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HYDRAULIC HOIST CONTROL CIRCUIT

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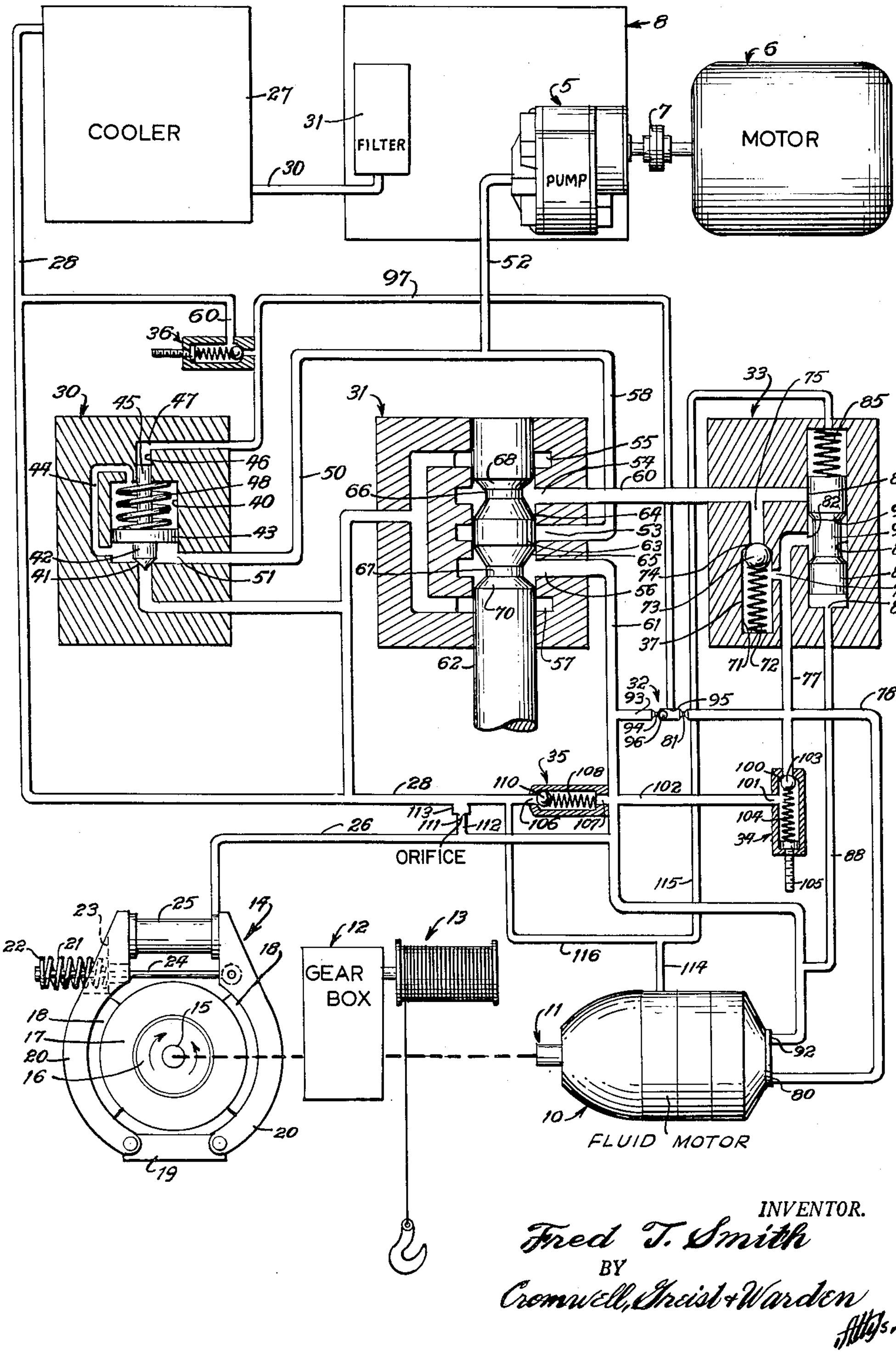

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HYDRAULIC HOIST CONTROL CIRCUIT

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This invention relates to innovations and improvements in a hydraulic control circuit or system for use in controllably moving a load in opposite directions, particularly in instances wherein the load has a tendency to overrun in one direction. The invention is particularly adapted for use in a hydraulic hoist wherein gravity tends to make the load overrun in the downward direction.

It is recognized that hydraulic hoists, including various control circuits or systems, are broadly old. However, the present invention embodies a number of improvements and innovations in the control circuits or control systems for hydraulic hoists which offer a number of important advantages and make hydraulic hoists embodying this invention particularly attractive to users.

The object of this invention, generally stated, is the provision of new and improved hydraulic hoists, and the control circuits or systems therefor.

More particularly, the object of the invention is the provision of hydraulic hoists and control circuits or systems therefor incorporating the following advantages, characteristics and novel features: conventional or slightly modified components can be used throughout; the circuit is balanced and chatter-free; there are three built-in safety features any one of which would normally be adequate for safety purposes in an emergency; the safety features are provided by components that have prime operating functions in the system; a minimum of maintenance is required; such few parts as do wear can be readily replaced and do not fail all at once but gradually with ample warning of their condition of wear; electrical connections are reduced to a minimum and may be restricted to just the insulated conductors required to energize one electric motor; the speed of the hook is and remains substantially independent of load; wear on the friction brake is reduced to a minimum; the hoist may be readily controlled from the cab and/or remotely, e.g. the floor; the hoist control means may be mechanical, pneumatic, hydraulic or electrical; even under full capacity load the hoist can be accurately and immediately controlled in either direction at extremely slow speeds of the order of 1/350 of full speed; during both lifting and lowering the load is continually under control of a hydraulic motor the fluid discharge from which on load lowering is throttled by a resistance to fluid flow in the nature of a restricted orifice; the hoist is self-limiting in that it will refuse to lift a load in excess of a predetermined safe setting; and, even with lowering under full load at relatively high speeds the hoist may be immediately stopped without damage to its mechanism.

