May 24, 1966 J. L. GRATZMULLER 3,252,381

RAPID RESPONSE HYDRAULIC SYSTEM

Filed Nov. 14, 1963 2 Sheets-Sheet 1

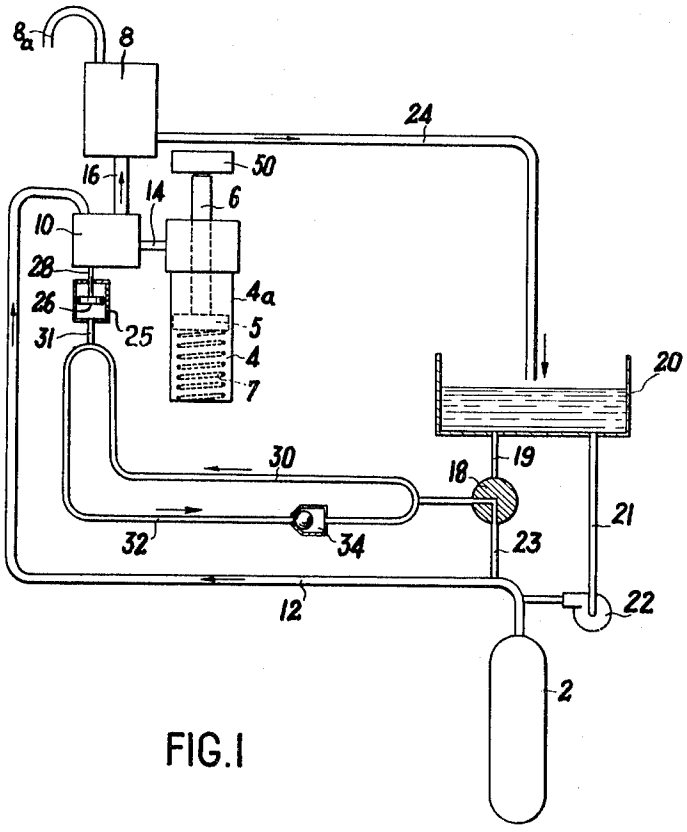

FIG.1

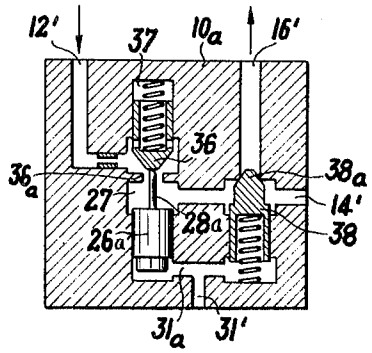

FIG.2

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RAPID RESPONSE HYDRAULIC SYSTEM

