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| [31] |           | <b>P 18 01 137.5</b>                                        |

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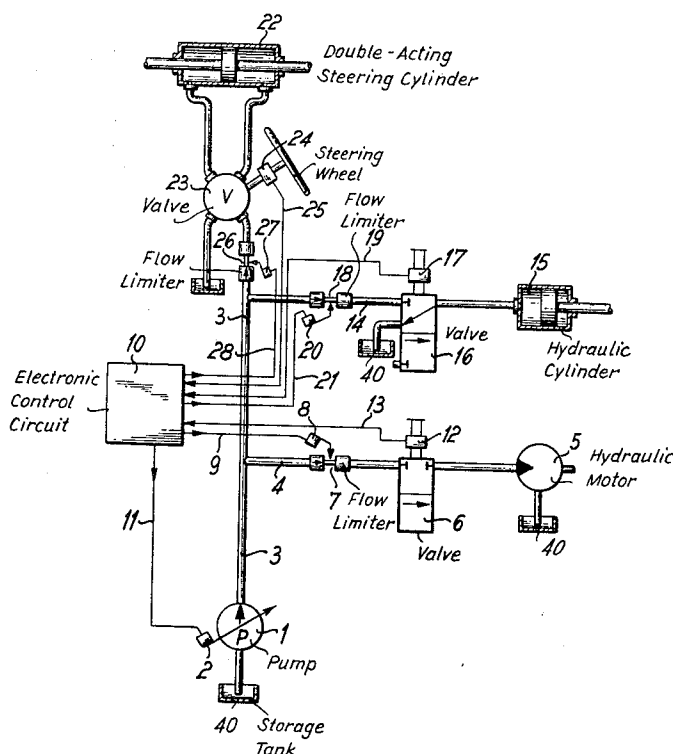
**[54] ADJUSTABLE HYDRAULIC OPERATION  
ARRANGEMENT  
10 Claims, 1 Drawing Fig.**

**[52] U.S. Cl..... 60/52,  
60/97**

**[51] Int. Cl..... F15b 11/16**

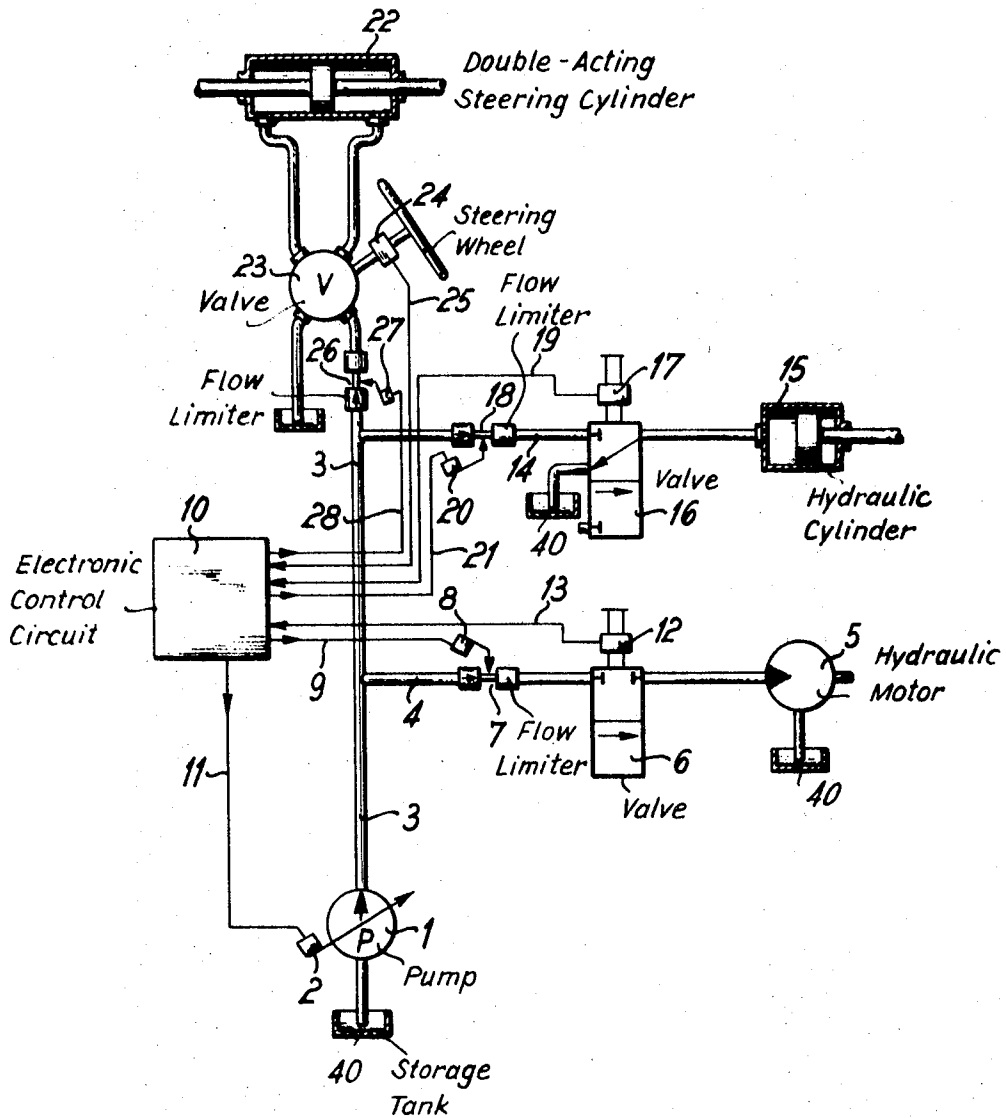
**[50] Field of Search..... 60/52  
(VSP), (E), 52 (S), 97 (P); 91/1**