The foregoing and certain other objects of the invention will in part be obvious, and will in part be made further apparent in connection with the following detailed description thereof.

For a more complete understanding of the nature and scope of the invention, reference may now be had to the following detailed description thereof taken in connection with the accompanying drawings wherein, the single figure is a diagrammatic drawing of a complete hydraulic hoist and control circuit or system therefor, embodying applicant's invention.

In the drawing, a positive displacement pump **5** of known type serves as the source of fluid pressure for operating the hoist. The pump **5** is driven by a unidirectional constant speed motor, such for example as a squirrel

cage type electric motor **6**. The drive shafts of the pump **5** and motor **6** are suitably connected by coupling indicated at **7**.

Through a control system or control circuit to be described below, the pump **5** delivers hydraulic fluid under pressure to a positive displacement hydraulic motor **10** of known type, such for example as an axial piston, rotary hydraulic motor. The motor **10** is reversible in that it is driven in one direction when the hoist is to be lifted or raised and is driven in the reverse direction when the hoist or load is to be lowered. The output shaft **11** of the motor **10** is suitably coupled to the input connection of a gear train indicated diagrammatically at **12**. The output connection of the gear train **12** is suitably connected to a cable drum of known type indicated at **13**. The mounting and interconnection of the gear train **12** and the cable drum **13** may follow conventional hoist construction practice. The drum **13** is indirectly connected through the gear box or as shown with the center shaft **15** of a safety brake of known type indicated at **14**, as is conventional.

The shaft **15** is mounted in the rotating element **16** of a free-running clutch, such as a Sprague clutch which is free to rotate in one direction only. In this case the brake shaft **15** is free to rotate in the hoist lifting direction.

The brake **14** has a brake drum **17** of relatively large diameter which may be clamped in braking relationship from opposite sides by means of a pair of brake shoes **18** mounted in the clamping arms **20—20** hinged at the bottom to a yoke **19**.

The arms **20** are normally pulled together at the top continuously by means of a heavy compression spring **21** which is maintained under compression between a disk **22** and a flat portion **23** on the adjacent arm **20**. The outer plate **22** is secured to the outer end of a rod **24**, the inner end of which is provided with an eye whereby it is pivotally connected to the opposite arm **20**. It will be seen that as the spring **21** is retained under compresion it continuously pulls the two arms **20** together and thereby sets the brake shoes **18** on the drum **17**.

It will be appreciated that the foregoing arrangement for keeping the brake **14** "set" or "on" may be varied and means other than a compression spring can be used although this is satisfactory and is highly reliable. A hydraulic cylinder unit **25** of known type may be utilized for overcoming the force of the spring **21** and separating the arms **20** sufficiently to release the brake **14**. Such a hydraulic cylinder unit **25** is indicated as being interposed between the upper ends of the arms **20** with a pressure line **26** extending thereto. It will be appreciated that when fluid pressure of a predetermined value is admitted to the cylinder **25** it will operate to overcome the force of the spring **21** and release the brake. If the pressure is admitted slowly the brake **14** can be very gradually released and an important operating advantage can be taken of this characteristic of the brake **14** as will be pointed out below.

Since under prolonged heavy duty operation the hydraulic fluid or oil will undergo a considerable rise in temperature, it is desirable to provide a cooler of known type such as that indicated diagrammatically at **27**. Preferably all of the oil is returned to the tank or reservoir via the cooler **27** through the return main or conduit **28**. The discharge side of the cooler **27** is connected by means of a conduit **30** with the inlet of an oil filter **31** disposed within the reservoir **8**. By means of the cooler **27** and the filter **31** the hydraulic fluid is kept cool and clean.

The hydraulic control system or circuit for interconnecting the pump **5** or other source of fluid pressure with the motor **10** and brake **14** will now be described.

This hydraulic control system comprises the following main components together with the necessary conduits or tubings for interconnecting the same: a sequence valve 30; a four-way control valve 31; a shuttle valve 32; a counter-balance valve 33; a relief valve 34; a check valve 35; a relief valve 36; and a check valve 37 (which is shown built into the counter-balance valve 33). Each of the foregoing components is of known type and is commercially available in several types from manufacturers thereof. For example, the sequence valve 30 is available from Vickers, Inc., Detroit, Michigan, as Vickers Model RG–O6–Z3 sequence valve, remote control, externally drained ¾ pipe sized for gasket mounting. The counter-balance valve 33 is available as Vickers Model RCG–O6–A3 counter-balance valve, remote controlled, externally drained, internal check, ¾ pipe sized for gasket mounting. The four-way valve 31 is available from Hydraulic Press Manufacturing Co., Mount Gilead, Ohio, as its HPM—No. 3217–C, lever operated four-way valve, ¾ size, style C spool, closed center with cylinder ports open to tank—3,000 p.s.i. flanged connected.

