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Appel

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[54] **HYDRAULIC DRIVE ARRANGEMENT**

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[52] **U.S. Cl.** **60/445,** 60/447, 60/448, 60/494

[51] **Int. Cl.** **F16h 39/46**

[58] **Field of Search** 60/443, 444, 445, 447, 60/448, 19, 463, 494

[56] **References Cited**

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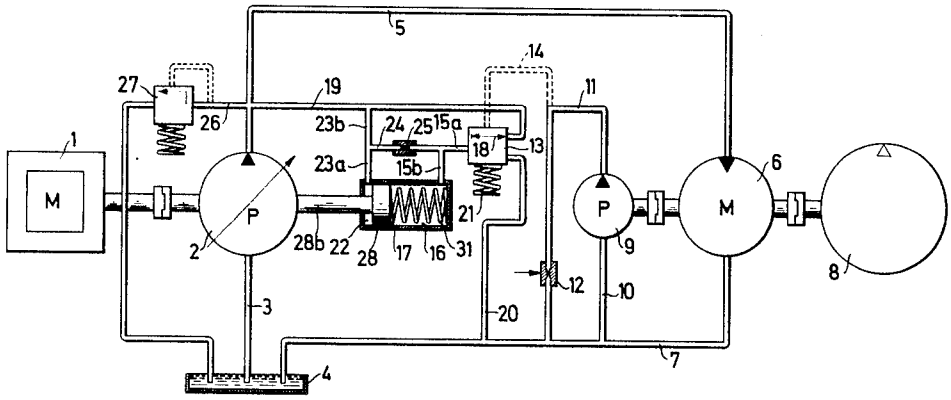
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Primary Examiner—Edgar W. Geoghegan

[57] **ABSTRACT**

A variable-output hydraulic pump is connected with a hydraulic motor, and each of them is also connected with a reservoir for hydraulic fluid. A cylinder and piston unit having a differential piston is connected with the hydraulic pump so as to vary the output thereof in dependence upon the movement of the piston. Movement of the piston in one direction is controlled by a force supplied in form of pressure which builds up in a conduit communicating with the hydraulic motor and the reservoir, and in which conduit a variable throttle is interposed so that the pressure varies as a function of the number of revolutions of the hydraulic motor.

