Jan. 6, 1953 F. B. LEVETUS 2,624,321

CONTROL SYSTEM FOR REVERSIBLE HYDRAULIC MOTORS

Filed June 28, 1951 2 SHEETS—SHEET 1

FIG. 1.

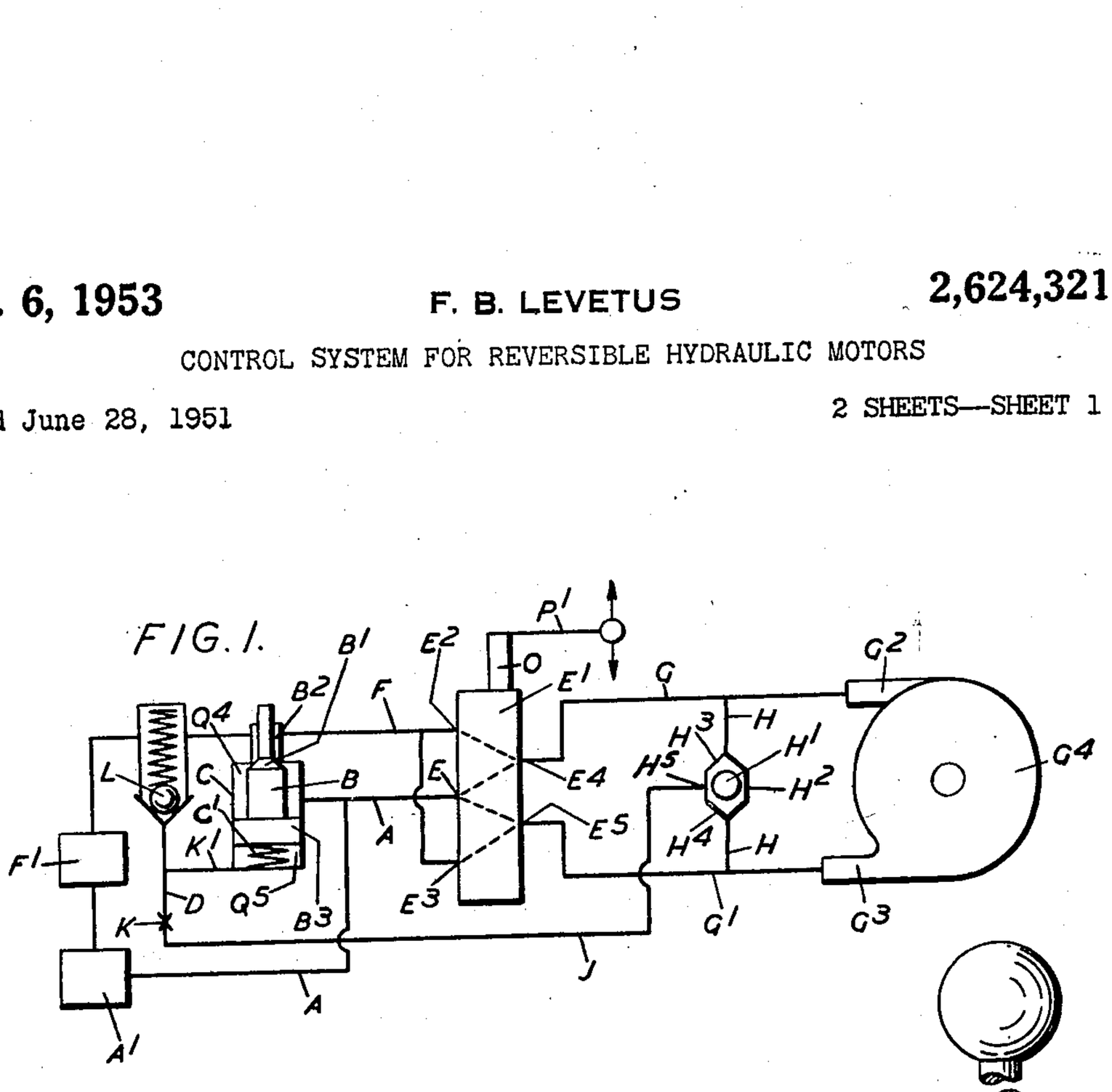


FIG. 2.

