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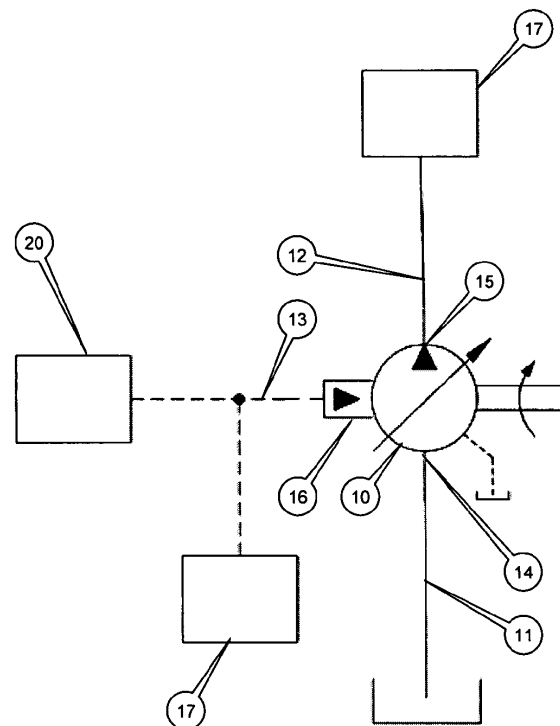
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(54) **A hydraulic system for a machine, a machine and a method of use**

(57) The present invention provides a hydraulic system for a machine comprising:  
a variable flow hydraulic pump (10), a low pressure input line (11), a high pressure output line (12) and a load sense line (13);  
the variable flow hydraulic pump (10) comprising a low pressure input (14) connected to the low pressure input line (11), a high pressure output (15) connected to the high pressure output line (12) and a load sense input (16) connected to the load sense line (13) for controlling the output flow at the high pressure output (15);  
the high pressure output line (12) being connected to an output device (17);  
the pressure at the load sense input (16) being variable in response to loads imparted on the output device (17);  
wherein the hydraulic system further comprises an ancillary pressure supply (20) connected to the load sense line (13) for boosting the pressure at the load sense input (16) of the variable flow hydraulic pump (10) to thereby boost the flow at the high pressure output (15).



**Fig. 1**

## Description

### Field

**[0001]** The present disclosure relates to a hydraulic system for a machine, a machine incorporating such a hydraulic system and a method of controlling a hydraulic system. In particular, the disclosure relates to improvements in connection with large work machines, such as used in the construction industry.

### Background

**[0002]** Large work machines having hydraulically controlled implements use a hydraulic system including one or more hydraulic pumps being driven by an internal combustion engine. The pumps are typically variable displacement pumps although fixed displacement pumps with an unloader valve are used. As the operator manipulates the hydraulically controlled implement through use of one or more levers, joystick or other control input devices, the hydraulic system responds by directing hydraulic fluid flow to the appropriate hydraulic circuits. Thus, the operator can request the implement to move in a desired direction at a prescribed velocity and to apply a desired amount of force by manipulating the appropriate input device.

**[0003]** As hydraulic load increases at the implement, the hydraulic control system increases the pressure to overcome that load. This type of system is called a 'load sensing' system.

**[0004]** The prior art discloses certain systems for adjusting the output flow of a variable flow pump of a hydraulic system under certain operating conditions.

**[0005]** For example, it is known from US5, 067, 321 to provide a system where the cracking pressure of an integral pressure relief valve (PRV) of a hydraulic circuit can be boosted. For operational safety, hydraulic circuits are usually provided with one or more PRVs to limit the maximum hydraulic loading within the circuit. If the maximum pressure is exceeded, for example where an unexpected transient load is imparted on the implement, the PRV actuates to safeguard the system components. In US 5,067,321 a system is described in which the PRV cracking pressure can be temporarily increased to allow for higher loads on the implement in situations where unexpected transient loads are unlikely to be experienced.

**[0006]** In another example, as described in US5, 939, 6464 a supplementary boost pump is provided, again to allow for larger loads to be manipulated.

