

[54] **CONTROL APPARATUS FOR A
HYDRAULIC CONSUMER MOTOR**

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[58] **Field of Search**..... **91/459, 275, 361,
91/461, 304; 137/625.63, 625.64**

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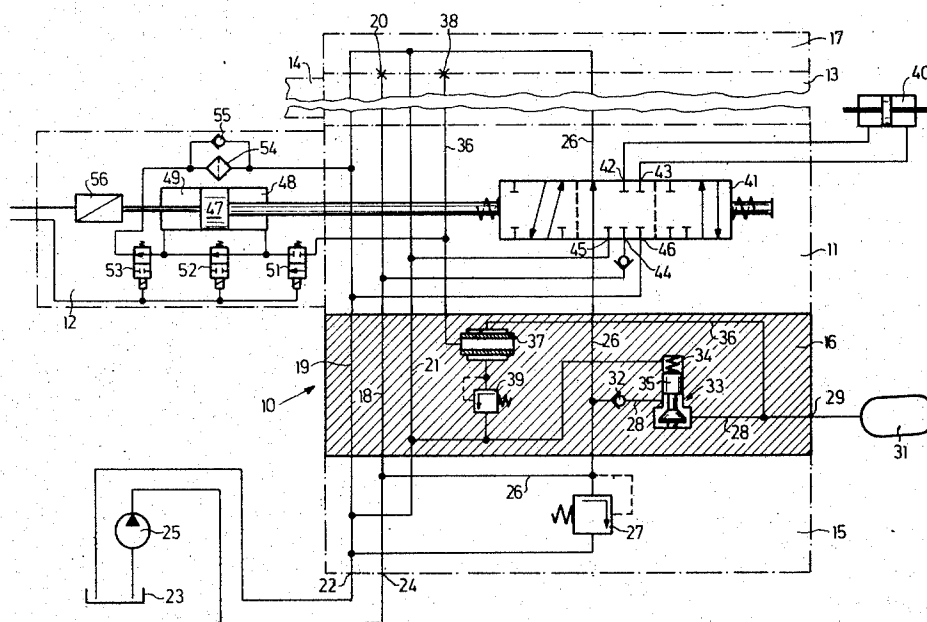
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[57] **ABSTRACT**

A control apparatus, which controls the operation of a hydraulic consumer motor, has a control valve for either connecting a pump with the consumer motor, or for connecting an idling conduit with the outlet and return conduits of the pump for obtaining idle circulation. A pressure fluid accumulator is connected by an accumulator conduit with the idling conduit and outlet conduit, and a pressure responsive valve in the accumulator conduit closes the same at a predetermined pressure, or charges the accumulator when its pressure is too low. A supply conduit connects the accumulator conduit with a hydraulic shifting motor by which the control valve is shifted between an idling position, and an operative position controlling the consumer motor. The hydraulic shifting motor is connected by a supply conduit with the accumulator, and operated by electromagnetically operated valves.

