(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 172 565 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
16.01.2002 Bulletin 2002/03

(51) Int Cl.[7]: **F15B 11/16**, E02F 9/22

(21) Application number: **01302794.1**

(22) Date of filing: **26.03.2001**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **10.07.2000 JP 2000208724**

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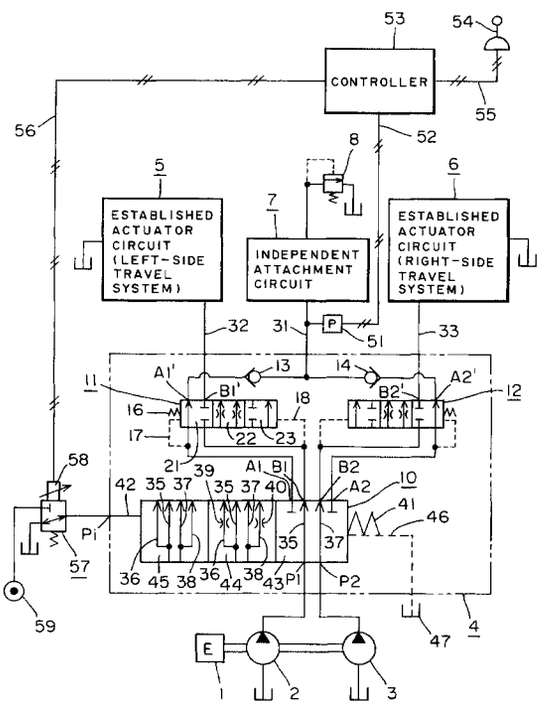
(54) Hydraulic circuit for construction machine

(57) To provide a way to ensure the supply of a necessary amount of hydraulic fluid to the established actuator circuits even if the pressure in the independent attachment circuit becomes excessively high. Hydraulic fluid fed from hydraulic pumps 2,3 is controlled by means of established actuator circuits 5,6 to operate established actuators of a construction machine. A flow dividing control valve 10 causes a part of the hydraulic fluid fed to the established actuator circuits 5,6 to branch off and be fed to the independent attachment circuit 7 with its amount controlled by variable throttles 39,40, thereby driving the attachment of the construction machine. Pressure compensation valves 11,12 respectively control the variable throttles 39,40 of the flow dividing control valve 10 to maintain a constant differential pressure between the inlet and the outlet of each variable throttle. When a controller 53 detects by a pressure sensor 51 that the circuit pressure in the independent attachment circuit 7 has increased to an excessively high level, the controller 53 controls an electromagnetic proportional control valve 57 regardless of operation signals from an attachment operation lever 54 so as to reduce the aperture areas of the variable throttles 39,40 of the flow dividing control valve 10.

FIG. 1



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Description

TECHNICAL FIELD

[0001] The present invention relates to a hydraulic circuit which is installed in a construction machine and includes an independent attachment circuit.

BACKGROUND OF THE INVENTION

[0002] Japanese Patent provisional Publication No. 2000-73409 discloses a hydraulic circuit of a construction machine, which is provided with a pressure compensation flow dividing valve disposed between a group of components consisting of a first hydraulic pump and a second hydraulic pump, and a group of components consisting of a left-side travel circuit, a right-side travel circuit and an independent attachment circuit.

[0003] The pressure compensation flow dividing valve contains flow dividing control valves and pressure compensation valves. The flow dividing control valves are adapted to control flow rate of the hydraulic fluid that branches off to the independent attachment circuit with respect to the travel circuits. Each pressure compensation valve is adapted to maintain a constant differential pressure between the inlet and the outlet of a variable throttle of the corresponding flow dividing control valve.

