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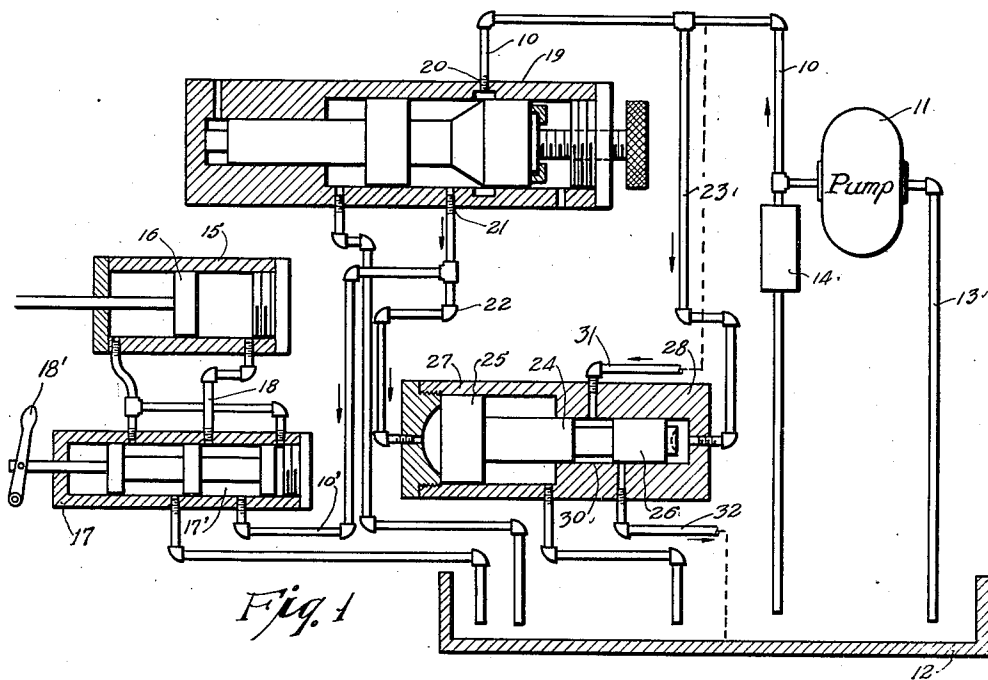
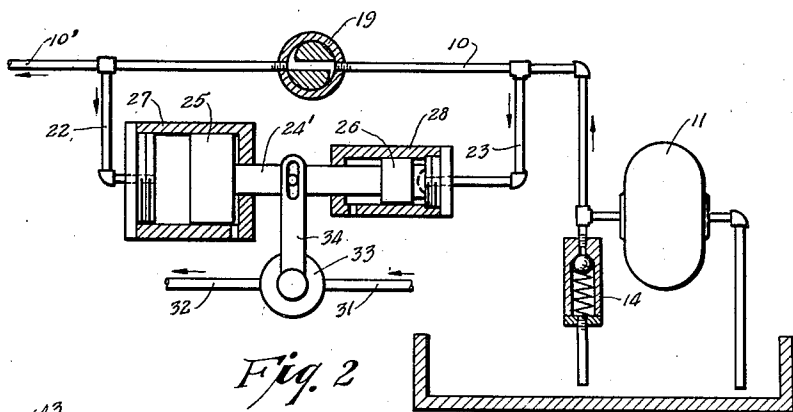
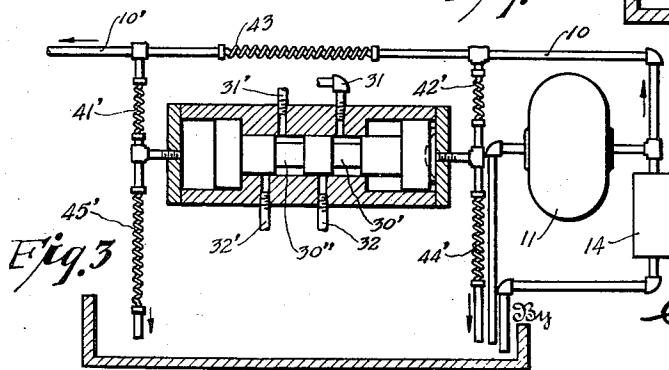
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HYDRAULIC CIRCUIT CONTROL MECHANISM

