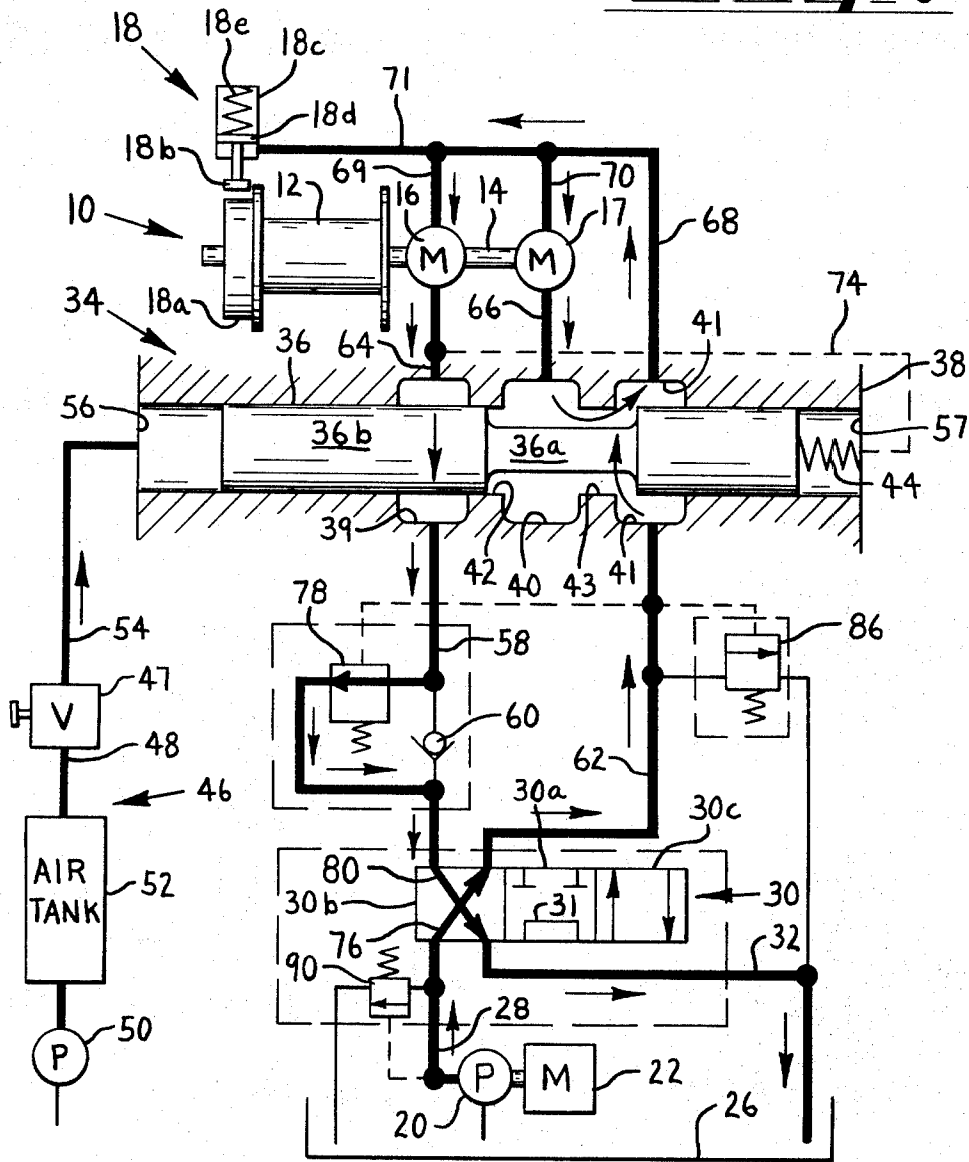


Fig 4

