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[54] **REGULATING SYSTEM FOR PUMPS**

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[51] **Int. Cl.** **F04b 49/00**

[58] **Field of Search** 417/212, 216, 218, 222; 60/449, 451

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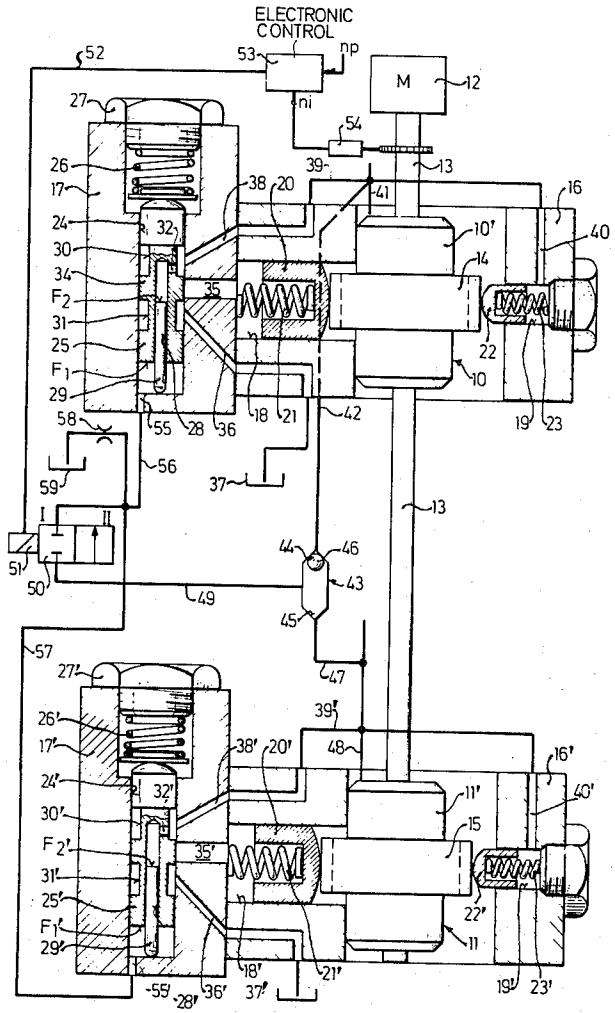
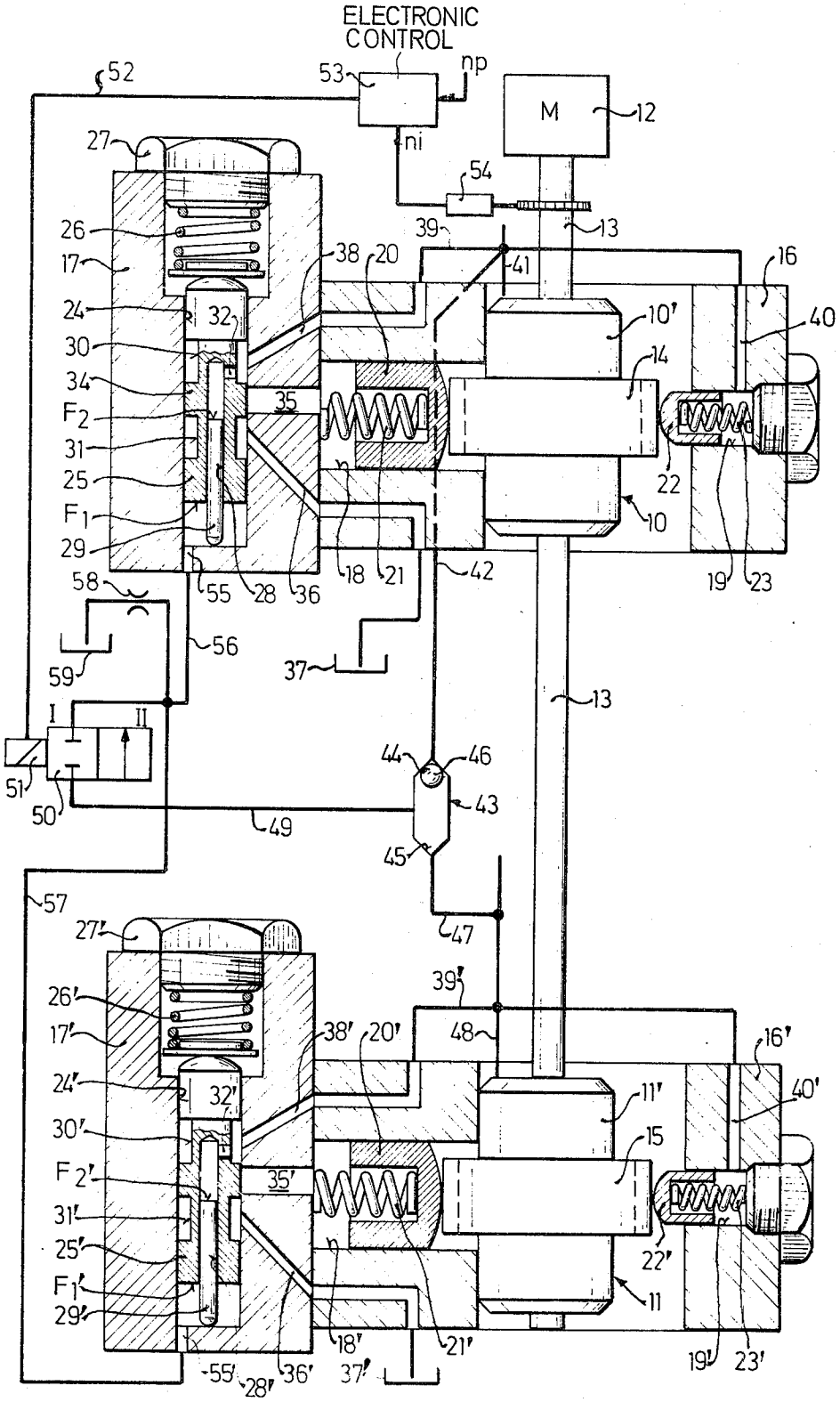
[57] **ABSTRACT**