**[0007]** However, manipulation of implements using hydraulic systems presents certain other technical requirements as well as the maximum load limit of the system. For example, the ability to accurately manipulate the implement is of prime importance, in particular where the implement is to be used in a confined space or near pre-existing installations that must not be damaged. A com-

mon example would be the control of a back hoe loader bucket that may be used for digging and moving matter from a location close to in-situ utility lines, e.g. water pipes or electricity cables. The requirement for accurate implement manipulation has tended to mean that prior hydraulic systems for large work vehicles have been configured to require relatively large operator movements on an input control device, such as a joystick, to produce relatively small and slow movements of the implement. In other words, there is a demand for low gearing between the input control device and the implement.

**[0008]** At other times, a higher gearing between the input control device and the implement would be desirable to allow for faster manipulation of the implement. For example, the procedure of 'bucket shake' is used by operators to reciprocally move the implement back and forth in a shaking movement to promote removal of foreign matter from the implement. However, low geared hydraulic systems are ill-equipped for this type of manoeuvre. The present disclosure aims to provide an improved hydraulic system, machine and method.

### Disclosure

**[0009]** Accordingly, the present disclosure describes a hydraulic system for a machine comprising:

a variable flow hydraulic pump, a low pressure input line, a high pressure output line and a load sense line; the variable flow hydraulic pump comprising a low pressure input connected to the low pressure input line, a high pressure output connected to the high pressure output line and a load sense input connected to the load sense line for controlling the output flow at the high pressure output; the high pressure output line being connected to an output device; the pressure at the load sense input being variable in response to loads imparted on the output device; wherein the hydraulic system further comprises an ancillary pressure supply connected to the load sense line for boosting the pressure at the load sense input of the variable flow hydraulic pump to thereby boost the flow at the high pressure output.

**[0010]** Utilising an ancillary pressure supply connected to the load sense line allows for the output flow of the hydraulic pump to be boosted in a very responsive manner. The boosted output flow (which produces a higher hydraulic pressure for the same imparted load) allows for a higher gearing between an input control device and an implement allowing faster, more responsive, manipulation of the implement under operator control.

**[0011]** The hydraulic system may further comprise a boost valve connected between the load sense input and the ancillary pressure supply which in an open configuration transmits pressure from the ancillary pressure supply to the load sense input, and in a closed configuration

blocks transmission of pressure from the ancillary pressure supply to the load sense input.

**[0012]** Use of a boost valve to control application of the ancillary boost pressure to the load sense input allows for the boost pressure to be selectively applied. This is a particular benefit where the implement of a machine incorporating the hydraulic system needs to be manipulated differently in different operational modes. For example, for precise manipulation of the implement during digging operations the boost valve can be closed. This could be the normal default setting. For bucket shake manipulation the boost valve could be opened to allow the implement to be vigorously moved back and forth using the boosted output pressure of the hydraulic pump.

**[0013]** Alternatively, where a boost valve is not utilised the system can be configured to provide a permanent boost to the output pressure of the hydraulic pump.

**[0014]** The boost valve may be a manually triggered valve.

**[0015]** The valve may be an electrically actuated solenoid valve.

**[0016]** The valve may be an unregulated valve or a regulated valve. The unregulated valve can act to supply the full ancillary pressure supply pressure to the load sense input on opening of the valve. The regulated valve allows for the whole or a portion of the ancillary pressure supply pressure to be transmitted on to the load sense input.

**[0017]** The ancillary pressure supply may be a pilot pressure system. The pilot pressure system may be a dedicated pilot pressure system used only for boosting the present hydraulic system. Alternatively, the pilot pressure system may be a general pilot system of the machine which is utilised for other purposes as well as providing ancillary pressure to the present hydraulic system.

