Jan. 12, 1971 F. M. LATHROP II 3,553,965

HYDRAULIC VALVE OPERATING SYSTEM AND APPARATUS

Filed Nov. 15, 1968 5 Sheets-Sheet 1

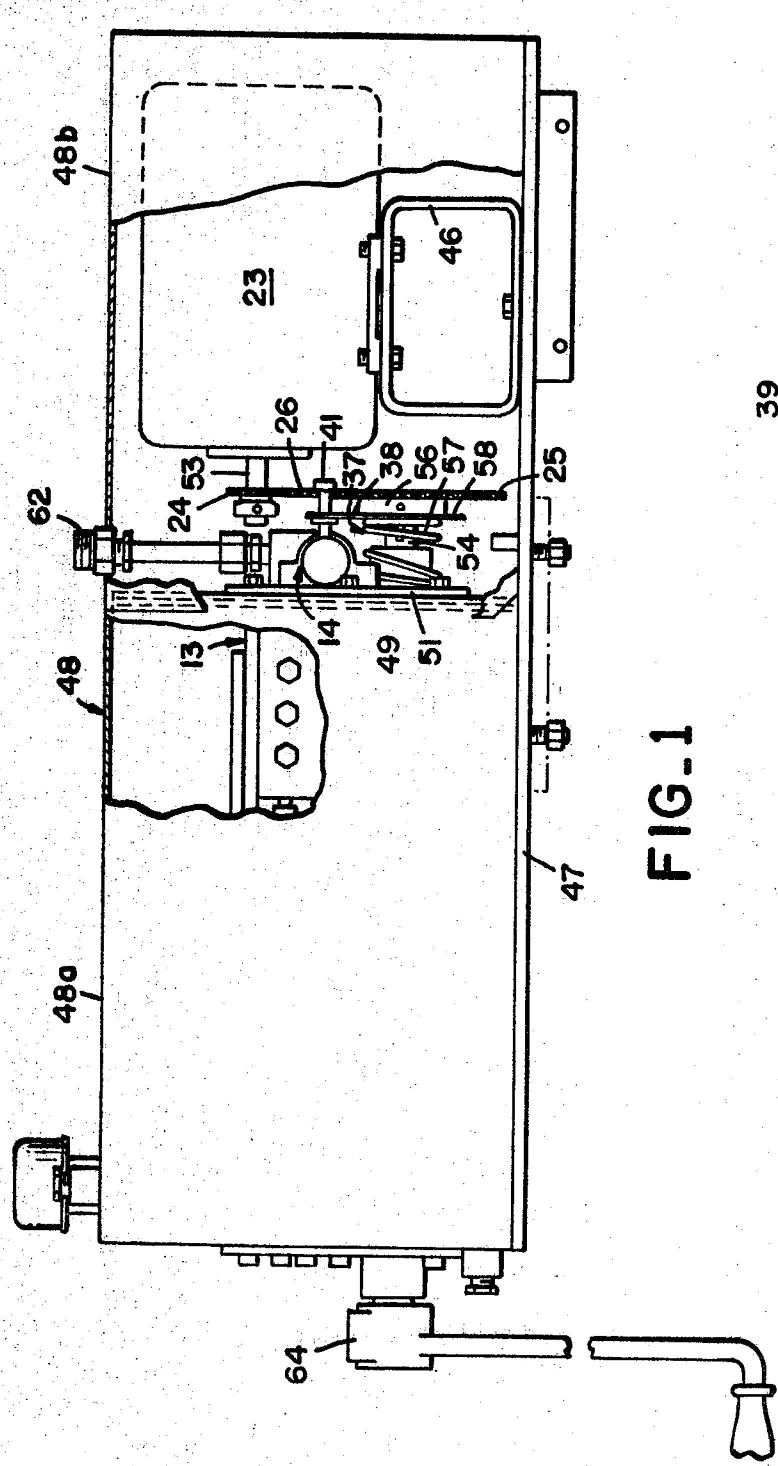