A motor, such as an internal combustion engine or an electric motor, drives two or more pumps, which pump fluid through a discharge system, and a speed measuring device is provided for producing a signal when the speed of the motor is reduced due to the load on the motor reaching a predetermined high value, short of an overload. Two or more pump discharge regulators are provided, one for each pump, cooperating with the measuring device to reduce the output of at least one of the pumps in response to a signal to thereby prevent overloading of the engine or motor.

8 Claims, 1 Drawing Figure




ELECTRONIC CONTROL
52
53
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M
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54
39
13
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26
17
24
30
34
F2
31
25
F1
29
32
35
38
20
41
16
10'
40
14
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10
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23
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21
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I
II
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27'
26'
17'
24'
30'
F2'
31'
25'
F1'
29'
32'
35'
38'
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48
39'
16'
40'
11'
15
22'
11
19'
23'
18'
21'
55'
28'
36'
37'

REGULATING SYSTEM FOR PUMPS

BACKGROUND OF THE INVENTION

The invention relates to a pump system of the type wherein pumps are driven by an internal combustion engine or an electric motor; wherein a signal is derived from the operating load on the motor, influenced by such characteristics as the motor speed and the discharge pressure of the pumps; and wherein such discharge pressure is utilized in a regulating device for adjusting the amount of fluid discharged by the pumps and particularly for reducing such amount in response to a high load, short of an overload which would stall the engine.

In typical systems of this kind constructed up to now, the amount of fluid delivered by each pump has been regulated in such a manner to fully utilize the torque of the motor while avoiding overloading the same, thereby synchronously adjusting both pumps. Such synchronizing is unsuitable in many cases and difficult to carry out in many pump constructions.

SUMMARY OF THE INVENTION

The invention has the object of overcoming the above-mentioned problems, and other problems previously encountered in connection with pump systems of the indicated type, as will be noted hereinafter.

