POWER CONTROL DEVICE FOR TWO OR MORE HYDRAULIC PUMPS

Inventor: Ludwig Wagenseil, Vohringen, Germany

Assignee: Hydromatik GmbH, Ulm/Donau, Germany

Filed: July 27, 1971

Appl. No.: 166,389

Foreign Application Priority Data
Aug. 5, 1970 Germany....................... P 20 38 968.8

U.S. Cl.................................................. 417/216
Int. Cl.................................................. F04b 49/00
Field of Search.............................. 417/216, 222, 213,
417/214; 91/505, 506; 137/99, 100

References Cited
UNITED STATES PATENTS
3,002,462 10/1961 Raymond....................... 417/214

3,188,971 6/1965 Puryear.......................... 417/222

FOREIGN PATENTS OR APPLICATIONS
2,017,656 4/1970 Germany........................ 417/216
1,922,269 4/1969 Germany........................ 417/216

Primary Examiner—William L. Freeh
Assistant Examiner—Gregory LaPointe
Attorney—Owen, Wickersham & Erickson

ABSTRACT
A power control device for two or more adjustable hydraulic pumps operated by a common driving means with each pump having its own power regulator and a power control device for continuously adjusting the regulator to maintain a desired power value of the pump. A pressure-responsive device on each pump is responsive to the delivery pressure of the companion pump for adjusting its own power according to the said delivery pressure.

4 Claims, 3 Drawing Figures
FIG. 3

INVENTOR
LUDWIG WAGENSEIL
BY

[Signature]
POWER CONTROL DEVICE FOR TWO OR MORE HYDRAULIC PUMPS

The invention relates to a power control device for two or more adjustable hydraulic pumps, operated by a common driving means and is particularly though not exclusively concerned with positive displacement pumps having means for adjusting their delivery flow, each pump being fitted with its own power control device, which is continuously adjustable to the desired power value of each pump by means of an adjustment device.

Such devices are intended on the one hand to protect the common driving apparatus operating the hydraulic pumps against overload, and on the other hand they make it possible to utilize as far as possible without loss the power capacity of the driving apparatus even when the load on the individual hydraulic pumps is different.

Power control devices are known for individual hydraulic pumps which keep constant the product p·Q determining the power of a hydraulic pump, where p is the working pressure and Q the output of the pump. With the simplest form of total output control for two or more pumps, the arrangement is designed in such a way that each pump takes half the power of the driving apparatus, and in addition the power control for each individual pump is carried out in normal manner.

It is also known to regulate double pumps jointly as soon as the total of the loads originating from the consumers on the individual pumps exceeds the maximum derived power torque of the driving apparatus operating the double pumps jointly. In this case the working pressures of the individual pumps are exerted on a common piston arrangement, preferably a differential or stepped piston, which constitutes a component part of the regulation device common to the double pumps. Thereby only an adjustment of the double pumps that is necessarily simultaneous and equally great is possible. This drawback is not eliminated either by a device already proposed in which a pressure regulator is fitted to each delivery circuit, to limit the working pressures individually. This has the drawback that when, for example, one of the pumps is adjusted to its zero position, the full output of the driving apparatus cannot be supplied to the other pump, as the total output of the installation must be such that all the pumps driven by the same driving apparatus can operate at their maximum output power.

With the form of power control in these known control devices, the product of the total of the working pressures by the arithmetic means of the output flow quantities is kept constant, i.e. sum of the individual performances

\[ N = \frac{(Q1 + Q2)}{2} \cdot (p1 + p2) = \text{const}. \]

This means that in the power control range in each instance of the individual pump more or less the same output flow is supplied to each of these pumps, if they are to take up the same power. In practical use this leads to the result that the units driven by the one pump with the higher working pressure perform undesirably fast movements, while the units driven by the other pump operating at a momentarily power working pressure, in accordance with the power control, are slowed down undesirably. A modification whereby the optimum output flow is supplied automatically, individually to the pressure for each working cycle, is not possible with the known power control devices.