**[0018]** The pilot pressure system may be supplied from the high pressure output line and comprises a pressure reduction device for reducing the pressure from the pressure of the high pressure output line to a pilot pressure. Conveniently, the pilot system is pressurised by branching off a pressurised line from the high pressure output of the variable flow pump. The pressure reduction device, such as a pressure reducing valve is used to both reduce the absolute pressure from, say, around 228 bar to, say, around 35 bar and also to stabilise the pressure in the pilot pressure system independent of variation of the pressure of the high pressure output of the variable flow hydraulic pump.

**[0019]** The present disclosure also provides a machine incorporating a hydraulic system comprising:

a variable flow hydraulic pump, a low pressure input line, a high pressure output line and a load sense line; the variable flow hydraulic pump comprising a low pressure input connected to the low pressure input line, a high pressure output connected to the high pressure output line and a load sense input connected to the load sense line for controlling the output

pressure at the high pressure output;

the high pressure output line being connected to an output device of the machine;

the pressure at the load sense input being variable in response to loads imparted on the output device; wherein the hydraulic system further comprises an ancillary pressure supply connected to the load sense line for boosting the pressure at the load sense input of the variable flow hydraulic pump to thereby boost the pressure at the high pressure output.

**[0020]** The machine may be a construction machine and the output device may be a construction implement.

**[0021]** The machine may further comprise a boost valve connected between the load sense input and the ancillary pressure supply which in an open configuration transmits pressure from the ancillary pressure supply to the load sense input, and in a closed configuration blocks transmission of pressure from the ancillary pressure supply to the load sense input.

**[0022]** The boost valve may be manually triggered by an operator of the machine by operation of a switching device located in an operator compartment of the machine.

**[0023]** The present disclosure also provides a method of controlling a hydraulic system of a machine of the type comprising:

a variable flow hydraulic pump having a low pressure input, a high pressure output and a load sense input; a low pressure input line connected to the low pressure input;

a high pressure output line connected to an output device of the machine; and

a load sense line connected to the load sense input;

comprising the steps of:

pressurising a working fluid received at the low pressure input from a low pressure to a high pressure and outputting said high pressure working fluid at the high pressure output;

varying the output flow of the high pressure working fluid dependent on a pressure of the load sense line at the load sense input;

varying the pressure of the load sense line at the load sense input in response to loads imparted on the output device; and

boosting the pressure of the load sense line at the load sense input of the variable flow hydraulic pump by use of an ancillary pressure supply to thereby boost the output flow at the high pressure output.

**[0024]** The pressure of the load sense line at the load sense input may be boosted by the ancillary pressure supply selectively by operation of a boost valve.

**[0025]** The boost valve may be switched by an operator of the machine by operation of a switching device

located in an operator compartment of the machine.

#### Brief Description of the Drawings

##### **[0026]**

Figure 1 is a schematic illustration of a first embodiment of the disclosure;

Figure 2 is a schematic illustration of a second embodiment of the disclosure and

Figure 3 is a schematic illustration of a third embodiment of the disclosure.

#### Embodiments of the Disclosure

**[0027]** As shown in Figure 1, a hydraulic system of the present disclosure comprises a variable flow hydraulic pump 10, which in use supplies pressurised hydraulic fluid to an implement 17 of a machine such as a large work vehicle, e.g. a construction vehicle such as a back hoe loader.

**[0028]** The pump 15 comprises a low pressure input 14 to which is connected a low pressure input line 11, a high pressure outlet 15 to which is connected a high pressure output line 12 and a load sense input 16 to which is connected a load sense input line 13.

**[0029]** The low pressure input line 11 connects to a hydraulic reservoir tank for supplying relatively unpressurised hydraulic fluid to the pump 10. The high pressure output line 12 connects between the pump 10 and the implement 17 of the machine. The load sense line 13 connects between the load sense input 16 and the implement 17 of the machine.