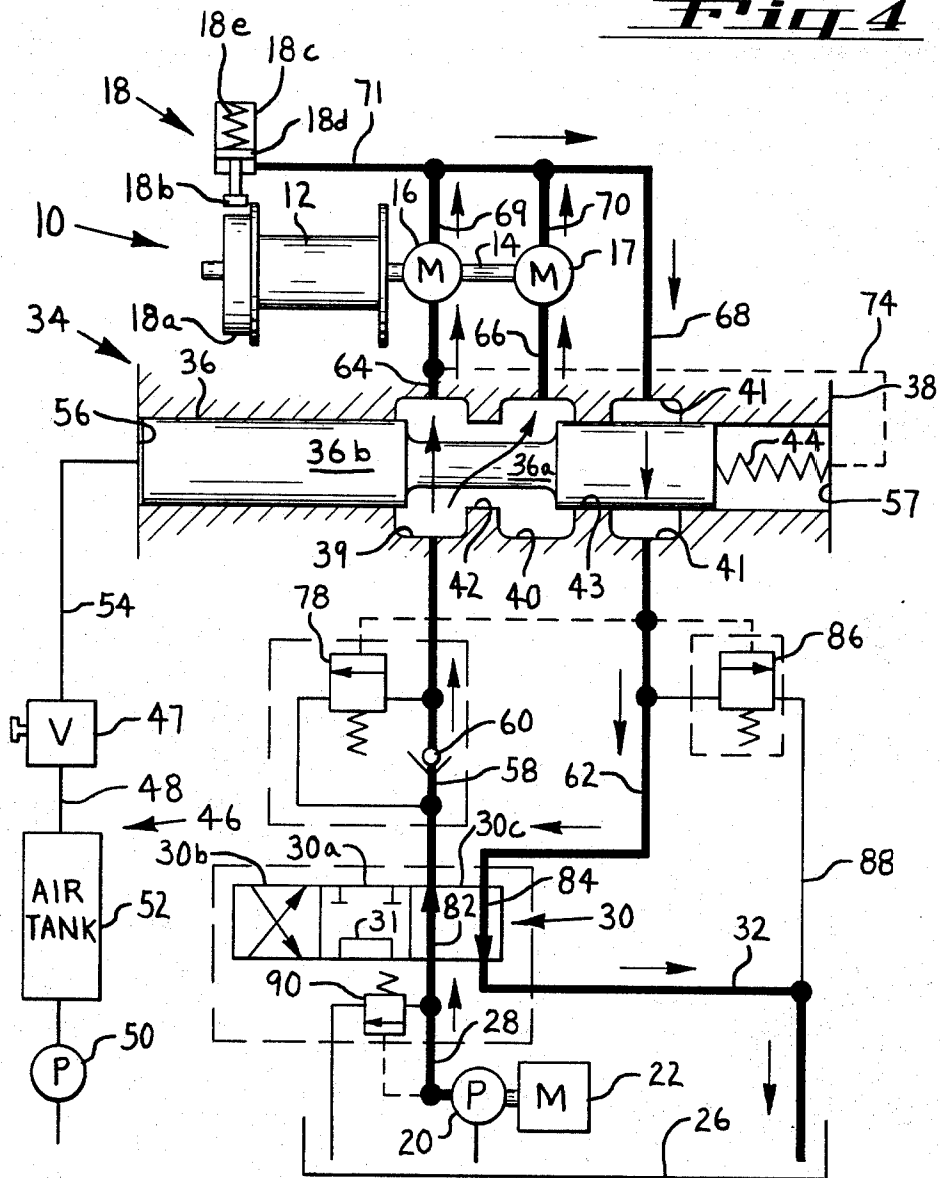
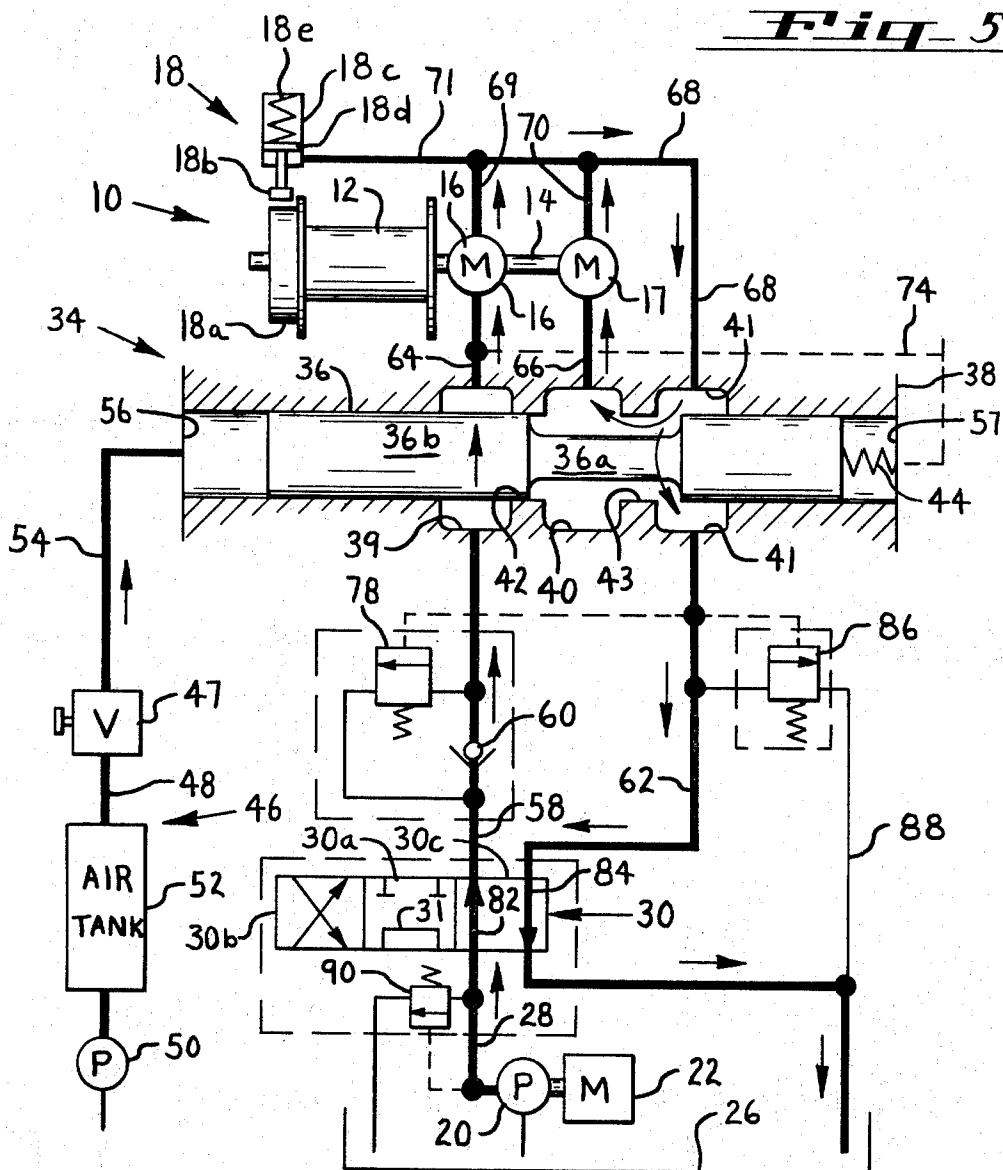