Filed May 27, 1932

2 Sheets-Sheet 1



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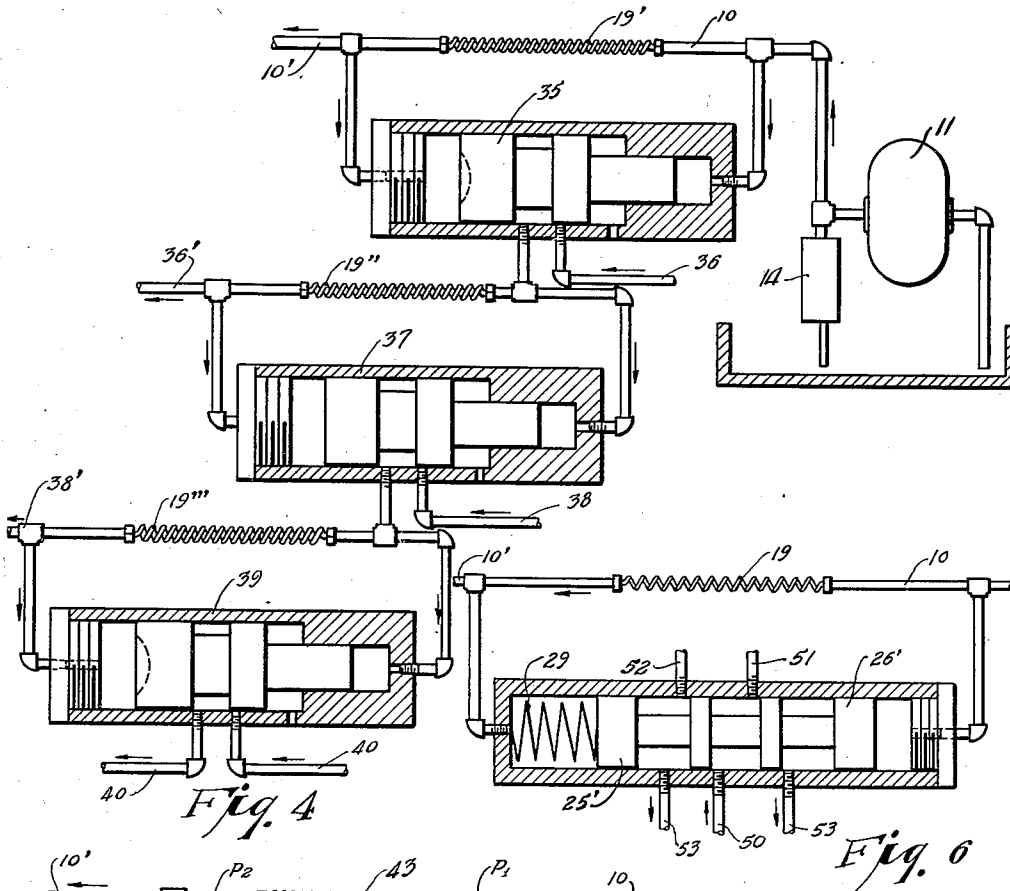
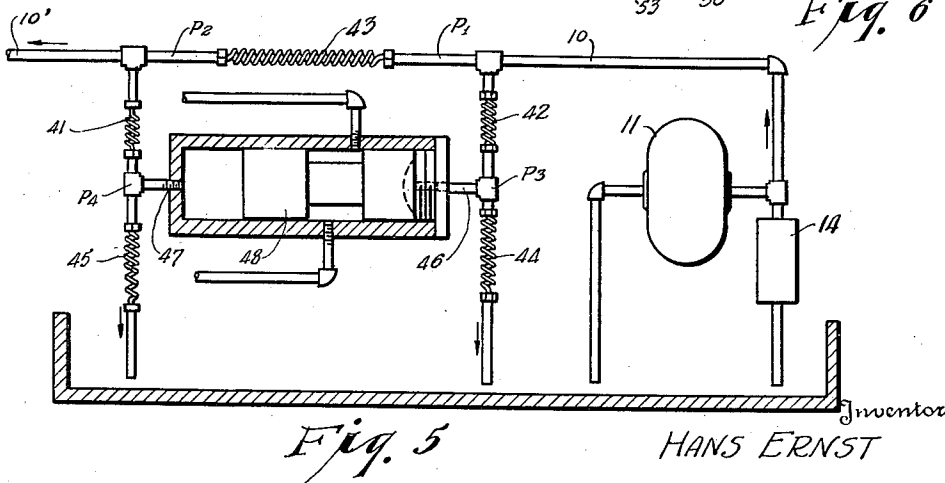
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HYDRAULIC CIRCUIT CONTROL MECHANISM