**[0030]** In addition, an ancillary pressure supply 20 is provided which connects to the load sense line 13.

**[0031]** The variable flow hydraulic pump 10 may be of any suitable type and may be, for example, a variable displacement pump such as a swashplate pump. The pump 10 acts to output hydraulic fluid at variable rates and by so doing to raise the pressure of the hydraulic fluid from a relatively low pressure to a relatively high pressure since the high pressure output line 12 is under a load. The required pressure in the high pressure output line 12 necessary to meet the requested hydraulic effort is achieved by varying the flow rate of the pump 10. Typically, the variable flow pump 10 may have a maximum rated output pressure of between 220 and 280 bar.

**[0032]** The low pressure input line 11, high pressure outlet line 11, high pressure outlet line 12 and load sense line 13 comprise conventional hydraulic conduits such as rigid or flexible hydraulic pipes. The hydraulic system may include other components as well known in the art including for example pressure relief valves (PRVs) and check valves which have been omitted from Figure 1 for reasons of clarity.

**[0033]** The implement 17 of the machine may be any required implement that is to be manipulated by hydraulic action. Examples include the hoe bucket of a back hoe

loader, front bucket of a back hoe loader, multi-purpose buckets and augers.

**[0034]** The ancillary pressure supply 20 may be any suitable pressure supply able to provide an additional pressure source for outputting hydraulic fluid to the load sense line 13. For example, the ancillary pressure supply 20 may be a supplementary hydraulic pump which may be a constant flow pump or a variable flow pump of a similar type to the variable flow hydraulic pump 10 described above.

**[0035]** Alternatively, the ancillary pressure supply 20 may be a pilot pressure system of the machine which will be described in further detail below with reference to Figure 3.

**[0036]** In use of the hydraulic system of Figure 1, the variable flow hydraulic pump 10 is driven by a suitable means such as the internal combustion engine of a machine to drive pressurised hydraulic fluid as required to the implement 17. Dependent on the loading requirements of the implement 17 the flow and hence pressure at the high pressure outlet 15 can be varied. In order to achieve a greater responsiveness of the implement 17, a boost pressure from the ancillary pressure supply 20 is supplied to the load sense line 13 to increase the pressure at the load sense input 16 to thereby result in the flow at the high pressure output 15 being boosted above its normal flow rate. This results in the flow and pressure to the implement 17 being boosted leading to more responsive movement of the implement 17.

**[0037]** In the hydraulic system of Figure 1, the ancillary pressure supply 20 may be a regulated or unregulated pressure supply meaning that the ancillary pressure provided by the ancillary pressure supply 20 may be a fixed pressure increment or may be a variable pressure increment. For example, the ancillary pressure supply 20 may be configured to provide an additional boost pressure of, say, 35 bar to the load sense line 13. Alternatively, the ancillary pressure supply 20 may be configured to provide a variable boost pressure of, say, between 0 and 35 bar when actuated.

**[0038]** A variation on the hydraulic system of the present disclosure is shown in Figure 2. Like components to that of the system of Figure 1 have been referenced with like numerals. The system of Figure 2 differs from that of Figure 1 by the provision of a boost valve 30 between the ancillary pressure supply 20 and the load sense line 13. The boost valve 30 may be any suitable valve device for use with hydraulic fluid and may be for example an electrically actuated solenoid valve. The boost valve 30 can be actuated by a manually operable trigger 40 which may be located, for example, in an operator cab of the machine. Unlike the system of Figure 1 where the boost pressure of the ancillary pressure supply 20 is permanently input to the load sense line 13, in the hydraulic system of Figure 2, the boost valve 30 is used to selectively actuate provision of the ancillary pressure to the load sense line 13. Thus, an operator of the machine may choose when to boost hydraulic flow and pres-

sure to the implement 17 by actuating the switch 40 which may be, for example, a button provided on the joystick control input device.

**[0039]** As with the system of Figure 1, the ancillary pressure supply 20 may be a regulated or unregulated pressure supply providing either a fixed increment pressure boost to the load sense line 13 or a variable pressure increment to the load sense line 13 on actuation of the boost valve 30.

