United States Patent [19]

Capelle et al.

[11] **3,897,174**

[45] **July 29, 1975**

[54] **DEVICES FOR FEEDING FLUID UNDER PRESSURE TO AT LEAST TWO LOAD CIRCUITS**

[75] Inventors: **Michel F. Capelle; Claude Pinson,** both of Senlis, France

[73] Assignee: **Societe Anonyme: Poclain,** Oise, France

[22] Filed: **Apr. 29, 1974**

[21] Appl. No.: **464,840**

[30] **Foreign Application Priority Data**

May 28, 1973 France 73.19331

[52] **U.S. Cl.** **417/216;** 60/421; 60/428

[51] **Int. Cl.²**..................... **F16D 31/02;** F04B 49/00

[58] **Field of Search** 60/421, 422, 428, 430; 417/216

[56] **References Cited**

UNITED STATES PATENTS

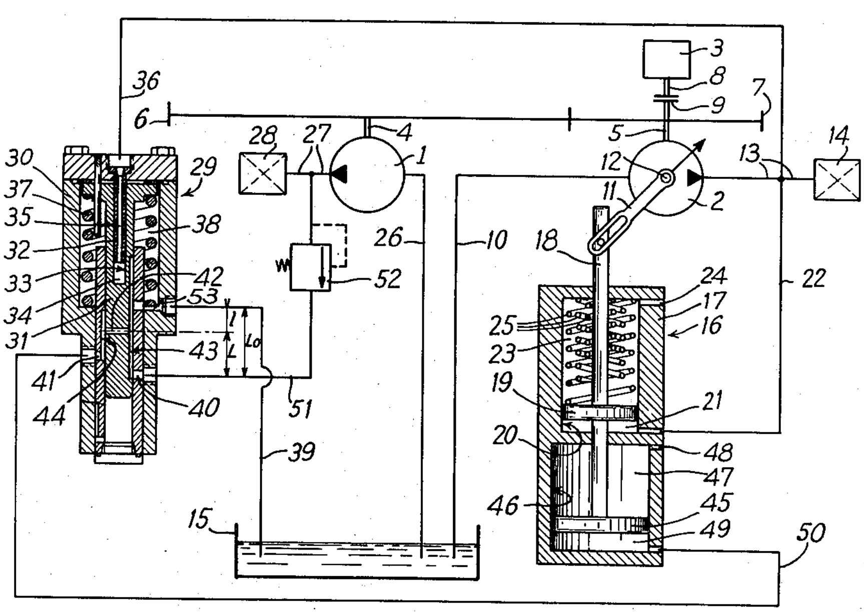
2,316,926	4/1943	Willett	60/421
3,355,994	12/1967	Malott	60/422
3,561,327	2/1971	Stremple	60/422
3,575,000	4/1971	Hufeld	60/422
3,767,327	10/1973	Wagenseil	417/216

Primary Examiner—William L. Freeh
Assistant Examiner—G. P. LaPointe
Attorney, Agent, or Firm—Fitzpatrick, Cella, Harper & Scinto

[57] **ABSTRACT**

In a device for feeding fluid under pressure to at least two load circuits, of which one has priority, the power required to drive a group of constant flow pumps connected to the priority load circuit is subtracted from the power of the motor driving this group of pumps and a second group of variable flow pumps connected to the non-priority load, the difference in the powers being used for the second group of variable flow pumps, the subtraction being effected by a valve coupled in a pipe connecting the delivery pipe from the constant flow group of pumps and an inlet chamber of a regulator of the group of variable flow pumps, the valve providing a variable fluid constriction which is varied in dependence on the pressure in the delivery pipe of the group of variable flow pumps.