The sequence valve 30 has a chamber 40 for hydraulic fluid with an outlet port 41 in the bottom thereof which communicates with one branch of the fluid return line 28. The port 41 is closable by a valve member 42 carried by a movable member in the form of a piston 43 which is slidable in the chamber 40 and separates the portion of the chamber underneath the piston 43 from the upper portion. The opposite ends of the chamber 40 are interconnected by means of a communicating passageway 44 therebetween. On the upper side of the plunger 43 there is a plunger 45 which is movable in a plunger chamber indicated at 46. The plunger chamber 46 receives fluid pressure in the upper end only through a pilot pressure inlet port designated at 47. The dimensions of the parts are such that the combined or total exposed area which is subject to fluid pressure on the underside of the plunger 43, including the valve member 42, is greater than the top surface of the plunger 43 which is exposed to the same fluid pressure. Accordingly, there is always a differential in pressure which tends to open the sequence valve by raising the valve member 42 from the port 41. In order to prevent the valve 42 from opening until at least a certain predetermined pressure has been reached or built up on the pressure fluid, a spring 48 is provided in the chamber 40 which bears on the top side of the plunger 43 and tends to hold the valve member 42 closed. The spring 48 will be selected as to strength so that it will act on the top of the piston 43 with the desired force. For example, the spring 48 may be selected so that the pressure in the chamber 40 must be at least 35 pounds per square inch (p.s.i.) before the sequence valve 30 will open. Fluid under pressure is delivered to the valve 30 by means of a conduit 50 communicating with the fluid inlet port 51 in the lower portion of the chamber 40. At its opposite end, the conduit 50 communicates with one end of a conduit 52 leading from the discharge connection of the positive displacement pump 5.

The four-way control valve 31 is of the type known as a closed center four-way valve with a center inlet port designated at 53. There is one pair of outlet ports on opposite sides of the center port 53. One of these pairs of ports (i.e. the top pair) is designated at 54 and 55, while the other pair (i.e. the bottom) is designated at 56 and 57. The center inlet port 53 receives hydraulic fluid through a conduit 58 connected with the main supply conduit 52. The outlet port 54 adjacent the center inlet port 53 on one side thereof is connected with a conduit 60 while the outlet port 56 adjacent to the center port 53 on the opposite side is connected with a conduit 61. The outlet ports 55 and 57 are in direct communication with the fluid return line 28 through passageways in the valve 31.

The valve 31 is controlled by means of a valve member 62 which is reciprocable in the valve body and is provided with a spool portion for suitably interconnecting, and disconnecting the ports 53–57. In the drawing the valve member 62 is shown in the closed or neutral position wherein the spool portion 63 closes the inlet port 53. At the same time the outlet ports 55 and 57, non-adjacent to the center port 53, are also closed. On opposite sides of the center spool portion 63 there are two tapered or frusto-conical portions 64 and 65. Outwardly from the portions 64 and 65 are neck portions 66 and 67 respectively and then relatively stepped or tapered frusto-conical portions 68 and 70 respectively.

When the control member or operating member 62 is moved downwardly from the position shown in the drawings it will be seen that the sections 64—66—68 will establish communication between the center inlet port 53 and the adjacent outlet port 54. Furthermore, it will be seen that there is a variable degree of communication established which depends upon the particular position of the control member 62. This is by reason of the taper on the section 64 which in effect provides an orifice of variable size between the ports 53 and 54. At the same time that communication is provided between the ports 53 and 54, the tapered and intermediate portion 63—65—67 establish communication between the other adjacent outlet port 56 and the associated tank return port 57. Conversely, when the control member 62 is moved in the opposite direction, i.e. upwardly as shown in the drawings, the communication is provided between the center inlet port 53 and the outlet port 56, while the ports 54 and 55 are brought into communication.

The control member 62 may be operated manually, or it may be operated remotely in known manner, mechanically (as by a Bowden wire control), electrically (as by a servo motor), hydraulically or pneumatically.

The counter-balance valve 33 may have the check valve 37 built into it or the latter may be separate therefrom. The check valve 37 is of known type and comprises a chamber 71 containing a light compression spring 72 which normally urges a ball valve member 73 into its closed position over the inlet port 74. A passageway 75 connects the port 74 with the conduit 60. The valve 37 has an outlet port 76 which is connected with a conduit 77 which interconnects with the conduit 78 at a cross connection therebetween. Thus, fluid can flow through the check valve 37 in one way only, i.e. from the conduit 75 to the conduit 77. The conduit 78 at one end is connected with one of the two main inlet connections of the hydraulic motor 10, the one being indicated at 80. At its opposite end the conduit 78 is connected with one of the three connections 81 of the shuttle valve 32.

At its upper end, the conduit 77 communicates with the inlet port 82 of the chamber 83 in the counter-balance valve 33. This chamber 83 contains a valve member in the form of a reciprocable spool 84, the opposite ends of which serve as plungers within the chamber 83. A spring 85 in the upper end of the chamber 83 normally holds the spool 84 in its downward position as shown. The upper end of the spool in this position closes the outlet port indicated at 86 which communicates with the conduit 60. In operation, force of the spring 85 is overcome by means of fluid pressure in the lower end of the chamber 83 delivered through the inlet port 87 which is in communication with the one end of the pressure line 88, the other end of which connects with the conduit 61. It will be seen that the reduced diameter portion 90 of the spool 84 is of such length that when the spool is moved upwardly it will provide communication between the ports 82 and 86. The reduced diameter portion 90 joins the upper end of the spool 84 through a tapered length 91. By reason of this taper an orifice of variable size is provided when the port 86 is opened.