**ABSTRACT:** A hydraulic arrangement in which a pump is adjustably set to supply pressurized fluid to a number of different hydraulically operated devices with different operating requirements. Each of the devices has connected in front of it a control valve which is, in turn, connected in series with a flow limiter. The control valves have position indicators which transmit signals indicative of the valve position. The flow limiters and the pump are settable through electrical signals derived from an electronic control circuit. The control circuit applies the setting signals to the pump and flow limiters in response to the electrical signals received from the valve position indicators.



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## ADJUSTABLE HYDRAULIC OPERATION ARRANGEMENT

### BACKGROUND OF THE INVENTION

The present invention resides in a hydraulic arrangement with an adjustable fluid pump which conveys or applies pressurized fluid to at least two hydraulically operated devices. Each one of the hydraulically operated devices is provided with an actuatable control valve for applying to the device the required amount of pressurized fluid obtained from the pump.

Such hydraulic arrangements, heretofore, have had the disadvantage that the energy required by the individual hydraulically operated devices cannot always be precisely delivered. Thus, the pump flow is either too large, corresponding to the constant pump, or the pressure is too high, corresponding to a regulated pump in a constant pressure system. Both of these arrangements lead to energy losses, since the pump delivers more pressurized fluid in one case, and produces a larger pressure in the other case, than what is required by the individual hydraulically operated devices.

Accordingly, it is an object of the present invention to provide a hydraulic arrangement with a plurality of hydraulically operated devices which are driven or operated with particularly high efficiency.

The object of the present invention is achieved by providing an indicator with each control valve which applies to an electronic control circuit, an electrical signal representing the position of the control valve. A flow limiting valve is, furthermore, provided in front of each control valve. These flow limiting valves are, in turn, set from signals delivered by the electronic control circuit. The electronic control circuit, furthermore, provides signals for setting the fluid pump. The preceding arrangement of the present invention has the advantage that the pump will always deliver only as much fluid as required by the hydraulically operated devices. As a result of this arrangement of the present invention, energy losses are avoided.

### Summary of the Invention

A hydraulic arrangement by which a pump delivers hydraulic fluid to meet the requirements of individually hydraulically operated devices connected to a hydraulic line fed by the pump. Each of the hydraulically operated devices is provided with a control valve connected directly in front of the device for regulating the flow of fluid to the device. Each of the control valves is, in turn, protected by a flow limiter which throttles the fluid to the valve, as required. Each of the control valves, furthermore, is provided with a valve position indicator which transmits an electrical signal indicative of the position or opening of the valve. The pump and the flow limiters have provision by which they may be set through electrical signals. An electronic control circuit arrangement receives the electrical signals from the valve position indicators, and after processing these received signals, the electronic control circuit transmits electrical signals to the pump and the flow limiters for setting and adjusting these devices so as to result in fluid flow having the requirements of the individual hydraulically operated devices.

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 drawing.

### BRIEF DESCRIPTION OF THE DRAWING

A schematic diagram of the hydraulic arrangement, in accordance with the present invention, shows the interrelationship of the hydraulically operated devices, the control valves for these devices, the pump which generates pressurized fluid, and the electronic control circuit through which the valves and the pump are regulated and set so as to result in fluid flow

meeting the specific requirements of the hydraulically operated devices.

### DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawing, an adjustable hydraulic pump 1 is provided with a setting element 2, and dips with its suction inlet, into a reservoir or storage tank 40. The pump 1 takes the fluid from the storage reservoir 40 and transmit it, under pressure, into the pressure line 3.