An object of the invention is to provide a control device which keeps constant the sum of all the individual powers, arrived at for each pump individually from the product of the working pressure and the output flow, i.e.

\[ N = Q1 \cdot p1 + Q2 \cdot p2 + \ldots + Qn \cdot pn = \text{constant}. \]

According to the invention a power control apparatus for two or more adjustable hydraulic pumps, driven by a common driving means and each having its own power regulator, includes a power control device for each pump for continuously adjusting the regulator to maintain a desired power value of the associated pump, and a pressure responsive device responsive to the delivery pressure of the companion pump and arranged to adjust the power of its own pump to the said delivery pressure. This makes it possible that when a working circuit does not take up the total driving power of the common driving apparatus, the excess is placed at the disposal of the other working circuit or circuits, while also the delivery flow is matched automatically to the working pressure prevailing in this working circuit or circuits on the basis of the individual power control.

In one form of the invention the apparatus is provided with a device limiting the maximum delivery pressure of each pump, in which the power control device for each pump also has a delivery flow responsive device responsive to the delivery flow of the companion pump and arranged to adjust the power of its own pump according to the said delivery flow. An additional result of this is that not only on the operation of one of the pumps at zero or reduced the output of the driving apparatus can be placed at the disposal of the other pump, but also this is also done when one of the pumps operates at maximum working pressure, but fails to take up the delivery flow or takes it up imperfectly.

In one arrangement the power control device of each pump comprises a pilot valve acted on by a spring, the force of which depends on the delivery flow adjustment of the pump, and having a piston surface acted on by a control pressure depending upon the delivery pressure of the pump, and derived from a point between two restricted orifices connected in series whilst the pressure responsive device comprises a throttle valve adjustable in accordance with the delivery pressure of the companion pump and connected in parallel with one of the restricted orifices. In such an arrangement the delivery flow measuring device may comprise a throttle valve adjustable in accordance with the delivery flow of the companion pump and also connected in parallel with the restricted orifice and the pressure responsive throttle valve. The pressure responsive throttle valve may constitute the restricted orifice.

Further features of the invention will be apparent from the following description of certain specific embodiments, given by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is a diagram of a control device according to the invention for two hydraulic pumps;
FIG. 2 is a similar diagram of a further arrangement; and
FIG. 3 shows performance curves to illustrate the modus operandi of the invention.

Two hydraulic pumps 1 and 2, adjustable with the aid of servo-motors 5 or 6, and driven by a driving appara-
tus not illustrated, deliver pressurized fluid in two working circuits 3 and 4 independent of each other. Mounted on each hydraulic pump 1, 2 is a power control device 7 or 8 consisting in a measuring spring assembly 9 and 10 and control slide valve 11 or 12, the force of which may be adjusted by means of an adjustment device comprising a stationary throttle valve 15, 16 and an adjustable regulating throttle valve 17, 18. The maximum pressure in the working circuits 3, 4 is limited by an over-pressure valve 21, 22 (FIG. 1) or a pressure regulating device 27, 28 (FIG. 2).

As previously known such a device operates as follows: When the pressure, in the working circuit 3, for example, increases, the pressure that builds up between the stationary throttle 15 and the regulating throttle valve 17 acts on the measuring or piston surface 13 of the control slide valve 11 against the force of the measuring spring assembly 9 of the power control device. When the control slide valve 11 opens it admits pressure fluid from the working circuit 3 to the adjusting piston of the servo-motor 5 to adjust the hydraulic pump 1 to prevent further rise of pressure. At the same time, the crosshead 19 raises the initial force of the measuring spring assembly 9 until the control slide valve 11 again closes.

When the pressure has reached, for example, the point B 1 (see FIG. 3) which is determined by the design of the power control device 7 and the power adjustment through the regulating throttle valve 17, the power control device 7 begins to operate in accordance with the curve N1, the characteristic of which is determined by the measuring spring assembly 9.

The regulated power is kept constant, as the delivery flow is continuously suited to the working pressure prevailing at any time.