5 Claims, 2 Drawing Figures



PATENTED JUL 29 1975

3,897,174

SHEET 1

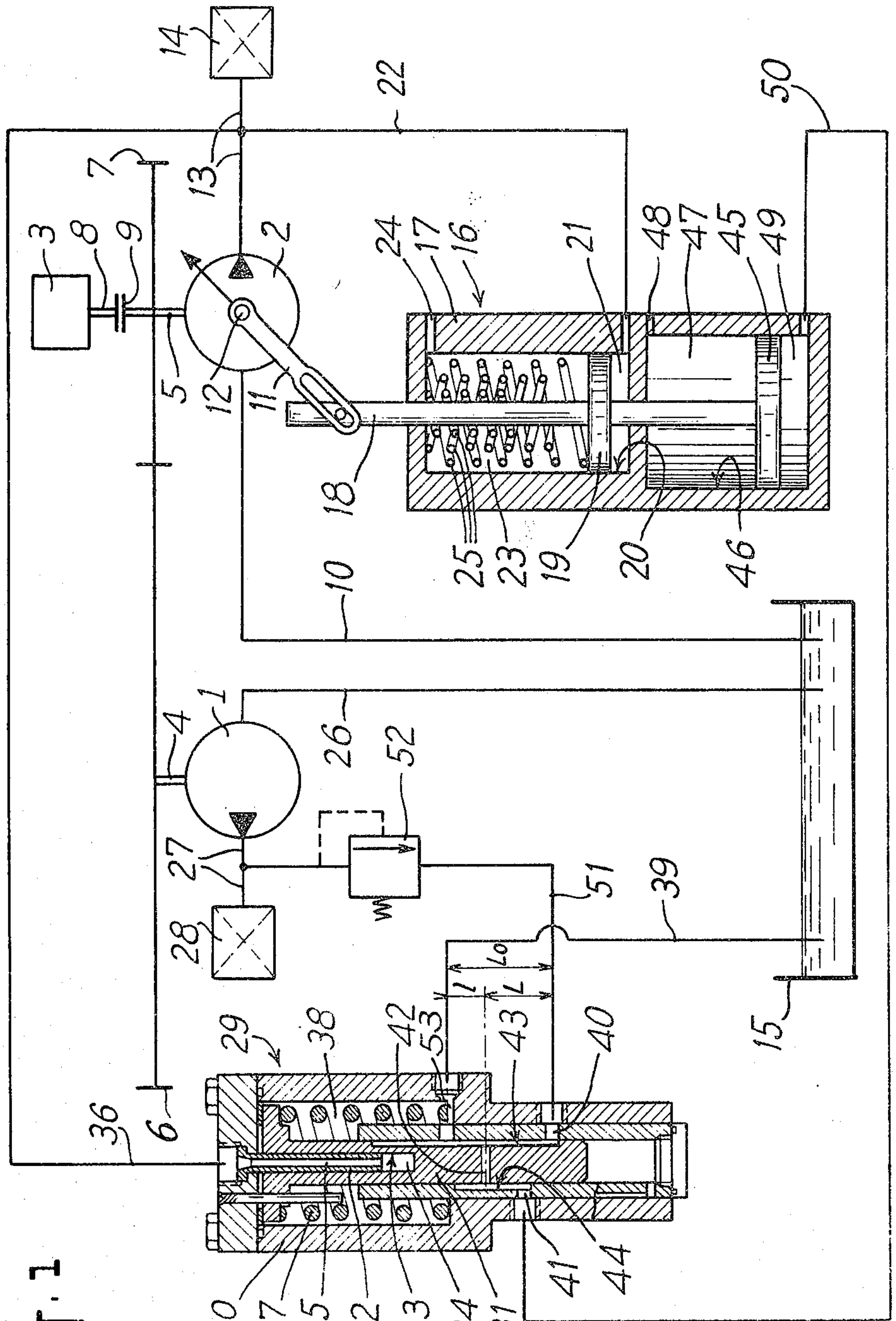
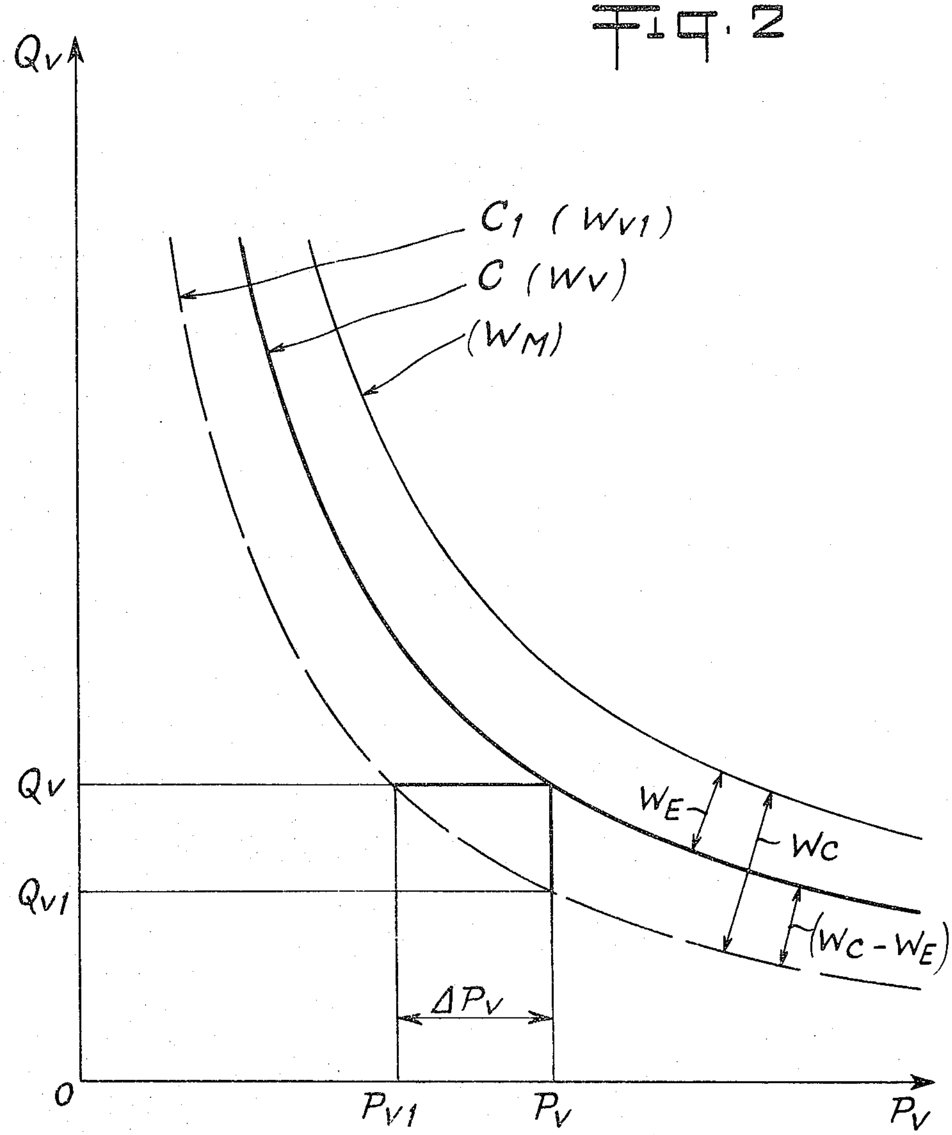