11 Claims, 4 Drawing Figures



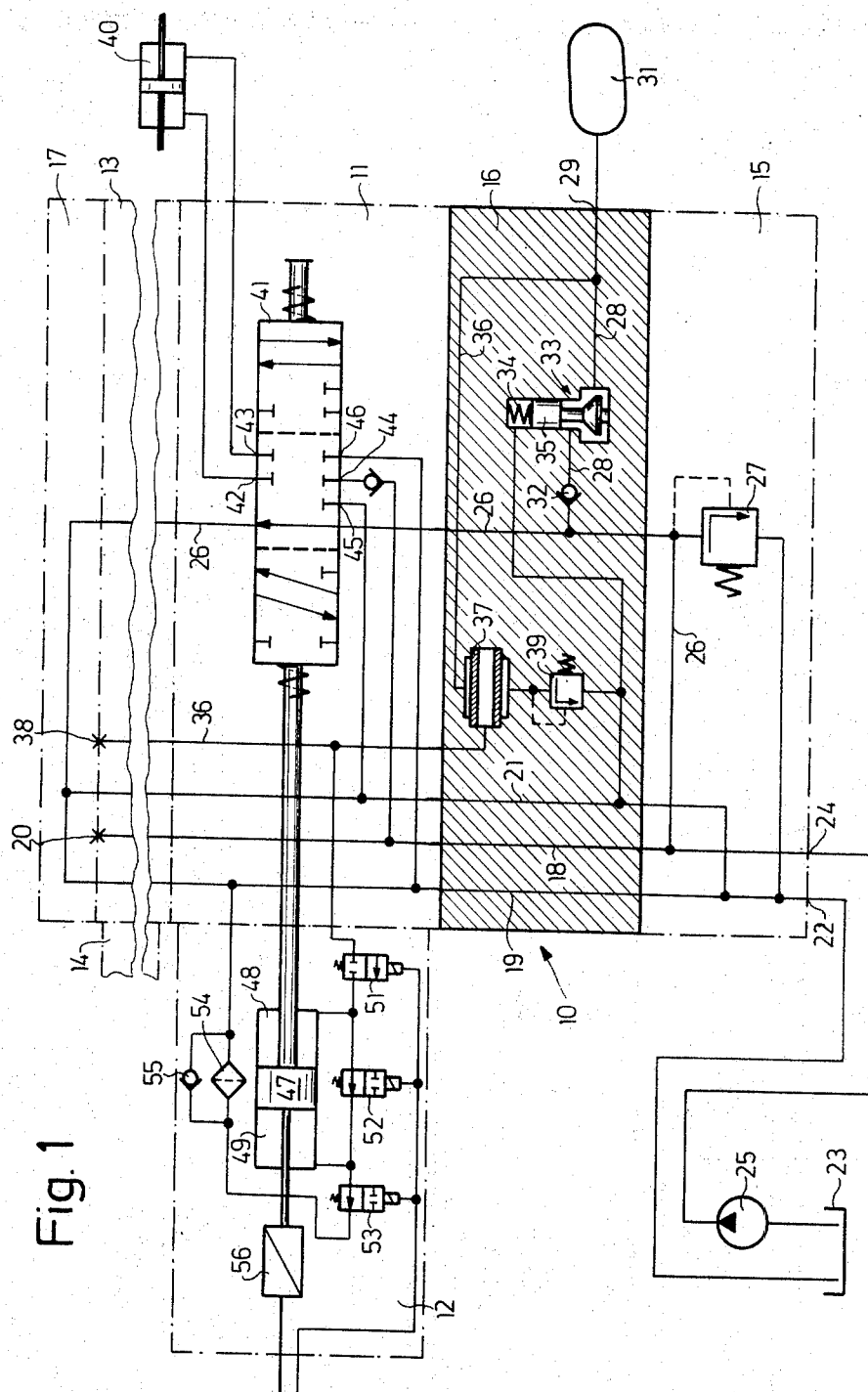
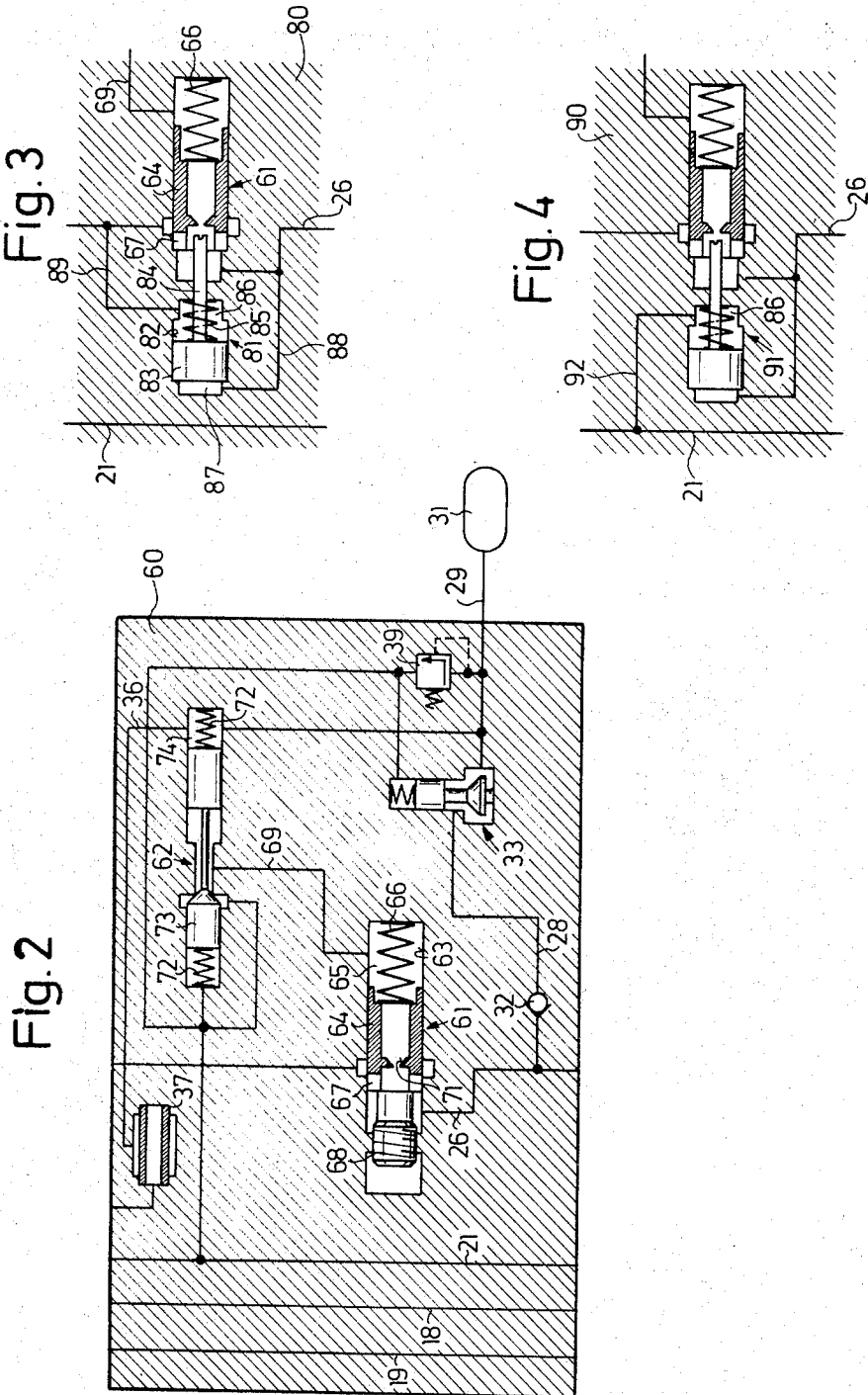