Fig. 5



HYDRAULIC CONTROL SYSTEM FOR TWO-SPEED WINCH

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a hydraulic control system for a two-speed, two-motor, hydraulic motor-driven hoisting winch.

2. Description of the Prior Art

It is known that a crane winch can be selectively driven at two different speeds through two hydraulic motors driving through a common drive shaft by selectively connecting the motors hydraulically either in series or in parallel using a suitable speed control valve. Such a winch driving system is shown, for example, in U.S. Pat. No. 3,390,785, issued July 2, 1968.

However, such prior two-speed hydraulic winch systems have no speed-limiting feature. That is, there is nothing to prevent the operator from shifting from the low-speed to the high-speed mode, even if the load to be hoisted is too heavy to be handled by the winch or its hydraulic system in the high-speed mode. Under such circumstances the system simply relieves excess pressure buildup through an appropriate relief valve while a check valve in the circuit prevents the load from back-driving the motors. However, the load remains at a standstill so long as the speed valve remains in its high-speed position, and valuable production time is lost.

Such prior winch-operating systems may also have an anticavitation protection feature which prevents cavitation at the motors while reeling in cable at high speed under light load or while paying out cable at high speed under heavy load. However, prior systems usually require a pressure-sensitive valve to provide this feature, which necessitates another movable control element capable of malfunction affecting the entire control circuit. Also, such an anticavitation valve usually operates by restricting return flow through the circuit, thereby limiting winch speed. Such a valve is also usually only operative when lowering a load so that there is no cavitation protection in the hoist mode.