It is a particular object of the invention to provide a regulator system for adjustable pumps which can operate without synchronizing the adjustment of the pumps.

Another object is to protect the drive motor for the pumps from overload by a regulating system of simple construction.

The objects are achieved by the invention, which for these purposes uses a plurality of pump discharge regulators, each regulator having pressure responsive means with two surfaces connected or connectable to fluid pressure. A load measuring device produces a signal in response to a predetermined high load on the motor for directing fluid pressure to one of these surfaces, whereupon the regulator causes the amount of fluid discharged by the respective pump to be reduced.

Advantageously, this load-responsive system is arranged so as to reduce, initially, the amount of fluid discharged by the pump which has the highest discharge pressure. If the resulting adjustment of the motor load is still insufficient to avoid the danger of overloading, the system also reduces the amount of fluid discharged by the other pump or pumps.

Other characteristics of the invention will be noted from the description which follows in connection with the drawing.

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

The single FIGURE is an elevational view of an embodiment of the invention, certain parts being shown in section and other parts being shown in block diagram form.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to the drawing, two or more adjustable pumps **10, 11** are driven by a motor **12,** common to these pumps **10, 11** and rigidly coupled to the pump rotors (not shown) by a shaft **13.** The pumps have separate discharge lines **41, 48** respectively. They are constructed to discharge an adjustable amount of fluid, and particularly an adjustable amount of liquid, into their respective discharge lines, against variable pressures prevailing in these lines. The adjustment of fluid volumes discharged by the illustrated pumps **10, 11** is performed, in a known manner, by adjusting means in form of control rings **15** which can be shifted transversely relative to the pump casings **10', 11'**; the pumps being preferably of the radial piston or vane piston type, known to persons skilled in the art. The control ring **14, 15** of each pump **10, 11** can be shifted from a centered position, shown in the drawing, relative to the respective casing **10'** or **11'** toward the right, as viewed in the drawing, to increase the amount of fluid delivered, or toward the left to decrease the amount.

Each pump **10, 11** is surrounded by a hydraulically operated adjusting device **16, 16'** for adjusting the eccentricity of the control ring **14, 15.** Both pumps are provided with identical adjusting devices, and therefore only the elements of the adjusting device for the pump **10** will now be described in detail. The corresponding elements of the adjusting device for the pump **11** are referred to with the same reference numerals to which a "prime" is added.

The adjusting device for the pump **10** may comprise a block **16** which surrounds the pump **10** and has transversely to the pump axis a large cylinder or bore **18** on one side of the pump and coaxially with cylinder **18** and transversely opposite the same on the other side of the pump, a smaller cylinder or bore **19.** A piston **20,** closely and slidably guided in cylinder **18,** is biassed into engagement with the control ring **14** by a spring **21** and additionally, in certain positions of the apparatus, by fluid pressure in cylinder **18.** Similarly a piston **22** is slidingly guided in the opposite smaller cylinder **19,** and is biassed by a spring **23** to contact the control ring **14** at a point diametrically opposed to the point of contact of piston **20.** Fluid pressure is supplied to the cylinders **18, 19** through ducts which will be described presently.

Supply of pressure fluid to the ducts is controlled by a pressure actuated regulator **17.** The regulator **17** is mounted on the aforementioned block **16** with the aid of conventional fastening and gasketing means, not shown. A control slide **25** is slidingly inserted in a bore **24** in regulator **17,** this bore being transverse to cylinder **18** and has a generally closed lower end, while its enlarged upper end contains a regulator spring **26.** An upper end of this spring bears against a regulating screw **27,** closing the upper end of bore **24.** The opposite lower end of spring **26** bears against the top of control slide **25.**

According to the invention the slide **25** has a central blind bore **28** which extends from the bottom of the slide **25** into the latter. A small piston or pin **29** is slidingly guided in bore **28.** This small piston **29** has a lower end bearing against the closed lower end of bore **24.** The area of the slide **25,** around the small piston **29,**

is identified as F1 while the small piston 29 has a cross section of an area F2.