**[0040]** Figure 3 illustrates a further embodiment of hydraulic system according to the present disclosure. Like components to that of Figures 1 and 2 have been referenced with like numerals. In the embodiment of Figure 3, the ancillary pressure supply 20 is illustrated as being provided by a pilot pressure system. The pilot pressure system may be a dedicated pilot pressure system used for only the hydraulic system of the present disclosure or alternatively may be a pilot pressure system which is used for other components or functions of the machine incorporating the hydraulic system of the present disclosure. In Figure 3, this possibility is illustrated by provision of a pilot pressure branch line 23 which may be connected to other functions of the machine which fall outside of the scope of the present disclosure. In the version of system shown in Figure 3, the pressurised working fluid for the pilot pressure system is provided by stemming off high pressure working fluid from the high pressure output line 12 of the variable flow pump 10. This working fluid is branched off using a pilot system input line 21 which connects to a pressure reduction valve 22 which acts to reduce the pressure of the working fluid from the relatively high output pressure of the variable flow pump 10 to a relatively low pilot pressure for use in the pilot pressure system 20. Typically, the pressure of such a pilot pressure system will be set at between 22 and 36 bar. The output of the pressure reduction valve is connected to the boost valve 30 which may be of the type as described above with reference to Figure 2. In addition, as shown in Figure 3, a check valve 24 may be provided between the boost valve 30 and the connection with the load sense line 13 to prevent back flow of hydraulic fluid.

**[0041]** In operation, boosting of the hydraulic flow and pressure to the implement 17 is the same or similar to that described above with reference to the system of Figure 2 in that actuation of the boost valve 30 provides additional pressure to the load sense line 13 and hence the load sense input 16 resulting in a boost in the output flow of the pump 10 and increased pressure in the high pressure output line 12.

## Claims

1. A hydraulic system for a machine comprising:

a variable flow hydraulic pump, a low pressure input line, a high pressure output line and a load sense line;

the variable flow hydraulic pump comprising a low pressure input connected to the low pressure input line, a high pressure output connected to the high pressure output line and a load sense input connected to the load sense line for controlling the output flow at the high pressure output;

the high pressure output line being connected to an output device;

the pressure at the load sense input being variable in response to loads imparted on the output device;

wherein the hydraulic system further comprises an ancillary pressure supply connected to the load sense line for boosting the pressure at the load sense input of the variable flow hydraulic pump to thereby boost the flow at the high pressure output.

2. A hydraulic system as claimed in claim 1 further comprising a boost valve connected between the load sense input and the ancillary pressure supply which in an open configuration transmits pressure from the ancillary pressure supply to the load sense input, and in a closed configuration blocks transmission of pressure from the ancillary pressure supply to the load sense input.
3. A hydraulic system as claimed in claim 2 wherein the boost valve is a manually triggered valve.
4. A hydraulic system as claimed in claim 2 or claim 3 wherein the valve is an electrically actuated solenoid valve.
5. A hydraulic system as claimed in claim 3 or claim 4 wherein the valve is an unregulated valve.
6. A hydraulic system as claimed in claim 3 or claim 4 wherein the valve is a regulated valve.
7. A hydraulic system as claimed in any preceding claim wherein the ancillary pressure supply is a pilot pressure system.
8. A hydraulic system as claimed in claim 7 wherein the pilot pressure system is supplied from the high pressure output line and comprises a pressure reduction device for reducing the pressure from the pressure of the high pressure output line to a pilot pressure.
9. A machine incorporating a hydraulic system comprising:

a variable flow hydraulic pump, a low pressure input line, a high pressure output line and a load sense line;

the variable flow hydraulic pump comprising a low pressure input connected to the low pressure input line, a high pressure output connected to the high pressure output line and a load sense input connected to the load sense line for controlling the output flow at the high pressure output;

the high pressure output line being connected to an output device of the machine;

the pressure at the load sense input being variable in response to loads imparted on the output device;

wherein the hydraulic system further comprises an ancillary pressure supply connected to the load sense line for boosting the pressure at the load sense input of the variable flow hydraulic pump to thereby boost the flow at the high pressure output.