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2 Sheets-Sheet 2



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HYDRAULIC CIRCUIT CONTROL MECHANISM

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10 Claims. (Cl. 60—52)

This invention relates to hydraulic circuits and more particularly to means for automatically determining flow in a secondary circuit from the condition of flow existing in a primary or controlling circuit.

In the application of hydraulic operation to machines having complicated movements, difficulty has been experienced in providing suitable control for initiating or stopping one member in timed relation to a second member and especially where the controlling member is timed to stop before initiation of movement of the controlled member; or the reverse condition where the controlling member is timed to start after cessation of movement by the controlled member. This is because the controlling member, being stopped, is unable to provide the necessary motive power to operate any type of mechanical trip which is the usual device utilized for automatic control. Furthermore, hydraulic circuits do not provide constantly rotating members from which motive power may be obtained to effect timed trip operation of one part with respect to another such as might be found in mechanical actuated devices.

One of the principal objects of this invention therefore is to utilize the flowage condition in one circuit whether active or passive as the controlling factor in determining operation, such as the initiation or cessation of flow, of a secondary circuit thereby overcoming the previously mentioned difficulties and making it possible for example to initiate operation of a secondary circuit after the part actuated by a first circuit has ceased moving as witnessed by the non-flowage of its actuating medium.

Another object of this invention is to provide mechanism which utilizes the variance in pressure differential across a resistance in an hydraulic channel caused by volume changes in the flow through the resistance as from zero to maximum or vice versa to control the flow in a secondary circuit.

A further object of this invention is to provide a control valve mechanism for determining flow in a secondary channel in accordance with the initiation or stoppage of flow in a primary circuit which may be adjusted to vary the time interval between the stopping of one member and the starting of the other.

An additional object of this invention is to provide an improved control valve mechanism of the character set forth which may be utilized to effect upon initiation, stoppage or merely volume variation flow in a primary circuit, the initiation, stop-

page or variation of the rate of flow in a secondary circuit.

Other objects and advantages of the present invention should be readily apparent by reference to the following specification considered in conjunction with the accompanying drawings illustrative of one embodiment thereof, but it will be understood that any modifications may be made in the specific structural details thereof within the scope of the appended claims, without departing from or exceeding the spirit of the invention.

Referring to the drawings in which like reference numerals indicate like or similar parts:

Figure 1 is a view partly in section of one form of control valve mechanism.

Figure 2 is a view partly in section of the control valve mechanism in combination with a simplified form of resistance.

Figure 3 is a view partly in section of a modified form of control valve mechanism.

Figure 4 is a view showing a plurality of control valves arranged in series for controlling a plurality of circuits.

Figure 5 is a view showing the application of variable resistances to the control valve to thereby vary the time relation between the stopping and starting of the different parts.

Figure 6 is a view showing a modified form of the invention.

Referring to Figure 1 the reference numeral 10 indicates a main hydraulic channel which is connected at one end to an incoming hydraulic flow. This flow may be under pressure from any suitable source such as an accumulator or a pump, the latter being shown in the drawings, and indicated by the reference numeral 11. A reservoir 12 may be provided from which fluid may be drawn by the pump through channel 13 and delivered under pressure to the channel 10. For the purpose of protecting the system, an emergency relief valve 14 may be connected to the channel 10 for discharging excess fluid to the reservoir.

The pressure channel 10 may be utilized for effecting operation of any desired movable part and in the present instance a conventional hydraulic motor comprising a cylinder 15 and contained piston 16 has been illustrated as the moving part and in order that the piston may be reciprocated a reversing valve 17 has been provided. This reverse valve may be manually actuated as by lever 18' or automatically actuated in accordance with the practice to which this device is applied.