Fig. 1



CONTROL APPARATUS FOR A HYDRAULIC CONSUMER MOTOR

BACKGROUND OF THE INVENTION

The present invention relates to electrohydraulic control apparatus for consumer motors which includes at least one control valve which is shiftable between a plurality of positions for supplying a fluid to a consumer motor.

The VDI Zeitschrift 113,971, No. 10, page 733, FIG. 9 discloses an electrohydraulic remote control of valves. The book "Hydraulik in Werkzeugmaschinen" by Duerr and Wachter, sixth edition, page 249, FIG. 347 illustrates an electrohydraulic control with several control valves and a control pump. The German AS 1,116,300, FIG. 3 discloses an apparatus in which the operative time period of an oil pump is reduced for a hydraulically operated electrical shifting arrangement. Pressure fluid accumulators are provided in the consumer circuit and in the control circuit.

The prior art, as represented by the above enumerated publications, requires complicated arrangements, and suffers from substantial losses of the operating fluid.

SUMMARY OF THE INVENTION

It is an object of the invention to overcome the disadvantages of prior-art constructions, and to provide a control apparatus for controlling a hydraulic consumer motor which is of simple construction, operates with low losses, and can be comparatively inexpensively manufactured.

With these objects in view, the present invention provides a control valve in an idling conduit connecting a source of pressure fluid with a return conduit, and the idling conduit is open in the central position of the control valve, and interrupted in at least one control position of the control valve. The idling conduit, which obtains idle circulation of the fluid between the inlet and outlet of the pump serving as source of fluid, is connected by an accumulator channel with a fluid pressure accumulator. A pressure responsive valve which controls the pressure in the accumulator, is arranged in the accumulator conduit, and is connected by a supply conduit downstream of the pressure responsive valve, and leading to the hydraulic shifting motor by which the control valve is operated. In this manner, electrohydraulically operated valves supply fluid to the shifting motor in a manner which causes very low losses.

