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PUMP AND MOTOR HYDRAULIC SYSTEM, INCLUDING REVERSING AND AUTOMATIC BY-PASS VALVE UNITS

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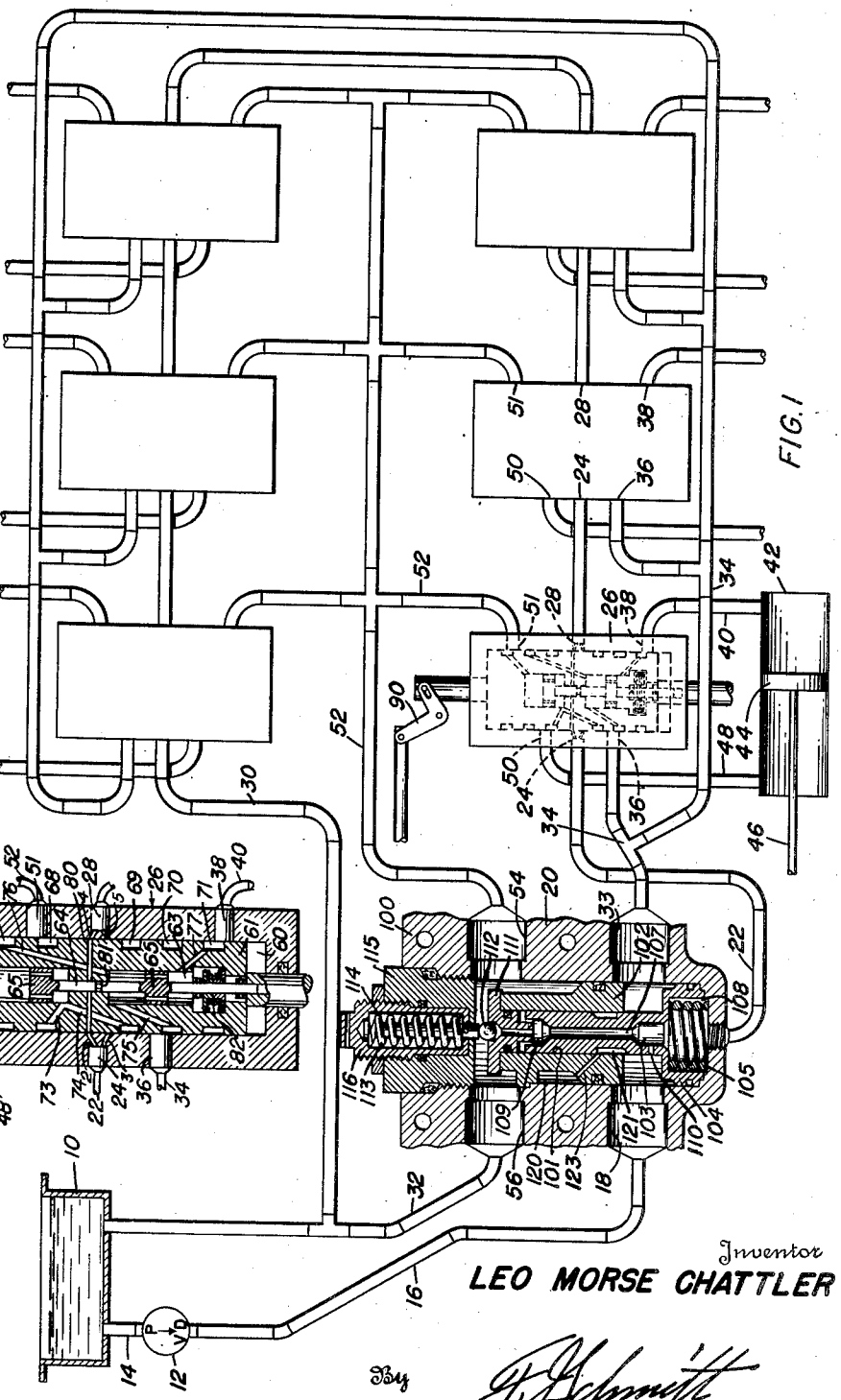


FIG. 1

FIG. 2

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PUMP AND MOTOR HYDRAULIC SYSTEM, INCLUDING REVERSING AND AUTOMATIC BY-PASS VALVE UNITS

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2 Claims. (Cl. 60—52)

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This invention relates to hydraulic systems in general and in particular to hydraulic systems which may be used on aircraft and which include a plurality of open center six port control valves arranged in series for center flow of the fluid through the system and in parallel for unit operation.