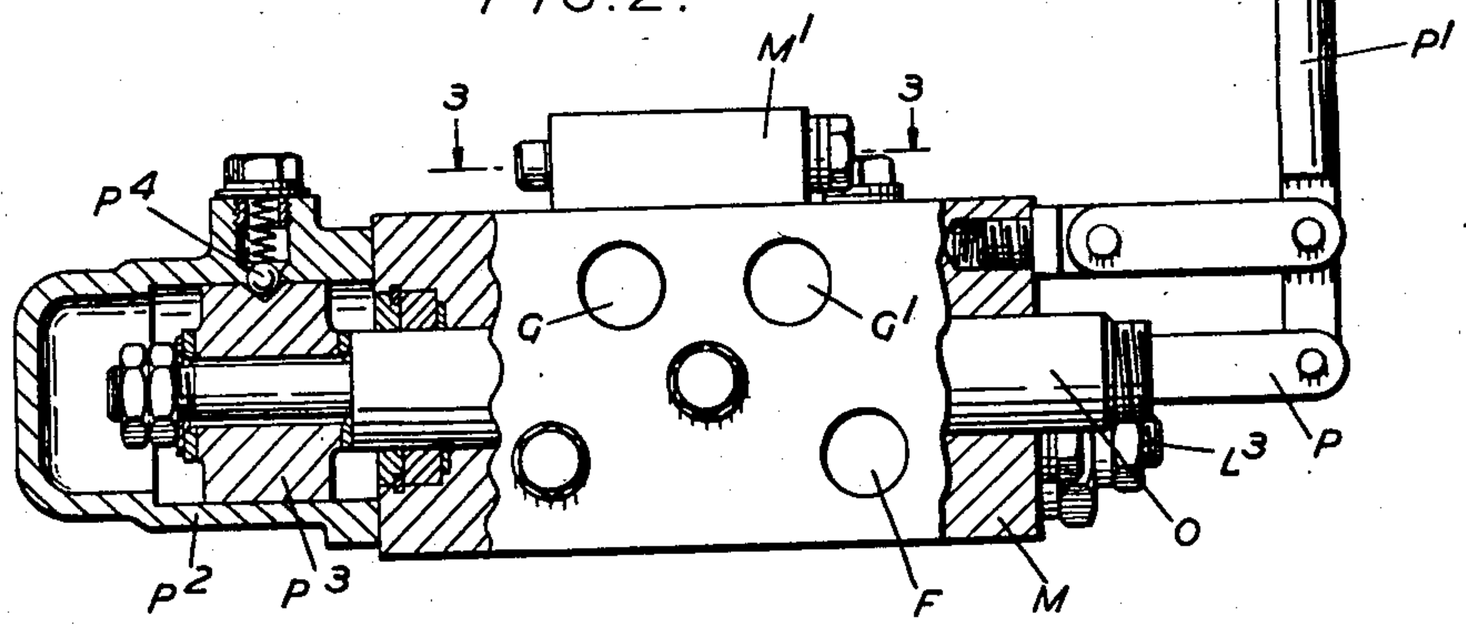
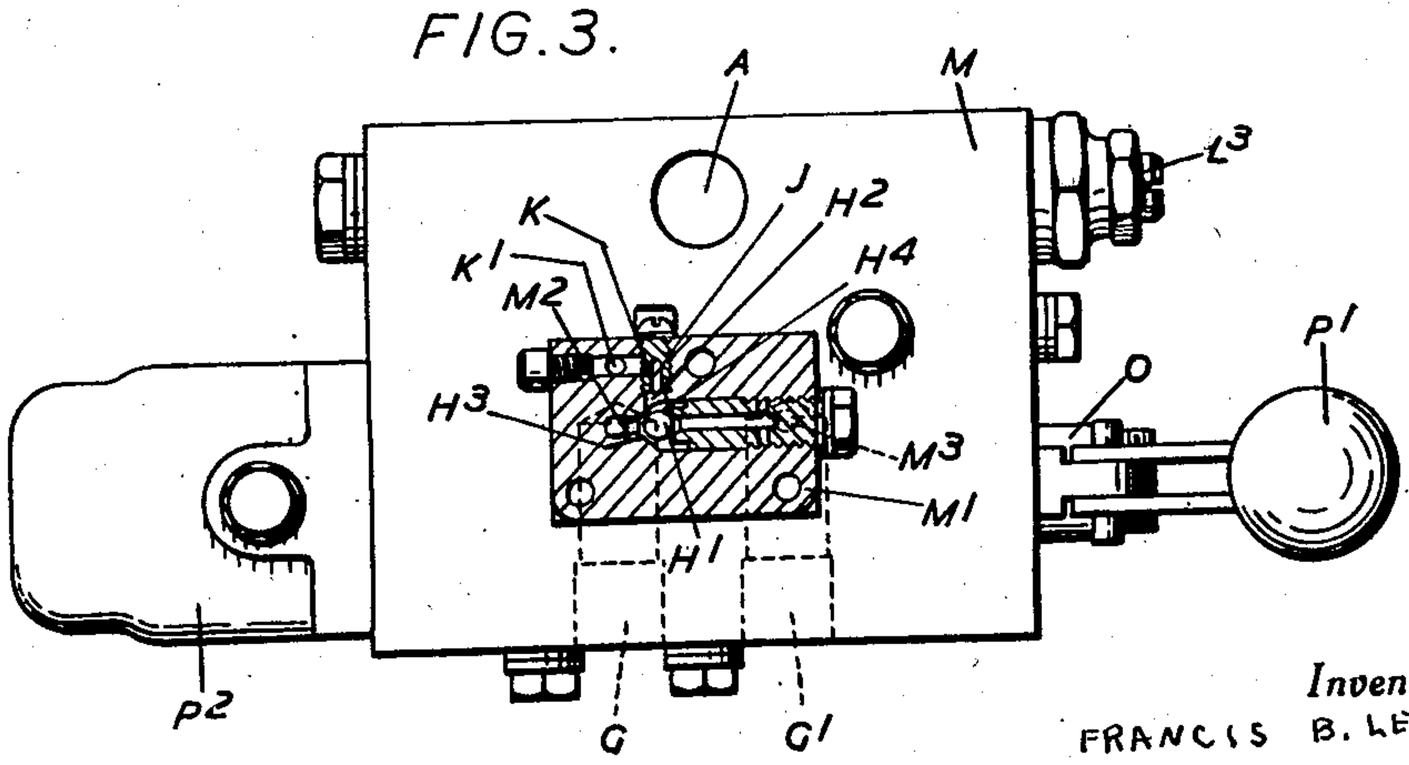