The control slide 25 is cylindrical and has two annular grooves 30, 31 spaced apart and spaced from the ends of the slide 25. The upper groove 30 is connected with the blind bore 28 by a transverse aperture 32. In the normal or neutral position of the slide 25, shown in the drawing, a land 34 between the two annular grooves 30, 31 closes a transverse aperture 35 which interconnects the regulator bore 24 with the cylinder 18 of the larger pump adjusting piston 20. Below this aperture 35 a duct 36 connects the regulator bore 24 with an open container or sink 37. Another duct 34, shown above the aperture 35, connects the regulator bore 24 with a conduit 39. The conduit 39 is also connected with a duct 40, extending through the pump adjustor block 16 to the smaller cylinder 19. Pressure is supplied to duct 39 by the discharge line 41 of pump 10. In the second unit, correspondingly, pressure is supplied to a duct 39' by the discharge line 48 of pump 11.

The discharge lines 41, 48 are further connected by conduits 42 and 47 to a selector valve 43, shown as a two-way valve with two valve seats 44, 45 with which the conduits 42, 47 respectively communicate. The seats 44, 45 are alternately closed or opened by a single valve member, shown as a ball 46. Between the two valve seats 44, 45 the two-way valve 43 is connected, by a pipe 49, with a solenoid valve 50 which has a closed position I and an open position II. The control magnet 51 of solenoid valve 50 can be energized through a conductor 52, from an electronic control device 53, which serves to compare a rated value *np* for the rotational speed of motor 12 with the actual rotational speed *ni*, determined by a speedometer 54 on shaft 13. When solenoid valve 50 is in open position II, it interconnects pressure line 49 with a duct 55 at the bottom of slide bore 24, through a duct 56. The corresponding ducts of the other regulator 17' are identified as 55' and 57 and are similarly connected to solenoid valve 50. Additionally connected to ducts 56 and 57 is a further duct which leads by way of a throttle 58 to a sink 59.

The operation of the illustrated regulation system can be described as follows, referring first to basic operative steps, which are known to persons skilled in the art.

When either pump 10 or 11 or both pumps discharge fluid against a low pressure, their motor 12 drives them at high speed and their control rings 14, 15 are adjusted for maximum eccentricity and maximum fluid displacement; for this purpose the control rings 14, 15 are displaced by their control pistons 20, 22, 20', 22' toward the right, from the position shown in the drawing. Slides 25, 25' then are in lower position than is shown, since they are biassed into such position by springs 26, 26' and are not exposed to sufficient hydrostatic pressure on the surface F1, F2 and F1', F2' to overcome the spring force. In this position, discharge pressure from lines 39, 39' is connected to the larger adjusting pistons 20, 20' through ducts 38, 38' and apertures 35, 35', these apertures being in communication with the upper grooves 30, 30' of sliders 25, 25'. Normally, pressure from duct 39 reaches the interior bore 28 in slide 25 of regulator 17, and tends to raise the slide 25 against the biassing force of spring 26, but is insufficient to overcome this biassing force, at the low pressures prevailing in the discharge system.

When the pressure in line 41 reaches higher values, slide 25 of regulator 17 is raised, as fluid at increased pressure then passes through ducts 39, 38, 32 into bore 28 and acts on the upper closed end of area F2. As the regulator slide 25 rises beyond the position shown in the drawing, pressure fluid from the cylinder 18 can pass through duct 35, the lower annular groove 31 and the vent duct 36 into sink 37. As the cylinder 18 of the large piston 20 is vented, it no longer supplements the force of spring 21 sufficiently to counteract the leftward forces exerted on control ring 14 by the spring 23 and the smaller piston 22 which is still acted upon by the pressure in line 41. The resulting leftward shifting of control ring 14 leads to a reduction of the fluid stream and fluid pressure furnished by the pump 10. It will be understood that both regulators 17, 17' thus respond to changing pressures in discharge lines 41, 48 and thereby shift control rings 14, 15 toward right or left, until in each case the discharge pressures balance the biassing forces of springs 26, 26'.

