Dec. 11, 1945. J. W. KELLY 2,390,716

POWER PUMP OPERATED SINGLE LINE HYDRAULIC SYSTEM

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FIG. 1.

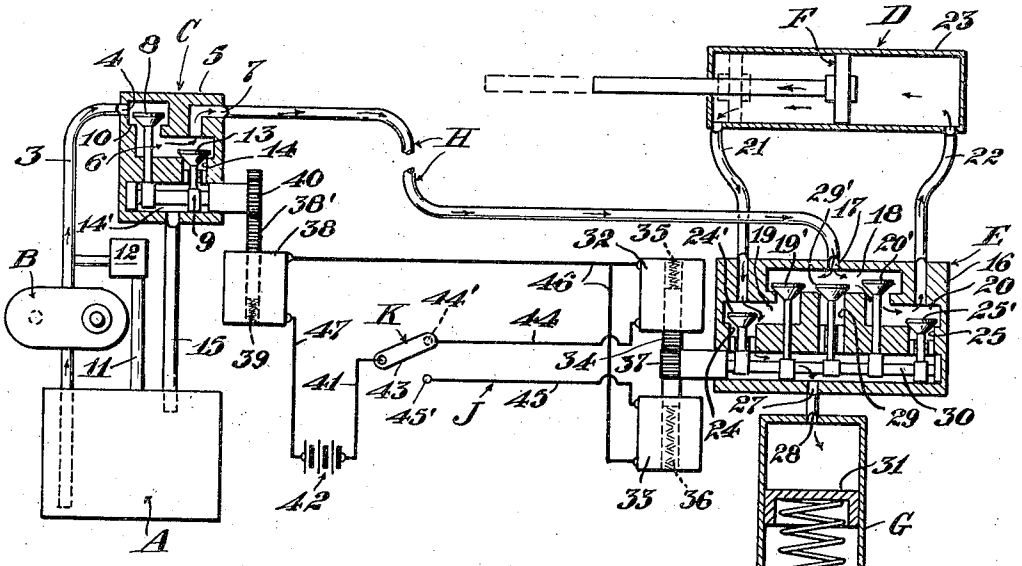
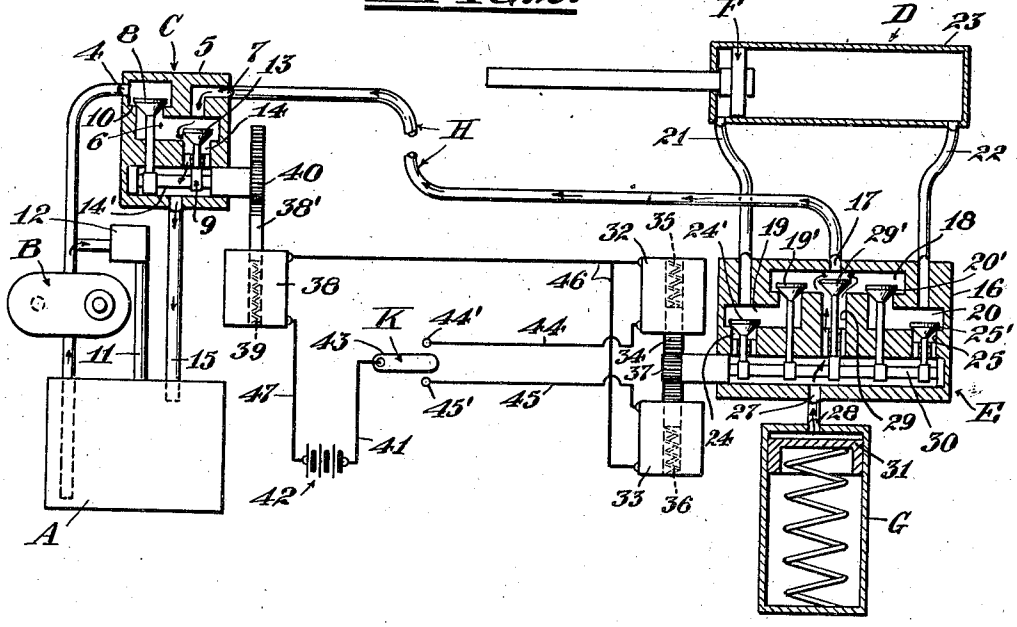


FIG. 2.