[0004] The flow dividing control valves have internal oil channels having aperture characteristics such that the flow rate of the hydraulic fluid that branches off from the first hydraulic pump to the left-side travel circuit is equal to the flow rate of the hydraulic fluid that simultaneously branches off from the second hydraulic pump to the right-side travel circuit. The flow dividing control valves are also provided with internal oil channels branching off from said internal oil channels and having aperture characteristics such that the flow rate of the hydraulic fluid that branches off from the first hydraulic pump and flows into the independent attachment circuit is equal to the flow rate of the hydraulic fluid that branches off from the second hydraulic pump and flows into the independent attachment circuit.

[0005] Each pressure compensation valve is adapted to supply the independent attachment circuit with hydraulic fluid at a flow rate corresponding to the degree of aperture of the variable throttle of the corresponding flow dividing control valve by applying control so as to maintain a constant differential pressure between the inlet and the outlet of the variable throttle regardless of the pressure in the left-side travel circuit, the right-side travel circuit or the independent attachment circuit.

[0006] Each hydraulic pump incorporated in such a construction machine as described above has a threshold curve between the pump discharge rate, which is determined by the engine power, and the pump discharge pressure. A diagram illustrating such a threshold curve (hereinafter called P-Q curve diagram) is shown in Fig. 3. In other words, the hydraulic pump is designed such that the higher the pump discharge pressure, the lower the pump discharge rate.

[0007] According to the structure of the conventional independent attachment circuit described above, the pressure compensation valves function in such a manner that the hydraulic fluid is fed to the independent attachment circuit at a flow rate corresponding to the degree of aperture of the variable throttle of each flow dividing control valve regardless of the pressure in the independent attachment circuit. Therefore, nearly all of the hydraulic fluid discharged from the pump flows into the independent attachment circuit even when the pump discharge rate is reduced as shown in the P-Q curve of Fig. 3 as a result of the pressure in the independent attachment circuit reaching a level high enough to be nearly equal to the relief pressure, should the throttle valves of the flow dividing control valves be widely open.

[0008] At that time, the pressure compensation valves limit the hydraulic fluid flowing to established actuators of working components mounted on the main body of the machine, i.e. hydraulic motors for travelling or swinging action, and hydraulic cylinders for a front attachment, e.g. a boom, an arm or a bucket. When operating an attachment in conjunction with a working component on the main body, reduction of the hydraulic fluid slows down the action of the component on the main body the moment when the pressure in the independent attachment circuit approaches the relief pressure.

[0009] In order to solve the above problem, an object of the present invention is to provide a way to ensure the supply of a necessary amount of hydraulic fluid to the established actuator circuits even if the pressure in the independent attachment circuit excessively increases during the process of causing a part of the hydraulic fluid fed to the established actuator circuits to branch off and be fed to the independent attachment circuit by means of a pressure-compensated flow dividing control valve

DISCLOSURE OF THE INVENTION

[0010] The invention as claimed in claim 1 relates to a hydraulic circuit of a construction machine, said hydraulic circuit including established actuator circuits for driving established actuators of the construction machine by controlling hydraulic fluid fed from hydraulic pumps; an independent attachment circuit adapted to drive an attachment of the construction machine independently of the established actuator circuits by controlling a part of the hydraulic fluid fed from the hydraulic pumps to the established actuator circuits; a flow dividing control valve adapted to cause a part of the hydraulic fluid fed from the hydraulic pumps to the established actuator circuits to branch off and be fed to the independent attachment circuit, the flow rate of the hydraulic fluid that undergoes branching process being controlled by means of variable throttles of the flow dividing control valve according to the stroke of the flow dividing control

valve; pressure compensation valves adapted to perform control so as to maintain a constant differential pressure between the inlet and the outlet of the variable throttles of the flow dividing control valve; a pressure sensor for detecting circuit pressure in the independent attachment circuit; an electromagnetic proportional control valve for controlling the stroke of the flow dividing control valve by means of pilot pressure; and a controller adapted to control the electromagnetic proportional control valve in such a manner that when the circuit pressure in the independent attachment circuit detected by the pressure sensor is not excessively high, the controller controls the variable throttles of the flow dividing control valve by controlling the electromagnetic proportional control valve in accordance with attachment operation signals and that when the circuit pressure in the independent attachment circuit has increased to an excessively high level, the controller controls the electromagnetic proportional control valve regardless of attachment operation signals so as to reduce the aperture areas of the variable throttles of the flow dividing control valve.