Filed Nov. 14, 1963 2 Sheets-Sheet 2

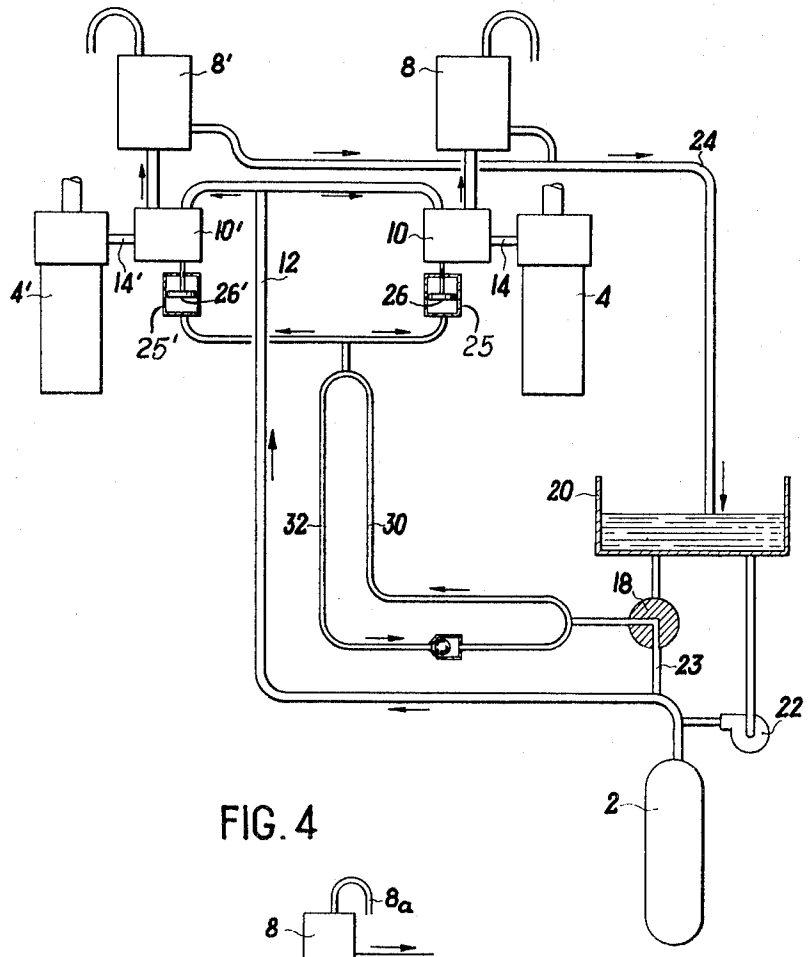

FIG. 4

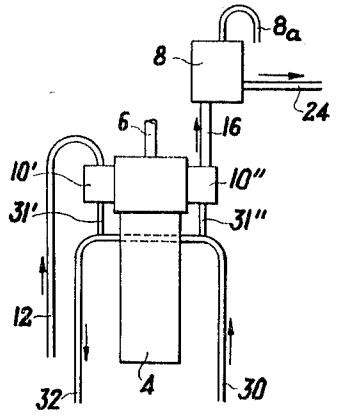

FIG. 3

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3,252,381

RAPID RESPONSE HYDRAULIC SYSTEM

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9 Claims. (Cl. 91—411)

This invention relates to hydraulic systems for controlling the operation of a hydraulic motor means such as a hydraulic jack. More particularly, the invention is concerned with such a system wherein the operation response time is controlled and made as rapid as possible whereby the system can be efficiently used to operate a separate element such as, for example, an electric circuit breaker.

In hydraulic systems utilized for control purposes and wherein a hydraulic motor means serves to provide the terminal mechanical movement, it has been difficult, if not impossible to achieve rapid system response times and accurate repeating system operation. More specifically, there is a tendency in such systems, as provided in the past, for air or other gas in the atmosphere in which the system is disposed, to become trapped in hydraulic lines, or components, and in turn system responses and/or repetitious operations become dependent on the characteristics of the entrapped gas or air. When air becomes trapped in a hydraulic control system of the type with which the invention is concerned, then the hydraulic pressures experienced within the system during either an activating or deactivating operation, first act to compress the entrapped air or gas, and then after such compression, the pressures are operative to perform the particular activating or deactivating movement. Since the amount of entrapped air or gas can vary, identical repeating operations cannot be easily achieved. Moreover, since time is required to compress the entrapped air or gas, the response times of prior systems of the type in question have been limited.

The problems discussed above become somewhat more severe when a hydraulic motor means, such as a hydraulic jack, is disposed at a vertical level substantially above and remote from a system distributor means incorporated to control the operation of the motor means or jack. Yet, in many instances it is desirable to locate the motor means at an upper vertical level and to locate the distributor means at a remote position on a lower vertical level. Further, it is desirable to eliminate the need for large conduits passing between different vertical levels by providing an auxiliary comparatively low pressure reservoir in the vicinity of the motor means, which reservoir is adapted to receive the fluid output of the motor means at a somewhat rapid rate, and then empty itself by drainage at a somewhat lower rate.

The present invention is directed providing a system which is free of the aforesaid disadvantages, which permits different vertical locations of system components, which incorporates an auxiliary reservoir means thereby eliminating the requirement for massive conduits, and which further insures complete system operation free of entrapped air or gas therein.

More specifically, the present invention is directed to the provision of a hydraulic system incorporating a hydraulic motor means, a comparatively high volume hydraulic power circuit for operating the hydraulic motor means and a comparatively low volume hydraulic control circuit for controlling the operation of the hydraulic motor means by the hydraulic power circuit, (a) which system is so constructed and arranged as to be free of entrapped air therein, and (b) which system provides

for rapid response times and permits substantially identical repeating operations.

Consistent with the preceding object, the invention contemplates utilizing an auxiliary low pressure reservoir for receiving fluid discharged from the hydraulic motor means during deactivation thereof, which reservoir is so located and coupled in the system that, once the system has started satisfactory operation, air cannot pass to the motor means or into the portion of the system coupling the reservoir with the motor means, notwithstanding the fact that system deactivation is achieved by venting to the atmosphere. Still further, in this regard, the invention contemplates utilizing (1) a hydraulically actuated control valve means which selectively controls the feed of the powering hydraulic fluid into and out of the motor means, and (2) a hydraulic control circuit which operates the control valve means, but yet is also so constructed and arranged as to operate with minor fluid flow, and as to eliminate the possibility of air or gas being entrapped therein, notwithstanding the use of atmospheric venting of the control circuit for deactivating operations.