FIG. 1

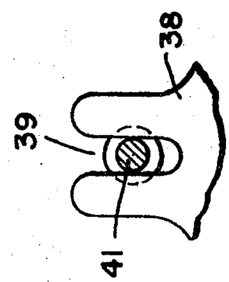

FIG. 4

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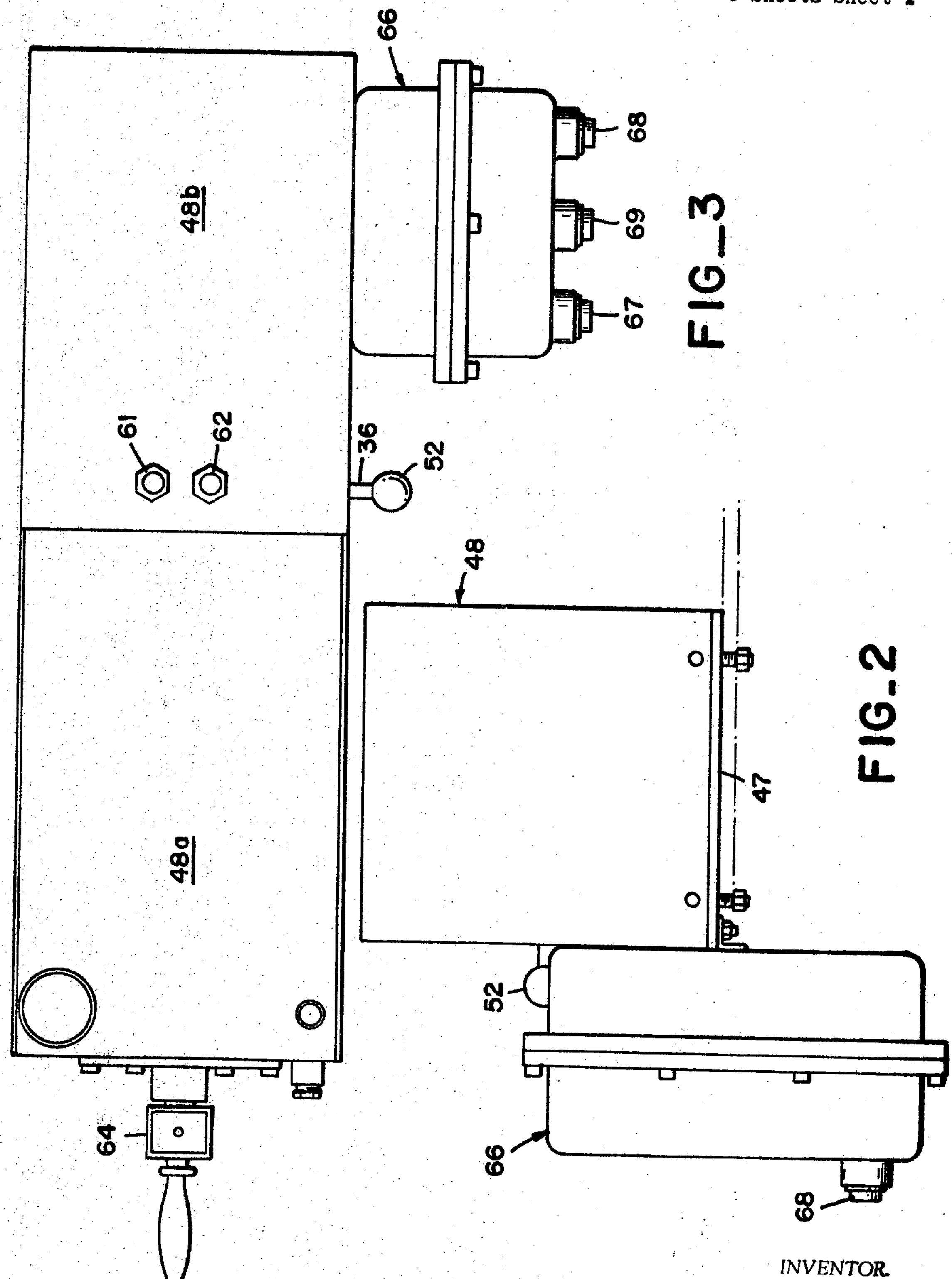