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POWER PUMP OPERATED SINGLE LINE HYDRAULIC SYSTEM

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10 Claims. (Cl. 60—52)

This invention relates to hydraulic systems for operating aircraft bomb doors, landing gear, wing flaps and the like, as well as other mechanisms or devices apart from aircraft.

An object of the invention is to provide a highly efficient, single line power pump-operated hydraulic system for the purposes described in which a single fluid line in one instance conducts operating fluid to a selective control valve for a reversible hydraulic motor or jack and in another instance returns fluid to the main reservoir so that one of the two fluid lines heretofore required in power pump-operated hydraulic systems between the pump and the valve, together with the plumbing, fittings and line supports therefor, are eliminated, and in consequence the costs of production, installation and upkeep, and the weight of my improved system are appreciably reduced as is also the space required for installation thereof.

Another object of my invention is to provide a hydraulic system wherein the advantages and objects thereof and the improvements contributed hereby are achieved by reason of the particular construction, arrangement and interrelation as herein set forth of a main reservoir, a pump connected thereto, a hydraulic motor, a control valve for the motor, a sub-reservoir connected to the control valve to receive fluid returned from the motor and having means to place the fluid therein under pressure, a single fluid line between the pump and the control valve serving as a combined pressure and return line, a valve interposed in said line for affording the communication of the line with the pump or the main reservoir, and a valve operating means common to and for simultaneously actuating and controlling said valves to direct in one instance the pressure fluid to the motor through said line while conducting return fluid into the sub-reservoir and in the other instance to shut off flow of fluid to the motor and direct the return fluid from said sub-reservoir through said line to the main reservoir.

Another object of my invention is to provide a hydraulic system such as described in which two control valves connected by a single fluid line are operated by means of a novel electrical mechanism of simple and inexpensive construction and arrangement including a two way circuit closer or switch which may be conveniently located in the cockpit of an aircraft and readily operated to selectively operate the system to drive the hydraulic motor in either direction, the use of the electrical means and the single line not only making possible the location of the hydraulic control valve close to the motor so as to provide for use of comparatively short fluid lines and reduce the cost and weight of the system, but also providing for conservation of space, quicker response of the system and a reduction of pressure drop as well as reduction of the vulnerability of the system where installed in military aircraft subject to attack and consequent battle damage.

With the foregoing objects in view together with such other objects and advantages as may subsequently appear, the invention resides in the parts and in the combination, construction and arrangement of parts hereinafter described and claimed, and the invention is carried into effect as illustrated by way of example in the accompanying drawing in which:

Fig. 1 is a schematic view of a hydraulic system embodying my invention, showing the apparatus as when the system is operated to move the motor in one direction:

Fig. 2 is a similar schematic view of the system when in a neutral or normal condition in which the single line operates to return fluid to the main reservoir rather than to direct pressure fluid to the main control valve as shown in Fig. 1.

Referring more specifically to the drawing it will be apparent that my improved system which in the present instance is particularly designed for use in aircraft, includes a main reservoir A, a power driven pump B connected thereto, a three way valve C directly connected to the pump and main reservoir in proximity thereto, a reversible hydraulic motor such as the jack D adapted to be connected to the control or device (not shown) to be operated by the system, a four-way main control valve E connected to the jack D in proximity thereto and operable to extend or retract the piston F of the jack, a spring loaded or otherwise "pressurized" sub-reservoir G directly connected to the valve E in proximity thereto for receiving the fluid returned from the jack through the valve E and maintaining such fluid under pressure, a single fluid line H hydraulically connecting the three way valve C with the four-way valve E; and an electrical valve-operating means J common to the valves C and E and subject to selective operation by means of a normally open two-way circuit closer or switch K which for example is located in the cabin or cockpit of the aircraft.

In accordance with my invention a fluid line 3 leads from the motor-driven or power-operated

pump B to the inlet port 4 in the body 5 of the three way valve C, which body has a passage 6 therein leading from inlet port 4 to a combined outlet and inlet port 7 from which the single fluid line H extends to the four-way valve E. A poppet valve member 8 is actuated by a cam shaft 9 in the valve C to seat and unseat relative to a seat 10 located between the ends of passage 6 so that when seated the pressure or operating fluid from the pump holds the valve 8 seated and shuts off flow through the passage 6, port 7 and single line H. At this time, as is customary in hydraulic systems, the fluid is passed back to the reservoir A through a short return line 11 leading from line 3 and controlled by an unloading valve 12 set to open only at a pressure above the normal working pressure of the fluid in a manner well known in the art.