**10.** A machine as claimed in claim 9 wherein the machine is a construction machine and the output device is a construction implement.

**11.** A machine as claimed in claim 9 or claim 10 further comprising a boost valve connected between the load sense input and the ancillary pressure supply which in an open configuration transmits pressure from the ancillary pressure supply to the load sense input, and in a closed configuration blocks transmission of pressure from the ancillary pressure supply to the load sense input.

**12.** A machine as claimed in claim 11 wherein the boost valve is manually triggered by an operator of the machine by operation of a switching device located in an operator compartment of the machine.

**13.** A method of controlling a hydraulic system of a machine of the type comprising:

a variable flow hydraulic pump having a low pressure input, a high pressure output and a load sense input;

a low pressure input line connected to the low pressure input;

a high pressure output line connected to an output device of the machine; and

a load sense line connected to the load sense input;

comprising the steps of:

pressurising a working fluid received at the low pressure input from a low pressure to a high pressure and outputting said high pressure working fluid at the high pressure output;

varying the output flow of the high pressure working fluid dependent on a pressure of the

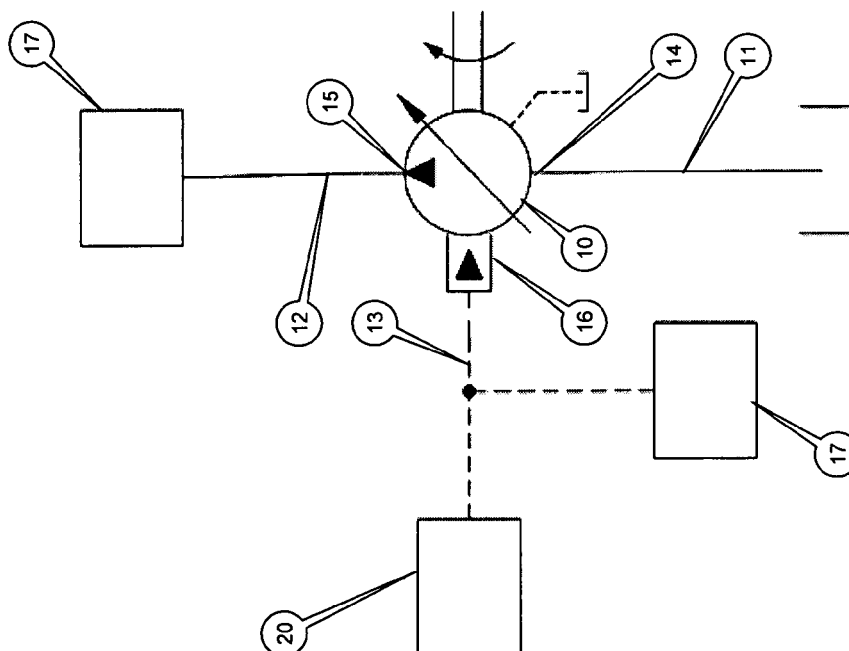
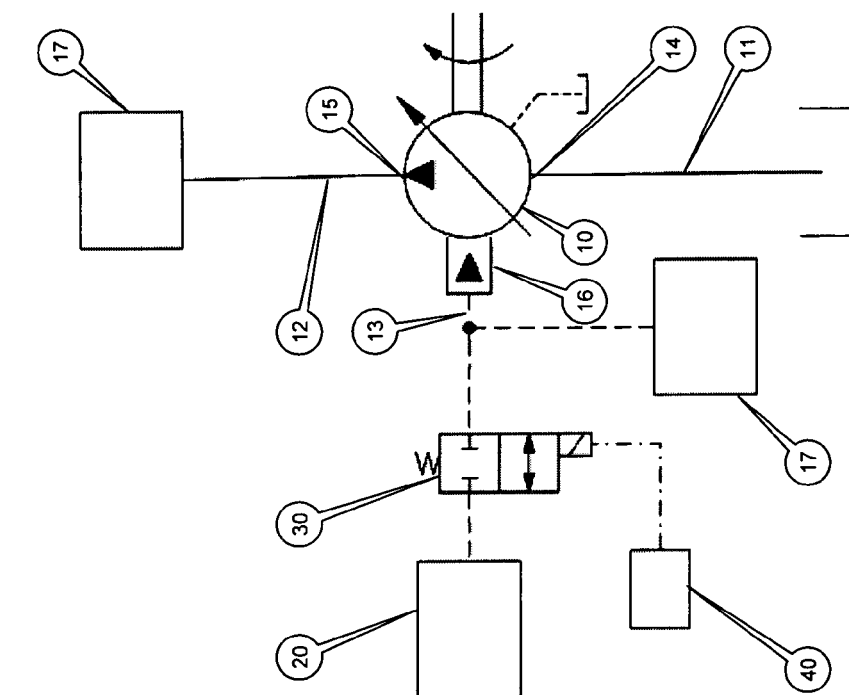
load sense line at the load sense input;