FIG_3

FIG_2

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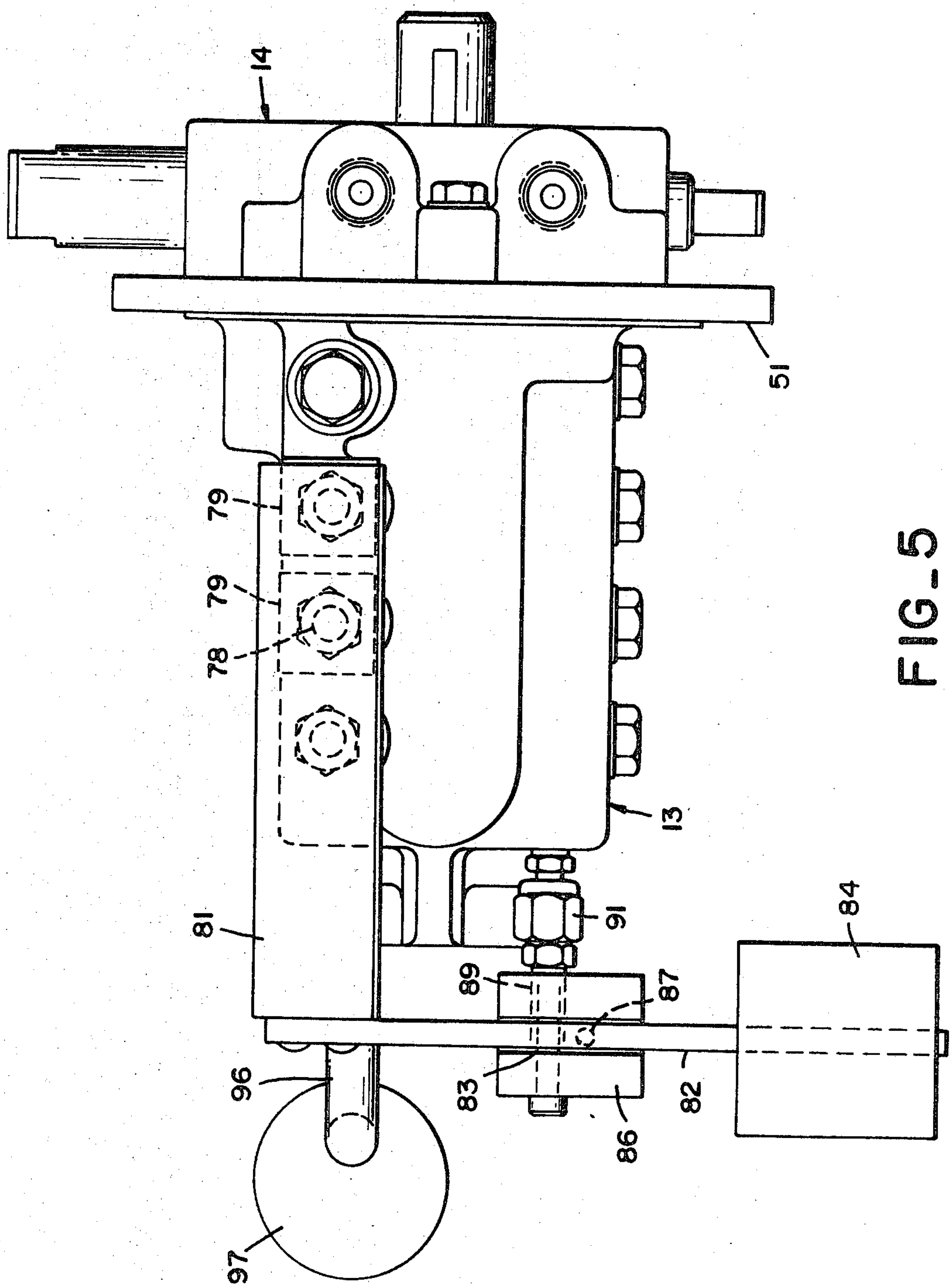

FIG_5

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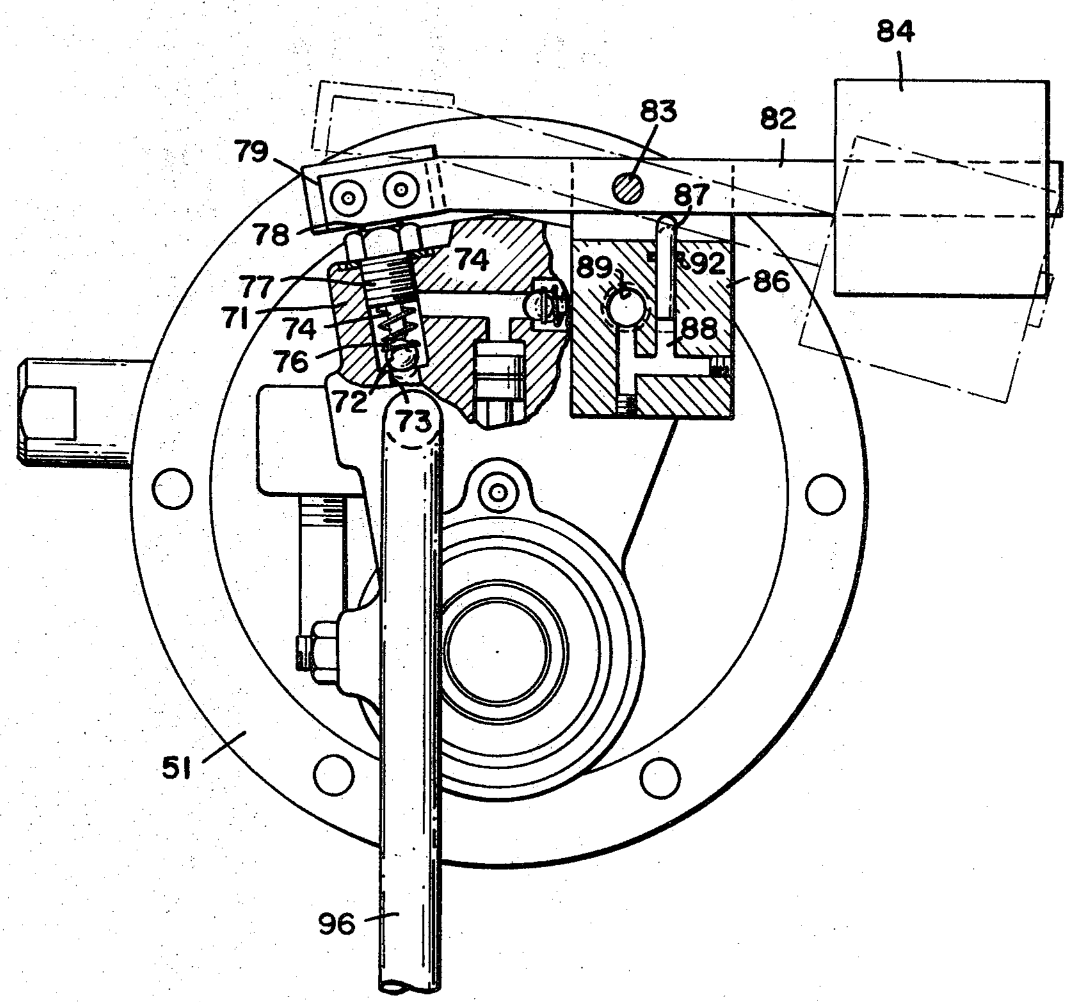