The conduit 61 at its lower end is connected with the second main connection of the hydraulic motor 10, which is indicated at 92. A short condit 93 connects the conduit 61 with the connection 94 of the shuttle valve 32. Intermediate between the inlet connections 81 and 94 of the shuttle valve 32 there is an outlet port 95. A ball valve member 96 is movable between opposite ends of the valve 32 so as to alternately close connections 81 and 94. The intermediate connection 95 is at all times in communication with the pilot pressure inlet port 47 in the sequence valve 30 by means of the conduit 97 communicating therebetween.

The relief valve 34 has an inlet port or connection 100 and a discharge port or connection 101. The former is connected to the bottom end of the conduit 77 while the latter is connected to the righthand end of a conduit 102 leading from the conduit 61. The valve 34 is provided with a ball valve member 103 which is adjustably held against the port 100 in closing position by means of a spring 104 the pressure on which is adjustable by means of the screw 105.

The relief valve 36 corresponds to the relief valve 34 with its inlet port being connected to the conduit 97 and with its outlet port being connected to the tank return line 28. The pressure settings on the relief valves 34 and 36 are different as will be explained hereinafter.

The check valve 35 has its inlet port 106 connected in communication with one branch of the tank return line 28, while its discharge port 107 is connected with the conduit 61. This valve is normally maintained in the closed position by means of a spring 108 urging the ball valve member 110 to a seated position over the port 106.

For a purpose to be described below, a direct communication is provided between the conduit 26 leading to the brake cylinder 25 and the tank return line 28. Such communication is provided by an orifice 111 in the connection between the stub line 112 from the conduit 26 and the stub line 113 from the tank return line 28. Some leakage may occur in the motor 10 and counter-balance valve 33 and this may be conveniently returned to the tank 8 by means of the conduits 114 and 115 respectively, which discharge into a conduit 116 connected to the tank return line 28.

Operation

Having described the construction of the hydraulic hoist including the control system therefor, its mode of operation will now be described. The electric motor 6 will be started and left running during the period in which the hoist is in operation even though it is not in continuous use. Assuming that the hoist is at rest and the control valve 31 is in closed or neutral position, then the hydraulic fluid continuously discharged from the positive displacement pump 5 is forced under low pressure through the conduits 52 and 50 through the outlet port 41 in the open sequence valve 30 and then through the tank return line to the reservoir 8. The spring 48 in the sequence valve may be set so that the valve member 42 opens when the pressure delivered to the chamber 40 equals 35 p.s.i.g. for example. The fluid from the pump 5 continues to circulate through this path as long as the control valve 31 is closed.

Assuming that it is now desired to lift a load with the hoist, the control member 62 for the valve 31 is shifted downwardly so as to permit the hydraulic fluid under pressure to pass from the center port 53 out through the outlet port 54 into the conduit 60. The proportion of the hydraulic fluid under pressure which passes out through the conduit 60 depends upon the degree to which the variable orifice opening between the ports 53 and 54 is opened. The balance of the fluid will continue to be discharged through the sequence valve 30 to the reservoir 8. The fluid under pressure flows through the conduit 60 to the right and since the port 86 is closed it is diverted downwardly through the conduit 75, check valve 37, conduit 77, and conduit 78 to the port 80 of the hydraulic motor 10.

Since the port 56 of the control valve 31 is in communication with the tank return line 28, the fluid introduced into the hydraulic motor 10 discharges an equal amount of fluid out through the connection 92 into the conduit 61, and then through the interconnected ports 56 and 57 into the return line 28. The motor 10 is thus driven so as to rotate the cable drum 13 in a lifting direction through the gear train 12. As explained above, the brake 14 is free-running in one direction (i.e. the lifting direction) and therefore the cable drum is free to turn in the lifting direction even though it is interconnected to the brake 14 which is set or on.

It will be seen that the ball valve member 96 of the shuttle valve 32 will be in the position shown closing the port 94 since high pressure is being admitted to the connection 81 from line 77, whereas, the connection 94 is at tank return pressure. Accordingly, the pressure in the lines 77 and 78 will be applied through the conduit 97 to the pilot pressure inlet port 47 so as to act on the upper end of the plunger 45. This added pressure combines with the spring pressure 48 and tends to close the valve member 42 on the port 41. By means of this arrangement it will be seen that a constant pressure drop is maintained across the variable orifice provided by the frustoconical tapered portion 64 on the valve member 62 between the ports 53 and 54. This drop is equal to the force of the spring 48, e.g. 35 p.s.i. Obviously, since the drop in pressure across this orifice is constant the wider the orifice is opened the greater will be the flow of fluid therethrough. Stated conversely, in order to maintain the pressure drop at a constant value, the flow of fluid has to be greater when the orifice is widened and has to be less when the orifice is reduced. It will therefore be seen that the wider the orifice is opened the faster will the hoist be operated, and conversely, the less it is opened the slower it is operated or raised. For any particular setting, the speed of the hoist will remain substantially constant regardless of variation in load applied to the drum 13.

In the foregoing manner, the hoist is operated in the lifting condition simply by lowering the valve member 62 a greater or less amount depending upon the rate at which it is desired to lift a particular load.