If the reversing valve is in the position shown, the pressure from channel 10 will flow through

the annular groove 17' of the reversing valve to channel 18 and into the right hand end of cylinder 15 causing movement of the piston and connected parts to the left. If this operation is permitted to continue without changing the position of the valve 17, it will be apparent that the piston 16 will reach the end of the cylinder and be unable to move further. When the piston has thus reached the end of its travel, it will be apparent that no further displacement can take place in the cylinder 15 and the flow of fluid thereto will cease, even although the pressure will rise. It is therefore apparent that stoppage of the moving part, irrespective of the reason therefor, causes a cessation of flow in the channel 10; or in other words a cessation of flow in channel 10 indicates that whatever is being actuated by the pressure medium has ceased to move. The flow condition, which term is to be understood herein as including all conditions from no flow to full flow, is therefore an indicator of the status of the movable member, that is if there is no flow, the movable part is stationary and if there is flow the part is presumed to be moving.

It is well known that a resistance formed in a working hydraulic channel causes a pressure differential to be set up in the channel at the opposite ends of the resistance, or in other words there is a drop in pressure between the inlet to the resistance and the outlet therefrom. This is true where the outlet or final termination of the circuit is at a lower pressure than the fluid entering the circuit, that is there is a pressure differential between the inlet and the outlet of the circuit and therefore a continuous drop in pressure from the inlet to the outlet takes place. If the outlet of the circuit is closed, it is apparent that there will be no escape of fluid and the pressure throughout the circuit will gradually equalize being similar to a closed vessel in which the pressure is equal at all points. As a result of this, two conditions arise in the present circuit. The first is that, when the piston 16 is moving, there is a form of outlet for the fluid in channel 10 caused by displacement in cylinder 15 due to movement of the contained piston, and there will be a drop in pressure across any resistance in the channel. The other condition is created when the piston 16 reaches the end of its travel, at which time the pressure throughout the channel 10 and cylinder 15 will all gradually rise to the same level and thus there will be no drop in pressure across the resistance.

In Figure 1 the resistance in channel 10 is indicated by the reference numeral 19 and in this case constitutes a variable throttle valve which may be utilized for controlling the rate of movement of the piston 16. It is therefore apparent that at the incoming port 20 of the resistance 19 that the pressure will be more or less constant while at the outlet port 21 the pressure will rise and fall in accordance with the flow condition. If no flow is occurring in the channel 10, the pressure at ports 20 and 21 will be substantially equal, while if a flow does take place a pressure differential will be created and the pressure at port 21 will be lower than the pressure at port 20.

Use is made of this pressure drop phenomenon to actuate an auxiliary control device which may be in the form of a control valve to determine the condition of flow in an auxiliary channel or independent circuit. To this end a channel 22 is connected to the port 21 and a channel 23 connected to the port 20, these

channels being ultimately connected to operating cylinders 27 and 28 for an interposed plunger 24. The valve portion may be either a reciprocable or a rotatable member, but the operating portion will comprise a pair of opposed piston members 25 and 26 reciprocally mounted respectively in cylinders 27 and 28. It is preferable that the pistons 25 and 26 be made of different projected pressure areas and this is necessary when no artificial means are utilized to assist valve operation because as previously mentioned when there is no flow in channel 10 the pressures at opposite sides of the resistance are equal and therefore equal piston areas would produce no movement. The areas may, however, be made equal as are pistons 25' and 26' if auxiliary means, such as spring 29, illustrated in Figure 6, is utilized at that end of the valve which is connected to the outlet side of the resistance. In this case it will be seen that when the pressures are equal, the added force of the spring 29 will assist in overbalancing the pressure at the resistance inlet and effect shifting of the valve.

In Figure 1 the valve and operating portions have been combined in a single plunger and in this case the plunger 24 is provided with an annular groove 30 for coupling the inlet line 31 with the outlet line 32 of an auxiliary or an independent circuit. If so desired, the valve may be made separate from the operating portion as shown in Figure 2 where the valve member 33 is rotatable and operatively connected to the plunger 24' by means of a slotted arm 34.

The channels 31 and 32 may represent the pressure line of any desired auxiliary or independent circuit, the operation of which is to be performed in some timed relation to the operation of the main circuit represented by the channel 10. It does not necessarily have to be an independent circuit as the channel 31 may be connected to the pressure line 10 at the outlet of the pump while the channel 32 could lead to the reservoir as shown by the dotted line connections in Figure 1, and the valve in such an instance would perform simply a by-pass function to relieve the pressure on the pump 11 during non-operation of the machine.