SUMMARY OF THE INVENTION

The present invention is a control system providing two speed-torque modes for a winch while also having a built-in automatically operating speed-limiting feature which prevents shifting the speed control to its high-speed mode, thereby maintaining it in its low-speed mode, unless the system in its high-speed mode is capable of hoisting the winch load.

The present invention also provides a hydraulic control circuit with built-in anticavitation protection operable in its high-speed mode regardless of the directional mode of the system. A recirculation subcircuit is automatically completed when the speed control is positioned in its high-speed mode so as to recirculate fluid from the inlet to the outlet sides of the motors and thereby ensure that the motor inlets have an adequate supply of fluid.

A primary object of the present invention is to provide a control system for a two-speed, two-motor hydraulic motor-driven winch having a speed control that can normally be shifted at the will of the operator between its high-and low-speed positions but which cannot be shifted from its low-speed position when the load being handled is too heavy to be lifted in the high-

speed mode. Thus load hoisting is not interrupted by an overly heavy load. Hoisting simply continues at a lower speed.

A second important object is to provide a control system as described which provides anticavitation protection for the two hydraulic winch motors when operating in the high-speed mode, regardless of the directional mode, without requiring additional valving for this purpose and without restricting the winch speed.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features and advantages of the present invention will become more apparent from the following detailed description and accompanying drawings, wherein:

FIGS. 1 through 5 are hydraulic circuit diagrams illustrating a control system of the invention in various modes of operation.

DETAILED DESCRIPTION

General

Referring to the drawings, FIG. 1 shows a control system of the invention for controlling the operation of a winch 10 used for hoisting loads on a mobile crane. The winch includes a winch drum 12 for storing cable. The drum is rotated in either direction through a drive shaft 14 driven by two hydraulic motors 16, 17. The winch also includes a brake 18 including a brake drum 18a forming an extension of the winch drum, brake shoe 18b and brake cylinder 18c. The brake cylinder houses a piston 18d connected by its piston rod to the brake shoe. The brake shoe is normally maintained in engaged position against the brake drum when the control system is de-energized by a spring 18e within the brake cylinder behind the piston.

The control system includes a hydraulic control circuit interconnecting the motors 16, 17 and a fixed displacement hydraulic pump 20. The pump is driven by a suitable motor 22. A suction line 24 extends from the pump into a hydraulic fluid reservoir 26. The pump outlet is connected to a pressure line 28 leading to a directional control valve 30. A second, return line 32 leads from valve 30 back to reservoir 26. In the center, neutral position 30a of valve 30 shown in FIG. 1, a valve passage 31 completes a fluid circuit from the pump back to reservoir through the valve without any fluid flow through the remainder of the circuit including the motors 16, 17.

The directional control valve 30 is a three-position control valve having in addition to its center, neutral position 30a, a "down" position 30b for paying out cable from the winch drum and thereby lowering a load, and an "up" position 30c for reeling in cable and thus hoisting a load.

In addition to the directional control valve, the circuit includes as one of its primary components the speed control valve means 34. Such means includes a manually controlled two-position valve spool 36 shiftable within a valve body 38 having enlarged valve cavities 39, 40, 41 and intermediate cavity restrictions 42, 43. The spool is normally biased to its left-hand, low-speed position as shown in FIG. 1 by the urging of a spring 44 at the right-hand end 57 of the main valve cavity.

An air pressure-powered valve-actuating means 46 includes a manually operated air valve 47 which when opened connects an air line 48 leading from an air

pump 50 and accumulator 52 to an air line 54. Air line 54 communicates with the end 56 of the speed valve cavity in opposition to spring 44 and when pressurized, at for example 100 psi, shifts spool 36 against spring pressure to its high-speed position as shown in FIGS. 3 and 5.