As a result, as the working pressure increases, the performance curve N1, will run from B 1 to C 1, while the output Q 1 will be decreased corresponding to the characteristic. In the diagrams A1 and A2 denote the points of maximum output of the pumps at zero pressure, and D 1 and D 2 the points where the output is nil at maximum output pressure in the working circuit. When the maximum pressure on the performance curve N1, i.e., the point C 1, is reached, there is a response on the part of the member limiting the maximum pressure, e.g. the overpressure valve 21, insofar as the entire output is not taken up by the consumer. If the two hydraulic pumps 1 and 2 are normally loaded within the illustrated regulation range of each pump, the respective power control devices 7 and 8 operate only in the applicable range B1 – C1 or B2 – C2 of the associated performance curve N1 or N2, so that in this range optimum matching of the sum of the powers of the two pumps to the power of the driving apparatus is possible.

In the embodiment of the invention shown in FIG. 1, each hydraulic pump 1 and 2 is provided with a pressure gauging member in the form of a pressure-responsive adjustable throttle valve 24 and 23 connected in parallel with the adjusting throttle valve 17 or 18 associated with the other pump. Thus, both the adjustable throttles 17 and 24 or 18 and 23 jointly influence the pressure acting on the measuring surface 13 or 14 of the control slide valve 11 or 12, depending upon the working pressure of both pumps 1 and 2 and thereby the power adjustment of the power control device 7 or 8. The pressure-dependent adjustable throttle valve 24 or 23 has for the purpose an adjusting piston 26 or 25 connected with the working circuit 4 or 3 of the other pump.

As long as the two working circuits 3, 4 are at zero pressure, the throttle valves 23, 24 are open. Thus, when one pump has zero output pressure the power control device 7, 8 or of the other is so adjusted that the latter pumps 1 or 2 could take up the entire output of the driving apparatus and could operate in accordance with the performance curve N1' or N2' of FIG. 3. If in the working circuit 3 the output pressure begins to rise from the point A1 to the point B1 in FIG. 3, then the pressure acts also upon the adjusting piston 25 which progressively closes the adjustable throttle valve 23, until the valve 23 is fully closed when the point B1 has been reached.

As long as the working circuit 4 of the pump 2 remains at zero pressure, corresponding to the point A2, the pump 1 can accept the entire driving power, and therefore work according to the curve N1’. As soon as the pump 2 is loaded and the pressure increases in the working circuit 4, its pressure acts upon the pressure gauging piston 26, which progressively closes the adjustable throttle valve 24. As the working circuit 3 is under pressure, a pressure accumulates between the fixed throttle valve 15 and the adjusting throttle valve 24, which acts additionally upon the measuring surface 13 of the control slide valve 11, thereby altering the power adjustment of the hydraulic pump 1, so that the performance curve N1’, (on which the pump 1 operates while the pump 2 operates between the points A2 and B2) is shifted in the direction of the performance curve N1. Each power adjustment of the hydraulic pump 2 is given a matching power adjustment of the hydraulic pump 1, which permits of the utilization of the total driving power, before the adjustment ranges originally allotted to the pumps (performance curves N1 and N2) are reached. The performance curve N1 is reached when the throttle valve 24 is closed, i.e. the pump 2 has reached the point B2 through adjustment and loading. The pressure in the working circuit can at a maximum reach the point B2, as with the closing of the throttle valve 23 the performance curve of the pump 2 would be shifted from N2’ to N2.

If the pressure of the pump 2 has reached the point B2, then the throttle valve 24 has closed and both pumps begin to operate in accordance with the curves N1 or N2 between the points B1-C1 or B2-C2. On reaching the point C1 and/or C2, i.e. maximum pressure, the output not taken up by the working circuits is released via the over-pressure valve 21 or 22.