According to the invention the regulating devices 17, 17' are additionally adapted to prevent overloading and stalling of internal combustion engines 12 driving the pumps, or stalling and burning of the motor windings when the drive motor is an electric motor.

The additional protection of the pump and motor system, against such high loads, is achieved by the simple and inexpensive provision of a tachometer and signalling unit 53, 54 and by a minor modification of the regulating system, as will now be described.

If the driving torque of the pumps 10, 11 exceeds the maximum torque of the motor 12, the actual rotational speed *ni* drops significantly below the rated rotational speed *np*, as measured by tachometer 54. The electronic control device 53 then sends a high-load signal through conductor 52 to solenoid 51 of valve 50, shifting this valve from its normal closed position to its open position II. Thereby, the ducts 56, 57 are connected with the duct 49, and the duct 49 is connected with that pump discharge line 41 or 48 in which the higher pressure prevails. The pressure from the higher pressure carrying line 41 or 48 acts now over the ducts 56, 57 on the annular surfaces F_1, respectively F_1, of the control slide 25, respectively 25', so that the control slide will be raised which is located in the bore subjected to the higher pressure. Assuming that the higher pressure prevails in the line 41, then this higher pressure passes through the ducts 39 and 38, the annular groove 30 and the transverse bore 32 into the blind bore 28 of the control slide 25 and acts on the end face of the small piston 29 in bore 28 and the closed end of the latter to raise the control slide 25. Thereby, the fluid pressure in the cylinder 18 is reduced, as described above, and the pump 11 is adjusted to deliver a smaller amount of fluid.

The resulting condition of the system is maintained until, due to reduction of the load on the drive motor 12, the rotational speed thereof rises again to its rated speed np. Thereupon, the solenoid valve 50 controls flow of the pressure medium to control slide 25 and throttle 58 in such a manner that the slide 25 is moved to its neutral position, as shown in the drawing, in which the land 34 of the slide closes the duct 35.

If the rotational speed of the drive motor 12 rises again beyond its rated speed, the solenoid valve 50 is moved to its closed position I, and the control slide 25 is moved downwardly by the pressure of the spring 26,

to adjust the pump to increase the amount of pumped fluid. This causes renewed rising of the load in this pump and corresponding reduction of the actual speed of motor **12.** The fluid displaced from bore **24** by regulating slide **25** is gradually vented through duct **56** and throttle **58** to sink **59.**

If the reduction of discharge of pump **10** is insufficient to avoid overloading of motor **12** or if the discharge pressure of the adjusted pump **11** is excessively reduced as a result of the reduction of its discharge amounts, the above-described procedures are initiated in connection with the pump **11** to the illustrated system. Pressure acting on surface F1′ of regulating slide **25′** then causes venting of cylinder **18′** through duct **36′**, thereby causes piston **19′** to reduce the eccentricity of control ring **15** and thus to further reduce the load on motor **12.**

A number of modifications is possible. For example both pumps **10, 11** may have their discharge lines **41,** 48 connected to a single discharge line (not shown) to expose both pumps to a single back pressure, and for example the system may be arranged so that the combined line receives the sum of the full discharges of pumps **10, 11.** It is still desirable, in many cases, to initially reduce the amount of fluid furnished by one of the pumps and only thereafter if necessary to reduce that of the other pump. In this event the sequence of regulating actions can be selected by differently adjusting the biasing springs **26** and **26′** of the pump regulators **17, 17′.**

The control signal responsive to the load on motor **12** can also be derived by devices other than a tachometer **54.** For example if motor **12** is a Diesel engine the actual speed *ni* can be impressed on the electronic control device **53** by variable positioning of the control lever of the fuel injection pump (not shown). It is also possible to use control signals other than the electronic ones mentioned above and correspondingly to use control valves **50** of other construction than the above-mentioned solenoid valve.