FIG. 3.



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Filed June 28, 1951 2 SHEETS—SHEET 2

FIG. 4.

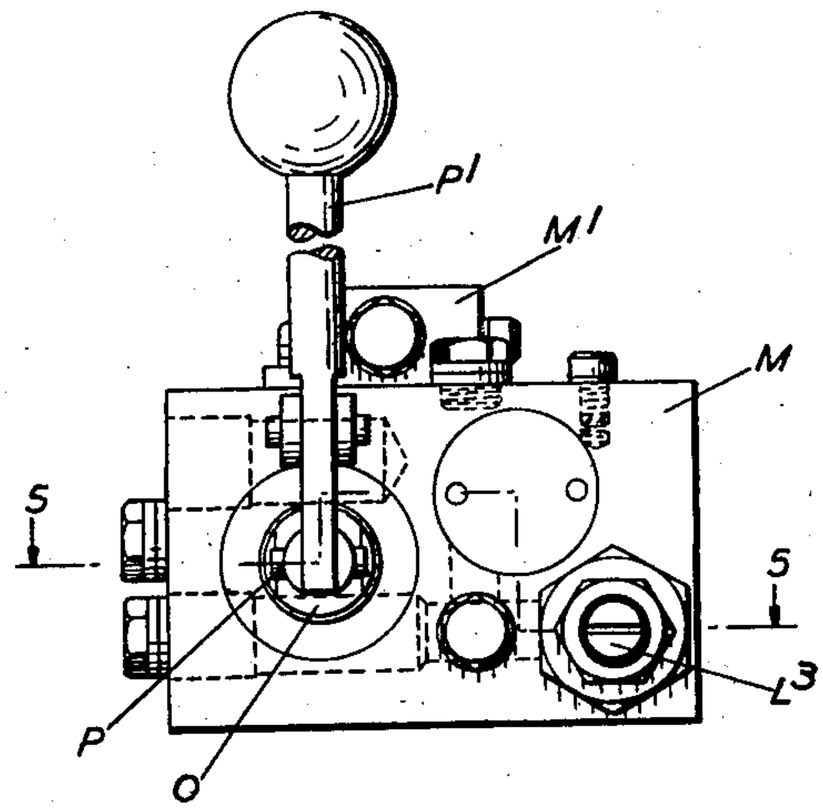
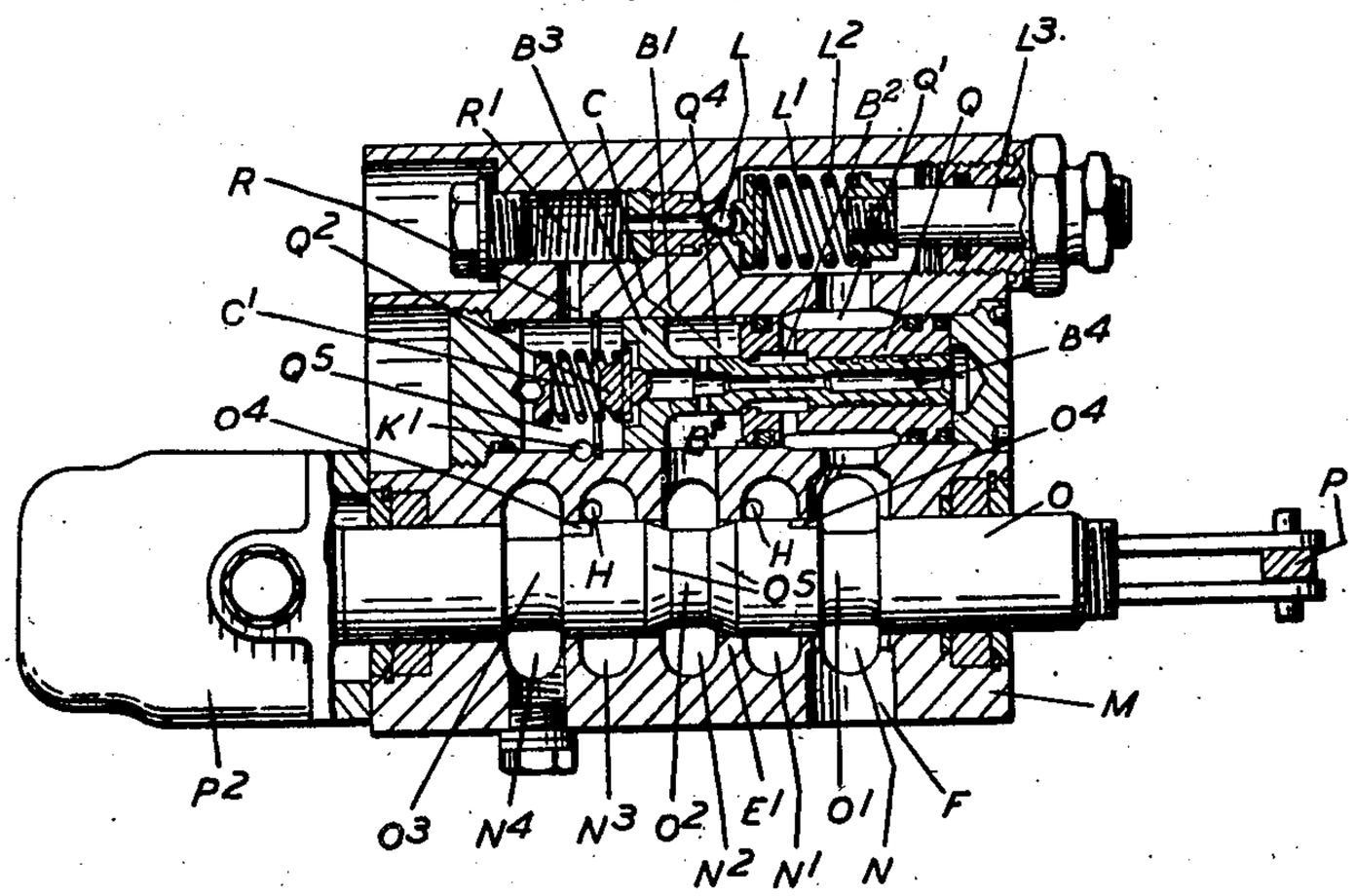


FIG. 5.



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CONTROL SYSTEM FOR REVERSIBLE HYDRAULIC MOTORS

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7 Claims. (Cl. 121—46.5)

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This invention relates to control systems for reversible hydraulic motors of the kind having inlet and outlet ports the functions of which are interchangeable by a reversing valve apparatus to reverse the motor, the reversing valve apparatus being so constructed and arranged that it can at will be caused to connect either of the two motor ports to a source of hydraulic pressure and the other to a relief passage or reservoir so as to cause the motor to be driven in one direction or the other, and in which the pressure supply passage by which the hydraulic fluid is delivered to the reversing valve has an automatic pressure-operated relief valve therein which is maintained open automatically when the full delivery of the source of hydraulic fluid under pressure is not being utilized by the motor so as to pass the excessive hydraulic fluid through a relief passage back to the hydraulic receiver and yet maintain the required pressure in the hydraulic supply passage at all times.

The object of the present invention is to provide an improved control system of the above general kind which will be simple in construction, will require a minimum number of separate valves of simple form and will yet meet all practical requirements including that of ensuring as far as possible that for any given setting of a control valve the speed of the motor will remain substantially constant irrespective of the load.