In specific situations in which a very great amount of pressure fluid is required, a control conduit upstream of the control valve is used for connecting the idling conduit with a return conduit of the pump. A throttle is provided in the control conduit, and downstream of the throttle, a pressure controlling valve is provided which influences the pressure in the control conduit opening and closes the same while a chamber of a switching valve in the idle conduit, is provided with pressure fluid. In this manner, the idling circulation is throttled to the maximum control pressure when the pressure in the accumulator has dropped to a minimum pressure. The automatic charging of the accumulator renders the supply of pressure fluid independent of the operations of the control valve in the consumer circuit.

In further advantageous embodiments of arrangement, means are provided to make the maximum pressure, obtained by throttling the idle circulation, inde-

pendent of the magnitude of the flow of pressure fluid which may be subject to great fluctuation during idle circulation. It is particularly advantageous that the throttled control pressure increases the required flow of pressure fluid only by the difference between the control pressure minus consumer pressure so that the source of pressure fluid is not subjected to an unnecessarily high load. A switching valve may be provided which maintains power losses particularly low, by interrupting the flow of pressure fluid to the return conduit of the pump if the pressure exceeds the maximum control pressure substantially, prevails during idle circulation.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic and diagrammatic view, partially in schematic section, illustrating an embodiment of the invention;

FIG. 2 is a fragmentary schematic sectional view illustrating a modification of the embodiment of FIG. 1;

FIG. 3 is a fragmentary schematic sectional view illustrating another modification of the embodiment of FIG. 1; and

FIG. 4 is a fragmentary schematic sectional view illustrating a further modification.

DESCRIPTION OF THE PREFERRED EMBODIMENTS:

Referring first to the embodiment of FIG. 1, the control apparatus generally indicated at 10, includes a first valve unit 11 with a first control valve 41 operated by a hydraulic shifting unit 12, a second valve unit 13 with a control valve 41, not shown, operated by a shifting unit 14, only partly shown, a connecting plate 15, an intermediate plate 16, and an end plate 17. The parts 15, 16, 11, 13, and 17 are provided with channels and ducts communicating with channels and ducts in the adjacent parts to form conduits.

The valve units 11 and 13, the intermediate plate 16, and the connector plate 15 form together an outlet conduit 18 for the pump 25, and return conduits 19 and 21 leading to the discharge container 23 from which the pump 25 pumps operating fluid, such as oil. The return conduits 19, 21 are connected in the connector plate 15 and in the end plate 17 with each other, and discharge through a return connector 22 in the connector plate 15, fluid into the open container 23. The output conduit of the pump enters the connector plate 15 at 24 and forms a conduit 18 whose end in the valve unit 13 is closed by a plug 20. An idling conduit 26 branches off the outlet conduit 18 in the connector plate 15 and is connected through intermediate plate 16 and valve units 11, 13 with the end plate 17 where the idling conduit 26 is connected with the return conduits 19, 21. A pressure limiting valve 27 in connector plate 15 prevents damage to pump 25 when excessive pressure occurs.

In the intermediate plate 16, an accumulator conduit 28 branches off the idling conduit 26, and is connected

at the point 29 with a pressure fluid accumulator 31. In the accumulator conduit 28, a check valve 32 is provided for protecting the accumulator 31, and following check valve 32, a pressure responsive valve 33 is provided. The pressure responsive valve 33 has a closure member 35 biased by a spring 34. Between the pressure responsive valve 33 and the connector 29, a supply conduit 36 branches off which leads through a filter 37 to the control valve units 11 and 13. Supply conduit 36 is closed by plug 38 in the second valve unit 13. An adjustable pressure limiting valve 39 is connected between supply conduit 36 and a return conduit 21 for protecting pressure fluid accumulator 31. A filter 37 is also provided in the supply conduit 36.