According to the invention, the aforesaid auxiliary reservoir is positioned above the highest level of hydraulic fluid within the hydraulic motor means. The control valve means serves to selectively couple the hydraulic motor means either with the auxiliary reservoir or a source of fluid under pressure. The control valve means is itself, as indicated, preferably hydraulically operated and coupled in a control circuit having parallel branches leading from a system distributor means which is located below the control valve means and below the auxiliary reservoir. The distributor means can be positioned at some remote location with respect to the motor means and the control valve means, and in any event is below such means. One of the parallel branches in the control circuit has a one-way valve therein permitting the flow of fluid from the branch only in the direction to the distributor, thereby providing for the purge of any air trapped in the control circuit.

The basic invention and preferred embodiments thereof will be better understood, and objects other than those set forth above will become apparent, when consideration is given to the following detailed description. Such description makes reference to the annexed drawings, presenting preferred and illustrative embodiments of the invention.

In the drawings:

FIGURE 1 presents a schematic side view of a hydraulic system constructed in accordance with the present invention;

FIGURE 2 is a transverse sectional view of a control valve means which can be utilized in the system of FIGURE 1; and

FIGURE 3 is a schematic side view of a fragment of the system of FIGURE 1, FIGURE 3 presenting modified control arrangement which can be utilized in accordance with the invention in the basic system of FIGURE 1;

FIGURE 4 is a schematic view of a hydraulic system controlling a plurality of hydraulic motor means.

The system, as shown in FIGURE 1, includes a hydraulic motor means 4 in the form of a hydraulic jack. Such jack comprises a housing 4*a* having a piston 5 reciprocably moveable therein. Extending upwardly from the piston 5 is a piston rod 6 which, with reciprocal movement of the piston 5, serves to control a circuit breaker 50. The circuit breaker 50 is but illustrative of one type of device which may be contolled through movement of the piston rod 6. However, the invention finds particular utility when employed for the control of the circuit breaker.

The particular mechanical connection (not shown) be-

tween the piston rod 6 and the device which is operated by movement of such piston rod can be conventional. The invention is not concerned with the particular mechanical link utilized for coupling the motor means 4 with the device to be operated by the system, and accordingly, suffice it to say, that the motor means 4 is adapted to operate some other device, such as the circuit breaker 50.

The hydraulic motor means 4 comprises part of a hydraulic circuit including a source of hydraulic fluid under pressure and an auxiliary reservoir. As shown, the source of hydraulic fluid under pressure comprises an accumulator 2 for supplying hydraulic fluid under a pressure within a given range. The auxiliary reservoir 8, on the other hand, takes the form of a tank which is preferably vented to the atmosphere as by a vent tube 8*a*. On the other hand, the auxiliary reservoir 8 could be under some pressure interiorly, and the important factor is that the pressure in the auxiliary reservoir is less than the pressure of the fluid supplied from the accumulator 2.

A conduit 12 serves to connect the accumulator 2 with a control valve means 10, and similarly a conduit 16 serves to connect the auxiliary reservoir 8 with the control valve means 10. Such valve means, as explained more fully below, is provided to permit selective coupling of the hydraulic motor means 4 alternately with the accumulator 2 and the auxiliary reservoir 8. To this end, a coupling conduit 14 leads from the uppermost portion of the housing 4*a* of the jack to the control valve means 10.

The control valve means 10, as shown, is hydraulically actuated, but the same may take various forms. Regardless of the particular control valve means used, it is operative in one position or condition to supply fluid under pressure from the accumulator 2 through the conduit 12 and into the conduit 14. When in such position or condition, the fluid reacts against the piston 5, thereby causing such piston to move vertically downward, as shown. The piston 5 preferably reacts during this travel against a means for normally urging the piston to an upper position, such means taking the form, for example, of the spring 7 shown in FIGURE 1. This spring is compressed between the lower face of the piston 5 and the bottom wall of the housing 4*a* when the fluid under pressure is causing the piston 5 to move downwardly.