A hydraulic line 4 branches from the pressure line 3, and leads to hydraulically operated equipment 5 which, for example, may be in the form of a hydraulic motor used to drive a motor vehicle. The pressurized fluid in the hydraulic line 4, is applied to the hydraulically operated equipment 5 through a control valve 6. An adjustable flow limit valve 7 is connected in the pressurized line 4, in front of the valve 6. The flow limit valve 7 is provided with a setting member 8 which is operatively connected to an electronic control arrangement 10, through the control line 9. A control line 11 also interconnects the electronic control arrangement 10 with the setting device 2 for the pump 1. The control valve 6 is provided with a valve opening or valve position indicator 12 which is also operatively connected with the control arrangement 10, by way of the control line 13. The control valve 6 possesses two operating positions. In one position of this control valve, pressurized fluid flows to the hydraulically operated equipment 5, through the hydraulic line 4. In the other one of these two positions, such flow connection is blocked or cut off.

A hydraulic line 14 further branches from the pressurized line 3, and leads to a second hydraulically operated device 15 which may, for example, be in the form of a simple hydraulic cylinder on the motor vehicle. Included within this hydraulic line 14 is another control valve 16 provided with a valve opening or a valve position indicator 17. A flow limit valve 18 is connected within this line 14 and in front of the control valve 16. A control line 19 interconnects the valve position indicator 17 with the electronic control circuit 10, whereas a control line 21 leads from the setting device 20 of the flow limiting valve 18 to the electronic control circuit 10. The control valve 16 has two operating positions. In one of these operating positions, pressurized fluid flows from the hydraulic line 14 to the hydraulically operated equipment 15. In the other one of these two operating positions of the valve 16, the pressurized fluid flows from the hydraulically operated equipment 15 and into the reservoir or storage tank for the hydraulic fluid.

The pressurized line 3 also leads to a third hydraulically operated device 22 which, for example, is in the form of the steering cylinder for the motor vehicle. Connected to the pressurized line 3, after the hydraulic line branch 14, is a control valve 23 for the hydraulically operated device 22. This control valve 23 is also provided with a valve opening or valve position indicator 24. In this particular case, in which this third hydraulically operated device 22 comprises the steering cylinder for the motor vehicle, the steering wheel is arranged on the valve position indicator 24.

A control line 25 leads from the valve position indicator 24 to the electronic control circuit 10. An adjustable flow limiting valve 26 is connected within the pressurized line 3 and before the control valve 23. This flow limiting valve 26 is provided with a setting device 27 which, in turn, is operatively connected to the control arrangement 10, by way of the control line 28. The hydraulically operated device 22 is in the form of a double-acting steering cylinder. Fluid flow from the steering cylinder also leads to a storage tank or reservoir.

The valve position indicators 12, 17 for the control valves 6, 16, respectively, are, for example, in the form of manually actuated linkages. The positions of these valve indicators 12 and 17, as well as 24, are transmitted to the electronic control arrangement through the aforementioned control lines.

When any one of the hydraulically operated devices becomes actuated, the electronic control circuit receives such information from the valve indicator of the valve associated

with the particular device which has been actuated. The electronic control circuit 10 responds to this information from the valve indicator, by causing the pump 1 to be adjusted or set to generating a predetermined fluid pressure and predetermined fluid flow established by the requirements of the hydraulically operated device. When the respective valve position indicator is at its maximum opening position, indicating that the control valve is at its maximum opening position, the pump 1 is set so that it will deliver maximum pressurized fluid flow to the hydraulically operated device. The line pressure which is used depends upon the prevailing fluid resistance of the particular hydraulically operated device which is selected. Thus, no energy losses are incurred.

If another hydraulically operated device becomes actuated at the same time, then the required pressurized fluid flow becomes added to the amount for the first device. Such additional pressurized fluid flow depends upon the valve position indicator of the associated control valve for the hydraulically operated device, as described above. The line pressure in the fluid conduit is determined by the hydraulically operated device with the greatest resistance. An energy loss appears, thereby, only through pressure difference between two hydraulically operated devices. In this case, the pressurized fluid flow becomes distributed through the flow limiting valves 12 and 17. These limiting valves become set through the electronic control arrangement 10, simultaneously with the valve position indicators. The flow limiting valves serve the purpose of preventing the condition, for example, that the entire pressurized fluid flow is first applied to the device with the lowest fluid resistance, when a plurality of hydraulically operated devices are actuated simultaneously. The hydraulically operated device with lowest fluid resistance is protected through the associated flow regulating valve which throttles the fluid flow to the device in the required manner.

The addition or summation of the pressurized fluid quantity delivered by the pump 1 is, of course, also carried out when still further hydraulically operated devices are connected to the hydraulic circuit. In the extreme case, the pump is to be designed or selected with capacity so that all hydraulically operated devices may receive their maximum fluid requirements under operating conditions.