At this point, the function of the relief valve 36 can best be described. This valve is provided so as to prevent the hoist from being overloaded and thereby exceed its capacity. Assume for example that a load is applied to the cable drum which is in excess of that which the hoist is intended to, or is set to, raise. Obviously, the greater the load the greater will be the pressure required on the fluid entering the motor 10 in order to raise the load. By setting the valve 36 at the desired upper safe pressure, e.g. 500 pounds per square inch, the valve 36 will open if a load requiring a greater pressure to lift it is applied to the drum 13. The liquid by-passes through the check valve 36 and prevents the pressure from exceeding the setting of the valve. Thus, no harm is done and the condition of overload will at once become apparent to the operator.

It will be seen that if at any time during the raising operation it is desired to discontinue or stop the lifting operation, the valve member 62 is simply moved to the center position where it closes the inlet port 53 and thereupon the admission of pressure to the motor 10 is discontinued and the raising stops immediately. The pump discharge will then flow through the sequence valve at low pressure back to the tank or reservoir 8 at low pressure.

When it is desired to operate the hoist in the lowering direction, the operating member 62 of the valve 31 is moved upwardly so as to establish communication between the inlet port 53 and the adjacent outlet port 56. The fluid under pressure then flows through the conduit 61 to the upper connection 92 of the motor 10. The pressure acts on the ball member 96 of the shuttle valve 32 and pushes this valve member to the opposite end of the valve so as to close the port of connection 81. It will be seen that the pressure in the line 61 now passes through the port 95 and the conduit 97 to the top of the plunger 45. The squence valve operates as it did before to maintain a predetermined drop in pressure across the orifice opening between the port 53 and the port 56. Thus, the wider this orifice opening is made then the greater will be the flow of fluid through the conduit 61 into the motor 10. The pressure in the line 61 acts through the conduit 26 upon the brake cylinder unit 25 which may be set to operate at a pressure of say 200 p.s.i.g. The brake 14 holds the cable drum 13 through the gear box 12 and thereby also the motor 10 from turning until the brake is released. Hence, the pressure has to build up in the line 61 to the predetermined pressure where the brake 14 opens. In this manner, by operating the valve member 62 the brake 14 can be released so that it just barely slips and allows the load to ease down while under complete control.

Since fluid acts in the cylinder 25 but does not flow through it, the only fluid flowing in line 61 will be that required to compensate for the small flow through the bleed orifice 111 and the slight leakage from the motor 10 and the valves 31 and 33 to tank. Fluid cannot discharge from the motor 10 through connection 80 since the path is blocked by the shuttle valve 32, the check valve 37 and the counter-balance 33. The counter-balance valve 33 is set to open at a pressure substantially above that required to release the brake 14, e.g. 300 p.s.i.g. when the brake releases at 200 p.s.i.g. The pressure acts on the bottom end of the spool 84 and the spring pressure 85 is overcome thereby lifting the spool so as to permit opening of the port 86. The pressure at which the counter-balance valve 33 opens is made higher than the pressure at which the brake 14 is released or slipped, in order to bring about release of the brake before the motor 10 is allowed to turn faster than the slow speed permitted by leakage. If the pressure on the spool 84 exceeds 300 p.s.i.g. then the port 86 will be opened a greater distance and a greater volume of liquid will be permitted to discharge through the counter-balance valve 33 and then across the ports 54—55 to the tank return 28. Thus, it will be seen that even during lowering the motor 10 operates under fluid pressure and is not free-running. That is, it must be driven down by pressure in line 61.

When the control valve member 62 is brought back to the neutral position during hoist lowering, it will be seen that the admission of fluid to the conduit 61 and the return of fluid through the conduit 78 is immediately stopped. That is, this is stopped in the control valve 31 itself. Accordingly, the motor 10 is stopped and no longer allows the hoist to lower. The brake 14 is permitted to close since the pressure in the line 61 and in the conduit 26 is permitted to drop through the orifice 111 into the return line 28. Thus, the brake 14 sets quickly after the valve 31 is brought to neutral. It will be seen that the pressure drops in the line 88 and this permits the counter-balance valve 33 to close. Accordingly, the load is prevented from dropping due to the brake being set, the motor 10 being stopped, the counter-balance valve 33 being closed, and the four-way valve 31 being closed. The slight amount of leakage that may occur through the motor 10 is discharged into the tank return line 28 through the conduits 114, 115 and 116. However, this and such other leakages as occurs in the system is small and does not permit the motor 10 to slip but very little and this can easily be restrained by the capacity of the brake 14.

By means of the foregoing control, it is possible to lower the hoist under full load by just cracking the four-way valve sufficiently to slip the brake 14 so that it lowers at speeds equal to a small fraction of full speed, e.g. 1/350 of full speed. One the other hand, the valve can be fully opened, and then the load can be lowered at full speed but always under control.

The relief valve 34 is provided to protect the system under the condition where a full load is being lowered at full speed and the valve member 62 is jerked into the closed position. As explained above, when this happens, the normal paths for fluid flow to and from the motor 10 are immediately shut off. However, the relief valve 34 will open under these conditions. The relief valve 34 will be set to open at a higher value or pressure than the relief valve 36. By reason of this relationship between the setting, it is established that the valve 36 is always open when the valve 34 opens and a short-circuiting of flow through the motor by way of the relief valve 34 is precluded.

The check valve 35 is provided as an added safety measure in the event the brake 14 should fail. If this happened, a load would tend to drive the motor 10 to allow the load to fall. However, with the control valve 31 closed the only fluid that can escape from the motor is that due to leakage through the motor 10 and counter-balance valve 33. This is very small. The check valve insures that this condition can be maintained as it will serve to prevent the motor 10 from starving for liquid. In that case the motor 10 would operate as a pump and the check valve 35 would open.