The lower position of the piston 5 can well be the activating position thereof when the same is coupled with a separate device, such as the circuit breaker 50. Assuming this to be true, then at some time, it would be desired to rapidly deactivate the separate device, and in turn to permit the piston 5 to return to its upper position or deactivated position. To achieve this result, the control valve means 10 is operated to a second position or condition where it dis-establishes or interrupts communication between the conduits 12 and 14, but at the same time establishes communication between the conduits 14 and 16. At this time, under the action of the spring 7, the piston 5 is urged upwardly, forcing hydraulic fluid thereabove to flow from the housing 4*a* into the conduit 14, through the control valve 10 and the conduit 16 into the auxiliary reservoir 8. The auxiliary reservoir 8 is dimensioned so as to easily receive the discharged fluid from the housing 4*a*, and moreover, since the auxiliary reservoir 8 is vented to the atmosphere, the force exerted by the spring 7 on the piston 5 to discharge the fluid is minimized.

The auxiliary reservoir 8 has a drain conduit 24 leading from the lower portion thereof and extending to a sump or main reservoir 20. The conduit 24 does not connect with the lowermost level of the auxiliary reservoir 8, but instead is preferably positioned such that it communicates with the auxiliary reservoir slightly above the lowest level therein. Conduit 24 permits discharged fluid to drain from the auxiliary reservoir 8 and to the sump or main reservoir 20 but, as should be apparent, the auxiliary reservoir 8 never becomes completely empty since the conduit 24 does not communicate with the lowest level thereof.

Now, bearing the foregoing ararngement in mind, it is important to note (1) that the auxiliary reservoir 8 is positioned above the highest level of fluid in the hydraulic motor means 4, and (2) that the control valve means 10 is positioned below the lowest level of fluid in the auxiliary reservoir and preferably adjacent the jack or motor means 4.

With such positioning of the auxiliary reservoir 8 and control valve means 10, fluid which is discharged from the jack passes upwardly. Due to the weight of such fluid maintained in the conduit 14 and in the housing 4*a*, there is always some pressure above the piston 5. Moreover, once the system has been operated the conduit 16 and the lower level of the auxiliary reservoir 8 are filled with fluid. This is an important aspect of the invention, as indicated above, since as long as the conduit 16 continually contains fluid under pressure, no air or gas can be entrapped in this conduit or in the paths leading therefrom through the control valve means 10. Should some air initially be trapped in the system described above, the same would be eliminated with the first one or few activating and deactivating operations because the air would be expelled with such operations through the vent tube 8*a*. Thus, when the control valve 10 is operated to shift positions after the system has been used, there is immediate fluid to fluid contact within the valve means 10 and between the conduits 12 and 14 or 14 and 16, as the case may be.

The sump or main reservoir 20 referred to above has a line 21 leading therefrom and to the conduit 12 or essentially the accumulator 2. A pump 22 is connected in such conduit so that hydraulic fluid can be returned from the sump 20 under the proper pressure to the hydraulic power circuit referred to above.

As will be noted from FIGURE 1, a line 19 leads from the sump to a distributor means 18 which takes the form of a conventional three-way valve. This valve is movable to alternately connect a hydraulic control circuit with the accumulator 2 as by the line 23, or with the sump 20 as by the line 19.

The distributor means 18 is part of the distributor or control circuit which operates with minor fluid flow as compared to the power circuit. The distributor or control circuit includes a pair of parallel conduits or circuit branches 30 and 32 which feed to a common output branch 31. The output branch 31 feeds into the control valve means 10.

The control valve means, as indicated above, can take various forms, and can include, as shown in FIGURE 1, a cylinder 25 connected to branch 31, with a piston 26 slidably mounted in the cylinder upon a piston rod 28 which connects to the control valve means 10, However, the control valve means 10 preferably takes the form of the valve means shown in FIGURE 2 and described more fully below. The significant factor to understand at this point is that the distributor circuit or control circuit includes two branches, one of which, namely the branch 32, has a one-way valve 34 therein, which valve permits the fluid in the distributor circuit to flow only toward the distributor means 18 as shown by the arrows adjacent the branches 30 and 32.

When the distributor 18 is positioned to couple the branch lines 30 and 32 with the accumulator 2, as via the line 23, then pressure is exerted by the control circuit, or specifically the fluid therein, on the control valve means 10. This results in actuating the control valve means to one of its two operating positions or conditions. When, however, the distributor means 18 is adjusted to couple the branch lines 30 and 32 with the sump 20, then the pressure on the fluid therein is essentially removed and the control valve means responds by moving to its other position or condition. However, the branch lines 30 and 32 as well as the lines leading thereto remain completely full

of hydraulic fluid, the action essentially being quite similar to that which is achieved in a barometer. For an explanation of the manner in which an automatic purge of air from the distributor or control circuit is achieved, attention is directed to French Patent No. 1,230,514, entitled, "Hydraulic Control Apparatus With Automatic Air Purge."