In the three way valve C is another poppet valve 13 controlling a return port 14 opening at one end in the passage 6 at a point between valve seat 10 and port 7, and at its other end into a cam shaft bore 14'. The cam shaft 9 is arranged so that when valve 8 is unseated, valve 13 will be seated and when valve 13 is unseated, valve 8 will be seated. A short return line 15 leads from the cam shaft bore 14' to the main reservoir A. In this connection it should be noted that the fluid lines between the pump and the main reservoir and between the pump and the three way valve as well as the return lines to the reservoir from line 3 and port 14 respectively are very short and that actually the pump, the reservoir and the three way valve may be arranged in direct or substantially direct connection with one another as a compact unit for location at the power plant of an aircraft with the pump driven thereby.

The control valve E has its body 16 provided with a combined inlet and outlet port 17 to which the single line H is connected, and which opens into a chamber 18. Cylinder ports 19 and 20 open into the chamber 18 at their inner ends and extend to an outer surface of the body where they are connected to cylinder lines 21 and 22 leading to opposite ends of the cylinder 23 of the jack D. Return ports 24 and 25 afford communication of the cylinder port 19 and 20 with a cam shaft bore 26 in the body 16 which bore is provided with a port 27 to which as here shown for clarity of illustration a short conduit 28 is connected to afford communication between port 27 and the sub-reservoir G.

A discharge port 29 in the body 16 of valve E extends between the cam shaft bore 26 and the chamber 18 so that fluid may be discharged from the sub-reservoir G through ports 29 and 17, into the single line H.

The cylinder ports 19 and 20 are controlled by normally seated valve members 19' and 20' held seated by pressure of fluid in the chamber 18. The return ports 24 and 25 are controlled by normally seated valve members 24' and 25'. The discharge port 29 is controlled by a normally unseated valve member 29' which is seated when either one of the valves 19' or 20' is unseated or in other words when operating fluid is being directed to the jack D.

A cam shaft 30 is mounted in the bore 26 and is constructed and arranged so that when turned in one direction from a normal position in which all of the valve members in valve E except the valve 29' are seated, the valves 20' and 24' will be unseated, and the valve 29' will be seated, while the valves 19' and 25' remain seated as shown in Fig. 2. On turning the shaft 30 in the opposite direction from its neutral position the valves 19' and 25' will be unseated while valve 29' will be seated and valves 20' and 24' will remain seated.

On return from an operative position to its neutral or normal position the cam shaft 30 will allow all valves to seat except valve 29' which is then unseated and so held as seen in Fig. 2.

As here shown the sub-reservoir G is provided with a spring loaded false bottom or piston 31 which will be moved against the tension of the spring to increase the capacity thereof to accommodate the fluid returned from the jack D through valve E thereby storing up said return fluid under pressure.

The valve operating means J which is common to the valves C and E is so constructed and arranged that it is operable to move the cam shaft 30 of valve E in either direction from the neutral position of the shaft which neutral position (see Fig. 2) is sustained by a force derived in the said valve operating means. The relation of the operating means J to the valve C is such that said means also normally holds the cam shaft 9 thereof in position to seat the valve 8 and unseat the valve 13 as shown in Fig. 2, but on each operation of cam shaft 30 to operate valve E to cause pressure fluid to flow to the jack D, the cam shaft 9 will be turned to reverse the position of valves 8 and 13 so that valve 8 opens the single line H to the pump while valve 13 seats and shuts off communication of passage 6 and line H to the main reservoir A.

As here shown the valve operating means J is electrically operated and includes axially opposed solenoids 32 and 33 having a common rack bar armature 34 normally held in a centered position by springs 35 and 36. This rack armature meshes with a pinion 37 on the cam shaft 30.

In association with the valve C is a solenoid 38 having a rack bar armature 38' normally extended by a spring 39 and meshed with a pinion 40. The spring 39 exterts a force for holding the valve C in normal setting as shown in Fig. 2 while springs 35 and 36 likewise operate to hold the valve E in its normal condition or setting also shown in Fig. 2.