FIG_6

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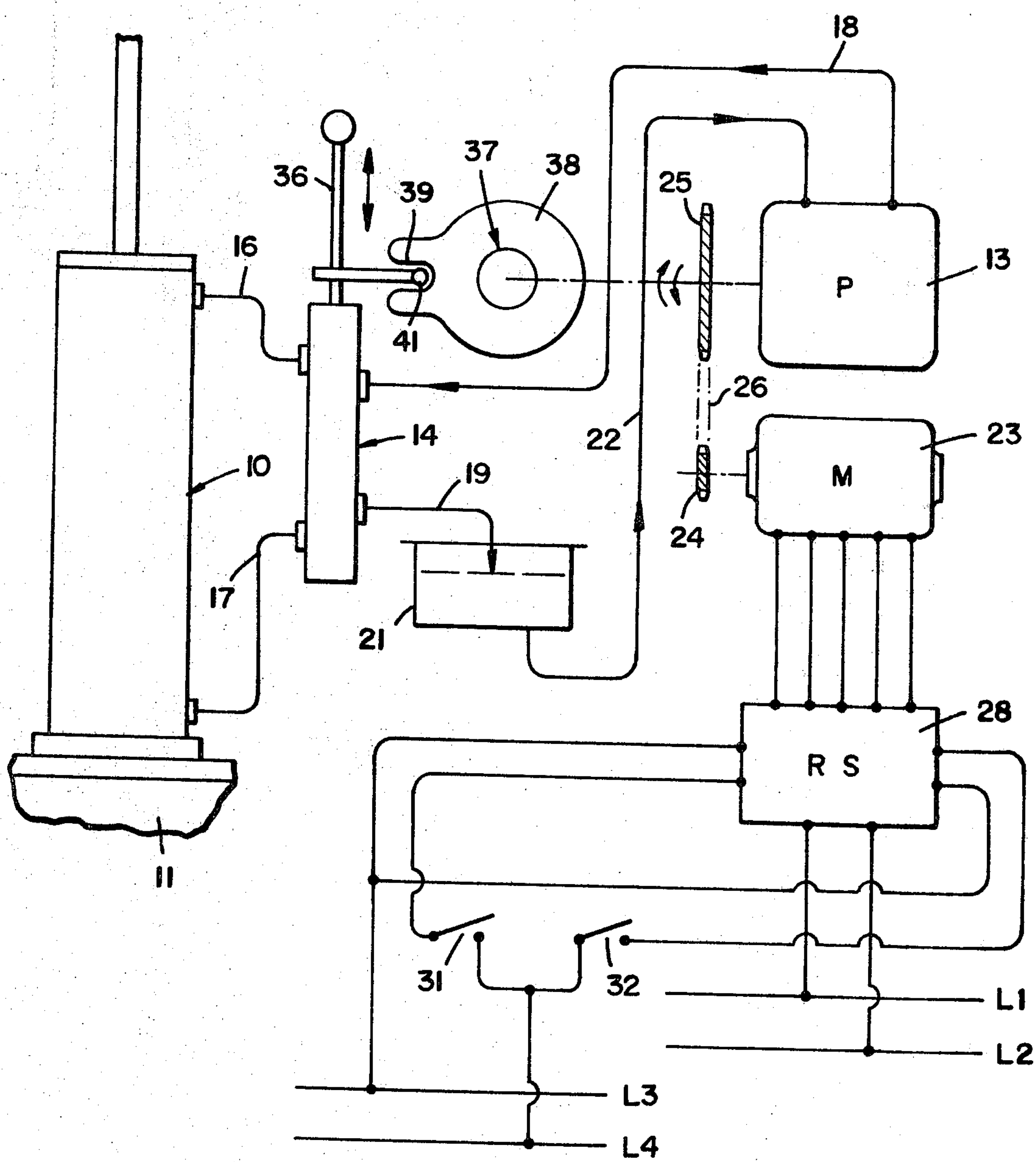