Fig. 1

FIG. 2



DEVICES FOR FEEDING FLUID UNDER PRESSURE TO AT LEAST TWO LOAD CIRCUITS

The present invention relates to improvements in devices for feeding fluid under pressure to at least two load circuits.

Devices are already known for feeding fluid under pressure, of which the single motor for driving various pumps has a maximum power less than the sum of the maximum powers of the pumps.

It can happen in the simplest case that one of the pumps has a constant flow and feeds a circuit which is considered to have priority, another of the pumps being variable-flow and feeding another circuit which does not have priority.

A device must be conceived, for use in the case in which the sum of the powers necessary at a given moment for driving these two pumps in greater than the maximum power of the motor, which enables driving of the constant-flow pump with the required power, and hence the feeding of the priority circuit to be continued, and automatically limits the driving power to the variable-flow pump so that the total power necessary for the driving of the pumps remains less than or at most equal to the maximum power of the motor.

According to the present invention there is provided a device for feeding fluid under pressure to at least two load circuits, comprising:

two groups of pumps for feeding fluid to a respective one of said load circuits and each including a pump, a driving shaft and a delivery pipe, one of said groups of pumps being constant-flow, and the other of said groups of pumps being variable-flow,

driving motor means having a single output shaft to which are coupled the driving shaft of said pumps,

power regulator means including a body and an element movable with respect to the body and which is coupled between the flow control means and the body of said variable-flow group of pumps, said regulator including ram means interposed between said body and said movable element of said regulator and comprising an inlet chamber,

pipe means connecting the delivery pipe from said constant flow group of pumps to said inlet chamber, and

a valve arranged in said connecting pipe means and comprising a body, a slide movably mounted in said body, an inlet connected to said delivery pipe by said connecting pipe means, two outlets of which a first outlet is connected to a fluid tank and the second outlet is connected to said inlet chamber of said ram means by said connecting pipe means, a fluid connection for control of the position of said slide, said fluid connection being connected to the delivery pipe of said variable-flow group of pumps, and a passage between said body and said slide of said valve at least one of the dimensions of which varies as a function of the position of the said slide in said body, said inlet, said first outlet and said second outlet being in permanent communications with said passage, said second outlet communicating with said passage at a region intermediate communication of said inlet and said first outlet with said passage, and the portion of said passage lying between the regions of communication of said inlet and said second outlet with said passage forming a variable fluid constriction.

Advantageously the device includes a calibrated valve arranged in said connecting pipe means between said valve and the connection of said connecting pipe means to said delivery pipe of said constant-flow group of pumps, to be piloted by the pressure of fluid in said delivery pipe.

Preferably the slide is mounted to slide in said body of said valve, is coupled to the movable member of a ram assembly, and is subjected to the effect of the pressure of the control fluid and the opposing action of a return member coupled between said slide and said body of said valve.

Advantageously said passage is defined by a groove in the outer face of said slide of said valve and a channel in said slide and connecting said groove with a recess in said body of said valve which is connected to said second outlet from said valve, said groove being permanently connected to said inlet and said first outlet, the value of said variable constriction being proportional to the distance separating the regions of communication of said first and second outlets with the passage.

The power regulator may include a second ram assembly which is interposed between its body and movable element and comprises an inlet chamber connected to said delivery pipe of said variable-flow group of pumps, a return member being interposed between said body and said movable element of said regulator and having an effect opposed to that of fluid when contained in the inlet chamber of the first ram assembly.

The invention will be better understood from the following description of an embodiment thereof, given by way of example only, with reference to the accompanying drawings, in which:

FIG. 1 is a diagrammatic view of an embodiment of a feeding device in accordance with the invention, showing part thereof in section; and

FIG. 2 is a graph illustrating the functioning of the feeding device of FIG. 1.

The device illustrated comprises a constant-flow pump **1** and a variable-flow pump **2**, which are driven in rotation by a single motor **3** of diesel type. In order to do this, the respective driving shafts **4** and **5** of the two pumps **1** and **2** are each furnished with a pinion **6**, **7** which is angularly fast therewith, the two pinions **6** and **7** meshing with one another. In addition, the output shaft **8** of the motor **3** is coupled in rotation to the driving shaft **5** of the variable-flow pump **2** by a known coupling **9**.

It should be made clear that the maximum power of the motor **3** is less than the sum of the maximum powers necessary for driving the pumps **1** and **2**. It is precisely in order to enable satisfactory operation, while using a motor **3** of only relatively limited power, that the feeding device which will now be described has been devised.

The variable-flow pump **2** is of a known type, for example, of the type with axial pistons arranged in a manner similar to a barrel, and furnished with a member for controlling its flow, which is indicated diagrammatically by a rod **11** mounted to pivot about point **12** and which in the assembly of an axial piston pump consists of a tiltable plate. The pump **2** has its delivery pipe **13** connected to a load circuit **14** and is connected to a fluid tank **15** by its suction pipe **10**.