5 Claims, 2 Drawing Figures



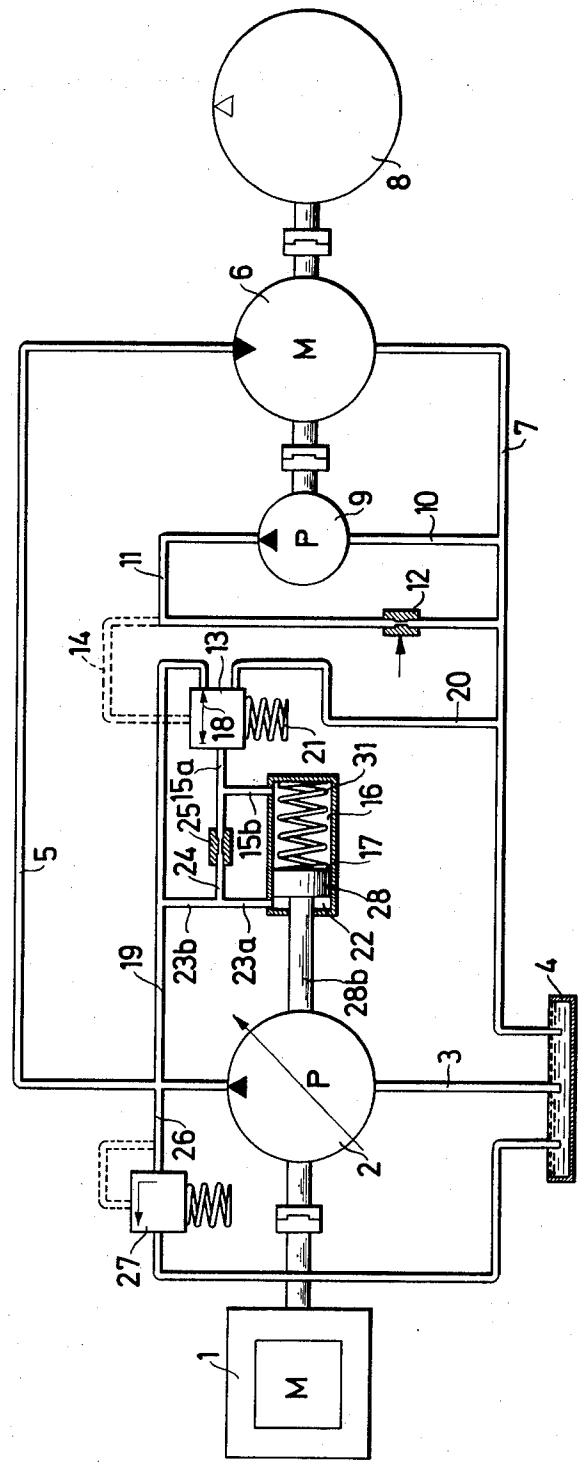

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FIG.1

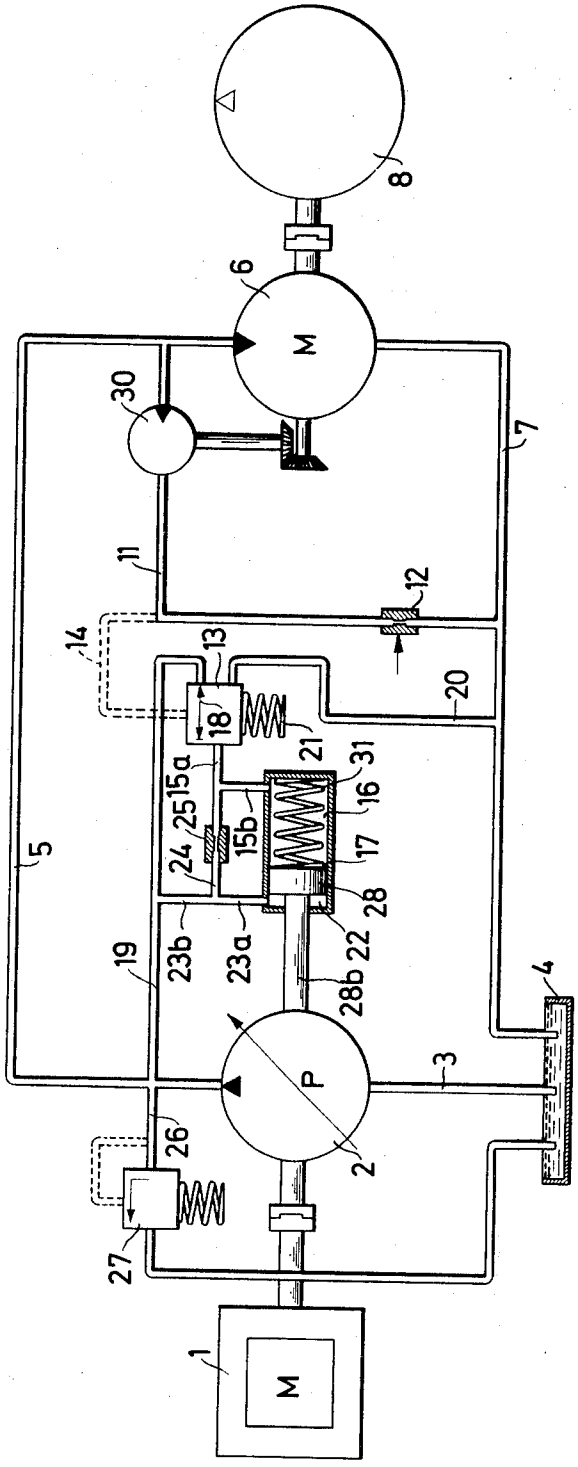

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FIG.2

HYDRAULIC DRIVE ARRANGEMENT

BACKGROUND OF THE INVENTION

The present invention relates to a hydraulic drive arrangement, and more particularly to a hydraulic drive arrangement having a variable-output hydraulic pump and a hydraulic motor driven by the pump, and an arrangement for controlling the operation of the pump as a function of the operation of the motor.

It is known in the prior art to provide hydraulic drive arrangements, particularly for high output capacities, having an arrangement for maintaining the output rpm constant despite variable input rpm. This type of arrangement is used in various applications, for instance it is known to interpose such an arrangement between a combustion engine having variable rpm characteristics and a compressor or a generator. The purpose here is to assure a constant number of revolutions for the compressor or generator despite the fact that the number of revolutions of the combustion engine varies.