A control system for a reversible hydraulic motor having inlet and outlet ports the functions of which are reversed to reverse the motor according to the present invention comprises a pressure supply passage arranged to be connected to a source of hydraulic pressure, a reversing valve controlling the flow of hydraulic fluid to the motor from the pressure supply passage and from the motor to a relief passage or reservoir and arranged so that in a neutral position it connects each of the ports of the motor to a relief passage while when moved from such neutral position in one direction or the other it progressively disconnects one or other of the ports of the motor from its relief passage and connects that port to the pressure supply passage, and a pressure responsive relief valve in the pressure supply passage the pressure responsive member of which is arranged to respond to the pressure difference in two chambers one of which is subject to pressure derived from the hydraulic supply passage while the other is arranged to be connected to one or other of the ports of the motor through an automatic change-over valve which connects it automatically to whichever of these two ports is at the moment at the higher pressure.

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Conveniently the pressure responsive relief valve comprises a pressure responsive piston member one face of which is subject to pressure derived from the pressure supply passage while the other face is subject to the pressure in a chamber which is connected to the change-over valve and through it to the motor port at the moment at higher pressure, the chamber which derives pressure from the pressure supply passage having also a port therein coaxial with the piston and leading to a relief passage, this port being controlled by a part formed integral with or connected to the piston and acting as the relief valve member. Preferably the relief valve is of the kind forming the subject of United States patent application Serial No. 190,420, now abandoned, so that the pressure difference on its pressure responsive member or piston necessary to maintain it open under any conditions is substantially the same as that required to cause it to open from its closed position, that is to say the opening of the valve does not bring into effect any additional areas on which act unbalanced pressures tending to open or close the valve.

The form of the reversing valve apparatus may vary but conveniently the valve is of the known type comprising a valve cylinder with an intermediate point in the length of which the pressure supply passage communicates continuously through a pressure supply port while relief ports communicate continuously with the opposite ends of the cylinder and inlet and outlet ports lead to the motor inlet and outlet ports respectively from points in the cylinder situated in transverse planes on opposite sides of the pressure supply port, and a valve member of the piston type comprising a central portion of reduced cross-section forming with the surrounding part of the cylinder a pressure chamber into which the pressure supply port opens continuously and end portions which fit the cylinder and control the inlet and outlet ports so as to enable either one of the two ports to be brought into communication with the pressure chamber while the other is in communication through the adjacent end of the cylinder with its associated relief port. When such a valve is used with the present invention the disposition and dimensions of the ports and of the end portions of the valve member are such that when the valve member occupies a neutral position its end portions serve respectively to cut off the inlet and outlet ports from the pressure chamber and maintain them in communication

respectively with the relief ports at the ends of the cylinder, whereas movement of the valve member from this neutral position in one direction or the other causes one or other of the end portions thereof progressively to cut off the port controlled by it from its associated relief port and to bring it progressively into communication with the pressure chamber. Moreover the formation of the ends of the valve member and/or of the inlet and outlet ports controlled thereby is preferably such that the rate of progressive opening and closing of the inlet and outlet ports with movement of the valve member is such as to provide sensitive control of the operation of the motor and preferably such that the rate of movement of the valve throughout its movement is approximately proportional to the rate of opening and closing of the ports.

The invention may be carried into practice in various ways but one form of control system according to the invention is illustrated by way of example in the accompanying drawings in which,

Figure 1 is a diagram showing diagrammatically the apparatus constituting the complete control system with the hydraulic pump and motor with which it is associated,

Figure 2 is a side elevation partly in section of the valve assembly incorporated in the system,

Figure 3 is a plan view of the valve assembly shown in Figure 2, partly in section on the line **3—3** of Figure 2,

Figure 4 is an end elevation of the valve assembly shown in Figures 2 and 3, and

Figure 5 is a sectional view of the valve assembly shown in Figures 2, 3 and 4 taken on the broken line **5—5** of Figure 4.

The apparatus constituting the control system shown in Figure 1 comprises a pressure supply passage A to which hydraulic fluid is delivered under pressure continuously by a constant delivery pump indicated at A^1. In permanent communication with the pressure supply passage A is a pressure-operated relief valve B including a valve part B^1 controlling a relief port B^2, and a piston part B^3 operating within a cylinder C with its upper face subject to the pressure in the passage A while its lower face is subject to the pressure in a passage D and to the force of a spring C^1 so that the valve B will open whenever a predetermined difference occurs between the pressures respectively in the passages A and D.