A power regulator **16** comprises a regulator body **17**, which is fixed to the body of the pump **2**, and a movable element which, in this instance, consists of a rod **18** which is mounted to slide in the body **17** and which is coupled to the rod **11**. In known manner, a piston **19** is fast with the rod **18** and is mounted to slide in the bore of a cylinder **20**. The piston **19** with the body **17** of the regulator defines two chambers **21** and **23**. Chamber **21** is connected by a pipe **22** to the delivery pipe **13** of the variable-flow pump **2**, and chamber **23** is connected to atmosphere (or possibly to the fluid tank **15** under zero pressure) by a channel **24**. A number of springs **25** of different stiffnesses and lengths are arranged in chamber **23** and are interposed between the piston **19** and the body **17** to have an effect opposing that of fluid in the chamber **21**.

Again in known manner, the combination of these springs **25** and the ram assembly, constituted by the piston **19** and the cylinder **20**, enables a substantially hyperbolic variation of the flow Q_v from the variable-flow pump **2** as a function of the delivery pressure P_v from this pump, equal to the pressure of the fluid contained in the pipe **13** or the chamber **21**, to be obtained. Substantially one has:

$$P_v \times Q_v = \text{constant} = W_v;$$

each of the curves C, C_1 in FIG. 2 corresponds with such a constant product which, as is known, is equal to the driving power W_v of the pump **2**.

The constant flow pump **1** is connected by its suction pipe **26** to the fluid tank **15** and by its delivery pipe **27** to a load circuit **28**.

A valve **29** to be called a power subtraction valve (which designation will be understood later) is included in the feeding device. The valve **29** consists of a valve body **30** inside which a slide **31** is mounted to slide with respect to the body **30** and with respect to a member **32** fixed relative to the body **30**. A bore **33** is provided in the slide **31** in which the member **32** is received, the slide **31** sealing against the member **32**. The member **32** and slide **31** together constitute a ram assembly which includes a chamber **34**. This chamber **34** is bounded by the member **32** and the wall of bore **33** and is connected to the outside of the body **30** by a duct **35** in the member **32**. The duct **35** is connected to the delivery pipe **13** of the variable-flow pump **2** by a pipe **36**. In addition, a spring **37** is interposed between the body **30** of the regulator and the slide **31** and has an effect which is opposed to that of the pressure of fluid in the chamber **34**. The spring **37** is housed in a chamber **38** which is in return communication with the tank **15** through a leakage return pipe **39** connected to a first outlet aperture **53** in the body **30**.

The valve body **30** is provided with an inlet aperture **40** and a second outlet orifice **41** which are in permanent communication with one another by means of a channel **42** extending transversely in the slide **31**, a groove **43** provided in the periphery of the slide and into which the inlet aperture **40** and the first outlet aperture **53** open permanently, and a recess **44** which is arranged in the body **30** and into which the channel **42** and the outlet aperture **41** open permanently. L_o is the distance separating the transverse planes through the apertures **40** and **53**, L is the distance separating the transverse planes through the channel **42** and the inlet aperture **40** and l ($= L_o - L$) is the distance separating the transverse planes through the first outlet orifice **53** and the channel **42**. It will be appreciated that the distance L (and therefore the distance l) is variable as a function of the pressure in the chamber **34** and of the stiffness of the spring **37**. The portion of the groove **43** of length L constitutes a constriction of variable value which is inversely proportional to the pressure in the chamber **34**, interposed between the inlet aperture **40** and the outlet aperture **41**, and the pressure in the channel **42** is in turn proportional to the distance l.

A second piston **45** is fast with the rod **18** of the power regulator **16** and is mounted to slide in a cylinder **46** fast with the body **17** of this regulator. The piston **45** defines two chambers **47**, **49**. Chamber **47** is connected to atmosphere through a duct **48**, and chamber **49** is connected to the outlet aperture **41** of the valve **29** by a pipe **50**.

A pipe **51** connects the delivery pipe **27** of the constant-flow pump **1** to the inlet aperture **40** of the valve **29**. A calibrated valve **52** is arranged in the pipe **51** and is piloted in a known manner by the pressure of fluid in the delivery pipe **27** (or in the portion of the pipe **51** between the delivery pipe **27** and the calibrated valve **52**). The calibration pressure of the valve **52** will be made clear later.