The general object of the invention is to provide a variable volume pump operated hydraulic system which will automatically unload the entire hydraulic system pressure when none of the hydraulic services are required.

It is also an object of the invention to provide such a hydraulic system in which, when any hydraulic service is required, the initial operation of any control valve automatically pressurizes the hydraulic system and maintains it under pressure until the unit operation is completed.

It is a further object of the invention to provide such a hydraulic system in which, when any unit operation is completed the system automatically returns to the circulatory back pressure of the open center circuit.

Other objectives will be obvious or apparent from the following description and in the drawing hereto appended in which Fig. 1 shows schematically the arrangement of a plurality of open center, six port, control valves and a pressure operated dump valve in hydraulic circuit relationship to a variable volume pump and reservoir; and Fig. 2 shows a detail of the valve system.

The present day or prior art method of performing the operation of an open center type system consists essentially in flowing hydraulic fluid through a series circuit of open center control valves with return to the reservoir. The operation of any control valve automatically directs the fluid into the operating circuit and the unit operation is performed. Manual return of the control valve to neutral position is required in order to drop the system pressure.

The disadvantages of the prior art method are:

1. It is a priority system in that the operation of only one circuit at a time may be allowed.

2. Larger lines are required in order to obtain a low pressure drop.

3. The system can not be maintained under pressure on the ground.

4. Flap follow-up systems are complicated.

The overcoming of these disadvantages and the attainment of the objectives given supra are accomplished in the hydraulic system illustrated in the accompanying drawing wherein a preferred arrangement of the component parts of a hydraulic system for control and operation of various functional units of an aircraft are shown and wherein, a reservoir for hydraulic fluid is indicated at 10. This reservoir is connected to the suction side of variable volume delivery pump 12 by conduit 14. The fluid delivery of pump 12 is led by conduit 16 to inlet port 18 of pressure responsive dump valve 20. This valve may be any conventional type of dump valve which has the characteristic of bleeding off from 5% to 10% of the delivery received to one conduit circuit, returning the balance to the system reservoir through conduit 32 when this conduit circuit is open and of feeding the entire received delivery into a high pressure conduit system when the said return of the balance to the reservoir is blocked by back pressure developed by the cutting off of flow through the open circuit conduit system.

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Valve 20 bleeds off from about 5% to about 10% of the hydraulic fluid delivered to it from pump 12 feeding this minor proportion via conduit 22 to open center inlet port 24 of six port control valve 26 which when in non-operating position feeds the hydraulic fluid through its center and out through outlet port 28 to other similar control valves in series to conduit 30 by which the fluid is returned to the system reservoir 10. When this center flow circuit is in operation pressure on the hydraulic fluid in the hydraulic system drops to a relatively low magnitude.

Reference is here made to Fig. 2 and to co-pending application of this inventor Serial No. 111,754, filed August 22, 1949, now Patent 2,530,377, as drawn to the six port center flow control valve unit 26 used in the hydraulic system of the instant application. This control valve unit comprises a valve casing 26, inlet and outlet ports 36 and 51, respectively, in the casing, a chamber 60 within the casing, a reciprocable valve 61 within said chamber having bearings in the end walls of the valve body, two chambers 62 and 63 within said reciprocable valve separated by a partition wall, a spool 64 projecting into said two chambers and mounted for reciprocation in said partition wall, a perforate piston 65 in each chamber mounted on said spool and dividing each chamber into two compartments, annular grooves 66, 67, 68, 69, 70 and 71 in the periphery of said reciprocable valve spaced with respect to the inlet and outlet ports 36 and 51, channels 72, 73, 74, 75, 76 and 77 in said reciprocable valve connecting said annular grooves with the said compartments, a transverse channel 80 in said valve positioned midway between the ends thereof, an annular groove 81 positioned on said

spool midway between the pistons thereon and resilient means 82 mounted on said spool for automatically moving said spool for registration of said annular groove 81 with said transverse channel 80 when the pressure on both sides of said motor piston is equalized. It is noted that inlet port 24 has upper and lower conduits 2 and 3 corresponding to upper and lower conduits 4 and 5 of outlet port 28, the conduits 2 and 4 connecting with channel 80 at the up position of valve 61 and conduits 3 and 5 connecting with channel 80 at the down position of this valve.