With the parts in the position shown in Figure 1, it will be seen that pressure fluid will flow from the pump 10 through the throttle valve to the cylinder 15 and while the piston 16 is free to move there will be a pressure drop from the port 20 to the port 21 of the throttle valve thereby causing the unit pressure in the cylinder 27 to drop below the unit pressure in the cylinder 28. The piston areas of the valve are so proportioned that the high unit pressure in cylinder 28 multiplied by the area of the piston 26 will be greater than the unit pressure in the cylinder 27 multiplied by the projected area of the piston 25. This will cause the plunger 24 to shift toward the left and disconnect the incoming channel 31 from the outgoing channel 32.

When the flow in channel 10 stops, as when the piston 16 has reached the end of its stroke, the pressure at 21 will gradually rise to the pressure at port 20 and this will cause an equalization of the unit pressures in cylinders 27 and 28, which, due to the larger area of piston 25, will now cause the valve plunger 24 to shift toward the right and effect connection of channel 31 with channel 32 thereby initiating flow in the secondary circuit. It will of course be apparent that the position of the channels 31 and 32 may

be reversed so that instead of initiating flow in the secondary circuit it may be utilized to stop the flow in this circuit. Under certain circumstances it may be desirable to simply reduce the flow of the secondary circuit rather than stop it entirely in which case the plunger 24 in Figure 1 or the valve 33 in Figure 2 may be made in the form of a throttle valve to thereby reduce the rate of flow in the outlet line rather than stop it.

Under other conditions there may be machines having a plurality of auxiliary circuits which are to be simultaneously affected in one manner or another upon the occurrence of a change in the manner of operation of the controlling member as witnessed by a change in the flow condition of its actuating medium. In such a case the plunger 24 may be elongated and provided with a plurality of annular grooves 30' and 30'' such as shown in Figure 3 for control of flow between lines 31 and 32 and between lines 31' and 32' respectively and the grooves may be so positioned as to effect simultaneously initiation or stoppage of flow in the auxiliary circuits represented by the different pairs of lines, or initiation of flow in one circuit and discontinuance of flow in the other circuit. The valve portion may be so arranged, as more particularly shown in Figure 6, that instead of effecting any of the foregoing changes in a single line it acts as a reversing valve to switch the pressure flow of a channel 50 from channel 51 to channel 52 and at the same time connect the first channel 51 to a return line 53.

If, instead of simultaneous operation, the plurality of circuits are to be successively operated, an arrangement such as shown in Figure 4 may be utilized. In this case the main channel 10 has the fluid control valve 35 connected across fixed resistance 19' therein for determining flow in channel 36, 36', which, through its control valve 37 connected across resistance 19'', determines the initiation of flow in channel 38, 38', and this channel through its control valve 39 connected across resistance 19''' may initiate flow in auxiliary channel 40, 40'. Since these control valves will be fired successively as flow ceases in the controlling channel it will be apparent that each will operate in succession after the cessation of flow in the preceding controlling channel.

Another method of connecting the valve to the controlling channel is shown in Figure 5. This arrangement makes it possible to use valves having piston areas which are equal and which will function without the use of the spring shown in Figure 6. In this case additional resistances are inserted in each branch line extending from opposite sides of resistance 43 in the main line to the valve 48 as shown in Figure 5 and may comprise for instance coils of tubing 41 and 42. Additional resistances 44 and 45 are connected to opposite ends 46 and 47 of the valve 48 leading to reservoir. This is similar to the arrangement shown in Figure 3 where resistances 41', 42', 44' and 45' correspond respectively to resistances 41, 42, 44 and 45.