FIG_7

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HYDRAULIC VALVE OPERATING SYSTEM AND APPARATUS

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U.S. Cl. 60—52 5 Claims

ABSTRACT OF THE DISCLOSURE

A hydraulic valve operating system making use of a hydraulic pump driven by a reversible motor. A double acting hydraulic actuator, adapted to be connected to a valve, is connected with the pump through control valve means. The control valve means is automatically set in either one of its two operating positions by torque taken from the motor when the motor is started in operation. Also a hydraulic pump which has its volumetric capacity for a given operating speed substantially reduced when the discharge pressure exceeds a predetermined level.

BACKGROUND OF THE INVENTION

It has been found desirable to operate gate, ball and other valves by hydraulic power means such as a double acting actuator of the cylinder-piston or rotary vane types. The equipment connected with the actuator for supplying and exhausting hydraulic liquid may include a four-way control valve whereby liquid under pressure is supplied to either one of the two liquid chambers of the actuator, and exhausted from the other. Liquid under pressure may be supplied by a hydraulic pump driven by pneumatic (e.g., gas), hydraulic or electrical motor. In a simple system the four-way valve may be positioned manually, but in more complicated systems it may be operated electrically or pneumatically from a remote station. In general it has been the custom to provide separate and independent means for initiating an interrupting operation of the pump and motor, and the setting of the four-way control valve. Thus, in a simple system for the operation of one valve, the electrical pump motor is started with separate setting of the four-way valve, and after the operating cycle has been completed, electrical energization of the motor is interrupted as by manually operating a switch or by operation of a limiting switch on the valve.

The hydraulic pumps used in such systems are generally of the positive displacement type, being provided with a plurality of operating cylinders. The more complicated and expensive of such pumps may have means which automatically reduces the volumetric capacity of the pump for a given operating speed, when the discharge pressure exceeds a predetermined level. This permits development of higher hydraulic pressures at low volumetric capacity, which is effective to start movement of the actuator when it meets unusual resistance, as for example when the associated valve becomes stuck. The simpler hydraulic pumps do not include means for automatically changing the volumetric capacity, and for a given applied torque from the driving motor at a given speed of operation, they are capable of supplying hydraulic liquid up to a pressure determined entirely by the pump design and the character of the driving motor.

SUMMARY OF INVENTION AND OBJECTS

This invention relates generally to systems and apparatus for the hydraulic operation of valves. More particularly it relates to systems utilizing hydraulic actuators of the double acting type which are connected to the movable member of a valve, together with a hydraulic pump and control valve means for supplying and exhausting hydraulic liquid from the actuator. The invention also pertains to the construction of hydraulic pumps and particularly pumps which have means for changing the volumetric capacity when the discharge pressure exceeds a predetermined level.

In general it is an object of the invention to provide a hydraulic system of the above character which effectively automates the setting of the four-way valve or other control valve used in the system. More particularly the setting of the four-way valve is made automatic in response to driving the pump motor in one direction or the other.

Another object of the invention is to provide means for automatically setting the four-way or other control valve, which is relatively simple, which does not prevent manual setting, and which facilitates simple pushbutton operation of the system.

Another object of the invention is to provide a hydraulic pump for systems of the above character, which is provided with novel means for automatically changing the volumetric capacity of the pump, when the discharge pressure exceeds a predetermined level. Particularly the pump is provided with magnetic means operating in connection with one or more of the suction valves of the pump, to render such valves inoperative and thereby decrease the volumetric capacity of the pump when the discharge pressure exceeds a predetermined level.

In general the invention consists of a hydraulic valve operating system having a hydraulic pump with a shaft rotatable in either direction. A reversible motor is connected to drive the pump. A double acting hydraulic actuator is mechanically connected to operate the valve. A control valve serves to connect the pump with the actuator and may be set in either one of two operating positions to cause the actuator to open or close the associated valve. Means is actuated by torque taken from the motor to set the control valve in either one of its two operating positions depending on the direction of rotation of the motor.

Additional objects and features of the invention will appear from the following description in which the preferred embodiment has been set forth in detail in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a side elevational view showing a pump and motor assembly incorporating the present invention, certain parts being broken away.

FIG. 2 is an end view of the assembly shown in FIG. 1.

FIG. 3 is a plan view of the same assembly.

FIG. 4 is a detail illustrating the connection between the operating member of the four-way control valve, and a torque clutch.