Each of the valve units 11, 13 includes a control valve, only the control valve 41 of the valve unit 11 being illustrated for the sake of simplicity. The control valve 41 is schematically shown to be operable between the illustrated normal position, and two control positions by shifting the valve slide of control valve 41 to left or right, as viewed in FIG. 1. In the illustrated central idling position of the control valve, the parts of the idling conduit 26 are connected, as indicated by an arrow in the central portion of control valve 41. Consumer conduits 42 and 43 are in this position interrupted so that no fluid is supplied to or exhausted from a consumer motor 40. The connections 45, 46, leading to the return conduits 19 and 21, and inlet 44, which is protected by a check valve and connected with a pump outlet conduit 18, 24, are also disconnected from the consumer conduits 42, 43.

When the control valve 41 is shifted to the left or right, as illustrated in FIG. 1, to one of two control positions, the outlet conduit 18 of pump 25, and one of the return conduits 19 or 21 of the pump 25 are connected with the consumer conduits 42 and 43, the flow of fluid being reversed in the two control positions of control valve 41. Depending on the magnitude of the displacement of the valve slide of control valve 41, a connection between the pump and the consumer conduit 42, 43 are more or less opened.

The control valve 41 is operated by a hydraulic shifting motor 12 which includes a cylinder and a piston 47 forming a first chamber 48 and a second chamber 49 in the cylinder. The effective surface of the piston 47 is smaller in cylinder chamber 48 than in cylinder chamber 49 due to the fact that a comparatively thick piston rod connects piston 47 with the valve slide of control valve 41. A thinner rod connects piston 47 through chamber 49 with a transmitter. The first chamber 48 is connected by an electromagnetically operated valve 51 with the supply conduit 36, and by a second electromagnetically operated valve 52 with the chamber 49, which is connected by a third electromagnetically operated valve 33 and by filter 54 and a check valve 55, with the return conduit 19.

The electromagnetically operated valves 51, 52 and 53 are individually operated by electronic control means, not shown, between open and closed positions.

The differential piston 47 is mechanically connected with the electric transmitter 56 whose signals are transmitted to the electronic control means. The magnetically operated valves 51, 52 and 53 cause so small displacements of the differential piston 47, that the shifting motor unit 12 obtains a practically continuous adjustment of the control valve 41.

The above-described apparatus operates as follows:

In the illustrated central position of control valve 41, the first electromagnetically operated valve 51 is closed, so that the hydraulic switching motor 47, 48, 49 is separated from the supply conduit 36 and from the pressure fluid accumulator 31. Valves 52 and 53 are in the opened positions, but receive no fluid from the supply conduit 36. Pressure fluid flows from pump 25 into outlet conduit 18 and through idling conduit 26 to the return conduit 22, practically without being throttled. When the electromagnetically operated valves 53 and 51 are shifted to close and open respectively, the chambers 48, 49 are connected by the supply conduit 36 with the accumulator 31, so that the control valve 41 is shifted by piston 47 to the right as viewed in FIG. 1. The control valve 41 closes idling conduit 26, and connects the outlet and return conduits of pump 25 with the consumer conduits 42 and 43. The accumulator 31 is automatically charged through the check valve 32 and the pressure responsive valve 33 with pressure fluid when the pressure in accumulator 31 drops below the pressure to which the pressure responsive valve 33 was set, and when the pressure in the idling conduit 26 is higher than the pressure in the accumulator 31. Idling conduit 26 is in this position interrupted by the control valve 41.

The check valve 32 prevents the flow of pressure fluid back from accumulator 31 to the idling conduit 26 when the pressure responsive valve 33 opens. When control valve 41 is shifted, very little pressure fluid is taken from the pressure fluid accumulator, namely an amount corresponding to the product of a difference between the effective surfaces of the piston 47, multiplied by its stroke. Even if it is assumed that the control valve slide of control valve 41 will complete a full stroke, a plurality of strokes of the valve slide of control valve 41 is possible, while during such strokes, the pressure in the idling conduit 26 has to exceed the pressure level only once.

Even in the event that accumulator 31 is without any pressure, a short direct displacement of the control valve slide of control valve 41 by manual operation is sufficient to charge the accumulator 31.