The functioning of the feeding device will now be set down. Let there be designated by:

W_M	the maximum power of the motor 3,
W_V, P_V, Q_V	the power, the pressure, and the flow of the variable-flow pump 2,
W_c, P_c, Q_c	the maximum power, the pressure and the flow of the constant flow pump 1.

In known manner one has:

$$W_v = P_v \times Q_v \quad (1)$$

$$W_c = P_c \times Q_c \quad (2)$$

Two functionings are possible:

$$W_m \geq (W_v + W_c) \quad (3)$$

$$(W_v + W_c) > W_m \geq W_c \quad (4)$$

The inequality (3) indicates that the power of the motor **3** is greater than the sum of the powers necessary for driving the pumps **1** and **2**. In that case there is clearly no problem of regulation.

On the other hand the double inequality (4) indicates that the power of the motor **3** may be sufficient for driving solely the constant-flow pump **1** but is insufficient for driving the two pumps **1** and **2** together. Now, assuming that the circuit **28** connected to the constant-flow pump **1** must be driven as a priority, and consequently the pump **1** must be driven at power W_c, it is absolutely necessary to accept driving the variable-flow pump **2** at only a reduced power W_{vl}:

$$W_v l = W_m - W_c \quad (5)$$

Naturally, if the power W_m of the motor **3** is greater than the power W_v for driving the variable-flow pump **2** it is sensible to start by placing at the disposal of the constant-flow pump **1** the excess of power W_E of the motor **3**, before starting to reduce the power available for driving the variable-flow pump **2**. If:

$$W_M > W_V \quad (6)$$

$$W_M = W_V + W_E \quad (7)$$

$$W_E = P_{CE} \times Q_C \quad (8)$$

P_{CE} being the delivery pressure of the constant-flow pump 1 corresponding to the excess power W_E. It is only when P_C becomes greater than P_{CE} that the driving power to the pump 2 must be reduced. The graph in FIG. 2 makes clear the sharing of power which has just been indicated. It is a question of performing the subtraction:

$$W_{Vl}=W_V-(W_C-W_E) \qquad (9)$$

which is deduced otherwise from comparison of (5) and (7).

The regulator **16** in principle knows nothing of the functioning of the constant-flow pump **1**. For the regulation of the variable-flow pump **2** to take into account the power already taken off first from the total power W_M of the motor **3** for the driving of the pump **1**, the regulator **16** has to be connected by the pipe **50** to the valve **29**. One has to pass from the operation represented by the curve C to that represented by the curve C_l. On this curve C_l one has:

$$W_{Vl}=P_V\times Q_{Vl} \qquad (10)$$

$$W_{Vl}=P_{Vl}\times Q_V \qquad (11)$$

according as one accepts reducing the flow from Q_V to Q_{Vl} or reducing the pressure from P_V to P_{Vl} of the variable-flow pump **2**, the pressure P_V or the flow Q_V respectively remaining constant.

By means of the piston **45** the regulator **16** can take into account the power (W_C-W_E) to be subtracted and which corresponds in fact in a simple manner for the pump **2** in a reduction ΔP_V in its delivery pressure, the flow Q_V remaining constant:

$$\Delta W_V=W_V-W_{Vl} \qquad (12)$$

$$\Delta W_V=(W_C-W_E) \qquad (13)$$

$$\Delta W_V=P_V\times Q_V \qquad (14)$$

with

$$P_V=P_V-P_{Vl} \qquad (15)$$

ΔW_V being the power having to be subtracted from W_V in order to enable effective driving of the two pumps **1** and **2** by the motor **3**. By comparing and combining (14), (13), (8), (2) and (1) one obtains successively:

$$\Delta P_V=\Delta W_V/Q_V$$
$$\Delta P_V=(W_C-W_E)/Q_V$$
$$\Delta P_V=(P_C\times Q_C-P_{CE}\times Q_C)/Q_V$$
$$\Delta P_V=Q_C\times(P_C-P_{CE})\times P_V/(P_V\times Q_V)$$
$$\Delta P_V=(P_C-P_{CE})\times P_V\times(Q_C/W_V) \qquad (16)$$