[0011] When there is no excessive pressure in the independent attachment circuit, the controller which has received the attachment operation signals outputs electric signals in proportion to the attachment operation signals to the electromagnetic proportional control valve, thereby controlling the stroke of the flow dividing control valve through the electromagnetic proportional control valve. In case an excessively high circuit pressure rises in the independent attachment circuit, the controller, which has detected it by means of the pressure sensor, controls the electromagnetic proportional control valve regardless of the attachment operation signals so as to reduce the aperture areas of the variable throttles, thereby reducing the hydraulic fluid fed to the independent attachment circuit. The amount of hydraulic fluid fed to the established actuator circuits can be restored by the amount equivalent to the reduction in the hydraulic fluid fed to the independent attachment circuit. Therefore, conjunctional operation of the attachment and established actuators can smoothly be performed.

[0012] The invention as claimed in claim 2 relates to a hydraulic circuit as claimed in claim 1, wherein the state where the circuit pressure in the independent attachment circuit is excessively high is defined as the state where circuit pressure in the independent attachment circuit is in the proximity of the relief pressure. The state where "circuit pressure in the independent attachment circuit is in the proximity of the relief pressure" means that the attachment is close to the state of stalling. As a minimal amount of hydraulic fluid, in other words hydraulic fluid just enough to maintain the circuit pressure, is therefore sufficient, the configuration of the invention described above is rational.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Fig. 1 is a hydraulic circuit diagram of the hydraulic circuit of a construction machine according to an embodiment of the present invention.

[0014] Fig. 2 is a characteristic diagram showing aperture characteristics of a flow dividing control valve in said hydraulic circuit.

[0015] Fig. 3 is a P-Q curve diagram showing pressure-flow rate characteristics of hydraulic pumps in said hydraulic circuit.

PREFERRED EMBODIMENT OF THE INVENTION

[0016] Next, the present invention is explained hereunder, referring to an embodiment thereof shown in Fig. 1.

[0017] Fig. 1 shows an example of an independent attachment circuit which is incorporated in a dual-pump type hydraulic shovel and uses a pressure compensation flow dividing valve.

[0018] Referring to Fig. 1, discharge openings of a first hydraulic pump 2 and a second hydraulic pump 3, both of which are designed to be driven by an engine 1 mounted on a hydraulic shovel as a construction machine, are connected via the pressure compensation flow dividing valve 4 to an established actuator circuit 5 of a left-side travel system, an established actuator circuit 6 of a right-side travel system and an independent attachment circuit 7, which is adapted to be controlled independently of the established actuator circuit 5 or the established actuator circuit 6.

[0019] By means of various control spools of main control valves (not shown), the established actuator circuits 5,6 serve to control the hydraulic fluid fed from the first hydraulic pump 2 and the second hydraulic pump 3 through the pressure compensation flow dividing valve 4, thereby controlling the established actuators of the hydraulic shovel, i.e. the hydraulic pumps of the travelling system and the swinging system, and the operation of the hydraulic cylinders of the front attachment, i.e. the boom cylinder, the arm cylinder and the bucket cylinder.

[0020] The established actuator circuit 5 constitutes a left-side travel system group that is adapted to control hydraulic fluid fed from the first hydraulic pump 2 so as to control a left-side-ravel hydraulic pump, which is adapted to drive at least a left-side crawler belt, by means of a left-side-travel spool. The other established actuator circuit 6 constitutes a right-side travel system group that is adapted to control hydraulic fluid fed from the second hydraulic pump 3 so as to control a right-side-ravel hydraulic pump, which is adapted to drive at least a right-side crawler belt, by means of a right-side-travel spool.