When the electromagnetically operated valves 51 and 52 are operated, the valve slide of control valve 41 can be moved by the shifting motor means 12 out of any position to the left as viewed in FIG. 1, and be placed in any selected position, while the accumulator 31 provides the required amount of pressure fluid at the necessary control pressure level.

From the above description of the embodiment of FIG. 1, it will become apparent that the control apparatus of the invention preferably comprises pump means 25 including outlet conduit means 24, 18 and return conduit means 22, 19, 21; idling conduit means 26 between the outlet conduit means and the return conduit means; at least one control valve means 41, 11 in the idling conduit means 26 having an idling position in which said idling conduit means 26 connects the outlet conduit means and the return conduit means of the pump, and at least one control position connecting the outlet and return conduit means of pump 25 with the consumer motor 40, and interrupting the idling conduit means 26; a pressure fluid accumulator 31; accumulator conduit means 28 connecting the accumulator 31 with the idling conduit means 26 and with the outlet conduit means 24, 18 upstream of the control valve means 41, 11; pressure responsive valve means 33 in

the accumulator conduit means 28 for closing the same at the predetermined pressure, and for charging the accumulator when the pressure in the accumulator is below the predetermined pressure; hydraulic shifting motor means 12, 47, 48, 49 for shifting the control valve means 41 between the idling position and the controlled position; supply conduit means 36 connecting the accumulator conduit means 28 downstream of the pressure responsive valve means 33 with the hydraulic shifting motor means 12, 47; and operating valve means 51, 52, 53 in the supply conduit means 36 for operating the hydraulic shifting motor means 12, 47.

The electrohydraulic shifting motor circuit 12 shown in FIG. 1 may be called "passive" since a high pressure obtained by the control valve 41 in the idling conduit 26 must be available for charging accumulator 31.

FIG. 2 illustrates a modification, particularly concerning the intermediate plate 17 which is designated in FIG. 2 by reference numeral 60. Elements which correspond to elements shown in FIG. 1 are indicated by like reference numerals.

The intermediate plate 60 is different from the intermediate plate 16 shown in FIG. 1, primarily by a controlled switching valve 61 located in the idling conduit 26, and by a pressure controlling valve 62 which is controlled by the pressure in the accumulator 31.

The switching valve 61 has a hollow valve slide 64 located in a cylinder bore 63 in the intermediate plate 60, and being biased by a spring 66 located in a chamber 65 to engage with a control edge 67 an adjusting screw 68, so that a certain normal position is obtained. The idling conduit 26 is connected by a control conduit 69 with the return conduit 21, and a throttle 71 inside of the hollow valve slide 64 and a chamber 65 form part of the control conduit 69. Downstream of throttle 71, the pressure controlling valve 62 is provided, which includes a control piston 73, biased by a spring 72 to close control conduit 69 in a position of rest. A pressure chamber 74, in which spring 72 is located and which is bounded by piston portion of control piston 73, is connected with a supply conduit 36.

The modified control device illustrated in FIG. 2 is operated substantially as explained with reference to FIG. 1, except that the pressure controlling valve 62 controls the switching valve 61 depending on the pressure in accumulator 31. The switching valve 61 throttles the idling conduit 26 to provide the pressure required for charging the accumulator 31, independently of the shifting of the control valve 41. The control device of FIG. 2 can be considered to be "active" and is particularly suited for operational conditions in which the control valve 41 is frequently operated, as well as when the consumer pressure is less than the control pressure.

If accumulator 31 is charged to maximum pressure, this pressure acts in the pressure chamber 74 on control piston 73 to move the same against the action of springs 72 to an operative position in which control piston 73 opens the control conduit 69. Consequently, a small stream of pressure fluid flows from idling conduit 26 through control conduit 69 to the return conduit 21. The pressure differential produced by the throttle 71 urges the hollow valve slide 64 against the action of spring 66 to a working position in which the idling conduit is opened by the control edge 67.

If the pressure in accumulator 31 drops below the minimum pressure, control piston 73 in the pressure controlling valve 62 closes the control conduit 69, and the pressure differential at the throttle 71 is equalized. Spring 66 then biases the hollow slide 64 toward the left as viewed in FIG. 2, whereupon the valve slide 64 throttles the upstream portion of the control valve 26 to produce a pressure sufficient for charging the accumulator 31 which is charged through check valve 32 and pressure responsive valve 33 until the pressure responsive valve 33 closes again, and the pressure controlling valve 62 opens control conduit 69 again. Maximum pressure then prevails in accumulator 31.