FIG. 5 is a plan view showing a preferred hydraulic pump.

FIG. 6 is an end view of the pump with certain parts being broken away to illustrate a suction valve.

FIG. 7 is a schematic view illustrating a complete system incorporating the invention, including the double acting hydraulic actuator.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring first to the system illustrated in FIG. 7, a double acting hydraulic actuator **10** of the cylinder-piston type is shown mounted upon a valve **11**, with its piston being directly connected to the valve operating rod (not shown). In place of an actuator of the cylinder-piston type, other types of double acting hydraulic actuators can be employed, such as actuators of the rotary vane type or reversible motors driven by hydraulic liquid under pressure. Hydraulic liquid under pressure is supplied to one or the other of the two fluid chambers of the actuator **10** by the pump **13**. Control valve means such as the four-way control valve **14** is interposed in the hydraulic connections between the actuator and the pump. Thus lines (e.g., hose lines) **16** and **17** connect between the four way valve **14** and the actuator **10**, and the pressure line **18** connects from the discharge side of the pump **13** to the four-way valve. Also the return or exhaust line **19** connects from the four-way valve **14** to the liquid reservoir **21**, and this reservoir connects with the suction line **22** leading back to the pump **13**.

The electric motor **23** is indicated as having a mechanical drive connection with the pump **13**, as by means of the sprockets **24** and **25** and sprocket chain **26**. The motor is of the reversible type and is connected to electrical power lines L1 and L2 through the reversing switch box **28**. The solenoids of this reversing switch are indicated as selectively controlled by the remote pushbutton switches **31** and **32**, which in turn control circuits energized from the supplemental power lines L3 and L4. The arrangement can be such that one or the other of the switches **31** and **32** is manually held closed while the motor operates for a sufficient period of time to complete an opening or a closing cycle of operation. However, it is also possible to provide limiting switches in connection with the travel of the actuator piston whereby the motor can be started by closing switch **31** or **32**, with energization of the motor continuing thereafter until the piston of the actuator has moved to its other limiting position and operated a limiting switch.

Although in the preferred embodiment of the invention the pump is driven by an electrical motor, it should be understood that this motor may be of the pneumatic (e.g., air or gas) or hydraulic type, provided suitable controls are provided for selectively driving the motor in either direction.

The movable valve member or spool (not shown) of the four-way valve **14** is connected to an operating member or rod **36** which is movable between opposite directions between limiting positions. In one position liquid is supplied from pump **13** through the four-way valve and line **16**, and liquid is exhausted from line **17** through the four-way valve and back to the reservoir **21**. In the other operating position liquid is supplied through line **17** to the actuator, and exhausted through line **16** back to the reservoir **21**. Thus the setting of the four-way valve controls application of liquid to the actuator whereby the associated valve **11** is either opened or closed.

The shaft of the pump **13** is shown coupled to a torque clutch **37**. This torque clutch can be the friction type capable of applying a predetermined torque to the member **38** in one direction or the other, depending upon the direction of rotation of the pump shaft. An extended portion of member **38** is provided with a slot **39** which loosely accommodates a pin **21** carried by the four-way valve operating rod **36**. It will be evident that when torque is applied to the member **38** in one direction or the other, it serves to apply thrust to the pin **41** and operating rod **36**, thereby setting the four-way valve in one or the other of its operating positions.

Operation of the system shown in FIG. 7 is as follows: Normally the motor **23** is deenergized and the valve **11** is in one or the other of its operating positions. Assuming that one desires to close the valve by applying liquid under pressure through line **16**, and exhausting liquid through line **17**, one or the other of the switches **31** or **32** (e.g., switch **31**) is closed manually and this serves to energize the electrical motor **23** to operate this motor in one direction. The motor in turn drives the pump **13** in one direction to apply liquid under pressure through line **18**, the four-way valve **14**, and line **16**. During the initial part of the driving of pump **13**, torque applied through the torque clutch **37** and member **38** serves to set the four-way valve **14** in a proper position, whereby the liquid is supplied to line **16**. When a closing cycle has been completed, this may be indicated to the operator following which switch **31** is opened. As previously mentioned the actuator may be provided with a limiting switch which automatically deenergizes the motor **23** when the valve has been closed. Conversely, if one wishes to open the valve, switch **32** is closed to cause electrical motor **23** to operate in an opposite direction, and with the pump **13** being driven accordingly. Again the initial rotation of the pump **13** applies torque through the clutch **37**, whereby the operating rod **36** of the four-way valve **14** is moved to set the four-way valve in its other operating position, whereby liquid under pressure is supplied to the actuator through line **17** and exhausted through line **16**.

In the operations just described it will be evident that mechanical torque is derived from the motor **23** to effect setting of the four-way valve **14**, dependent upon the direction of rotation of the motor. However, manual operation of the four-way valve may be superposed over automatic operation, simply by applying sufficient manual force to the operating rod **36**, to overcome any opposing torque applied by the torque clutch **37**.