It is important to here note that the distributor or control circuit in the system as well as the power circuit of the system described initially, both provide for venting to the atmosphere. Yet, in each instance the supply conduits remain completely full of fluid, thereby eliminating air or gas pockets and resulting slow and irregular response times.

Referring to FIGURE 2, the hydraulic control valve means shown therein includes a housing **10***a* having a plurality of passageways **12'**, **14'**, **16'** and **31'** corresponding to the conduits **12**, **14**, **16** and **31** to which they are respectively coupled. The passageway **31'** leads to a lower internal chamber **31***a* which communicates with respective piston chambers housing a piston **26***a* and a piston **38**. The piston **26***a* is coupled by a shaft **28***a* to an input valve control member **36**. When fluid under pressure is applied through the passageway **31'**, the same reacts on the piston **26***a* thereby lifting the valve member **36** to permit fluid to flow through the passageway **12'** and into the passageway **14'**. At this time, the pressure in the lower chamber **31***a* of the valve means **10** forces the piston **38** upwardly thereby blocking the passageway **16'**. Still, the fluid can flow around the plug end **38***a* of the piston **38** which blocks the passageway **16**.

When the pressure of fluid is removed from the passageway **31'**, the valve member **36** moves downwardly under the action of its associated biasing spring **37** and closes communication between the passageway **12'** and the passageway **14'** by blocking the valve seat **36***a*. Once this has occurred, the piston **5** is urged upwardly by its biasing spring **7** and the fluid in the housing **4***a* is forced through the conduit **14** into the passageway **14'**. This fluid reacts on the piston **26***a* to maintain the valve member **36** seated on the valve seat **36***a*, but at the same time reacts against the piston **38** to displace the same downwardly, compressing the biasing spring **39** for piston **38** and opening communication between the passageway **14'** and the passageway **16'**.

From the above description, it should be apparent that when fluid under pressure is in the passageway **31'**, the conduit **12** is coupled through the valve means **10** and the conduit **14'** with the interior of the housing **4***a*, and the piston **5** is accordingly moved downwardly to its lowermost position. When the pressure on the fluid in the passageway **31** is removed, then the piston **5** returns to its initial position with the fluid being discharged through the conduit **14** and passing to the conduit **16** reacting against the pressure face of the piston **26***a* in the upper housing chamber **27** (FIGURE 2) to maintain the valve member **36** in its closed position. In this latter regard, it is to be noted that the pressure face of the piston **26***a* in the chamber **27** is greater than the pressure face of the valve member **36** in such chamber, and that the valve member **36** has openings **36***a* therein which permit the fluid under pressure in the passageway **12'** travelling from the accumulator **2** to equalize on opposite sides of the pressure face of the valve member **36**, thereby permitting the control referred to above without interference from the power fluid under pressure.

Although the arrangement of FIGURE 2 is simple and accordingly desirable for use in the system of FIGURE 1, a pair of control valves can be used as the control valve means **10**. In FIGURE 3, a pair of control valves **10'** and **10''** are shown as being coupled in the distributor or control circuit by means of the respective output lines **31'** and **31''**. These output lines are connected with the branch lines **30** and **32**, and the respective valves **10'** and **10''** are conventional valves. These valves work oppositely with one valve **10'** assuming an open position when there is pressure on the fluid in the control circuit and with the other valve **10''** assuming an open position when the pressure on the fluid in the control circuit is reduced. The operation of the valves **10'** and **10''** corresponds to the operation of the control valve means **10** described above, and accordingly further description of this modification appears unnecessary.

It is to be understood that even though a jack forms the preferred hydraulic motor means utilized in accordance with the invention, other motor means can be incorporated in the system. Moreover, where a jack is used, same need not take the exact form shown in the drawings, and can be reversed in so far as movement is connected. Regardless of the particular motor means used, the system is readily adapted to provide rapid response control for a hydraulic motor means disposed at an upper convenient vertical level with the basic control or distributor located at some lower vertical level and in a remote position with respect to the motor means and the control valve and auxiliary reservoir associated therewith.

Substantial advantage is obtained with the invention in connection with the hydraulic lines or conduits required. Specifically, only one long conduit with a heavy flow capacity is needed. The remaining conduits or lines, including the return line of the power system and the supply lines of the control system, need only be of minimal size and capable of handling comparatively small fluid flows. Of course, it will be appreciated that the fluid flow in the control or distributor circuit is minor compared with the fluid flow in the power circuit.