[0021] The aforementioned independent attachment circuit 7 includes an attachment control spool (not shown) for controlling the hydraulic fluid that has branched off by the pressure compensation flow divid-

ing valve 4 from the hydraulic fluid fed from the first hydraulic pump 2 and the second hydraulic pump 3 to the established actuator circuits 4,5. By means of the hydraulic fluid controlled by the attachment control spool, the independent attachment circuit 7 operates an attachment, e.g. a hydraulic breaker or a crusher, which is attached to the front end of the front working equipment of the hydraulic shovel in the place of the bucket so that the attachment is operated independently of the established actuator circuits 5,6.

[0022] The independent attachment circuit 7 is provided with an attachment relief valve 8, which serves to set a relief pressure for the independent attachment circuit 7.

[0023] The pressure compensation flow dividing valve 4 contains a flow dividing control spool 10 as a flow dividing control valve, a pair of pressure compensation spools 11,12 and check valves 13,14 respectively disposed in the output circuits from the two pressure compensation spools 11,12 to the independent attachment circuit 7. Each pressure compensation spool 11/12 serves as a pressure compensation valve for controlling its flow rate by compensating the pressure of the hydraulic fluid that is caused by the flow dividing control spool 10 to branch off to the independent attachment circuit 7.

[0024] The flow dividing control spool 10 serves to cause a part of the hydraulic fluid fed from the first hydraulic pump 2 to the established actuator circuit 5 of the left-side travel system group to branch off and be fed to the independent attachment circuit 7 and also controls the flow rate of the hydraulic fluid which has branched off by means of a variable throttle 39 according to the stroke of the flow dividing control spool. Meanwhile, the flow dividing control spool 10 also serves to cause a part of the hydraulic fluid fed from the second hydraulic pump 3 to the established actuator circuit 6 of the right-side travel system group to branch off and be fed to the independent attachment circuit 7 and controls the flow rate of the branched hydraulic fluid by means of a variable throttle 40 according to the stroke of the flow dividing control spool.

[0025] A spring 16 is disposed at one side of one of the pressure compensation spools, i.e. the pressure compensation spool 11, and applies constant force to the pressure compensation spool 11. The hydraulic pressure from the A1 port and hydraulic pressure from the B1 port of the flow dividing control spool 10 are respectively directed through the oil channels 17,18 to the two opposing ends of the pressure compensation spool 11. The pressure compensation spool 11 is capable of changing its position against the constant force applied by the spring 16; the pressure compensation spool 11 is arranged such that when the differential pressure between the B1 port and the A1 port of the flow dividing control spool 10 (PB1 - PA1) reaches a given differential pressure (ΔP), the pressure compensation spool 11 shifts from position 21 to position 21, and, when the differential pressure increases further, from the position 22 to position 23.

[0026] With the configuration as above, the pressure compensation spool 11 performs pressure compensation control so as to maintain the aforementioned differential pressure (PB1 - PA1), in other words the differential pressure between the inlet and the outlet of the variable throttle 39 at a constant level. Likewise, the other pressure compensation spool 12 is adapted to perform pressure compensation control so as to maintain the differential pressure between the B2 port and the A2 port of the flow dividing control spool 10 (PB2 - PA2), i.e. the differential pressure between the inlet and the outlet of the variable throttle 40, at a constant level.

[0027] An A1' port of the pressure compensation spool 11 and an A2' port of the pressure compensation spool 12 are connected to the independent attachment circuit 7 via an independent attachment line 31, which extends from the independent attachment circuit 7 and is divided into two ways that respectively pass through the check valves 13,14 and lead to the A1' port and the A2' port. A B1' port is connected to the established actuator circuit 5 of the left-side travel system group via a left-side travel system line 32. A B2' port is connected to the established actuator circuit 6 of the right-side travel system group via a right-side travel system line 33.