The known arrangements of this type have a throttle which is interposed in the pressure conduit and whose pressure drop is maintained constant by a valve which acts upon the output-adjusting element of the hydraulic pump, in order to obtain a constant fluid feed of the pump despite a variable rpm of the pump occasioned by the variable rpm of the combustion engine which drives the pump. In these prior-art arrangements the entire amount of fluid being pumped must pass through the throttle. This is acceptable in hydraulic drives of low output capacity, but in hydraulic drives of high output capacity — where substantial amounts of fluid must be pumped — the losses incurred with such an arrangement are of such magnitude that they make the use of the arrangement economically impossible.

SUMMARY OF THE INVENTION

It is, accordingly, a general object of the present invention to overcome the disadvantages of the prior art.

More particularly it is an object of the present invention to provide a hydraulic drive arrangement of the general type outlined above, which avoids the aforementioned disadvantages.

An additional object of the invention is to provide such a hydraulic drive arrangement which is particularly although not exclusively suitable for high output use but which will, contrary to the prior art, have relatively small losses.

In keeping with the above objects, and with others which will become apparent hereafter, one feature of the invention resides in an arrangement of the character described above, having a combination comprising a variable-output hydraulic pump, a hydraulic motor, a reservoir for hydraulic fluid, and first conduit means connecting the pump with the reservoir and with the motor. Varying means is provided for varying the output of the pump, comprising a cylinder and a differential piston in the cylinder which divides the interior of the latter into two axially spaced chambers. Second conduit means connects one of the chambers with the first conduit means, and the third conduit means connects the motor with the reservoir. Fourth conduit means connects the first conduit means in the region upstream of the motor with the reservoir, and fifth conduit means connects the fourth conduit means with the other of the chambers. The throttling means is interposed in the fourth conduit means intermediate the fifth conduit means and the reservoir, and variable valve means is interposed in the fifth conduit means and communicates with the reservoir. The valve means is controlled by pressure which develops in the fourth conduit means upstream of the throttling means and serves to vary the extent to which the other chamber can communicate with the reservoir.

With this arrangement the pressure losses are determined exclusively by the amount of control fluid which passes through the throttle, not by the entire amount of hydraulic fluid being pumped by the variable-output pump. Only a small amount of fluid is necessary for controlling the valve means, and therefore the losses incurred for maintaining the output of the drive constant, can be small and therefore are within the range of economic feasibility. It is advantageous, although not necessary, that the stream of control fluid which passes through the throttle and which acts upon the variable valve means is produced by an auxiliary hydraulic pump which is coupled with the hydraulic motor to be driven by the same.

However, in place of the pump the stream of control fluid can also be constituted by the amount of hydraulic fluid which passes through an auxiliary hydraulic motor connected with the pressure conduit of the variable-output hydraulic pump. In this case the adjustable throttle can be utilized in a simple manner for varying the rpm of the hydraulic motor.

The novel features which are considered as characteristic of 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 DRAWING

FIG. 1 is a diagrammatic view illustrating one embodiment of the invention; and

FIG. 2 is a view similar to FIG. 1 but illustrating a somewhat different embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Discussing now the drawing in detail, and referring firstly to FIG. 1, it will be seen that reference numeral 1 diagrammatically identifies a combustion engine which operates at variable rpm. The combustion engine is coupled with and drives a variable-output hydraulic pump 2 which is of any well-known construction and therefore requires no detailed description. A suction conduit 3 connects the hydraulic pump 2 with a reservoir 4 for hydraulic fluid, so that the pump 2 draws this fluid out of the reservoir 4 and pumps it via the pressure conduit 5 to a hydraulic motor 6 which is to be driven by the thus-pumped fluid. The fluid passes through the hydraulic motor 6, driving the same, and is returned to the reservoir 4 via the return conduit 7. The hydraulic motor 6 in turn is to be coupled with a user which is to be driven by it, for instance a diagrammatically illustrated compressor 8, which must be driven at constant rpm, a requirement which would be impossible of fulfillment if the compressor 8 were directly coupled with the combustion engine 1.