The electrical circuit for the solenoids is controlled by the normally open two way circuit closer or switch K and including a conductor 41 leading from one side of a battery 42 or other source to the movable contact member 43 of the switch K, conductors 44 and 45 leading from the contact points 44' and 45' of said switch to the solenoids 32 and 33 respectively, a conductor 46 branched to connect to each of the solenoids 32 and 33 and leading therefrom to solenoid 38; and a conductor 47 leading from solenoid 38 to the other side of the battery 42.

Operation

Normally the valves C and E are in the set position shown in Fig. 2 due to the action of the springs 35, 36 and 39, the valve members 8 and 13 of valve C being respectively seated and unseated, while all valve members of valve E are seated except valve 29'. At this time the system is filled with fluid except the sub-reservoir G, the spring loaded piston 31 which is extended as shown in Fig. 2.

Assuming that piston F of jack D is in the position shown in full line in Fig. 1 and it is desired to move it to the left into the dotted position also shown in Fig. 1, or to a position short of the dotted position, the operator moves the switch

member 43 to contact the contact member 44' as shown in Fig. 1 whereupon the current from battery 42 flows through conductor 41, member 43, contact 44', conductor 45, solenoid 32, conductor 46, solenoid 38 and conductor 47 back to the battery 42, thereby energizing solenoids 32 and 38. Solenoid 38 retracts the rack bar armature 38' into position shown in Fig. 1 thereby turning the cam shaft 9 so as to unseat valve 8 and seat valve 13. At the same time solenoid 32 retracts the rack bar armature 34 so that the cam shaft 30 is turned to open valves 20' and 24' and close valve 29' as shown in Fig. 1, the other valves 19' and 25' remaining closed. Fluid under pressure now flows from the pump B through line 3, port 4 of valve C, past open valve 8, passage 6 in valve body 5, port 7, fluid line H, port 17 in body 16 of valve E, chamber 18, past open valve 20', thence through cylinder port 20 and line 22 to right end of cylinder 23 of jack D thereby moving piston F to the left. Fluid forced out of the left end of the cylinder 23 passes through the cylinder line 21 into return port 24 past open valve 24' therein, into the cam shaft bore 26 thence through port 27 and line 28 into the sub-reservoir G. The fluid thus discharged into the sub-reservoir forces the spring loaded piston 31 toward the bottom proper of the reservoir thus increasing the reservoir capacity sufficiently to receive the fluid displaced from cylinder 33 and thereby placing the fluid therein under pressure.

When the piston F has been moved a desired extent in the manner hereinbefore stated, the operator manipulates the switch K to open the circuits for all the solenoids whereupon the springs 35 and 36 move the armature 34 so as to operate the cam shaft 30 to restore the valve E to normal condition shown in Fig. 2 wherein all valves are seated except valve 29' which is then held open. At the same time that valve E is restored to neutral position, valve C is likewise operated by means of the spring 39 so that the valve member 8 is closed to shut off the supply of pressure fluid to line H, while return valve 13 is unseated as shown in Fig. 2.

Immediately upon closing of valve 24' the port 24 is closed and the valve 29' is opened as aforesaid, thus allowing the fluid stored under pressure in sub-reservoir G to be forced by action of the spring loaded piston 31 throughout the line 28, port 27, cam shaft bore 26, discharge port 29 past open valve 29' into chamber 18, thence out through port 17 and single line H, port 7 in valve C, passage 6, past then open valve 13 and through port 14 and line 15 to the reservoir A, whereby in this instance the single line H acts as a return line. The spring loaded piston 31 in sub-reservoir G assumes its extended position shown in Fig. 2 when the fluid therein is discharged as aforesaid to the main reservoir and the system is ready for another operation.

It is now apparent that when it is desired to move the jack piston F to the right, say from the position shown in full or dotted lines in Fig. 1, the operator moves the switch member 42 into contact with contact point 45' thereby simultaneously energizing solenoids 33 and 38 so that valve member 8 in valve C will be opened and valve members 13 thereof closed, while valve members 19' and 25' of valve E are opened and valve members 20', 24' and 29' are closed. This causes the pressure fluid from the pump to pass through valve C and line H into chamber 18 of valve E. When solenoid 38 is energized solenoid 33 is also energized and moves armature 34 so that cam shaft 30 is turned to open valves 19' and 25' and close valve 29', the other valves 20' and 24' remaining closed. Fluid will now flow past open valve 19' into cylinder line 21 to the left end of cylinder 23 thus moving the piston F to the right. Fluid discharged from the right end of the cylinder is now returned through line 22 past open valve 25' into cam shaft bore 26 thence through port 27 and line 28 into sub-reservoir G in which piston 31 is moved inward to accommodate the displaced fluid as hereinbefore explained. The fluid thus stored in said sub-reservoir will be discharged through valve E, line H and valve C to the main reservoir when the valves C and E are restored to normal condition upon the opening of circuits for solenoids 33 and 38 through appropriate manipulation of switch K.