In commercial practice it is desirable to include the motor **23**, pump **13**, and the four-way valve **14**, in one assembly unit, such as shown in FIGS. 1–3. Thus a mounting **46** serves to carry the electric motor **23** and in turn is carried by the base plate **47**. A housing **48** is secured to the base plate **47**, and may be made in the two parts or sections **48*a*** and **48*b***. Section **48*a*** serves to house the hydraulic pump **13**, and section **48*b*** houses the electric motor **23** and the four-way valve **14**. The pump **13** may be carried by the vertical partition wall **49** which is interposed between the two housing sections. The lower portion of the housing section **48*a*** forms a liquid reservoir. The four-way valve **14** is shown mounted directly upon the mounting flange **51** of the pump. The operating rod **36** of the four-way valve is shown (FIG. 3) extending through a side wall of the housing section **48*b***, where it is provided with a knob **52** for hand operation. The motor shaft **53** is connected to the pump shaft **54** by the sprockets **24** and **25** and the sprocket chain **26**. The torque clutch **37** as illustrated in FIG. 1 consists of the annular member **38** which may be made of metal, and which has a slot **39** engaging the pin **41**. Member **38** is free to rotate relative to shaft **54**, and is urged toward the flat end face of collar **56** by compression spring **57**. A friction disk **58** of suitable material, such as a nonmetallic composition, is shown interposed between the member **38** and the adjacent end face of collar **56**. The collar **56** is fixed to rotate with the shaft **54**.

The torque clutch described above will apply a predetermined amount of thrust to the pin **41** of the four-way valve, depending upon the direction of rotation of the shaft **54**, the amount of thrust being sufficient to move the operating rod **36** of the four-way valve to one or the other of its two operating positions. However, the thrust applied by the torque clutch can be overcome by manual operation of the rod **36**.

In the assembly of FIGS. 1–3 the fittings **61** and **62** are provided for making connection with hoses extending to the double acting hydraulic actuator. These fittings are on the ends of pipes which make connection with the four-way valve 14. The other ducts of the four-way valve are directly connected to the pump 13, and to the liquid reservoir provided in the housing section 48*a*. The housing section 48*a* may also enclose a second liquid pump (not shown) which may be operated by the hand crank 64. Such a pump may be used manually to effect emergency opening or closing of the valve in the event of power failure. The assemblies may also include a box 66 for the purpose of enclosing certain electrical components associated with the motor 23, including the solenoid operated reversing switch. The pushbuttons 67 and 68 mounted upon the exterior wall of box 66 represent the manually operated switches 31 and 32 of FIG. 7. An additional pushbutton 69 can be provided for emergency shut-down.

While various types of positive displacement hydraulic pumps can be used with the system described above, it has been found desirable to use a simple type of pump having multiple cylinders, with the pistons directly connected to a crank shaft. Many hydraulic pumps of this type are found on the market. The suction valves associated with these cylinders frequently consist of a ball spring pressed toward its seat, and movable to open position by differential pressure during the suction stroke of the piston. A pump of this type is shown in FIGS. 5 and 6, and in this instance is provided with four operating cylinders. The liquid pressure which a hydraulic pump of this type may deliver is dependent upon its design, and the character and horsepower rating of the driving motor. In a typical instance the pump may deliver a maximum pressure of 1,500 p.s.i. for a motor of a given capacity and torque capability.

Valves of the gate or ball types which may be operated by the system may be satisfactorily operated by hydraulic pressures ranging up to 1,500 p.s.i., with a given type and size of actuator, but conditions may arise when such a maximum pressure is not sufficient. For example, the valve gate or other valve operating member may become stuck or jammed in either open or closed position, thus requiring extra hydraulic pressure to initiate its movement. It is possible to provide a special and relatively expensive hydraulic pump which would satisfy this requirement, as for example a pump having cam means capable of automatically adjusting its volumetric capacity as the discharge pressure increases. The present invention satisfies this requirement by relatively simple means. Referring to FIG. 6 the cylinder block 71 of the pump is broken away to show one of the suction valves, together with one cylinder and piston. The suction valve consists of a steel ball 72 operating in conjunction with the valve seat 73. Its movement to open position is limited by engagement with the stop pin 74. The valve ball 72 is urged toward closed position by compression spring 76. In accordance with the present invention at least one of the suction valves is disabled by magnetically retaining it in open position, when the discharge hydraulic pressure exceeds a predetermined value. Thus, the stop pin 74 is made of paramagnetic material, such as soft steel, and is carried by fitting or bushing 77 which is made of non-magnetic material, such as bronze or brass. The exterior end 78 of the pin 74 is associated with the permanent magnet 79 which is movable in response to changes in discharge pressure. In the embodiment illustrated the magnet 79 is in the form of a bar, and is mounted within the channel like arm 81. One end of this arm is fixed to the free end of the lever 82. The lever is carried by the fulcrum pin 83, and it is mechanically biased to rotate in one direction by spring means or by a counter-weight 84. A ported block 86 is disposed below the lever 82 and is fitted with a movable piston or plunger 87. The space 88 immediately below the plunger 87 is in communication with duct 89, and this duct is connected with the discharge manifold duct of the pump by fitting 91.