Since these branch lines are open channels, the pressures at opposite ends of the valve will be different from the case where the lines are closed. For instance, assuming the pressure at the inlet of the resistance 43 as P_1 , and at the right hand end 46 of valve 48 as P_3 , the pressure P_3 would vary with respect to the pressure P_1 by the ratio of the resistance 44 to the total resistance in that branch line, which is equal to the

sum of the resistance 42 and 44. The same would be true of the relationship between P_2 , assumed to be the pressure at the outlet side of the resistance 43, and P_4 assumed to be the pressure at the left hand port 47 of the valve; that is the ratio of resistance 45 to the total resistance in that branch line which would be the sum of resistances 41 and 45. If P_1 and P_2 are equal, which would be the case when the flow was blocked in the outgoing portion 10', then the pressures at P_3 and P_4 would depend upon the ratio of the fractions

$$\frac{44}{42+44} \text{ to } \frac{45}{41+45}$$

Since these fractions can be made to have any value, it will be seen that the pressure at P_4 can be made greater than the pressure at P_3 , and the valve shifted to the right even although the piston areas are the same. When flow occurs in the line 10', the pressure difference must be great enough so that the larger fraction of the smaller pressure P_2 is less than the smaller fraction of the larger pressure P_1 . Due to the small differences in pressure that can be obtained in this manner, a very flexible arrangement is provided that can be made sensitive to slight changes in flow.

It will be evident that, with this arrangement, due to the added resistances, the actual rate of movement of the valve 48, in either direction, may be varied at will by a proper selection of the valves of the several resistances.

There has thus been provided an improved hydraulic flow detecting mechanism which is sensitive to the flow condition in a main or controlling hydraulic circuit to which it is connected, in such a manner that a change in the flow condition in that circuit will effect actuation of auxiliary mechanism to vary or change the flow condition in an auxiliary or controlled system.

What is claimed is:

1. In an hydraulic system, the combination of a main channel for delivering fluid under pressure for operation of a fluid operable device, said channel having a resistance therein causing a drop in pressure during flow of fluid therethrough, a second channel for delivery of fluid having a control valve therein, means for positioning said valve in accordance with the flow condition in the main channel including a pair of opposed pistons operatively connected to said valve, a fluid circuit including the resistance in the main channel for connecting one piston to the other, equal areas on said pistons subjectable to the pressure at opposite ends of said resistance whereby during flow the pressure on the pistons will be unequal, causing a movement of said control valve to a first position, and supplementary means operative upon equalization of pressure on said equal areas due to stoppage of flow in the main line to cause movement of the control valve to a second position, including a spring operative on one of said pistons for shifting the valve when the pressure on the pistons is equal, said spring being so proportioned as to be ineffective when the pressure on said pistons is unequal.

2. In an hydraulic system, the combination of a main channel for delivering fluid under pressure for operation of a fluid operable device, said channel having a resistance therein causing a drop in pressure during flow of fluid therethrough, a second channel for delivery of fluid having a control valve therein, means for positioning said valve in accordance with the flow condition in the main channel including a pair of opposed

pistons operatively connected to said valve, a fluid circuit including the resistance in the main channel for connecting one piston to the other, equal areas on said pistons subjectable to the pressure at opposite ends of said resistance whereby during flow the pressure on the pistons will be unequal, causing a movement of said control valve to a first position, and supplementary means operative upon equalization of pressure on said equal areas due to stoppage of flow in the main line to cause movement of the control valve to a second position, including additional resistances individual to the respective pistons for establishing unequal pressures on said pistons having a resultant in a direction opposite to the first movement when the pressures at opposite ends of the resistance in the main channel are equal.

3. An hydraulic circuit comprising a first channel, a pump for delivering fluid to the channel, a fluid operable device connected to said channel for movement through a predetermined stroke, a second flow channel having a valve therein movable between a first and second position, fluid operable means for automatically shifting said valve at the completion of a stroke of said fluid operable device, including a pair of opposed piston members operatively connected to the valve, means to supply operating fluid to said members from two different points in the first channel, and fluid resistance means located in the channel between said points and responsive to stoppage of flow to said device for causing an unbalancing of the total pressure on said pistons to shift said valve.

4. An hydraulic circuit comprising a first channel, a pump for delivering fluid to the channel, a fluid operable device connected to said channel for movement through a predetermined stroke, a second flow channel having a valve therein movable between a first and second position, fluid operable means for automatically shifting said valve at the completion of a stroke of said fluid operable device, including a pair of opposed piston members operatively connected to the valve, means to supply operating fluid to said members from two different points in the first channel, fluid resistance means located in the channels between said points and responsive to stoppage of flow to said device for causing an unbalancing of the total pressure on said pistons to shift said valve, said last named means also being responsive to renewed movement of said fluid operable device to cause a reverse unbalancing of pressure on said pistons to shift the valve to its other position.