The valve **29** enables ΔP_{Vl} to be obtained proportional to ΔP_V, the coefficient of proportionality being constant for a given feeding device. This pressure ΔP_{Vl} acts on the piston **45** and provides a force which is added to the force from the pressure P_{Vl} acting on the piston **19**. The system of regulation in that case functions as if the delivery pressure from the variable-flow pump **2** were equal to P_V and corresponded with the curve $C(W_V)$ whereas in fact the pump **2** functions in accordance with the curve C_1 (W_{Vl}). That is, the pressure of the fluid which enters through the inlet aperture **40** is equal to the difference (P_C-P_CE) between the delivery pressure P_C of the constant-flow pump and the calibration pressure of the valve **52**, which is exactly equal to P_CE. The pressure of the fluid which leaves the valve **29** through the outlet orifice **41** is deduced from the pressure of the inlet fluid except for the load loss. This pressure is therefore also in turn proportional to the difference (P_C-P_{CE}).

On the other hand, the constriction constituted by the length L_o of the groove **43** being of linear type, the pressure obtained in the channel **42** and consequently at the level of the outlet orifice **41** is proportional to the length l as has already been observed. The latter is obviously proportional to the pressure of the fluid contained in the chamber **34**, that is to say, still to the delivery pressure P_V of the variable-flow pump **2**.

Consequently, the pressure of the fluid which leavs the valve **29** through the aperture **41** is equal to:

$$\Delta P_{Vl}=(P_C-P_{CE})\times P_V\times K \qquad (17)$$

K being a constant proportionality coefficient, the value of which depends in particular upon the stiffness of the spring **37**.

If this pressure ΔP_{Vl} acted directly upon the piston **19** of the regulator **16** it would act upon the rod **18**, taking into consideration the springs **25**, in the same way as the pressure P_V of the fluid contained in the chamber **21**. It may be necessary to make it act upon piston **45** distinct from the piston **19**. If in that case S_{19} and S_{45} are the respective sections of the pistons **19** and **45**, the pressure of the fluid contained in the pipe **50** which is to act upon the piston **45** should have the value:

$$\Delta P_V=\Delta P_{Vl}\times(S_{45}/S_{19}) \qquad \text{(b 18)}$$

By replacing ΔP_V in (18) by the value quoted in (16) and ΔP_{Vl} by the value indicated in (17) one obtains:

$$(K\times S_{45})/S_{19}=Q_C/W_V \qquad (19)$$

The choice of the stiffness of the spring **37**, section of the bore **33**, and sections of the pistons **19** and **45**, Q_C and W_C being imposed functional values, enable the equation (19) to be very easily satisfied.

So doing, the power (W_C-W_E) is effectively subtracted from W_V which becomes W_{Vl}, equation (9) being realized, whilst the power W_C necessary for driving the constant-flow pump **1** is realized by the sum on the one hand of W_E, the excess power defined by the equation (7') derived from (7), and on the other hand of the power (W_C-W_E) previously subtracted from the driving of the variable-flow pump **2**.

$$W_C=W_E+(W_C-W_E) \qquad (20)$$

with

$$W_E=W_M-W_V \qquad 7')$$

Naturally, of course, the power W_M of the motor **3** is found to be equal to the sum of the powers necessary for driving the pumps **1** and **2**:

$$W_M=W_{Vl}+W_C=W_{Vl}+W_E+(W_C-W_E)$$
$$W_M=W_{Vl}+W_C \qquad (21)$$

The equation (21) is in fact nothing else but (5) rewritten in another form.

There is thus described a device which is simple in construction which enables its manufacture at not very high cost.

It will be appreciated that the above described device may be modified without departing from the scope of the invention.

Thus, of course, the regulation can be effected in the case of a number of variable-flow pumps. In this configuration the fluid in the pipe **36** has a pressure equal, not to the delivery pressure from one of the variable-flow pumps, but to the arithmetic mean of the delivery pressures of all the variable-flow pumps. The outlet pressure from the valve **29** (aperture **41**) may in that case be employed for shedding the load from either one or a number of the variable-flow pumps.