Plunger 87 is sealed by suitable means such as the resilient O-ring 92.

When the pressure in the discharge manifold of the pump exceeds a given value, say 1,500 p.s.i., the plunger 87 is forced upwardly against the lever 82 with sufficient force, whereby lever 87 is rocked counterclockwise to bring the magnet 79 into juxtaposition with the upper end of the paramagnetic pin 74. The magnetic flux thus provided in pin 74 is sufficient to retain the magnetic ball 72 in its full open position as shown in dotted lines in FIG. 6, whereby the cylinder associated with this valve is ineffective to supply liquid to the discharge manifold. The maximum pressure level beyond which the suction valve is disabled can be adjusted by adjusting the mechanical bias on lever 82, or in other words by adjusting the counter-weight 84.

In actual practice, with a pump having four cylinders, it is desirable to disable two cylinders and their associated suction valves when the discharge pressure exceeds a predetermined maximum. Thus FIG. 5 shows the bar 79 dimensioned to cooperate with the stop pins 74 of two adjacent suction valves. This serves to substantially reduce the volumetric capacity of the pump, whereby for a given speed of operation and for a given torque delivered by the electric motor, the pump may deliver liquid at a pressure substantially above that which could be delivered without a valve disabling means just described. By way of example, a hydraulic pump which under normal operations would not deliver a pressure in excess of 1,500 lbs., can with my invention deliver a hydraulic pressure at a substantially reduced value, of the order of 2,000 p.s.i.

As previously mentioned the hydraulic pump when incorporated in an assembly such as is shown in FIGS. 1–3, has a suction side communicating with the reservoir formed by the housing section 48*a*. In FIGS. 5 and 6 a suction tube 96 is shown attached to the pump and extending downwardly into the reservoir where it is provided with a strainer 97.

Assuming use of the special hydraulic pump illustrated in FIGS. 5 and 6, the overall operation of the system and apparatus is as follows: The motor is energized and the pump 13 is placed in operation by closing either one of the switches 31 or 32 (i.e., switch button 67 or 68). With the initial turning of the pump shaft the torque clutch 37 applies force to the operating rod 36 of the four-way valve 14, thus automatically setting this valve for the desired operation of the valve 11. Assuming that the valve tends to resist movement, the hydraulic pressure may build up to a value sufficient to rotate lever 82 counterclockwise as viewed in FIG. 6, thus lowering the magnetic bar 79 into proximity with the pins 74 of two of the suction valves. This serves to retain the associated valve balls 72 in open position (after they have been moved to open position by suction), thus reducing the volumetric capacity of the pump, whereby the pump can temporarily supply a substantially higher hydraulic pressure to start the movable valve member toward the operating position desired. When the valve member moves more freely the hydraulic pressure drops and lever 82 moves under the urge of counter-weight 84 to elevate the magnet bar 78 away from the paramagnetic pins 74, thus reducing the magnetic flux through these pins 74 to a minimum, with the result that the suction valve balls 72 are released for normal operation. In this manner the pump is restored to normal volumetric capacity.

I claim:

1. In a hydraulic valve operating system, a hydraulic pump having suction and discharge ducts and having a shaft rotatable in either direction, a reversible motor for driving the pump, a double acting actuator adapted to be mechanically connected to operate a valve, means including a control valve serving to connect the pump with the actuator, the valve means being adapted to be set in either one of two valve operating positions to cause the actuator to open or close the associated valve, and means

actuated by torque taken from the motor to set the control valve in either one of its two operating positions, depending upon the direction of rotation of the motor.

2. A hydraulic valve operating system as in claim 1 in which the control valve means is a control valve of the four-way type.

3. A hydraulic valve operating system as in claim 1 in which said means operated by torque taken from the motor consists of a clutch of the torque type.

4. A hydraulic valve operating system as in claim 2 in which the four-way valve includes an operating member movable in opposite directions between said two operating positions, and in which said means utilizing torque taken from the motor consists of a torque clutch driven by the motor and means forming a mechanical connection between said torque clutch and said operating member of the four-way valve.

5. A hydraulic valve operating system as in claim 1 in which said driving motor is of the electrical type, and in which electrical circuitry connects with said motor and includes reversing switch means.

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U.S. Cl. X.R.

64—30; 251—14