5. An hydraulic circuit comprising a first channel, a pump for delivering fluid to the channel, a fluid operable device connected to said channel for reciprocating movement with a predetermined stroke, a throttle valve in said channel for determining the rate of said movement whereby all fluid delivered to said device will pass through said valve, said throttle valve also causing a drop in pressure in the channel during flow there-through, a second flow channel having a two-position valve therein, a pair of opposed piston members of different areas operatively connected to the valve, channel means for connecting said members to said first channel at opposite ends, respectively of the throttle valve, whereby during movement of said fluid operable device the total pressure on one of said pistons will be greater than the pressure on the other to move the valve to one position, and upon stoppage of said fluid operable device the unbalance of pressure on said

piston will be reversed to move the valve to its other position.

6. An hydraulic circuit comprising a first channel, a fluid operable device connected to said channel for movement through a predetermined stroke, a pump for delivering fluid under pressure to the channel to cause operation of said device, a throttle valve in the channel for controlling the rate of movement of said device whereby all fluid delivered to said device will pass through said valve, said throttle valve also causing a drop in pressure in the channel, a reversing valve for determining the direction of movement of said device, a second channel, a control valve in the last named channel, having a first and second position, opposed piston members of different areas operatively connected to the control valve for moving the same from one position to the other, said opposed pistons being respectively connected to the first channel adjacent opposite ends of the throttle valve whereby during flow in the channel to cause movement of said device the total pressure on said opposed pistons will be unbalanced to cause movement of the control valve to one position, and stoppage of said fluid operable device will cause a reverse unbalancing of pressure on said pistons to cause shifting of the control valve to a second position, and means to shift said reversing valve to cause return movement of said fluid operable device and a simultaneous shifting of said control valve to its first position.

7. An hydraulic system comprising a main channel for supplying fluid to a fluid operable device, a single means for continuously delivering fluid under pressure to said channel, a second flow channel, a fluid resistance inserted in the main channel whereby all fluid delivered to said device will pass through said resistance, and a movable control in the second channel having unequal piston portions fluid connected to opposite ends of said resistance whereby during delivery of fluid to said device through said resistance means the total pressure on one of said pistons will be greater than that on the other to cause said control to be stabilized in a first position, and upon stoppage of flow to said device, said control will be moved and stabilized in a second position.

8. An hydraulic system comprising a main channel for delivering fluid to a fluid actuable device, a single means for delivering fluid under pressure to said channel and thereby to said device, a flow detecting instrumentality connected in series in said channel whereby all fluid delivered to said device will pass through said instrumentality, said instrumentality causing a permanent drop in pressure throughout the portion of the channel between it and said device during flow in the channel, a second channel for receiving fluid from a source which is independent of said fluid delivering means, a control valve in said second channel, and operating means for said valve connected to said instrumentality for operation thereby whereby during flow in the main channel said valve will be moved to a first position, and upon termination of flow in said main channel the control valve will be moved to a second position.

9. An hydraulic system comprising a uni-directional flow channel, means for delivering fluid under pressure to said channel, a fluid resistance connected in series in said channel, a fluid operable device connected to said channel for receiving fluid from said resistance for actuation thereby,

a second channel for receiving fluid from an independent source of fluid supply, fluid operable means for controlling the flow in said second channel including piston portions of differential area and respectively connected to the first-named channel at opposite ends of said fluid resistance, the piston of smaller area being connected to the intake side of said resistance whereby a pressure drop across said resistance during flow to said device will shift said fluid operable means to a first position, and equalization of pressure across said resistance caused by termination of flow in the first-named channel will shift said fluid operable means to a second position.

10. An hydraulic system comprising a uni-directional flow channel, a single means for causing

a flow under pressure in said channel, a fluid operable device connected to said channel for actuation by the fluid therein, a fluid resistance in the channel whereby all fluid delivered to said device will pass through the resistance, a second channel having an independent source of supply, a control member for said second channel including differential pistons respectively connected to the first-named channel at opposite ends of the resistance therein whereby during flow in the first channel said control member will be shifted to a first position and upon termination of flow in the first channel said control member will be shifted to a second position.

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