Two main hydraulic fluid passages extend between the directional control valve 30 and speed control valve 34, one passage 58 extending through a check valve 60 to valve cavity 39 and the other 62 extending directly to valve cavity 41. Three passages then extend between the speed control valve and the motors, including a first passage 64 between valve cavity 39 and one side of motor 16, a second passage 66 between valve cavity 40 and the corresponding side of motor 17 and a third passage 68 with branches 69, 70 extending from valve cavity 41 to the opposite sides of the two motors 16, 17. An extension 71 of line 68 leads to the lower end of brake cylinder 18c to release the brake when the line is pressurized.

The circuit also includes a bypass valve 78 off of line 58 which bypasses fluid around check valve 60 in the "down" directional mode of operation of the circuit. A quick dump valve 86 off of line 62 is capable of bypassing fluid to reservoir around directional valve 30 when the latter valve is shifted from its up mode back to neutral. The usual system high-pressure relief valve 90 is also provided upstream of directional valve 30 to relieve the system of excessively high pressures. Typically, quick-dump valve 86 might be set to dump at 50 psi. Bypass valve 78 might be set to close at 300 psi in line 62.

Speed Control Feature

The control system described includes a speed control feature provided by a pilot line 74 leading from a connection with line 64 to the spring end 57 of the speed valve cavity. When the circuit is in its "hoist" mode, as represented by FIGS. 4 and 5, pilot line 74 senses the inlet pressure at motor 16 and transmits such pressure to the spring end of the speed valve cavity. If such pilot pressure exceeds a predetermined pressure level, for example 1,000 psi, indicative of the system's inability to raise a load acting on winch drum 12 in the high-speed position of valve 36, then such pressure, transmitted through the pilot line, overcomes any air pressure acting at the opposite end 56 to prevent spool 36 from shifting to its high-speed position. If spool 36 is already in its high-speed position, it will shift back to its low-speed position automatically when the pressure at the motor inlet becomes excessive. That is, any hydraulic pressure exceeding the preselected limit pressure acting through pilot line 74 acts through pilot line 74 at end 57 of the valve cavity together with the pressure of spring 44 to prevent any counteracting valve-actuating air pressure acting through line 54 at the opposite end 56 of the cavity from shifting or maintaining the valve spool in its high-speed position.

The speed-limiting feature described acts in the same way when the circuit is in its down mode to prevent the pay-out of cable under a heavy load at an excessive speed. In this case, as shown, for example, in FIGS. 2 and 3, the pilot line 74 senses the outlet pressure of motor 16 and such pressure when beyond the speed limit pressure will cause valve spool 36 to shift to its low-speed position to slow down the lowering speed

and thus limit the extent to which the load on the winch cable can back-drive motors 16 and 17 as pumps.

Anticavitation Feature

FIG. 3, illustrating the circuit in its high-speed down mode, shows the circuit's built-in anticavitation feature in operation. In this mode directional spool 30 is shifted to its down position 30b and air valve 47 is actuated to admit air to the left-hand end 56 of the speed spool cavity to shift the speed spool 36 to its high-speed position shown. In these positions of the directional and control spools, fluid flow is from pump 20 to valve cavity 41 via line 62. Fluid flows from this cavity into line 68. At the intersection of lines 68 and 70, the flow divides, one part going into line 70 to the inlet side of motor 17 and another part going on to line 69 and to the inlet of motor 16, the division of flow being dictated by the respective fluid pressures at the inlets of motors 16, 17. Exhaust fluid from motor 16 flows through line 64 to valve cavity 39, and back to reservoir through line 58.

However, the exhaust flow from motor 17 cannot take the same direct path as just described. In this regard, exhaust flow from motor 17 is through line 66 into speed valve cavity 40. The flow is blocked at this point from entering valve cavity 39 and return line 58 by the speed valve land 36b. Instead, exhaust flow in cavity 40 flows across cavity restriction 43 and spool groove 36a back to valve cavity 41 and line 68 to be recirculated through the motors. Thus exhaust flow from motor 17 cannot return to reservoir until it has also passed through motors 16. Therefore the motors are hydraulically series-connected in this mode of the circuit and exhaust fluid from motor 17 is recirculated through the motor circuit from its outlet side to the inlet sides of the motor, thereby ensuring an adequate pressure at the motor inlets to prevent cavitation, which might otherwise easily result in this high-speed down mode, particularly under heavy cable loads.