FIG. 2 shows a modified arrangement in which the output that would be lost through this release from one pump is made available to the other pump. For this purpose each of the hydraulic pumps 1 and 2, is provided with a further output-dependent adjustable throttle valve 30 or 29, which is connected with the servo-motor 6 or 5 of the other pump 2 or 1, via a lever 32 or 31 connected to the crosshead 20 or 19, so as to depend on the position of adjustment of the pump. The adjustable throttle valves 29, 30 are connected in parallel with the adjustable throttle valves 23, 24 and, like them, affect the output adjustment of the hydraulic pump, as described already for the pressure-responsive adjustable throttle valves 23, 24. As long as the two hydraulic pumps 1, 2 operate in their adjustment ranges B1 – C1 or B2 – C2 along the performance curve N1
or N2, the throttle valves 29, 30, variable according to the output delivery, are closed.

For example, if the pump 2 reaches the point C2, i.e. its maximum pressure, and if less and less output is taken up by the working circuit 4, then the pressure regulating valve 28 (replacing the overpressure valve 22) will respond, and will connect the working circuit 4 with the adjusting piston of the servo-motor 6, whereupon the hydraulic pump 2 adjusted to reduce its delivery. This causes the crosshead 20 and the throttle valve link 32, to open the adjustable throttle valve 30. The effect of this on the output adjustment of the pump 1, as described with reference to Fig. 1, is that the performance curve is shifted from the curve N1 towards the curve N1', so that the pump 1 can now operate at a higher output in such a way that the entire drive output is again utilized by the two pumps.

For constructional and economic reasons it is advisable to unite the function of the adjusting throttle valves 17 or 18 with the function of the throttle valves 24 or 23. For this purpose the throttle valves 23 or 24 may be so designed that their closure by the adjusting pistons 25 and 26 is multiply limited; thus, they may be closed up to only a preset degree, when points B2 or B1 are reached.

By connecting in parallel further throttle valves (not shown) with the throttle valves 17, 18, 23, 24, 30 or 31, it is possible without further difficulty to affect additionally the setting and/or the adjustment of the power control device, and thus to include in the power control further parameters, e.g. the output take-up of additional units, which are also driven by the common driving apparatus.

The concept of the invention may also be applied to more than two hydraulic pumps, when the pumps are, as regards power control, suitably considered pairwise, to carry out in connection with other pumps or pairs of pumps a control according to the invention.

To those skilled in the art to which this invention relates, many changes in construction and widely differing embodiments and applications of the invention will suggest themselves without departing from the spirit and scope of the invention. The disclosures and the description herein are purely illustrative and are not intended to be in any sense limiting.

I claim:

1. A power control apparatus for two or more adjustable hydraulic pumps, driven by a common driving means and each having its own power regulator, including a power control device for each pump for continuously adjusting the regulator to maintain a desired power value of the associated pump, and a pressure responsive device in fluid communication with and responsive to the delivery pressure of the companion pump and arranged to adjust the power of its own associated pump according to the said delivery pressure of the companion pump, and wherein the power control device of each pump comprises a pilot valve acting on a spring, the force of which depends on the delivery flow adjustment of its associated pump, said pilot valve having a piston surface in fluid communication with and acted on by a control pressure depending upon the delivery pressure of its associated pump, the power control device of each pump also comprises two restricted orifices connected in series and in fluid communication with the output of its associated pump, and wherein said control pressure is derived from a point between the two restricted orifices connected in series whilst the pressure responsive device comprises a throttle valve adjustable in accordance with the delivery pressure of the companion pump and connected in parallel with one of the restricted orifices, said pilot valve having a piston surface in fluid communication with and acted on by a control pressure depending upon the delivery pressure of its associated pump, the power control device of each pump also comprises two restricted orifices connected in series and in fluid communication with the output of its associated pump, and wherein said control pressure is derived from a point between the two restricted orifices connected in series whilst the pressure responsive device comprises a throttle valve adjustable in accordance with the delivery pressure of the companion pump and also connected in parallel with the restricted orifice and the pressure responsive throttle valve.

3. Control apparatus according to claim 1, in which an adjustable throttle valve constitutes said one of the restricted orifices.

4. Control apparatus as claimed in claim 2, in which the pressure-responsive throttle valve closes as the delivery pressure of the companion pump increases, and the flow-responsive throttle valve opens as the flow of the companion pump decreases, and the arrangement is such that in the regulation range of the power control device the two throttle valves are closed, or offer a maximum restriction.