It will be seen that there are in effect three safety features in the control circuit which has been described which prevent a load from falling or getting away. First, there is the brake 14 itself which is especially efficient when the load is at a standstill since the brake will then exert its maximum braking or holding capacity. In addition, the counter-balance valve 33 and the four-way control valve 31 constitute added safety features against a load getting away. If the brake 14 fails, the control valve 31 will prevent the load from lowering except at very slow speed. If the counter-balance valve 33 fails and the motor 10 starts to run away, the pressure on the brake 14 will fall and the brake will set. If the brake 14 and counter-balance valve 33 should both fail, the control valve will hold the load against dropping. It is very unlikely that the brake 14, the control valve 31 and the counter-balance valve 33 will all fail at once.

Since certain changes and modifications can be made in the embodiments of the invention as described and shown in the accompanying drawing without departing from the spirit and scope of the invention, it is intended that all matter described above or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

What is claimed as new is:

1. A reversible hydraulic hoist drive comprising: a positive displacement pump having an inlet communicating with a return line and an outlet connected to a pressure line; a four-way throttling valve having a reciprocable spool movable to the raise, lower and neutral positions and a body defining a discharge port connected to the return line, an inlet port connected to the pressure line and first and second valve ports, all of said ports being blocked when said spool is in neutral position; a reversible positive displacement hydraulic motor having first and second ports connected respectively to said first and second valve ports by first and second conduits; a check valve in said first conduit preventing flow therethrough from said motor; a counter-balance valve connected in parallel around said check valve and having a control member operable in a control chamber to open the counter-balance valve proportionately to pressures in said control chamber above a predetermined minimum; a first control conduit connecting said counter-balance control chamber with said second conduit; a sequence valve biased towards closed position having an inlet connected to said pressure line, an outlet connected to said return line, and a pressure control chamber having a plunger operable therein to urge the valve towards closed position upon an increase in pressure within the chamber; a shuttle valve having inlets connected between said first and second conduits and having an outlet; and, a second control conduit connecting said

pressure chamber of said sequence valve with the outlet of said shuttle valve.

2. In a hydraulic hoist system adapted to drive a cable drum and including a positive displacement pump, a reservoir for hydraulic fluid, and a reversible hydraulic motor having first and second connections, a hydraulic control system operably connecting said pump and motor comprising; a sequence valve having an inlet port, an outlet port and a pilot pressure port; a four-way control valve having an inlet port, a discharge port and first and second delivery ports; a shuttle valve having opposed first and second inlet ports and an intermediate outlet port; first conduit means interconnecting said inlet port of said sequence valve with discharge connection of said pump; second conduit means interconnecting said inlet port of said four-way valve with the discharge connection of said pump; third conduit means interconnecting said first delivery port of said four-way valve with said first connection of said motor and said first inlet port of said shuttle valve; fourth conduit means interconnecting said second delivery port of said four-way valve with said second connection of said motor and with said second inlet port of said shuttle valve; fifth conduit means interconnecting said outlet port of said shuttle valve with said pilot pressure port; and sixth conduit means interconnecting said outlet port of said sequence valve and said discharge port of said four-way valve with said reservoir.

3. In the hydraulic control system called for in claim 2, in said third conduit means a one-way check valve permitting fluid flow only towards said hydraulic motor, and flow-resistance means in parallel relationship with said one-way check valve permitting only fluid under at least a predetermined pressure to flow only from said hydraulic motor.

4. In the hydraulic control system called for in claim 2, a one-way check valve having its outlet port in communication with said fourth conduit means and having its inlet port in communication with said sixth conduit means.

5. In the hydraulic control system called for in claim 2, a pressure relief valve having its inlet port in communication with said fifth conduit means and having its discharge port in communication with said reservoir.

6. In the hydraulic control system called for in claim 2, a pressure relief valve having its inlet port in communication with said third conduit means and having its discharge port in communication with said fourth conduit means.

7. In the hydraulic control system called for in claim 2, a pressure relief valve having its inlet port in communication with said fifth conduit means and having its discharge port in communication with said reservoir, and a second pressure relief valve having its inlet port in communication with said third conduit means and having its discharge port in communication with said fourth conduit means, said first pressure relief valve being set to operate at a pressure below that at which said second pressure relief valve is set to operate.