The preceding arrangement, in accordance with the present invention, has also the advantage that fine control or precise control may be realized as a result of the treatment or processing of the pressurized flow through the valve position indicator at the control valve and the throttling effect realized from the settable flow-limiting valves. This advantageous feature is accomplished through particularly simple construction of hydraulic control apparatus.

In particular, the electronic control arrangement or circuit 10 includes an adder which adds signals derived from the valve position indicators, and sets the pump 1 responsively so as to provide the required quantity of pressurized fluid. Thus, these valve position indicators 12 and 17 may include, for example, electrical potentiometers which transmit the electrical signals proportional to the position of the respective valves. These electrical signals from the different potentiometers on the valve position indicators are then added in a conventional summing amplifier, for example, for the purpose of obtaining a sum total representing the full quantity of required fluid flow. The output of such summing amplifier is then applied to the electrically operated setting device 2, so that the pump 1 is adjusted to deliver the required amount of fluid flow. Such conventional summing amplifiers by which the pump 1 is set, are well known in the art and are, for this reason, not further described.

The electronic control arrangement of circuit 10 also includes means for detecting which ones of the hydraulically operated devices have become actuated, so as to apply the required amount of throttling by the appropriate flow limiters. Such detection of the actuated and hydraulically operated devices, and responsive setting of the flow limiters, may be accomplished through conventional switching circuits in which

the appropriate switches corresponding to the devices being actuated, become set to predetermined positions. The switching circuit will then in return set the appropriate flow limiters. Such switching circuits may be constructed of conventional switching devices such as relays or transistors, for example.

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 constructions differing from the types described above.

While the invention has been illustrated and described as embodied in hydraulically operated arrangements, 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.

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

I claim:

1. A hydraulic operating arrangement comprising, in combination, adjustable hydraulic pump means; a source of fluid communicating with the intake of said pump means and being raised in pressure by said pump means; at least two hydraulically operated devices communicating with the outlet of said pump means and receiving pressurized fluid from said outlet; control valve means connected in front of each hydraulically operated device and having variable setting means for controlling the flow of fluid to said device from said pump means; valve position indicating means arranged with each control valve for transmitting an electrical signal indicative of the position of said control valve; flow limit valve means connected in front of each control valve for limiting fluid flow to said control valve and having setting means responsive to an electrical signal so that said limit valve means is set through an electrical signal applied to said setting means; and electronic control means connected to said valve position indicating means for receiving the electrical signals from said valve position indicating means and in response to said received signals transmitting electrical signals for setting said limit valve means and adjusting said pump means, whereby said pump means delivers pressurized fluid with the requirements of said hydraulically operated devices.

2. The hydraulic operating arrangement as defined in claim 1 including power amplifier means arranged on said pump means and responding to electrical signals from said electronic control means for setting said pump means.

3. The hydraulic operating arrangement as defined in claim 1 wherein one of said hydraulically operated devices comprises a hydraulic motor, said control valve in front of said hydraulic motor having one position for transmitting pressurized fluid to said hydraulic motor, and said control valve having a second position for inhibiting fluid flow to said hydraulic motor.

4. The hydraulic operating arrangement as defined in claim 1 wherein one of said hydraulically operated devices comprises a hydraulic cylinder and piston, said control valve in front of said hydraulic cylinder and piston having one operating position for transmitting pressurized fluid to said hydraulic cylinder and having a second operating position for transmitting fluid from said hydraulic cylinder to said source of fluid communicating with the intake of said pump means.

5. The hydraulic operating arrangement as defined in claim 1 wherein one of said hydraulically operated devices comprises a double-acting hydraulic cylinder and piston for steering a motor vehicle, the steering wheel of said motor vehicle being mechanically linked to said control valve means in front of said double-acting steering cylinder for setting the control valve in front of said double-acting steering cylinder.

6. The hydraulic operating arrangement as defined in claim 1 wherein said flow limit valve means throttle the pressurized fluid flowing to said control valve means.

7. The hydraulic operating arrangement as defined in claim 1 wherein said hydraulically operated devices have different fluid pressure requirements for operation.

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8. The hydraulic operating arrangement as defined in claim 1 wherein said hydraulically operated devices have different fluid flow quantity requirements for operation.

9. The hydraulic operating arrangement as defined in claim 1 including main fluid conduit means connected to the outlet of said pump means for receiving pressurized fluid from said pump means; and secondary conduit means branching from

said main conduit means and leading to said hydraulically operated devices.

10. The hydraulic operating arrangement as defined in claim 1 including fluid storage means connected to at least said pump means for storing a predetermined quantity of fluid to operate said hydraulic devices.

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