A similar recirculation occurs when the circuit is in its high-speed up mode as shown in FIG. 5. In this case, the flow of fluid under operating pressure at the motor end of the circuit is first through line 64 to motor 16. Exhaust flow from the outlet side of motor 16 is through line 69 and from there to line 68 and into speed valve cavity 41. From there flow proceeds across valve cavity restriction 43 as permitted by spool land 36a into valve cavity 40 and motor inlet line 66 to the inlet side of motor 17. Exhaust flow from motor 17 is then through line 70 back into line 68 and valve cavity 41, across valve groove 36a and into return line 62 back to reservoir. Thus in this high-speed, up mode there is also a recirculation of fluid from the outlets of both motors to the inlet of motor 17. This recirculation has the dual purposes of connecting motor 17 in series with motor 16 and preventing cavitation at the inlet of motor 17.

OPERATION

Neutral Mode

In the neutral mode of the circuit, shown in FIG. 1, there is no fluid flow through the motor portion of the circuit. Directional control valve is in its centered neutral position 30a, and all flow from pump 20 is through line 28, valve passage 31 and line 32 back to reservoir. There being no flow to the motors or to line 68, there is no flow through line 71 to the brake cylinder 18c. Therefore, brake shoe 18b is applied to brake drum 18a

to prevent free-spooling of the winch drum 12 under load.

Down, Low-Speed Mode

To operate the system in its down, low-speed mode as shown in FIG. 2 so as to pay out cable slowly from winch drum 12, air valve 47 remains closed, directional valve 30 is shifted to its down position 30b, and, because of the condition of air valve 47, speed valve spool 36 remains in its low-speed position shown.

Fluid flow under operating pressure is from pump 20 through line 28, directional valve passage 76, line 62, speed valve cavity 41, and line 68 to branch lines 69, 70, and from there to the inlets of both motors 16, 17. Simultaneously line 71 and the lower end of brake cylinder 18c are pressurized, thereby releasing brake shoe 18b from brake drum 18a so that the winch drum can rotate.

Exhaust flow from motors 16, 17 is through lines 64 and 66 into valve cavities 39, 40 respectively. Flow from both cavities then proceeds through line 58 and through bypass valve 78, bypassing check valve 60, to directional valve passage 80 and from there through line 32 back to reservoir 26.

Thus in this condition of the circuit, the motors 16 and 17 are connected hydraulically in parallel so that each receives only approximately one-half of the available flow, thereby operating them at half their top speeds, assuming the motors are of identical capacity. At the same time the torque developed by the motors is double that which would be produced when the motors are series-connected.

Down, High-Speed Mode

To shift from the low-speed to the high-speed down mode as shown in FIG. 3, air valve 47 is opened to admit air pressure to end 56 of the speed valve cavity. Assuming that the load is not so great that it would back-drive the motors to an extent producing an excessive outlet pressure in line 64 and thus pilot line 74, valve 36 shifts to its high-speed position shown in FIG. 3 under the influence of air pressure at 56. Directional valve 30 remains in its down position 30b. Flow is as it is in the low-speed down mode from pump 20 through line 28, valve passage 76, and line 62 to valve cavity 41 and then through line 68 to branch lines 69 and 70 to the inlets of motors 16 and 17.

However, in the high-speed mode the exhaust flow from the motors is different, as discussed previously with respect to the anticavitation feature, in that exhaust flow from motor 17 is blocked from entering return line 58 by speed valve land 36b. Instead, such flow recirculates through valve cavity restriction 43, cavity 41 and line 68 to the inlet sides of the motors 16, 17. Eventually such flow returns to reservoir through motor 16, line 64, cavity 39 and line 58. Since all flow is forced through motor 16, the motors 16, 17 are in effect hydraulically series connected, thereby driving them and the connected winch drum 12 at high speed and low torque, that is, at approximately double their speeds when connected in parallel.

As previously mentioned in discussing the speed-limiting feature, speed valve spool 36 automatically shifts back to its low-speed position when the outlet pressure of motor 16 exceeds a predetermined pressure of, say 1,000 psi. This would indicate that the load on the winch is so great that it is back-driving the motors

at an excessive speed and therefore perhaps lowering the load at a dangerously high speed.