While the valve B is shown diagrammatically for simplicity of illustration in Figure 1 in a form in which the piston surface subject to the pressure in the passage A is smaller than that subject to the pressure in the passage D, the valve would in fact be constructed, for example, in the manner described hereinafter with reference to Figures 2 to 5 so that the effective piston area on which the pressure in the passage A acts is substantially equal to the effective piston area on which the pressure in the passage D acts, so that the valve will open automatically whenever the pressure in the passage A exceeds that in the passage D by a predetermined amount sufficient to cause the valve members B, B^1 and B^3 to move downward against the action of the spring C^1.

The valve B thus acts to maintain a pressure in the passage A representing a predetermined difference between the pressures respectively in the passages A and D.

The pressure supply passage A leads to a pressure supply port E entering the cylinder E^1 of a control valve at approximately the centre of its length while the ends of the control valve cylinder

are provided with relief ports E^2, E^3 communicating with a relief passage F which leads, preferably through a reservoir F^1, to the inlet side of the pump A^1.

The valve cylinder E^1 is also provided with inlet and outlet ports E^4, E^5 communicating respectively through passages G, G^1 with the inlet and outlet ports G^2, G^3 of a reversible hydraulic motor G^4.

The control valve cylinder E^1 contains a piston type control valve member O hereinafter more fully described which in its central or neutral position maintains the ports E^4 and E^5 in continuous communication respectively with the ports E^2 and E^3, whereas movement of the valve member in one direction or the other from this neutral position progressively shuts off communication between one of the ports E^4 and E^5 and its associated port E^2 or E^3 and brings it into communication with the pressure supply port E.

Extending between the passages G and G^1 is a passage H in which is arranged an automatic change over valve in the form of a ball H^1 arranged in a valve chamber H^2 having seatings H^3, H^4 as its ends by way of which the chamber communicates respectively with the passages G and G^1 and intermediate port H^5 leading to a passage J which communicates by way of a small leak orifice indicated at K and a passage K^1 with the lower end of the cylinder C and also with a spring pressed ball valve L controlling a port leading to the relief passage F. Thus, the ball valve H^1 will be forced into engagement with one or other of the two seatings H^3, H^4 according to which of the two passages G and G^1 happens at the moment to be at higher pressure so as to connect the high pressure one of these two passages always automatically to the passage J. The flow through this passage J will be small by reason of the small metering orifice K but sufficient, whenever working pressure exists in one or other of the passages G, G^1, to cause the valve L to be lifted, thus maintaining a predetermined pressure in the passage D and hence in the delivery passage K^1 and in the lower end of the cylinder C whenever working pressure exists in one or other of the passages G, G^1, while also permitting the relief valve B to open at a considerably lower pressure and thus largely relieve the pressure in the passage A when both passages G and G^1 are connected to their respective relief ports E^2 and E^3.

In the practical construction of valve assembly shown in Figures 2 to 5 the various valves are all arranged within a single structure and for convenience the parts of this practical structure corresponding to the various parts indicated diagrammatically in Figure 1 are identified by the same reference letters as in that Figure 1.

Thus the complete valve assembly comprises a main casing M of approximately rectangular form with a subsidiary casing M^1 formed or mounted thereon so as in effect to form part thereof.

Leading from the main casing M, as shown, are the passages G, G^1, the passage F and the passage A, and formed within the casing are the two cylinders E^1 and C and a chamber containing the ball valve L, while formed in the subsidiary casing M^1 is the chamber H^2 of the change-over valve.

The cylinder E^1 is formed as shown with five annular recesses N, N^1, N^2, N^3 and N^4, communicating with the ports E^2, E^4, E, E^5 and E^3, respectively, as illustrated in Figure 1, of which N and

N^4 communicate with the passage F (N directly and N^4 through a passage in the casing M (not shown)). The recesses N^1 and N^3 communicate by passages H, H respectively with ports M^2, M^3 respectively at opposite ends of the chamber H^2, while the recess N^2 communicates with the passage A.

Mounted to slide in the cylinder E' is a piston type control valve member O having three waisted or reduced portions O^1, O^2, O^3 which, when the valve member is in its neutral position, as shown, lie respectively in the recesses N, N^2 and N^4, as shown in Figure 5. Each of the reduced portions O^1 and O^3 has, in addition, leading from it towards the reduced portion O^2, a channel O^4 and these channels O^4, when the valve member is in its neutral position, maintain communication respectively between the recesses N and N^1 and between the recesses N^4 and N^3.

The reduced portion O^2 is, on the contrary, provided with frusto conical extensions O^5 which, when the valve member is in its neutral position, terminate just short of the adjacent ends of the recesses N^1 and N^3.