While I have shown and described a specific embodiment of my invention I do not limit myself to the exact details of construction set forth.

I claim:

1. In a hydraulic system, a main reservoir, a power operated pump operatively associated with said reservoir, a hydraulic reversible motor, a main control valve associated with said motor for directing pressure fluid for moving the motor in either direction and for shutting off the flow between the valve and the motor, a sub reservoir connected to said valve for reception of fluid returned through the valve from said motor, means in the sub reservoir yielding upon introduction of such return fluid thereto and placing such fluid under pressure sufficient to expel it therefrom when said valve is actuated to shut off flow of fluid between the valve and the motor, a single fluid line for directing fluid from the pump to the control valve and for returning fluid to the main reservoir, a second valve for controlling said single line and having a connection with said main reservoir and being operable for selectively controlling the communication of said single line with the pump and said main reservoir, and operating means common to said valves and normally maintaining the second valve in position to close the single line to the pump and open it to communication with said reservoir while also normally maintaining said control valve in position to shut off communication of the single line with said motor but open said single line to communication with said sub-reservoir, and which when operated to actuate the main control valve to direct fluid for operating the motor in either direction also operates the main control valve to open the sub-reservoir to communication with said motor to receive return fluid therefrom and simultaneously actuates the second valve to open the single line to communication with the pump and close it to communication with said main reservoir.

2. In a hydraulic system, a main reservoir, a power operated pump operatively associated with said reservoir, a hydraulic reversible motor, a main control valve associated with said motor for directing pressure fluid for moving the motor in either direction and for shutting off the flow between the valve and the motor, a sub reservoir connected to said valve for reception of fluid returned through the valve from said motor, means in the sub reservoir yielding upon introduction of such return fluid thereto and placing such fluid under pressure sufficient to expel it therefrom when said valve is actuated to shut off flow of fluid between the valve and the motor, a single fluid line for directing fluid from the pump to the control valve and for returning

fluid to the main reservoir, a second valve for controlling said single line and having a connection with said main reservoir and being operable for selectively controlling the communication of said single line with the pump and said main reservoir, and operating means common to said valves and normally maintaining the second valve in position to close the single line to the pump and open it to communication with said reservoir while also normally maintaining said control valve in position to shut off communication of the single line with said motor but open said single line to communication with said sub-reservoir, and which when operated to actuate the main control valve to direct fluid for operating the motor in either direction also operates the main control valve to open the sub-reservoir to communication with said motor to receive return fluid therefrom and simultaneously actuates the second valve to open the single line to communication with the pump and close it to communication with said main reservoir, said valve operating means including electrically responsive valve actuating mechanisms, electrical circuits therefor, spring means associated with said devices for maintaining said valves in their aforesaid normal positions and returning them to such positions upon deenergization of said devices, and a circuit closer for controlling said circuits.

3. In a hydraulic system, a main reservoir, a pump connected with said reservoir, a hydraulic motor, a control valve for directing fluid under pressure to and for returning fluid from said motor and for shutting off flow of fluid between it and the motor, a sub-reservoir connected with said valve to receive return fluid from said motor, means yielding incident to the introduction of return fluid into said sub-reservoir and placing the fluid under pressure sufficient to expel it through said valve when the latter is operated to shut off the flow of fluid between said valve and the motor, a single fluid line for directing pressure fluid from the pump to the control valve in one operation of the system and for discharging return fluid from the sub-reservoir in another operation of the system, another valve for controlling said single line having a connection with said main reservoir and operable for selectively affording communication of said single line with said pump and said main reservoir, and valve operating means common to said valves, normally holding the second named valve in position to shut off communication of the pump with said single line and establish communication of said line with said main reservoir while at the same time normally maintaining said control valve in position to shut off flow of fluid between the control valve and the motor and establish communication between the sub-reservoir and the single line, and which when actuated to operate said control valve to direct fluid under pressure to the motor, causes the control valve to shut off communication of the single line with the sub-reservoir and establish communication between the motor and the sub-reservoir for conducting return fluid to the latter and at the same time operates the second named valve to open said line to the pump and close it to the main reservoir; said operating means when operated to actuate the control valve to shut off flow of fluid between the motor and the control valve causing said valves to return to normal position whereby the fluid is expelled from the sub-reservoir through said single line into said main reservoir.