8. In a hydraulic hoist system adapted to drive a cable drum and including a positive displacement pump, a reservoir for hydraulic fluid, and a reversible hydraulic motor, a hydraulic control system operably connecting said pump and motor comprising: a sequence valve of the type having a fluid chamber therein, an outlet port for said chamber, a valve member for closing said outlet port carried on a movable member separating fluid in one end of the chamber from fluid in the other end, an inlet port on the same side of said movable member as said outlet port, a passageway communicating between opposite ends of said chamber for equalizing the fluid pressure therein, spring means continuously acting on said movable member to urge said valve member to close said outlet port, a plunger aligned with said valve member and connected with said movable member on the side opposite said valve member and reciprocable in a plunger chamber, and a pilot pressure inlet port into said plunger chamber; a closed-center four-way control valve having a center inlet port, one pair of ports on one side of said inlet port one being adjacent thereto and one being non-adjacent, a second pair of ports on the other side of said inlet port, one being adjacent thereto and one being non-adjacent, a movable valve member having a center position wherein all of said ports are shut off from each other, having a range of positions on one side of its center position wherein said inlet port is in a variable degree of communication with the adjacent port on said one side thereof and wherein the pair of ports on the opposite side of said center position are placed in communication with each other, and having a range of positions on said opposite side of its center position wherein said inlet port is in a variable degree of communication with the adjacent port on said opposite side and wherein the pair of ports on said one side are placed in communication with each other; a shuttle valve having two ports in opposite ends of a chamber and a third port in said chamber intermediate its opposite ends, a valve member in said chamber movable between opposite ends thereof to alternately close said end ports while leaving said intermediate port in communication with the unclosed end port; first conduit means interconnecting said inlet port of said sequence valve with the discharge connection of said positive displacement pump; second conduit means interconnecting said center inlet port of said four-way control valve with the discharge connection of said positive displacement pump; third conduit means interconnecting one of said adjacent ports of said four-way control valve with one of the two connections of said hydraulic motor and also with one of said end ports of said shuttle valve; fourth conduit means interconnecting the other of said adjacent ports of said four-way control valve with the second connection of said hydraulic motor and also with the second one of said end ports of said shuttle valve; fifth conduit means interconnecting said intermediate port of said shuttle valve with said pilot pressure inlet port of said sequence valve; and sixth conduit means interconnecting said outlet port of said sequence valve and said non-adjacent ports of said four-way control valve with said reservoir.

9. In a hydraulic hoist system adapted to drive a cable drum and including a positive displacement pump, a reservoir for hydraulic fluid, a reversible rotary hydraulic motor having two fluid connections with fluid entering one connection under pressure and exiting through the other connection under a lower pressure when the motor is driven in one direction and entering said other connection under pressure and exiting through said one connection under a lower pressure when the motor is driven in the opposite direction, and a brake operably coupled with said motor, said brake being free-running in the lift direction of said motor and having pressure supply means normally holding said brake "on" so said motor is not free to turn in the lowering direction and having a hydraulic cylinder unit whereby hydraulic pressure may be used to overcome said pressure supplying means and release said brake, a hydraulic control system operably interconnecting said pump, motor and brake, comprising: a sequence valve of the type having a fluid chamber therein, an outlet port for said chamber, a valve member for closing said outlet port carried on a movable member separating fluid in one end of the chamber from fluid in the other end, an inlet port on the same side of said movable member as said outlet port, a passageway communicating between opposite ends of said chamber for equalizing the fluid pressure therein, spring means continuously acting on said movable member to urge said valve member to close said outlet port, a plunger aligned with said valve member and connected with said movable member on the side opposite said valve member and reciprocable in a plunger chamber, and a pilot pressure

inlet port into said plunger chamber; a closed-center four-way control valve having a center inlet port, one pair of ports on one side of said inlet port, one being adjacent thereto and one being non-adjacent, a second pair of ports on the other side of said inlet port, one being adjacent thereto and one being non-adjacent, a movable valve member having a center position wherein all of said ports are shut off from each other, having a range of positions on one side of its center position wherein said inlet port is in a variable degree of communication with the adjacent port on said one side thereof and wherein the pair of ports on the opposite side of said center position are placed in communication with each other, and having a range of positions on said opposite side of its center position wherein said inlet port is in a variable degree of communication with the adjacent port on said opposite side and wherein the pair of ports on said one side are placed in communication with each other; a shuttle valve having two ports in opposite ends of a chamber and a third port in said chamber intermediate its opposite ends, a valve member in said chamber movable between opposite ends thereof to alternately close said end ports while leaving said intermediate port in communication with the unclosed end port; first conduit means interconnecting said inlet port of said sequence valve with the discharge connection of said positive displacement pump; second conduit means interconnecting said center inlet port of said four-way control valve with the discharge connection of said positive displacement pump; third conduit means interconnecting one of said adjacent ports of said four-way control valve with the connection of said hydraulic motor into which fluid flows when said motor is driven in a lifting direction and also with one of said end ports of said shuttle valve; fourth conduit means interconnecting the other of said adjacent ports of said four-way control valve with the connection of said hydraulic motor into which fluid flows when said motor is driven in a lowering direction and also with the other of said end ports of said shuttle valve; fifth conduit means interconnecting said intermediate port of said shuttle valve with said pilot pressure inlet port of said sequence valve; sixth conduit means interconnecting said outlet port of said sequence valve and said non-adjacent ports of said four-way control valve with said reservoir; a one-way check valve in said third conduit means permitting fluid flow only toward said hydraulic motor; a pressure-actuated counter-balance valve in parallel with said one-way check valve, said counter-balance valve having an inlet port, an outlet port, a valve member closing at least one of said ports when in one position and having a range of positions providing a variable degree of communication between said ports, resilient means normally holding said valve member in its port-closing position, plunger means operable in a plunger chamber and connected with said valve member for moving it to a port opening position when sufficient pressure is applied thereto, and a pressure inlet in said plunger chamber; seventh conduit means connecting said fourth conduit means with said hydraulic cylinder unit of said brake; and eighth conduit means connecting said fourth conduit means with said pressure inlet in said plunger chamber of said counter-balance valve, said pressure actuated counter-balance valve being set to open at a pressure in excess of the pressure required to actuate said hydraulic cylinder unit.

10. In the hydraulic control system called for in claim 9, ninth conduit means providing a restricted passageway between said seventh conduit means to said sixth conduit means.