One end of the valve member O is connected through a link P to a control P^1 by which it can thus be moved longitudinally, while its other end extends into a cylindrical chamber P^2 and carries a piston-like member P^3 having a conical recess in its circumference into which is adapted to be forced a spring pressed ball P^4 when the valve member occupies its neutral position so as not only to hold it in that position against unintentional displacement but to indicate to an operator by feel when it occupies that position.

The cylinder C contains the relief valve B, comprising the piston part B^3 and a valve part B^1 which co-operates with a seating in the adjacent end of a tubular insert Q around a port B^2 therein leading to a relief chamber Q^1 between the outer wall of said insert and cylinder C, which relief chamber in turn communicates with the recess N and hence at all times with the passage F. The tubular insert Q also serves as a guide for a rod-like extension B on the valve part B^1. The valve member B is hollow, the end of the bore of the extension B^4 being open while the opposite end of the bore is closed by a valve Q^2 normally maintained upon its seat by a spring C^1 which thus also acts on the valve member *b* and tends always to maintain the valve part B^1 upon its seating. The bore also opens by way of lateral passages into the chamber Q^4 within the cylinder C on the side of the piston B^3 remote from the spring C^1, which chamber is in open communication at all times with the recess N^2 and thereby with the pressure supply A.

The chamber Q^5 in which the spring C^1 lies communicates by way of a passage R with a chamber R^1 which is closed at one end and communicates at its other end through the spring pressed valve L with a chamber L^1 in open communication through the relief chamber Q^1 with the recess N and passage F. The spring L^2 acting on the valve L is adjustable by means of an adjustable abutment L^3 of known general type.

The chambers R^1 and Q^5 are in continuous communication through the passage K^1, a small metering orifice K and the passage J with an intermediate point in the length of the chamber H^2 in which the change-over valve H^1 lies between the two seatings H^3 and H^4 by way of which seatings the chamber communicates respectively with passages H, H leading respectively to the recesses N^1, N^3. Thus the valve H^2 is moved into engagement with one or the other of the seatings H^3 or H^4 according to whether one or the other of the recesses N^1 or N^3 is at the higher pressure at any moment.

The operation of the apparatus is as follows:

When the control valve O occupies its neutral position as shown, the recesses N^1 and N^3 are maintained in communication with the recesses N and N^4 respectively and hence with the relief passage F and both the ports G^2 and G^3 of the motor G^4 are thus connected to the relief passage F. Under these conditions also the change over valve H^1 is not maintained in engagement with either of the seatings H^3 and H^4 and the passages J and K^1 are thus also connected to the relief passage F and there is therefore no appreciable fluid pressure in the chamber Q^5. The relief valve B^1, B^3 will thus maintain in the recess N^2 and passage A a pressure only sufficient to over-come the force of the spring C^1.

When the control valve member O is moved to the left in Figure 5 from its neutral position it will be seen that it first closes communication between the recess N^3 and the recess N^4 through the adjacent groove O^4 and then progressively opens communication between the recess N^3 and the recess N^2 as the adjacent frusto-conical part O^5 moves into the recess N^3. The recess N^3 and hence the passage G is thus progressively connected to the pressure supply passage A so that pressure fluid is supplied to the port G^2 of the motor G^4. At the same time the passage M^2 is pressurised so that the change-over valve H^1 is moved into engagement with the seating H^4 and pressure fluid is thus delivered through the metering orifice K and passage K^1 to the chamber Q^5. The relief valve L is so set that it opens if this pressure exceeds a predetermined value such that with the pressure in the chamber Q^5 at that predetermined value, the valve B^1 will open at the maximum permissible working pressure in the parts of the system which during operation are subject to the working pressure.

Thus the motor G^4 is brought into operation in one direction and such operation is under sensitive control by means of the lever P^1.

If it is desired to cause the motor G^4 to operate in the opposite direction, the control valve member O is moved to the right in Figure 5 from its neutral position so that the recess N^1 is cut off from the recess N and then progressively brought into communication with the recess N^2. The port G^3 of the motor G^4, is thus supplied with pressure fluid under the control of the valve O, the change-over valve H^1 being caused to engage the seating H^3 so that the chamber Q^5 is brought into communication with the recess N^1 by way of the passage M^3, the chamber H^2, the passage J, the metering orifice K and the passage K^1, and the pressure conditions in the apparatus are thus the same as when the valve O is moved to the left from its neutral position.

The valve Q^2 acts as a safety valve to permit escape of fluid from the chamber Q^4 into the chamber Q^5 and thence through the valve L in the event of very sudden rises in pressure.