The valve 26 also includes outlet port 38 connected to valve compartment 63 by duct 77 and leading by conduit 40 to one end of servo-motor 42 wherein piston 44 and piston rod 46 will be moved to the left to operate the desired mechanism, as shown in Fig. 1. The other end of the servo-motor has a conduit connection 48 to the port 50 at the left upper side of valve unit 26, this port having connection with the groove 66 when the valve 61 is at its upper limit. Conduit 72 connects groove 66 to compartment 62. Referring to valve 20 in greater detail, a housing 100 is provided having inlet port 18 connected to the pump conduit 16 and outlet port 33 connected to the main conduit 34 feeding to the control valve system. The housing also has a return port 54 associated with the outlet port 56 connecting the reservoir conduit 32. A central bore in the housing 100 contains a sleeve and spool assembly, the sleeve 102 being fixed in the bore and the spool 103 being slidable in bore 101 of the sleeve. The spool has an enlarged head at the lower end and hollowed to form an inverse cup 104 adapted to receive a coil spring 105 which normally tends to move the spool into the sleeve.

The spool has also a central bore 107 extending from the enlarged opening 108 in the terminal cup 104 to a small cavity 109 at the other end of the spool. A duct 110, in the wall of the enlarged end of the spool, connects the cup-cavity 108 to the inlet port 18 so that a permanent open fluid connection between the inlet port and conduit 22 is provided.

The bore 101 is closed at its upper end by a plug 111. This plug is fixed to the top end of the sleeve 102 and has a central duct for fluid communication between the return passageway 54–56 and cavity 109 at the upper end of the spool 103. The upper end of this duct is recessed to form a seat and in this seat a valve ball 112 is yieldingly retained by means of the rod follower 114 and coil spring 113 surrounding the follower. The plug 115 fastened in the housing, in line with the sleeve 102, is hollowed to receive the casing 116 in which the rod follower is secured.

The sleeve 102 is grooved on its periphery to form a channel 120 communicating directly with the outlet port 56. A channel 121 is likewise formed on the periphery of the spool 103 in such position that, when the spool is seated at the lower terminus of the housing, a fraction of the axial channel length is open to the inlet port 18, but on upward movement of the spool in sleeve 102 this communication is closed. A duct 123 connects the channels 120 and 121.

Let it be assumed that initially the valve 61 is at either limit of movement within valve chamber 60, as for example, at the lower end. In this position the channel 80 is connected with conduits 3 of inlet port 24 and conduit 5 of outlet port 28 so that continuous center flow through valve unit 26 is maintained, the servo-motor 114 being inactive, with the piston 44 at one end thereof.

When it is desired to operate any one of the functional units, for example to lower the landing gear, the plane pilot moves the control valve to upper position. By this movement the valve 61 is lifted and the circulation of the hydraulic fluid through center channel 80 is immediately cut off causing back pressure to develop in spool cavity 108 of the dump valve to force the spool 103 upwardly in the sleeve 102, thereby cutting off the main by-pass flow of fluid in the dump valve by way of 18—121—123—120—56 and thus developing pressure in dump valve outlet 33 leading to the control valve 26 and the operating circuit of the system, in the following sequence, 34—36—75—63—77—38—load 42; load 42—48—50—72—62—73—68—51—52. This forces perforated pistons 65 downwardly closing channel 80 and preventing release of pressure on the spool 103 of the dump valve, when the valve reaches its upper limit in casing 27.

After work piston 44 has moved to its left limit, the pressures in cylinder 42 become static and flow ceases in compartments 62 and 63 by virtue of spring 82 and realignment of ducts 80 and 81. Thereupon, the pressure drops in conduit 22 and dump valve spool cavity permitting the pressure in inlet 18 to force the spool downwardly thereby opening by-pass channel 121—123—120—56 and reducing the system pressure to a desirable low value. A reversal of lever 90, lowering control valve cylinder 61, will produce a reversal in the above described action.

If excess pressure should develop in the system circuit, due, for example, to accidental stoppage in the pipe line, the dump valve ball 112 will release, permitting the spool to drop and thus opening the dump by-pass to relieve the excess pressure. This release is momentary, the action being repeated as long as the abnormal condition remains.

If it is desired to operate any particular unit to an intermediate position, as in the case of feathering of a wing flap, the control valve for that particular unit is moved to the operating position to move the flap to the desired angle. As the flap reaches the desired angle of inclination, the control valve is moved to a position intermediate the "raise and lower" positions. In this position flow of hydraulic fluid to and from the operating unit, and center flow through the valve is cut off. The entire delivery from pump 12 is returned from the inlet side of valve 20 acting as a relieve valve to reservoir 10 via conduit 32, through the release of dump valve ball 112.

