This invention relates broadly to pressure regulators, but more particularly to a device for controlling the pressure in one hydraulic circuit by virtue of pressure variations in another circuit.

One object of this invention is to provide a hydraulic system having primary and secondary circuits, with a controlling device automatically actuated by virtue of a pressure increase in the primary circuit to relieve the pressure in the secondary circuit.

Another object of this invention is to provide a hydraulically actuated rock drilling motor and feeding mechanism therefor, with a controlling device which will automatically relieve the pressure of the feeding mechanism upon a torque increase of the drilling motor.

Another object of this invention is to provide a hydraulically actuated drilling apparatus with such a controlling device capable of instantaneous action upon any torque increase of the drilling motor and the consequential pressure increase of its actuating hydraulic fluid.

Other objects of this invention will be apparent from the following detailed description wherein similar characters of reference designate corresponding parts, and wherein:

Figure 1 is a diagrammatic view of a hydraulic system showing how a controlling device embodying the invention is connected thereto.

Figure 2 is a longitudinal sectional view of the controlling device embodying the invention.

Figure 3 is a view similar to Figure 2, but showing parts in different positions.

Referring to the drawing, and more particularly to Figure 1, except for the controlling device and its connections, the diagram represents a typical hydraulic system for a rock drilling motor 10 imparting rotation to an auger 11 and fed to the work by a feeding mechanism 12, which is connected to the motor by such means as a piston rod 13.

The operating pressure fluid of the system is furnished by a pump 14 driven by a motor 15, drawing fluid from a tank 16 through a conduit 17. From the pump the fluid flows through a conduit 18 to a conventional relief valve 19, which is set to hold the fluid of the entire system to a predetermined pressure, and is adapted to bypass any excessive pressure from the pump into the tank 16 through exhaust conduits 20 and 21. From the relief valve 19, the fluid flows through a supply conduit 22 and therefrom is channeled into the primary circuit of the system through a service conduit 23, a conventional shut off valve 24, and therefrom to the motor control valve 25 through conduit 26. With the control valve 25 opened, fluid will flow to motor 10 through service conduit 27 and after actuating the motor will return to the tank 16 through exhaust conduits 28, 29 and 21. With the valve 25 closed, conduit 27 is of course shut off, and conduit 26 is connected to an exhaust conduit 30 to return the fluid to the tank 16 via conduits 29 and 21.

From the supply conduit 22, fluid is also channeled into the secondary circuit of the system through service conduit 31, conventional flow control valve 32, and four-way valve 33 through conduit 34. The four-way valve 33 may be positioned to connect conduit 34 to a conduit 35 for admitting pressure fluid to one end of the feeding mechanism 12 for effecting longitudinal motion of the motor 10 toward the work, while the other end of the feeding mechanism is exhausted through a conduit 36 which is connected by the valve 33 to the tank 16 by exhaust conduits 37, 29 and 21. In another position of the valve 33, conduits 34 and 36 are connected for supplying pressure fluid to the feeding mechanism 12 for effecting longitudinal motion of the motor 10 in the other direction. In this instance, conduit 35 is connected to the tank 16 through conduits 37, 29 and 21.

From the diagram so far described, it will be understood that the system includes the motor or primary circuit starting with the conduit 23, and the feed mechanism or secondary circuit starting with the conduit 31. Both circuits, except for the controlling device about to be described, would operate independently of each other. Hereuntofore when the drilling motor encountered unusual resistance or was otherwise subjected to operating conditions necessitating reduction of its feeding speed, it was necessary for the operator to reduce its feeding speed by manipulating the four-way valve 33. In order to relieve the operator of this task, eliminate human error and provide for a feed control device instantaneously responsive to pressure fluctuations of the drilling motor, there is connected to the circuits the pressure regulator embodying the invention, which includes a housing 40 having a bore or valve chamber 41, of different diameters, and extending axially therethrough and normally closed by an upper cap 42 or a lower cap 43. Three connections 44, 45 and 46 open into the bore 41 through longitudinally spaced annular recesses 47, 48 and 49 respectively. A three step spool valve 50 is slidable in the bore or valve chamber 41, the first and largest step 51 of which normally closes the recess 47. The central step 52 is slidable between the recesses 48 and 49 in a bore reduced portion or bearing 53, while the third step 54 is slidable in the inner end of the bore or bearing 55 which is of smaller diameter than the bearing 53. A compression spring 56 is in the bore 41 with one end resting on the valve 50, and the other end engaging a valve seat 57 having a stem 58 screwed through the cap 42 and locked by a check nut 59. The bore 41 above the valve 50 is connected to the recess 47 through a port 60, while the bottom of the bearing 55 is also connected to the exhaust recess 47 through a connection 61, conduit 62, T 63, conduit 64 and connection 44.

As clearly shown in Figure 1, the valve connection 45 is fixed to the conduit 35 of the secondary circuit through a conduit 65 and the valve connection 46 to the conduit 23 of the primary circuit through a conduit 66, while the T 63 is connected to the tank 16 through exhaust conduits 67 and 21.