Up, Low-Speed Mode

Operation of the system in an up mode at low speed is illustrated in FIG. 4. In this mode, air valve 47 is closed, placing speed valve spool 36 in its low-speed position. Directional spool 30 is shifted to its up position 30c. In these positions of the directional and speed valves, flow is from pump 20 through line 28, a directional valve passage 82, line 58, and check valve 60 into speed valve cavity 39. Flow is then from both cavities 39 and 40, as permitted by spool land 36a, into both motor inlet lines 64, 66 to the inlet sides of motors 16, 17. Exhaust flow from the motors and lines 60, 70 pressurizes line 71 to disengage the brake. Return flow proceeds through line 68, speed valve cavity 41, line 62, directional valve passage 84 and line 32 back to reservoir. In this mode, the speed valve 36 connects motors 16 and 17 hydraulically in parallel, thereby driving the motors at low speed but at a high torque suitable for lifting heavy loads.

If the load being hoisted is too heavy to be lifted in the high-speed mode, an excessive inlet pressure develops at motor 16 and in line 64. This pressure, transmitted by pilot line 74 to the right-hand end 57 of the speed valve cavity, prevents shifting of the speed valve spool 36 to its high-speed position, even if commanded to shift by the operator through the opening of air valve 47.

Up, High-Speed Mode

To change from low speed to high speed when hoisting, the operator simply opens air valve 47 to admit air under pressure to the left-hand end 56 of the speed valve cavity. Assuming that the load being hoisted is not so great that it causes an excessively high inlet pressure in line 64 and thus pilot line 74, speed valve spool 36 shifts to its high-speed position shown in FIG. 5 against the pressure of spring 44. In this position, flow is from pump 20 through line 28, through passage 82 of the directional valve, line 58 and check valve 60 into speed valve cavity 39. From this cavity flow is to line 64 only and to the inlet of motor 16. From the outlet of motor 16, exhaust flow is through lines 69 and 68 to valve cavity 41. From cavity 41 at least part of the flow, induced by low pressure at the inlet of motor 17, is across cavity restriction 43, as permitted by spool groove 36a, into line 66 and to the inlet of motor 17. Exhaust flow from motor 17 is to line 70 and then is recirculated to line 68 and from there through valve cavity 41 to either return line 62 and to reservoir 26 or back to line 66, depending on the inlet pressure at motor 17.

Thus all flow goes initially through motor 16 before returning to reservoir. In addition, there will be at least sufficient flow through motor 17 to prevent cavitation because of the position of speed valve spool groove 36a permitting recirculating flow from both motor outlets to the inlet of motor 17.

Having illustrated and described what is presently a preferred form of my invention, it should be apparent to those skilled in the art that the same permits of modification in arrangement and detail. I claim as my invention all such modifications as come within the true spirit and scope of the following claims.

I claim:

1. A hydraulic control system for a two-speed winch including a winch drum driven by a pair of hydraulic motors drivingly connected to a common power transmission, said control system comprising:

a source of hydraulic pressure fluid,
a hydraulic fluid circuit interconnecting said source and said hydraulic motors,

directional control valve means in said circuit (a) operable in a first neutral position to interrupt flow of pressure fluid from said source to said motors, (b) operable in a second hoist position to direct fluid under operating pressure to said motors in a direction for winding cable on said drum and (c) operable in a third lowering position to direct fluid under operating pressure to said motors in a direction for unwinding cable from said drum,

speed control valve means in said circuit between said directional control valve means and said motors operable in a first low-speed position to connect said motors hydraulically in parallel with said source and operable in a second high-speed position to connect said motors hydraulically in series with said source when said directional control valve is in either its hoist or lowering said positions, said speed control valve means being normally biased to said low-speed position and being selectively positionable in said high-speed position, with said directional control valve means in said hoist position, only when the maximum inlet pressure at said motors is below a predetermined pressure level.

2. A control system according to claim 1 wherein said speed control valve means selectively operable by a fluid pressure tending to move said valve means to said high-speed position and is sensitive to said motor inlet pressure in a manner opposing movement of said valve means to said high-speed position when said directional control valve is in said hoist position.