4. In a hydraulic system a main reservoir, a pump, a reversible hydraulic motor, a selective control valve for reversing the flow of fluid to said motor, a fluid line between the pump and said control valve, a valve for controlling said line, having a flow connection with said reservoir, a sub-reservoir connected with said selective control valve to receive fluid returned from the motor through said selective control valve, means for placing return fluid in said sub-reservoir under pressure, said selective control valve including valve members operable to direct fluid for operating the motor in either direction and for conveying return fluid to said sub-reservoir while shutting off communication of said line with said sub-reservoir and also operable for shutting off flow of fluid between it and the motor while establishing communication between said sub-reservoir and said line; the second named valve including valve members operable to shut off flow from the pump to said line while opening said line to the main reservoir and vice versa; and operating means common to said valves normally holding the valve members of both valves in position such that the second named valve shuts off flow from the pump to said line and opens said line to communication with said main reservoir, while the control valve opens the line to communication with the sub-reservoir and shuts off flow between the control valve and the motor; and means for operating said valve operating means to operate said valves so that the second named valve opens the line to the pump and closes the line to the main reservoir while the control valve directs operating fluid from the line to the motor and conducts return fluid from the motor to the sub-reservoir.

5. In a hydraulic system, a reversible motor, a control valve selectively operable for directing fluid to operate the motor in either direction, a main reservoir, a pump connected with the reservoir, a single fluid line leading from the pump to the control valve and serving as a combined pressure and return line, a valve in said line having a flow connection to said main reservoir and operable in one instance to establish communication between said pump and said line and shut off communication between said line and said main reservoir and operable in another instance to open said line to the reservoir and close said line to the pump, a sub-reservoir connected to said control valve to receive fluid returned from the motor, means associated with the sub-reservoir for placing the fluid therein under pressure sufficient to expel it through the control valve and said line and second named valve to said main reservoir incident to coordinated operation of the said valves, said control valve having valve members operable in one instance to simultaneously communicate said line with the motor and communicate said motor to the sub-reservoir, and operable in another instance to shut off the flow of fluid to and from the motor and communicate said sub-reservoir with said line, and means for effecting a coordinated operation of said valves to operate the system as aforesaid.

6. In a hydraulic system, a reversible motor, a control valve selectively operable for directing fluid to operate the motor in either direction, a main reservoir, a pump connected with the reservoir, a single fluid line leading from the pump to the control valve and serving as a combined pressure and return line, a valve in said line having a flow connection to said main reservoir and operable in one instance to establish communi-

cation between said pump and said line and shut off communication between said line and said main reservoir and operable in another instance to open said line to the reservoir and close said line to the pump, a sub-reservoir connected to said control valve to receive fluid returned from the motor, means associated with the sub-reservoir for placing the fluid therein under pressure sufficient to expel it through the control valve and said line and second named valve to said main reservoir incident to coordinated operation of the said valves, said control valve having valve members operable in one instance to simultaneously communicate said line with the motor and communicate said motor to the sub-reservoir, and operable in another instance to shut off the flow of fluid to and from the motor and communicate said sub-reservoir with said line, and means for effecting a coordinated operation of said valves to operate the system as aforesaid, including electrically responsive mechanism for each valve, electrical circuits for said mechanisms providing for simultaneous operation thereof, and a switch means for controlling said circuits.

7. In a hydraulic system, a reversible motor, a control valve selectively operable for directing fluid to operate the motor in either direction, a main reservoir, a pump connected with the reservoir, a single fluid line leading from the pump to the control valve and serving as a combined pressure and return line, a valve in said line having a flow connection to said main reservoir and operable in one instance to establish communication between said pump and said line and shut off communication between said line and said main reservoir and operable in another instance to open said line to the reservoir and close said line to the pump, a sub-reservoir connected to said control valve to receive fluid returned from the motor, means associated with the sub-reservoir for placing the fluid therein under pressure sufficient to expel it through the control valve and said line and second named valve to said main reservoir incident to coordinated operation of the said valves, said control valve having valve members operable in one instance to simultaneously communicate said line with the motor and communicate said motor to the sub-reservoir, and operable in another instance to shut off the flow of fluid to and from the motor and communicate said sub-reservoir with said line, and means for effecting a coordinated operation of said valves to operate the system as aforesaid, including a pair of solenoids for operating the control valve, a solenoid for operating the second named valve, electrical circuits affording the selective operation of the solenoids of said pair simultaneously with the operation of the solenoid for said second named valve, and switch means for controlling said circuits.