[0028] The flow dividing control spool 10 is explained in more detail hereunder. The flow dividing control spool 10 is provided with internal oil channels 35,36 extending from the first hydraulic pump 2 and internal oil channels 37,38 extending from the second hydraulic pump 3. The internal oil channel 35 is provided for the hydraulic fluid that branches off to the left-side travel system line 32 of the established actuator circuit 5, and the internal oil channel 36 is provided for the hydraulic fluid that branches off to the independent attachment line 31 of the independent attachment circuit 7. The internal oil channel 37 is provided for the hydraulic fluid that branches off to the right-side travel system line 33 of the established actuator circuit 6, and the internal oil channel 38 is provided for the hydraulic fluid that branches off to the independent attachment line 31 of the independent attachment circuit 7.

[0029] The internal oil channels 35,37 of the flow dividing control spool 10 have such aperture characteristics as to make the flow rate of the hydraulic fluid that is fed from the first hydraulic pump 2 and branches off to the left-side travel system line 32 equal to the flow rate of the hydraulic fluid that is simultaneously fed from the second hydraulic pump 3 and branches off to the right-side travel system line 33. Meanwhile, the internal oil channels 36,38 have such aperture characteristics as to make the flow rate of the hydraulic fluid that is fed from the first hydraulic pump 2 and branches off to the independent attachment line 31 equal to the flow rate of the hydraulic fluid that is simultaneously fed from the second hydraulic pump 3 and branches off to the independent attachment line 31.

[0030] The internal oil channels 36,38 for the hydraulic fluid that branches off to the independent attachment line 31 are respectively provided with the aforementioned variable throttles 39,40. As shown in Fig. 2, each variable throttle 39/40 is capable of changing its aperture area in accordance with the valve stroke of the flow dividing control spool 10.

[0031] The flow dividing control spool 10 is so designed as to receive the constant force applied from a spring 41 at one end and receive at the other end the pilot pressure introduced from a Pi port via a pilot pressure introducing channel 42 so that the spool valve stroke is controlled at the equilibrium point between the pushing force of the pilot pressure and the rebounding force of the spring 41.

[0032] To be more specific, the lower the pilot pressure at the- Pi port, the closer the flow dividing control spool 10 to position 43. However, the higher the pilot pressure at the Pi port, the closer the flow dividing control spool 10 shifts through position 44 towards position 45 so that the variable throttles 39,40 open more widely. A drain oil channel 46 is drawn out of the flow dividing control spool 10 and communicates with a tank 47.

[0033] As the components of the flow dividing control spool 10 dedicated to the right-side travel and the pressure compensation spool 12 function according to the same principles as those for the left-side travel components of the flow dividing control spool 10 and the pressure compensation spool 11, the same explanation as above is applicable, except that the P1 port, the A1 port, the B1 port, the A1' port and the B1' port should respectively be read as the P2 port, the A2 port, the B2 port, the A2' port and the B2' port. Therefore a particular explanation thereof is omitted herein.

[0034] As shown in Fig. 1, a pressure sensor 51 for detecting the circuit pressure in the independent attachment circuit 7 is disposed in the independent attachment line 31, through which the pressure compensation flow dividing valve 4 is connected to the independent attachment circuit 7. A signal detection line 52 of the pressure sensor 51 is connected to a signal input element of a controller 53.

[0035] An operation lever 54, which is an electric joy stick for operating the attachment, is connected to the input element of the controller 53 via an input signal line 55.

[0036] An output element of the controller 53 is connected to a solenoid 58 of an electromagnetic proportional control valve 57 via an output signal line 56.

[0037] The electromagnetic proportional control valve 57 is a solenoid-controlled valve adapted to function in proportion to the value of the control current output from the controller 53 and directed to the solenoid 58, thereby controlling the stroke of the flow dividing control spool 10 by means of pilot pressure. A primary port of the electromagnetic proportional control valve 57 is connected to a pilot hydraulic pressure source 59, whereas a secondary port is connected to the Pi port for inputting switching signal pressure to the flow dividing control spool 10.