It will be appreciated that the presence of the calibrated valve **52** is only really interesting when:

$$W_M > W_V \qquad (6)$$

That is, if $W_M = W_V$ it is necessary, from the start of the regulation, to reduce W_V.

But it must likewise be observed that even if (6) is realized, the calibrated valve **52** is not indispensable. Nevertheless, if the calibrated valve **52** is not provided the excess power W_E and the pressure P_{CE} which corresponds to it will be considered as being equal to zero in the various equations so that from the very start of driving the constant-flow pump **1** its driving power W_C will be wholly subtracted from the driving power W_V to the variable-flow pump **2**. That can still be imagined by reason of simplification when W_C is relatively low and moreover $(W_M - W_V)$ is likewise low.

Purely by way of example, the load circuit **14** may consist of the circuit for translation of the hydraulic shovel, the load circuit **28** in that case consisting of the circuit for feeding the boom and the bucket of the shovel and being considered as priority during work on the site of public works.

Finally, it will be observed again that it is possible in order to increase the properties of regulation of the complete device, to arrange in one of the two pipes **50** or **51** a supplementary constriction which is variable and manually adjustable.

What is claimed is:

1. A device for feeding fluid under pressure to at least two load circuits, comprising:

two groups of pump means for feeding fluid to a respective one of said load circuits and each including a pump, a driving shaft and a delivery pipe, one of said groups of pump means being constant-flow and the other of said groups being variable-flow,

flow control means associated with said variable-flow group,

driving motor means having a single output shaft to which are coupled the driving shafts of said pumps,

power regulator means including a body and an element movable with respect to the body and which is coupled between the flow control means and the body of said variable-flow group of pump means, said regulator including ram means interposed between said body and said movable element of said regulator and comprising an inlet chamber,

pipe means connecting the delivery pipe from said constant-flow group of pump means to said inlet chamber, and

a valve arranged in said connecting pipe means and comprising a body, a slide movably mounted in said body, an inlet connected to said delivery pipe by said connecting pipe means, two outlets of which a first outlet is connected to a fluid tank and the second outlet is connected to said inlet chamber of said ram means by said connecting pipe means, a fluid connection for control of the position of said slide, said fluid connection being connected to the delivery pipe of said variable-flow group of pump means, and a passage between said body and said slide of said valve at least one of the dimensions of which varies as a function of the position of the said slide in said body, said inlet, said first outlet and said second outlet being in permanent communications with said passage, said second outlet communicating with said passsge at a region intermediate communication of said inlet and said first outlet with said passage, and the portion of said passage lying between the regions of communication of said inlet and said second outlet with said passage forming a variable fluid constriction.

2. A feeding device as claimed in claim **1**, including a calibrated valve arranged in said connecting pipe means between said valve and the connection of said connecting pipe means to said delivery pipe of said constant-flow group of pump means, to be piloted by the pressure of fluid in said delivery pipe.

3. A feeding device as claimed in claim **1**, wherein said slide is mounted to slide in said body of said valve and is bored to receive an elongate control fluid delivery member in sealing engagement therewith, said slide being movable relatively to said elongate member, and being subjected to the effect of the pressure of the control fluid and the opposing action of a return member coupled between the slide and said body of said valve.

4. A feeding device as claimed in claim **1**, wherein said passage is defined by a groove in the outer face of said slide of said valve and a channel in said slide and connecting said groove with a recess in said body of said valve which is connected to said second outlet from said valve, said groove being permanently connected to said inlet and said first outlet, the value of said variable constriction being proportional to the distance separating the regions of communication of said first and second outlets with the passage.

5. A feeding device as claimed in claim **1**, wherein the power regulator includes second ram means interposed between its body and movable element and comprises an inlet chamber connected to said delivery pipe of said variable-flow group of pumps, a return member being interposed between said body and said movable element of said regulator and having an effect opposed to that of fluid when contained in the inlet chamber of the first ram means.

* * * * *