The initial position of the hollow valve slide 64 can be adjusted by an adjusting screw 68 forming an adjustable stop, so that even when the flow in the idling conduit 26 is the expected minimum, the pressure for charging accumulator 31 can be obtained in the idling conduit 26 by throttling.

The switching valve 61 of the above-described active control device, has a particularly simple construction and is very well suited for operational conditions in which the magnitude of the flow through the idling conduit 26 is substantially constant.

FIG. 3 illustrates a further modification 80 of the intermediate plate 16 or 60, which is different from the control device shown in FIG. 2 by the provision of adjustable stop means 81 for the switching valve 61. The stop means 81 includes a piston 83 having a piston rod 84 and being slidably guided in a cylinder bore 82. A measuring spring 85 biases piston 83 and is located in a spring chamber 86 separated by piston 83 from a pressure chamber 87 which is connected by a channel 88 with the idling conduit 26 upstream of the switching valve 61. A channel 89 connects the spring chamber 86 with the idling conduit 26 downstream of the switching valve 61.

The operation of the switching valve 61 cooperating with adjustable stop means 81 differs from the operation of the switching valve 61 described with reference to FIG. 2, as follows:

When the hollow valve slide 64 throttles the idling circuit during the charging of accumulator 31, the pressures in the idling conduits 26 upstream and downstream of the switching valve 61, act in the pressure chamber 87 and on the pushrod 84. The piston 83 is also subjected to the force of spring 85, and an opposing force which is the product of the effective piston ring surface multiplied with the pressure differential, due to the throttling action of the control edge 67.

Increased flow in idling conduit 26 results in a pressure increase in pressure chamber 87 whereby piston 83 with pushrod 84 displaces the hollow valve slide 64 against the action of the spring 66. In this manner, the control edge 66 opens the idling conduit 26 farther, and the pressure in pressure chamber 87 drops again. On the other hand, when the flow in idling conduit 26 is reduced, the pressure in pressure chamber 87 drops, the measuring spring 85 presses piston 83 to the left as viewed in the drawing, and the control edge 67 throttles the idling conduit 26 to a greater extent. In this manner, the control edge 67 can obtain a constant pressure drop which is independent of the magnitude of the flow in the idling conduit 26, and consequently initiates a reliable charging operation of accumulator 31. The pressure difference is adjustable by variation of

the pretension of measuring 85 or by displacement of rod 84.

The switching valve 61 with the adjustable stop means 81 is therefore particularly suited for use in operational condition in which the idle recirculating current substantially fluctuates. Since the pressure drop in the switching valve 61 is added to the pressure required by the consumer motor 40 when control valve 41 is operated, it is advisable not to operate the control valve 41 of the control unit 11 or 13 during the charging of accumulator 31.

The switching valve 61 must be constructed in accordance with the requirement for a substantially unthrottled idle circulation, and a requirement for a large range of adjustment. Additionally, it is particularly advantageous to construct the switching valve 61 in such a manner that the valve slide 64 closes the control conduit 69 if the pressure exceeds the maximum control pressure by about 20% whereby, even if accumulator 31 is charged, the small flow of pressure fluid to the return conduit 21 is interrupted. Thereby, power losses are brought to a minimum.

FIG. 4 illustrates a further modification 90 of the intermediate plates 16, 60 or 80. The adjustable stop means 91 is different from the construction described with reference to FIG. 3, inasmuch as only the spring chamber 86 is connected by conduit 92 with the return conduit 21. Due to this relief of the spring chamber 86 to the return conduit 22, the result is obtained that the pressure in the portion of the idling conduit 26 upstream of the switching valve 61, becomes independent of the pressure downstream of the switching valve 61, as long as the last-mentioned pressure is less than the maximum control pressure. If a consumer motor and the accumulator 31 are simultaneously provided with pressure fluid, pump 25 must pump against the control pressure, and not against the pressure resulting from consumer pressure and control pressure.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of control apparatus for hydraulic consumer motors differing from the types described above.