A small auxiliary hydraulic pump 9 is coupled with the hydraulic motor 6 and is driven by the same. The

pump 9 is connected with the conduit 7 by means of a suction conduit 10, so that it can draw a stream of control fluid from the conduit 7 via the conduit 10. This stream of control fluid is returned back into the conduit 17 via a pressure conduit 11 in which an adjustable throttle 12 is interposed. Upstream of the throttle 12 a conduit 14 communicates with the conduit 11; the conduit 14 leads to a variable control valve 13. Varying means for varying the output of the hydraulic pump 2 is provided, in form of a cylinder and piston unit 17 the cylinder of which is subdivided into two cylinder chambers 16 and 22 by a differential piston 28 whose piston rod 28*b* is connected with the hydraulic pump 2, that is with the component thereof which effects the adjustment of its variable output. The valve 13 connects the cylinder chamber 16 via the conduit portions 15*a* and 15*b* either with the conduit 19 which communicates with the pressure conduit 5, or with the conduit 20 which communicates with the return conduit 7, depending upon the position of the valve member 18 in the valve 13. The valve member 18 is urged by a spring 21 to a position in which the conduit 19 is in communication with the conduit portion 15*a*. It can be biassed to a position connecting the conduit 20 with the conduit portion 15*a* when it is subjected to a control pressure acting upon it from the interior of the control conduit 14.

The cylinder chamber 22 is connected with the conduit 19 via the conduit portions 23*a* and 23*b*, so that it is at all times and in all operating conditions at the same pressure which prevails in the conduit 5. In addition, the cylinder chamber 22 is connected with the cylinder chamber 16 via a conduit 24 in which a fixed throttle 25 is interposed. The conduit 24 will be seen to communicate with the conduit portions 23*a*, 23*b* as shown. To prevent the possibility of damage, a pressure limiting valve 27 is connected with the pressure conduit 5 via a conduit portion 26.

The operation of the arrangement thus far described will already be evident from what has been set forth above. When the combustion engine 1 is started, the spring 31 accommodated in the cylinder chamber 16 initially urges the piston 28 towards the left in FIG. 1, so that the hydraulic pump 2 is originally set for maximum output. The hydraulic motor 6 and the small auxiliary hydraulic pump 9 coupled with the same, are driven in accordance with the amount of hydraulic fluid which is pumped per unit of time and which depends upon the throughput volume and the rpm of the hydraulic pump 2. The stream of hydraulic fluid which is pumped by the auxiliary pump 9 causes upstream of the adjustable throttle 12 a fluid-pressure build-up which is communicated via the conduit 14 to the valve member 18 of the valve 13, so that a pressure is exerted upon the valve member 18 in a sense displacing the latter to a position in which the valve 13 establishes a communication of the cylinder chamber 16 with the reservoir 4 via the conduit portions 15*a*, 15*b* and the conduit 20, as well as the return flow conduit 7. Once this communication is established, the initially prevailing pump pressure in the cylinder chamber 16 is reduced, depending upon the extent to which the valve 13 is opened. The farther the valve 13 opened, the smaller the pressure will become in the cylinder chamber 16. The extent to which the valve 13 is opened is in turn dependent upon the pressure which exists in the conduit 14 in dependence upon the setting of the adjustable throttle 12 and upon the amount of fluid being pumped by the auxiliary pump 9.

When the pressure in the cylinder chamber 16 drops to a magnitude — due to an appropriate opening of the valve 13 — at which the force acting in the cylinder chamber 22 upon the piston 28 is greater than the force acting in the cylinder chamber 16 (and composed of the pressure therein as well as the force of the spring 31), then the piston 28 with piston rod 28*b* moves towards the right in the chamber 16. In so doing the piston rod 28*b* displaces the control element of the variable-output hydraulic pump 2 in a sense reducing the output of the pump. This means that although the number of revolutions per minute performed by the pump 2 does not change, the amount of fluid being pumped by the pump 2 per unit of time is now decreased. This decrease, in turn, results in a reduction in the number of revolutions per minute performed by the hydraulic motor 6, and therefore in a decrease of the amount of fluid being pumped by the pump 9 which is coupled with the motor 6. This, in turn, causes a reduction in the amount of fluid pressure which exists upstream of the throttle 12, so that the pressure acting upon the valve member 18 decreases and permits the spring 21 to displace the valve member 18 upwardly. When this takes place, the flow-through cross-section opened in the valve 13 also decreases and, correspondingly, the pressure in the cylinder chamber 16 can increase so that the piston 28 with the piston rod 28*b* is again displaced towards the left in the chamber 22. This movement towards the left continues only until the forces acting upon the piston 28 in the chambers 16 and 22 are in equilibrium. The movement of the piston 28 towards the left in the chamber 22 of course results in an adjustment of the output of the hydraulic pump 2 towards a greater amount of fluid being pumped per unit of time, with the revolutions per minute remaining constant. The greater amount of fluid being pumped per unit of time increases the number of revolutions of the hydraulic motor 6 and results in an increase in the amount of fluid being pumped by the auxiliary pump 9 so that the pressure upstream of the throttle 12 incresaes again. This series of adjustments resulting from the feedback-effect built into the novel arrangement according to the present invention will finally cause the amount of liquid being pumped by the pump 2 — and therefore the number of revolutions per minute performed by the hydraulic motor 6 — to be regulated so as to assume a constant value independently of the number of revolutions per minute performed by the combustion engine 1 which drives the pump 2. This value can be determined by the setting of the flow-through cross-section of the throttle 12. Evidently, the more the throttle 12 decreases the flow-through cross-section, the smaller will the amount of fluid be which has to be pumped by the auxiliary pump 9 to obtain a pressure required for controlling the valve 13.