3. A control system according to claim 1 wherein said speed control valve means comprises a spool valve having a valve spool and means biasing said spool to the low-speed position of said valve, fluid pressure valve-operating means selectively operable to act against said spool in a direction tending to shift said spool to said high-speed position, and speed-limiting means including pilot passage means in said circuit extending, with said circuit in a hoist mode, between an inlet side of one of said motors and said valve means in a manner such that motor inlet pressure acts on said spool in a direction opposing said fluid pressure valve-operating means.

4. A control system according to claim 3 wherein motor inlet pressure above a predetermined pressure level indicative of a winch load beyond the high-speed mode capacity of said motors is operable acting through said pilot passage means to shift said spool to said low-speed position.

5. A control system according to claim 1 wherein said speed control valve means when in said high-speed position completes a recirculation subcircuit operable in the hoist and lowering modes of said circuit to recirculate pressure fluid from the outlet side of at least one of said motors to the inlet side of at least one of said motors to inhibit cavitation at said motors.

6. A hydraulic control system for a two-speed winch including a winch drum driven by a pair of hydraulic

motors drivingly connected to a common power transmission, said control system comprising:

a source of hydraulic pressure fluid,
a hydraulic fluid circuit interconnecting said source and said hydraulic motors,

directional control valve means in said circuit (a) operable in a first neutral position to interrupt flow of pressure fluid from said source to said motors, (b) operable in a second hoist position to direct fluid under operating pressure to said motors in a direction for winding cable on said drum and (c) operable in a third lowering position to direct fluid under operating pressure to said motors in a direction for unwinding cable from said drum,

speed control valve means in said circuit between said directional control valve means and said motors operable in a first low-speed position to connect said motors hydraulically in parallel with said source and operable in a second high-speed position to connect said motors hydraulically in series with said source when said directional control valve is in either its hoist or lowering said positions, said speed control valve means when in said high-speed position being operable to complete a recirculation subcircuit operable in the hoist and lowering modes of said circuit to recirculate pressure fluid from the outlet side of at least one said motor to the inlet side of at least one said motor and thereby inhibit cavitation at said motors.

7. A hydraulic control system for a two-speed winch driven by a pair of hydraulic motors drivingly connected to a common drive transmission, said system comprising:

a hydraulic fluid circuit interconnecting a pump means and said motors and including selectively operable directional control valve means and speed control valve means, said speed control valve means being biased to a low-speed position, but selectively movable to a high-speed position,

and speed-limiting means operable to maintain said speed control valve means in said low-speed position when the maximum inlet pressure at said motors exceeds a predetermined limit pressure level.

8. A hydraulic control system for a two-speed winch driven by a pair of hydraulic motors drivingly connected to a common drive transmission, said system comprising:

a hydraulic fluid circuit interconnecting a pump means and said motors and including selectively operable directional control valve means and speed control valve means,

speed-limiting means operable to maintain said speed control valve means in a low-speed position when the maximum inlet pressure at said motors exceeds a predetermined limit pressure level,

and selectively operable speed control valve-actuating means for shifting said speed valve means between high-speed and low-speed positions,

said speed-limiting means being operable to override said valve-actuating means and maintain said speed valve means in, or shift said speed valve means to, said low-speed position when said limit pressure is exceeded.

9. A hydraulic control system for a two-speed winch driven by a pair of hydraulic motors drivingly connected to a common drive transmission, said system comprising:

a hydraulic fluid circuit interconnecting a pump means and said motors and including selectively operable directional control valve means and speed control valve means,

speed-limiting means operable to maintain said speed control valve means in a low-speed position when the maximum inlet pressure at said motors exceeds a predetermined limit pressure level,

and anticavitation means operable at a high speed position of said speed valve means to protect said motors from cavitation.

10. A hydraulic control system for a two-speed winch driven by a pair of hydraulic motors drivingly con-

nected to a common drive transmission, said system comprising:

a hydraulic fluid circuit interconnecting a pump means and said motors and including selectively operable directional control valve means and speed control valve means,

and anticavitation means operable in a high-speed position of said speed valve means to provide a regenerative motor subcircuit of said hydraulic circuit and thereby ensure adequate flow to both said motors.

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