varying the pressure of the load sense line at the load sense input in response to loads imparted on the output device; and

boosting the pressure of the load sense line at the load sense input of the variable flow hydraulic pump by use of an ancillary pressure supply to thereby boost the output flow at the high pressure output.

**14.** The method of claim 13 wherein the pressure of the load sense line at the load sense input is boosted by the ancillary pressure supply selectively by operation of a boost valve.

**15.** The method of claim 14 wherein the boost valve is switched by an operator of the machine by operation of a switching device located in an operator compartment of the machine.



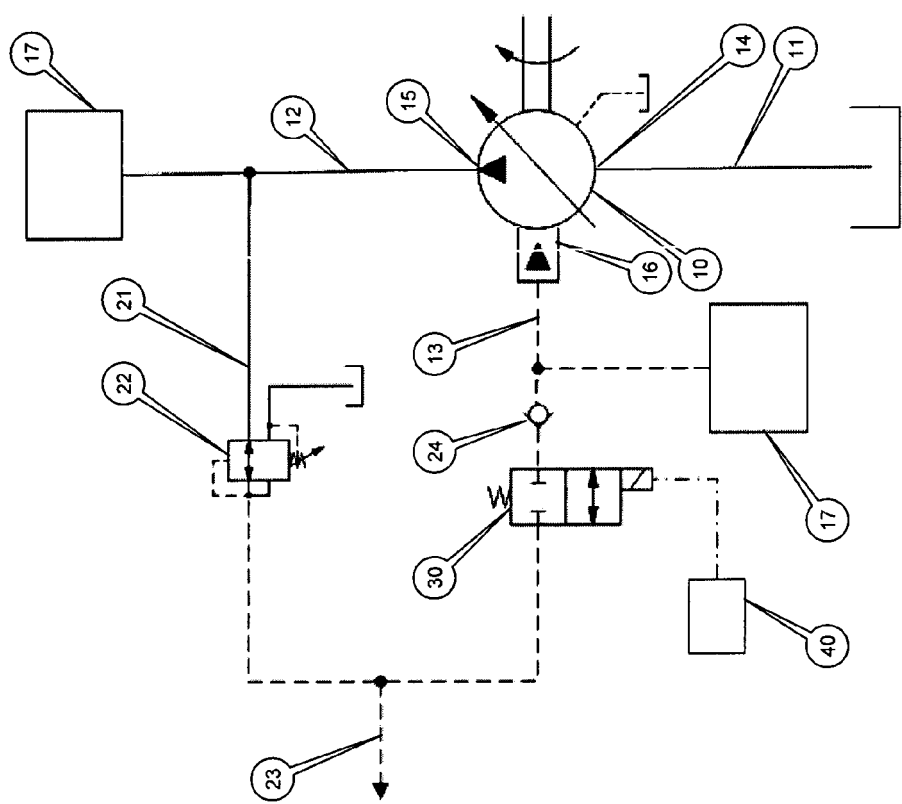


Fig. 3



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Application Number  
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