While two pumps **10** and **11** have been shown it will be further appreciated that more than two pumps, coupled to one another and driven by single motor **12,** can be regulated by a system in accordance with the invention, it being necessary only that the system includes at least two pumps and at least two regulators, connected to them respectively.

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 regulation systems for pumps differing from the types described above.

While the invention has been illustrated and described as embodied in a regulation system for pumps, 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.

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

I claim:

1. In a pump system wherein at least two pumps are coupled to a single drive motor for pumping fluid under pressure through a discharge system, a regulating arrangement for preventing overloading and stalling of the drive motor, said regulating arrangement comprising at least two displacement control regulating means, one for each pump, and each having control slide means having a first and a second surface adapted to be subjected to the fluid pressure in the discharge system for moving the respective displacement control regulating means to thereby regulate the amount of fluid pumped by the respective pump; signalling means cooperating with said drive motor for producing a signal in response to a predetermined high load on the motor; and means for subjecting said first surface to the fluid pressure in the discharge system in response to one of said signals so as to move the control slide means of at least one of said pumps to thereby reduce the amount of fluid delivered by said at least one pump.

2. The regulating arrangement as defined in claim **1,** wherein said signalling means comprises a speedometer producing a signal when the number of revolutions per time unit of said drive motor drops below a predetermined minimum.

3. The regulating arrangement as defined in claim **2,** wherein said means for subjecting said first surface to said fluid pressure comprises a control valve.

4. The regulating arrangement as defined in claim **1,** wherein said discharge system comprises a separate discharge line for each of said pumps, and including selector valve means for selecting the discharge line of that one pump which pumps fluid at the highest pressure and for connecting the discharge line of said one pump to said means for subjecting said first surface to the fluid pressure.

5. The regulating arrangement as defined in claim **1,** wherein each of said displacement control regulating means comprises a housing formed with a bore, said control slide means comprising a control slide movable in said bore of said housing and being formed with a blind bore extending from one end of said control slide into the latter and having a closed end, and a piston in said blind bore projecting beyond said one end of said control slide and abutting against said housing, said first surface being an annular surface at said one end of said control slide about said piston and said second surface being the surface at said closed end of said blind bore, passage means for normalling subjecting the interior of said blind bore to the fluid pressure in the discharge system to thereby move said control slide in a first direction and biassing means for moving said control slide in a second direction opposite to said first direction, said control slide being movable from a neutral position in said first direction when the pressure in said discharge system drops below a predetermined pressure to thereby regulate the respective pump to increase the amount of fluid pumped thereby, and said control slide moving in said second direction upon subjecting said first surface to said fluid pressure to thereby regulate the respective pump to decrease the amount of fluid pumped thereby.

6. The regulating arrangement as defined in claim **5,** wherein each of said pumps comprises adjusting means for regulating the amount of fluid delivered by the respective pump, said adjusting means comprising an adjusting member movable in one direction for increasing the amount of fluid delivered by said pump and in the

opposite direction for decreasing the amount and a pair of cylinder and piston means for moving said adjusting member in the one and in the opposite direction, and including passage means for supplying fluid to said cylinder and piston means for moving said adjusting member in said one direction when said control slide is moved from said neutral position in said first direction and for moving said adjusting member in said opposite direction when said control slide is moved from said neutral position in said second direction.

7. The regulating arrangement as defined in claim **3**, wherein said signalling means produces an electric signal and wherein said pilot valve comprises a solenoid valve.

8. The regulating arrangement as defined in claim **7**, wherein said discharge system comprises a separate discharge line for each of said pumps, and including selector valve means for selecting the discharge line of that one pump which pumps fluid at the highest pressure and first conduit means connecting said selector valve means to said solenoid valve, said solenoid valve being normally in a closed position and being moved from said closed to an open position upon receiving a signal from said signalling means and further conduit means to direct fluid from said first conduit means to said first surfaces of said regulating means in said open position of said solenoid valve.

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