What I claim as my invention and desire to secure by Letters Patent is:

1. A control system for a reversible hydraulic motor having inlet and outlet ports the functions of which are reversed to reverse the motor, comprising a pressure supply passage arranged to be connected to a source of hydraulic pressure, a reversing valve controlling the flow of liquid to the motor from the pressure supply passage

and from the motor to a relief passage or reservoir and arranged so that in a neutral position it connects each of the ports of the motor to a relief passage while when moved from such neutral position in one direction or the other, it progressively disconnects one or other of the ports of the motor from its relief passage and connects that port to the pressure supply passage, a pressure-responsive relief valve in the pressure supply passage having a pressure-responsive member which responds to the pressure difference in two chambers, one of said chambers being subject to pressure derived from the hydraulic pressure supply passage, and automatic change-over valve means by which the other of said chambers is connected to whichever of the two ports of the motor is at the moment at the higher pressure, said change-over valve means including a pressure responsive valve member subject to pressure derived respectively from said two motor ports and automatically movable by the pressure difference acting thereon to cause said means to function.

2. A control system for a reversible hydraulic motor as claimed in claim 1, in which the pressure-responsive relief valve is in the form of a piston one face of which is subject to the pressure in the pressure supply passage while its other face is subject to the pressure in the chamber which is connected to the change-over valve means and through it to the motor port at the moment at higher pressure, the chamber which derives pressure from the pressure supply passage having also a port therein coaxial with the piston and leading to a relief passage, this port being controlled by a part formed integral with or connected to the piston and acting as the relief valve member.

3. A control system for a reversible hydraulic motor as claimed in claim 2, in which the pressure-responsive relief valve includes piston surfaces of substantially equal area subject respectively to the pressures on the inlet and outlet sides of the valve and a spring tending always to maintain the valve closed.

4. A control system for a reversible hydraulic motor as claimed in claim 1, in which the reversing valve comprises a valve cylinder having a port at an intermediate point in its length communicating with the pressure supply passage, relief ports at its opposite ends communicating continuously with the relief passage and outlet ports situated in planes respectively on opposite sides of the port communicating with the pressure supply passage and communicating respectively with the inlet and outlet ports of the motor, and said reversing valve also comprises a valve member of the piston type having a central portion of reduced cross-section forming with the valve cylinder a pressure chamber into which the pressure supply port opens continually, and end portions which control the cylinder outlet ports and, when the valve member occupies a neutral position, serve respectively to cut off said cylinder outlet ports from the pressure chamber and maintain them in communication respectively with the relief ports at the ends of the cylinder, whereas movement of the valve member from this neutral position in one direction or the other causes one

or other of the end portions thereof progressively to cut off the port controlled by it from its associated relief port and to bring it progressively into communication with the pressure chamber.

5. A control system for a reversible hydraulic motor as claimed in claim 4, in which the end portions of the valve member and the cylinder outlet ports are so formed that the rate of progressive opening and closing of the latter is substantially in proportion to the movement of the valve member.

6. A control system for a reversible hydraulic motor as claimed in claim 1 in which the pressure responsive relief valve comprises a pressure-responsive piston member one face of which is subject to the pressure in the pressure supply passage while its other face is subject to the pressure in a chamber which is connected to the change-over valve and through it to the motor port at the moment at higher pressure, the chamber which derives pressure from the pressure supply passage having also a port therein coaxial with the piston and leading to a relief passage, this port being controlled by a part formed integral with or connected to the piston and acting as the relief valve member, and in which the reversing valve comprises a valve cylinder having a pressure supply port at an intermediate point in its length with which the pressure supply passage communicates continuously, relief ports continuously open at its opposite ends and outlet ports communicating with the inlet and outlet ports of the motor from points in the cylinder situated in planes respectively on opposite sides of the pressure supply port, and said reversing valve also comprises a valve member of the piston type having a central portion of reduced cross-section forming with the valve cylinder a pressure chamber into which the pressure supply port opens continually, and end portions which control the outlet ports and when the valve member occupies a neutral position, serve respectively to cut off the outlet ports from the pressure chamber and maintain them in communication respectively with the relief ports at the ends of the valve cylinder whereas movement of the valve member from this neutral position in one direction or the other causes one or other of the end portions thereof progressively to cut off the port controlled by it from its associated relief port and to bring it progressively into communication with the pressure chamber.

7. A control system for a reversible hydraulic motor as claimed in claim 6 in which the pressure-responsive relief valve includes piston surfaces of substantially equal area subject respectively to the pressures on the inlet and outlet sides of the valve and a spring tending always to maintain the valve closed.

FRANCIS BENJAMIN LEVETUS.

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