While the invention has been illustrated and described as embodied in a control apparatus including a control valve for connecting a consumer motor to a pump, and having a position in which the pump idles, in combination with a pressure fluid accumulator which supplies fluid to a hydraulic shifting motor by which the control valve is operated, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims.

We claim:

1. Control apparatus for a hydraulic consumer motor comprising a consumer motor; pump means including outlet conduit means and return conduit means; idling conduit means between said outlet conduit means and said return conduit means; at least one control valve means in said idling conduit means having an idling position in which said idling conduit means connects said outlet conduit means and said return conduit means, and at least one control position connecting said outlet and return conduit means with said consumer motor and interrupting said idling conduit means; a pressure fluid accumulator; accumulator conduit means connecting said accumulator with said idling conduit means and with said outlet conduit means upstream of said control valve means; pressure responsive valve means in said accumulator conduit means for closing the same at a predetermined pressure and for charging said accumulator when the pressure in said accumulator is below said predetermined pressure; hydraulic shifting motor means for shifting said control valve means between said idling position and said control position; supply conduit means connecting said accumulator conduit means downstream of said pressure responsive valve means with said hydraulic shifting motor means; and operating valve means in said supply conduit means for operating said hydraulic shifting motor means.

2. Control apparatus as claimed in claim 1 further comprising a check valve in said accumulator conduit means for blocking flow from said accumulator into said idling conduit.

3. Control apparatus as claimed in claim 1, further comprising control conduit means connecting said idling conduit means with said return conduit means upstream of said control valve means; a throttle in said control conduit means; a pressure controlling valve downstream of said throttle in said control conduit means and operated depending on the pressure in said accumulator, said pressure controlling valve controlling the pressure in said control conduit means by opening and closing the same; and a switching valve in said idling conduit means having a chamber connected with said control conduit means.

4. Control apparatus as claimed in claim 3 wherein said pressure controlling valve includes a control piston and a spring urging said control piston to a position of rest interrupting the flow in said control conduit means, and being moved by high pressure from said accumulator to an operative position opening said control conduit means against the action of said spring.

5. Control apparatus as claimed in claim 4, wherein said switching valve means includes a hollow valve slide inside of which said throttle is formed, a spring located in said chamber and urging said slide to a normal position in which said valve slide interrupts the flow in said idling conduit means at least partly, said valve slide having a plurality of working positions for opening said idling conduit means to different degrees, without influencing the communication with said control conduit means.

6. Control apparatus as claimed in claim 5 further comprising an adjustable stop on which said valve slide abuts in said normal position.

7. Control apparatus as claimed in claim 5 further comprising a cylinder, a piston in said cylinder forming a chamber on one side of said piston, and another chamber on the other side of said piston and a measur-

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ing spring located in said other chamber, said piston having on said other side a piston rod projecting out of said other chamber in said cylinder and having a free end spaced from said valve slide when said piston is in a position of rest.

8. Control apparatus as claimed in claim 7 wherein said other chamber communicates with said idling conduit means downstream of said switching valve means, and wherein said chamber on said one side of said piston communicates with said idling conduit means upstream of said switching valve means.

9. Control apparatus as claimed in claim 7 wherein said other chamber communicates with said return conduit means; and wherein said chamber on said one side of said piston communicates with said idling conduit means upstream of said switching valve.

10. Control apparatus as claimed in claim 7 wherein said valve slide is displaced by said piston to a position in which said valve slide closes said control conduit

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means and fully opens said idling conduit means.

11. Control apparatus as claimed in claim 1 wherein said hydraulic shifting motor means includes a hydraulic cylinder, a shifting piston movable in said hydraulic cylinder between at least two positions and including means connected with said control valve means for moving the same between said idling and control positions, said shifting piston dividing said hydraulic cylinder into a first chamber having a small effective surface, and a second chamber having a larger effective surface; and wherein said operating valve means includes a first magnetically operated valve for connecting said first chamber with said supply conduit means, a second magnetically operated valve for connecting said first and second chambers, and a third magnetically operated valve for connecting said second chamber with said return conduit means.

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