While the invention has been shown in FIGURE 1 and described above as including a single motor means, the system is readily adapted to operate a plurality of motor means, for instance two hydraulic jacks **4—4'**, as shown on FIGURE 4. For this purpose, a group of control valves **10—10'** would be utilized and coupled in parallel to the line or conduit **12**. Moreover, a separate auxiliary reservoir **8—8'** would be incorporated for each motor means with the return line from each auxiliary reservoir draining to the sump or main reservoir **20**. For common operation of the various motor means, a single distributor means **18** can be used. The multiple motor means system can be operated from the same source of hydraulic fluid under pressure (preferably a hydro-pneumatic accumulator **2**) notwithstanding the separate auxiliary reservoir associated with each individual motor means.

Having now described illustrative and preferred embodiments of the present invention in considerable detail, it will be appreciated that the objects set forth at the outset of the present specification have been successfully achieved.

What is claimed is:

1. In a hydraulic system of the type including a hydraulic circuit having therein hydraulic motor means, a source of hydraulic fluid under pressure within a given range, a main reservoir positioned below the lowest level of fluid in said motor means, an auxiliary reservoir under a pressure less than the pressures within said given range and communicating with said main reservoir and hydraulically actuated control means for selectively coupling said hydraulic motor means alternatively with said source of hydraulic fluid and said auxiliary reservoir, the improvement comprising:

(a) said auxiliary reservoir being positioned above the highest level of fluid in said motor means,

(b) a distributor circuit including distributor means positioned below said hydraulic motor means for selectively coupling said control valve means with said source of hydraulic fluid to actuate said control valve means, and

(c) said control valve means being positioned above said distributor means and below the lowest level

of fluid in said auxiliary reservoir, whereby said hydraulic motor means, said control valve means and the portion of said hydraulic circuit between said auxiliary reservoir and said control valve means remain filled with hydraulic fluid regardless of the selective coupling of said motor means with said auxiliary reservoir and said source of hydraulic fluid.

2. The improvement defined in claim 1, wherein said distributor circuit includes a pair of parallel branches, one of which branches has a one-way valve therein for permitting the flow of liquid within said one branch only toward said distributor means.

3. The improvement defined in claim 1 and further including means for passing fluid from said main reservoir to said source of fluid under pressure.

4. The improvement defined in claim 3 wherein said auxiliary reservoir has an output line leading to said main reservoir, said output line being in communication with said auxiliary reservoir above the lowest level therein.

5. The improvement defined in claim 1, wherein said hydraulically actuated control means comprises a pair of hydraulically operated valves coupled in said distributor circuit for common operation by said distributor means.

6. The improvement defined in claim 1 wherein said distributor means is coupled with said source of hydraulic fluid under pressure and operative to exert pressure on the fluid in said distributor circuit transmitted from said source.

7. The improvement defined in claim 1 wherein said distributor means is operative to alternately selectively couple said distributor circuit with said main reservoir and said source of hydraulic fluid under pressure.

8. A hydraulic system comprising a plurality of hydraulic motor means, fluid supply means for delivering hydraulic fluid under pressure within a given range, a plurality of reservoirs under pressures less than the pressures within said given range, said reservoirs each being

coupled respectively with a different one of said hydraulic motor means, said reservoirs being positioned above the highest level of fluid respectively in the hydraulic motor means with which said reservoirs are respectively coupled, control valve means for selectively coupling said hydraulic motor means with said fluid supply means and said reservoirs, hydraulic control circuit means coupled with said control valve means and including distributor means positioned below said hydraulic motor means and said reservoirs for selectively actuating said control valve means.

9. A hydraulic system including a hydraulic jack having a hydraulic fluid inlet in the upper portion thereof, a circuit breaker operated by said jack, a source of hydraulic fluid under pressure, an auxiliary low pressure reservoir positioned above said fluid inlet in said jack, a main reservoir for receiving fluid from said auxiliary reservoir under gravity flow, hydraulically actuated control valve means positioned above said main reservoir and below said auxiliary reservoir for selectively coupling said jack alternatively with said source of hydraulic fluid and said auxiliary reservoir, hydraulic control circuit means coupled to said control valve means and including distributor means positioned below said jack and said control valve means for selectively coupling said control circuit means with said source of hydraulic fluid to actuate said control valve means.

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