8. In a hydraulic system, a reversible motor, a control valve selectively operable for directing fluid to operate the motor in either direction, a main reservoir, a pump connected with the reservoir, a single fluid line leading from the pump to the control valve and serving as a combined pressure and return line, a valve in said line having a flow connection to said main reservoir and operable in one instance to establish communication between said pump and said line and shut off communication between said line and said main reservoir and operable in another instance to open said line to the reservoir and close said line to the pump, a sub-reservoir connected to said control valve to receive fluid returned from the motor, means associated with the sub-reservoir for placing the fluid therein under pressure sufficient to expel it through the control valve and said line and second named valve to said main reservoir incident to coordinated operation of the said valves, said control valve having valve members operable in one instance to simultaneously communicate said line with the motor and communicate said motor to the sub-reservoir, and operable in another instance to shut off the flow of fluid to and from the motor and communicate said sub-reservoir with said line, and means for effecting a coordinated operation of said valves to operate the system as aforesaid, including a pair of solenoids for operating the control valve, a solenoid for operating the second named valve, electrical circuits affording the selective operation of the solenoids of said pair simultaneously with the operation of the solenoid for said second named valve, switch means for controlling said circuits, and spring means operating through said valve operating means for normally holding said valves in position such that the control valve shuts off flow to and from the motor and affords communication between said sub-reservoir and said line, and the second named valve is likewise held in position to shut off said line to the pump and open said line to the main reservoir.

9. In a hydraulic system, a reversible motor, a control valve selectively operable for directing fluid to operate the motor in either direction, a main reservoir, a pump connected with the reservoir, a single fluid line leading from the pump to the control valve and serving as a combined pressure and return line, a valve in said line having a flow connection to said main reservoir and operable in one instance to establish communication between said pump and said line and shut off communication between said line and said main reservoir and operable in another instance to open said line to the reservoir and close said line to the pump, a sub-reservoir connected to said control valve to receive fluid returned from the motor, means associated with the sub-reservoir for placing the fluid therein under pressure sufficient to expel it through the control valve and said line and second named valve to said main reservoir incident to coordinated operation of the said valves, said control valve having valve members operable in one instance to simultaneously communicate said line with the motor and communicate said motor to the sub-reservoir, and operable in another instance to shut off the flow of fluid to and from the motor and communicate said sub-reservoir with said line, and means for effecting a coordinated operation of said valves to operate the system as aforesaid, including a pair of solenoids for operating the control valve, a solenoid for operating the second named valve, electrical circuits affording the selective operation of the solenoids of said pair simultaneously with the operation of the solenoid for said second named valve, a normally open switch selectively operable to close the circuits for the solenoids of said pair and simultaneously close the circuit for the solenoid for the second valve, and spring means operating upon the opening of said switch to simultaneously actuate said valves to shut off flow from the pump and open the single line for conducting fluid from said sub-reservoir to said main reservoir.

10. In a hydraulic system, a main reservoir, a pump having its intake connected to said main reservoir, a three-way valve at the discharge side of said pump and having communication with said reservoir, an actuating means for said valve operable to hold it normally open to said reservoir and closed against the discharge of said pump, a reversible hydraulic motor, a sub-reservoir, a flow reversing valve operably connected to said hydraulic motor and said sub-reservoir, a single fluid conduit extending between said valves, means for simultaneously operating said valves, said means being constructed and arranged to selectively shift said flow reversing valve from a normally-occupied neutral position and to open said three-way valve to said pump discharge and to close it to said reservoir, thereby effecting movement of said hydraulic motor, and means associated with said flow reversing valve operable to permit fluid discharged from said motor to be stored in said sub-reservoir under pressure, said flow reversing valve including means operable automatically to effect the return of fluid from said sub-reservoir through said single fluid conduit to said main reservoir during periods when said flow reversing valve is in neutral position.

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