11. In a hydraulic hoist system including a positive displacement rotary motor requiring a minimum fluid pressure in order to be driven in a load lowering direction and having leakage below said minimum pressure, and including flow control means for delivering a desired volume of pressure fluid to said motor, in combination, a friction brake for opposing rotation of said motor in load lowering, means operably interconnecting said brake and motor, means for applying said brake, and hydraulic means for opposing said brake applying means and releasing said brake at a pressure below said minimum pressure, control means operably connected with said hydraulic means for releasing said brake to a degree proportionate to the rate of flow of pressure fluid to said motor whereby a load may be lowered by slipping said brake at flow rates proportionate to leakage through said motor.

12. In a hydraulic hoist system including a positive displacement rotary motor with inlet and outlet conduits thereto and requiring a predetermined minimum fluid pressure in order to be driven in a load lowering direction and having leakage below said minimum pressure, and including flow control means for delivering a desired volume of pressure fluid to said motor, in combination, a friction brake operably connected with said motor through a clutch permitting free control of said motor in load raising, said brake opposing rotation of said motor in load lowering, means for applying said brake, and hydraulic means for opposing said brake applying means and releasing said brake at a pressure below said minimum pressure, conduit means communicating between said inlet conduit and said hydraulic means, the release of said brake being proportionate to the rate of flow of pressure fluid to said motor whereby a load may be lowered by slipping said brake at flow rates proportionate to leakage through said motor.

13. In a hydraulic hoist system adapted to drive a cable drum and including (1) a source of fluid under pressure, (2) a reversible rotary hydraulic motor having two fluid connections with fluid entering one connection and exiting through the other connection when the motor is driven in one direction and entering said other connection and exiting through said one connection when the motor is driven in the opposite direction, and (3) a brake operably coupled with said motor, said brake being free-running in the lift direction of said motor and having pressure means normally applying said brake so said motor is not free to turn in the lowering direction, and having a hydraulic cylinder unit whereby hydraulic pressure may be used to overcome said pressure supplying means and release said brake, the improvement comprising, first conduit means connected with that fluid connection of said motor through which fluid exits when said motor is driven in load lowering direction, resistance means in said first conduit means preventing fluid flow therein below a predetermined pressure, second conduit means connected with that fluid connection of said motor through which fluid enters under pressure when said motor is driven in load lowering direction, and third conduit means connecting said hydraulic cylinder unit with said second conduit means, said predetermined pressure necessary to permit fluid flow in said first conduit means being in excess of the pressure required to actuate said cylinder unit and release said brake.

14. Hydraulic hoist driving means comprising a positive displacement hydraulic pump having an inlet in communication with a return conduit and an outlet communicating with a pressure conduit, a reversible positive displacement rotary hydraulic motor having first and second motor ports, said hydraulic motor being adapted for pumping fluid when driven by a load operatively connected with said motor, a four-way throttling valve having an inlet port communicating with the pressure conduit, a discharge port communicating with the return conduit and first and second valve ports, said valve including a member movable to define a continuously variable orifice between said inlet port and one of said first and second valve ports selectively, first and second motor

conduits connecting the first and second valve ports with the first and second motor ports, a sequence valve biased toward closed position and having an inlet port communicating with the pressure conduit between the pump outlet and said inlet port and an outlet port communicating with the return conduit, said sequence valve including a control chamber for forcing the sequence valve toward closed position as pressure in the control chamber increases, control conduit means connected to the control chamber, and a three-way valve communicating with the control conduit and the first and second motor conduits for transmitting to the control chamber of the sequence valve continuously the maximum hydraulic pressure in said first and second motor conduits.

15. The structure defined in claim 14 which includes a check valve in the first motor conduit for blocking flow from the hydraulic motor to the four-way valve, a counterbalance valve in parallel with said check valve in the first motor conduit biased toward closed position for blocking flow from the hydraulic motor to the four-way valve, said valve being balanced with respect to pressure in said first conduit and having a control chamber for moving said valve toward an open position and conduit means communicating with said control chamber in the counterbalance valve and the second motor conduit.

16. The structure defined in claim 15 which includes friction brake means operably coupled with said reversible positive displacement hydraulic motor through a one-way clutch permitting free operation of said motor in load raising while opposing rotation of said motor in load lowering, means for normally applying said brake means, hydraulic cylinder means for opposing and overcoming said brake applying means to release said brake means, and conduit means interconnecting said hydraulic cylinder means with the one of said motor ports into which hydraulic fluid is introduced to drive said motor for load lowering.

17. In a hydraulic hoist system adapted to drive a cable drum and including (1) a source of fluid under pressure, (2) a reversible rotary hydraulic motor having two fluid connections with fluid entering one connection and exiting through the other connection when the motor is driven in one direction and entering said other connection and exiting through said one connection when the motor is driven in the opposite direction, and (3) a brake operably coupled with said motor, said brake being free-running in the lift direction of said motor and having pressure means normally applying said brake so said motor is not free to turn in the lowering direction, and having a hydraulic cylinder unit whereby hydraulic pressure may be used to overcome said pressure supplying means and release said brake, the improvement comprising, first conduit means connected with that fluid connection of said motor through which fluid exits when said motor is driven in load lowering direction, flow resistance means in said first conduit means providing a regulatable orifice for resisting and restricting fluid flow therein, second conduit means connected with that fluid connection of said motor through which fluid enters under pressure when said motor is driven in a load lowering direction, and third conduit means connecting said hydraulic cylinder unit with said second conduit means.

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