The invention is therefore seen to reside in the arrangement in a hydraulic system of a plurality of open center six port control valves in a series circuit as to center flow of the hydraulic fluid and in parallel circuit as to hydraulic fluid flow in unit operation. That is to say that the hydraulic system comprises an arrangement of these control valves in both series and parallel flow circuits whereby any one or more of the functional units may be operated simultaneously and when none of the functional units are in operation the hydraulic fluid flows through the system under a relatively low pressure.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental

purposes without the payment of any royalties thereon or therefor.

What is claimed is:

1. In a hydraulic system containing hydraulic fluid, the combination of a reservoir for said fluid, a delivery pump in communication with said reservoir on its suction side, a back pressure responsive dump valve for receiving the delivery of fluid from said pump and for dividing said delivery into relatively large and small proportions and for conducting said small proportioned flow to main and by-pass outlets, said dump valve comprising a casing having a tubular cavity, a valvular element slidably movable in said cavity, ducts formed in the casing wall, a conduit between one of said ducts and said pump, a conduit between another of said ducts and said reservoir, a first duct in said valvular element adapted at one limit of movement of said element to pass fluid directly from the pump to the reservoir in said large proportioned flow, a second duct in said valvular element adapted to conduct fluid from the pump duct to said by-pass outlet, said valvular element having an expanded pressure terminal susceptible to back pressure for moving said valvular element to close said first duct, a valve unit including a stationary tubular section and a valve section movable inside said stationary tubular section, main and by-pass ducts in opposed sides of the casing wall, main and by-pass ducts in said movable valve section, conduits connecting the dump valve main and by-pass outlets to the inlets of the main and by-pass ducts of said stationary valve section, outlet conduits for the main and by-pass conduits of said stationary valve section, manual means for moving said movable valve section to connect said stationary and movable main ducts and said stationary and movable by-pass ducts and to disconnect said stationary and movable by-pass ducts, whereby back pressure is made effective on the expanded pressure terminal of the valve element of said dump valve to cut off the large proportioned flow therethrough, a valve in said movable by-pass duct, a fluid pressure sensitive device connected to said movable by-pass valve for actuation thereof, a fluid pressure mechanism external to said valve unit, and a conduit connecting said fluid pressure mechanism and said pressure sensitive device, said pressure mechanism being operative to actuate said pressure sensitive device to open said movable by-pass duct whereby large proportioned flow through the dump valve may take place.

2. In a hydraulic system containing hydraulic fluid, the combination of a reservoir for said fluid, a delivery pump in communication with said reservoir on its suction side, a back pressure responsive dump valve for receiving the delivery of fluid from said pump and for dividing said delivery into relatively large and small proportions and for conducting said small proportioned flow to main and by-pass outlets, said dump valve comprising a casing having a tubular cavity, a valvular element slidably movable in said cavity, ducts formed in the casing wall, a conduit between one of said ducts and said pump, a conduit between another of said ducts and said reservoir, a first duct in said valvular element adapted at one limit of movement of said element to pass fluid directly from the pump to the reservoir in said large proportioned flow, a second duct in said valvular element adapted to conduct fluid from the pump duct to said by-pass outlet, said valvular element having an expanded pressure terminal susceptible to back pressure for moving said valvular element to close said casing reservoir duct, a valve unit including a stationary tubular section having main and by-pass wall ducts through the walls theerof, conduits connecting the inlet ends of said ducts to the outlet ducts of said dump valve, and a movable valve section slidably movable within the tubular cavity of said stationary section and having a first duct and a by-pass duct communicating respectivelly with the outlets of said stationary section main and by-pass ducts, conduits connecting the outlets of the stationary section main and by-pass ducts to said reservoir, manual means for moving said movable section to connect said stationary and movable main ducts and said stationary and movable by-pass ducts and to disconnect said stationary and movable by-pass ducts, fluid pressure responsive valvular means in said valve unit for closing and opening said movable by-pass duct including a first perforated piston slidably movable in said first main duct and formed in the movable valve section, a second main duct through said movable valve section, stationary wall ducts adapted to communicate with said main duct, a second perforated piston movable in said second main movable duct, a slide valve rigidly connected between said first and second pistons and movable therewith to open and close the by-pass duct in said movable valve section, and fluid pressure responsive means external to said valve unit and connected to said valve unit duct for changing the pressure effective on said piston slide valve, whereby the by-pass duct through the movable valve unit section is opened.

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