Before operation, the compression of the spring 56 through the valve seat 57, is first adjusted so that valve 50 will remain substantially in the position shown in Figure 2 during normal operation of the system. To that end, the compression of the spring is adjusted so that its thrust on the valve 50 equals the normal pressure of the primary circuit acting on the effective pressure area of the valve step 52 in the recess 49, together with the normal pressure of the secondary circuit acting on the effective pressure area of the valve step 51 in the recess 48. In practice the sizes of these two valve pressure areas and the normal pressures to which they are subjected, are calculated to produce a valve thrust opposed and equal to the spring thrust when the valve is positioned substantially as in Figure 2.

In a normal drill cycle, the feeding mechanism 12 has
its conduit 35 connected by the valve 33 to the conduit 34 for imparting longitudinal motion to the motor 10 toward the work. When the drilling motor encounters resistance causing it to slow down in its drilling, it is imperative that its feeding speed be reduced, which heretofore was done by the operator manipulating the valve 33. In the present construction, reduction in the speed of the motor 10 by virtue of its increased resistance, causes a pressure increase in the entire primary circuit, which acts on the effective area of the valve step 52 in the recessary 49 and together with the pressure of the secondary circuit acting on the effective area of step 51, overcomes the thrust of the spring 56. As the valve is moved upwardly, its step 51 will at least partially uncover the recess 47, thereby enabling partial pressure release from conduit 35 of the secondary circuit through conduit 65, connection 45, annual recesses 46 and 47, connection 44, conduit 64,T 63 and exhaust conduits 67 and 21 and tank 16.

Should this partial pressure release of the secondary circuit and the consequential feed reduction of the feeding mechanism 12 be insufficient to enable the motor 10 to resume normal operation, the still further increased pressure of the primary circuit will finally cause valve 50 to move further against spring 56, causing valve step 51 to completely uncover recess 47, as shown in Figure 3, for completely exhausting the fluid pressure from the feeding mechanism 12 and stop further feeding motion of the motor 10.

As the motor 10 resumes its normal operation and the primary circuit its normal pressure, spring 56 will again shift the valve 56 to the position shown in Figure 2, it being maintained in that position by normal pressure of the primary and secondary circuits on the effective areas of the valve steps 52 and 51 respectively.

Any escape of pressure fluid which might take place between valve step 54 and bearing 55 is free to be returned to the tank 16 through the connection 61, conduit 62, T 63 and exhaust conduits 67 and 21. Similarly, any pressure fluid which may escape past the valve step 51 into the bore 41, is free to flow to the exhaust 47 through port 60.

From the foregoing description, it will be understood that the compensating pressure regulator is automatically operated by virtue of pressure variations in the primary circuit for controlling the pressure in the secondary circuit. As the pressure in the primary circuit increases above a set or predetermined maximum, the pressure in the secondary circuit decreases proportionately, and the reverse takes place until the pressure fluid of the secondary circuit again reaches its normal pressure.

It will also be understood that by varying the sizes of the valve effecting pressure areas as well as varying the compression of the spring 56 through the adjustable valve seat 57, it is possible to control the pressure of the secondary circuit for different pressure ranges of the primary circuit.

The details of structure and arrangement of parts shown and described may be variously changed and modified without departing from the spirit and scope of the invention.

1. For use with a hydraulic system having a primary and secondary circuit filled with pressure fluid supplied thereto by a pump, a control apparatus automatically reducing the pressure of the secondary circuit upon a pressure increase in the primary circuit, said apparatus comprising: a housing, a valve slidable in said housing, a spring exerting spring thrust on said valve, primary and secondary pressure areas on said valve, means between said areas and their named circuits aforesaid admitting fluid pressure therefrom on said areas producing an axial thrust on said valve opposed and equal to said spring thrust, fluid return means leading from said valve to the input side of the pump aforesaid, means on said valve normally closing said return means, said axial thrust being increased and the valve moved thereby against said spring thrust upon a pressure increase on its primary area from said primary circuit, and means on said valve affording a source of communication between said secondary circuit and return means as it moves against said spring thrust.

2. For use with a hydraulic system having a primary and secondary circuit filled with pressure fluid supplied thereto by a pump, a control apparatus automatically reducing the pressure of the secondary circuit upon a pressure increase in the primary circuit, said apparatus comprising: a housing having a bore extending therethrough, primary and secondary conduits connecting said bore with their named circuits aforesaid, a return conduit connecting said bore with the input side of the pump aforesaid, a valve slidable in said bore, a spring exerting a thrust on said valve, primary and secondary pressure areas on said valve having fluid pressure supplied thereto from their named conduits to produce an axial thrust on said valve opposed and normally equal to said spring thrust, means on said valve closing said conduits from each other when said axial thrust equals said spring thrust, said axial thrust being increased and the valve moved thereby against said spring thrust upon a pressure increase on its primary area from said primary conduit, and means on said valve affording a path of communication between said secondary and return conduit as said valve moves against said spring thrust.

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