It will be evident that since the auxiliary pump 9 is coupled with the hydraulic motor 6, and since the number of revolutions of the latter thus determine the amount of fluid being pumped by the pump 9 per unit of time, a small flow-through cross-section set with the adjustable throttle 12 will cause a small number of revolutions for the motor 6, whereas a large flow-through cross-section will cause a large number of revolutions for the motor 6 to be selected. It will be appreciated that the number of revolutions of the motor 6 can also

be determined by an appropriate selection of the force of the spring **21** acting upon the valve member **18** of the valve **13.** The embodiment in FIG. **2** is analogous to that of FIG. **1**; like the reference numbers identify like elements. FIG. **2** differs from FIG. **1** in that the auxiliary pump **9** is replaced by a small auxiliary hydraulic motor **30** which is coupled with the hydraulic motor **6** and connected with the pressure conduit **5** upstream of the connection of the latter with the hydraulic motor **6.** The amount of hydraulic fluid which passes through a hydraulic motor per unit of time is dependent upon the number of revolutions of the hydraulic motor per unit of time, just as is the amount of hydraulic fluid being pumped per unit of time by a hydraulic pump. That being the case it will be appreciated that in the embodiment of FIG. **2** it is the variation in the amount of fluid which can pass through the hydraulic motor **30** per unit of time which causes in the conduit **11** upstream of the throttle **12** the development of the pressure necessary for controlling the operation of the valve **13.** In this embodiment, however, it is necessary to take care that the auxiliary hydraulic motor **30** is constructed to be able to withstand the full operating pressure of the arrangement, because otherwise it would become damaged.

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 a hydraulic drive arrangement, it is not intended to be limited to the details shown, since various modifications and structual 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 be 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:

1. In an arrangement of the character described, a combination comprising a variable-output hydraulic pump; a hydraulic motor; a reservoir for hydraulic fluid; first conduit means connecting said pump with said reservoir and said motor; varying means for varying the output of said pump, comprising a cylinder, and a differential piston in said cylinder and dividing the interior thereof into two axially spaced chambers; second conduit means connecting one of said chambers with said first conduit means; third conduit means connecting said motor with said reservoir; fourth conduit means connecting said first conduit means in the region downstream of said motor with said reservoir; fifth conduit means connecting said fourth conduit means with the other of said chambers and communicating with said reservoir; variable valve means in said fifth conduit means; and throttling means communicating with said reservoir and with said variable valve means, said valve means being controlled by pressure which develops at said throttling means and varying the extent to which said other chamber can communicate with said reservoir.

2. A combination as defined in claim **1**; and further comprising an auxiliary hydraulic pump coupled with said hydraulic motor to be driven thereby, said pump communicating with said fourth conduit means.

3. A combination as defined in claim **1,** wherein said throttling means comprises an adjustable throttle.

4. A combination as defined in claim **1**; and further comprising an auxiliary hydraulic motor interposed in said first conduit means intermediate said pump and the first-mentioned hydraulic motor.

5. In an arrangement of the character described, a combination compressing a variable-output hydraulic pump; a hydraulic motor operable at different numbers of revolutions per unit of time; a reservoir of hydraulic fluid; conduits connecting said pump and motor with one another, and connecting each of them with said reservoir; a differential cylinder-and-piston unit connected with said pump for varying the output thereof; and means, including a variable valve and throttle which communicates with said valve and determines the variable setting thereof, operatively associated with said unit and said motor for adjusting the former the thereby the output of said pump, as a function of the number of revolutions of said motor per unit of time.

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