[0038] The electromagnetic proportional control valve 57 is adapted to control the stroke of the flow dividing control spool 10 against the spring 41 by converting a given, constant primary pilot pressure, which has been fed from the pilot hydraulic pressure source 59, into a secondary pilot pressure that changes in proportion to the value of the control current output from the controller 53 and directed to the solenoid 58, and outputting said secondary pilot pressure to the Pi port.

[0039] When the pressure in the independent attachment circuit 7 detected by the pressure sensor 51 is not excessively high, in other words when it has not yet reached the proximity of the relief pressure set by the relief valve 8, the aforementioned controller 53 receives attachment operation signals, which are electric signals output from the attachment operation lever 54 in proportion to the degree of operation of the lever, and outputs electric signals (electric current) corresponding to the attachment operation signals to the solenoid 58 of the electromagnetic proportional control valve 57, thereby controlling the electromagnetic proportional control valve 57 to control the stroke of the flow dividing control spool 10. Thus, the controller 53 controls the areas of the apertures of the variable throttles 39,40. When the pressure in the independent attachment circuit 7 detected by the pressure sensor 51 becomes excessively high, in other words when the circuit pressure approaches the relief pressure set by the relief valve 8, the controller 53 detects it by means of the pressure sensor 51 and reduces the current to the solenoid 58 of the electromagnetic proportional control valve 57 regardless of the attachment operation signals so that switching pressure for switching the flow dividing control valve output from the electromagnetic proportional control valve 57, is automatically reduced. Thus, the controller 53 controls the variable throttles 39,40 to reduce their aperture areas.

[0040] Next, the function of the embodiment shown in Fig. 1 is explained hereunder, referring to Fig. 2.

[0041] Two lines of hydraulic fluid respectively discharged from the first hydraulic pump 2 and the second hydraulic pump 3, which are driven by the on-vehicle engine 1, flow through the pressure compensation flow dividing valve 4, at which they are divided and fed to the two established actuator circuits 5,6 and the independent attachment circuit 7.

[0042] Using at least the left-side-travel spool, the established actuator circuit 5 controls the left-side travel hydraulic motor for driving the left-side crawler belt and other relevant components, while the other established actuator circuit 6 controls the right-side travel hydraulic motor for driving the right-side crawler belt and other relevant components, by using at least the right-side-travel spool.

[0043] By means of the attachment control spool, the independent attachment circuit 7 controls the hydraulic

fluid fed to an attachment, e.g. a hydraulic breaker or a crusher, which is attached to the front end of the front working equipment in the place of the bucket.

[0044] The pressure compensation flow dividing valve 4 feeds the hydraulic fluid discharged from each pump 2/3 through the flow dividing control spool 10 and either pressure compensation spool 11 or 12 to the corresponding established actuator circuit 5 or 6, or divides said hydraulic fluid by the flow dividing control spool 10, compensates the pressure in each line by the pressure compensation spool 11/12, and, after the divided flows pass through the check valves 13,14 and joined, feeds the joined flow of hydraulic fluid into the independent attachment circuit 7.

[0045] By the pilot pressure from the Pi port, the stroke of the flow dividing control spool 10 is changed against the constant force of the spring 41 so that the flow dividing control spool 10 easily controls the flow rate of the hydraulic fluid from the P1 port, which is connected to the first hydraulic pump 2, to the A1 port and the flow rate of the hydraulic fluid from the P2 port, which is connected to the second hydraulic pump 3, to the A2 port in accordance with the aperture characteristics of the variable throttles 39,40 shown in Fig. 2.

[0046] When no pilot pressure is applied to the Pi port, all the hydraulic fluid from the P1 port flows to the B1 port, while all the hydraulic fluid from the P2 port flows to the B2 port. The two lines of hydraulic fluid respectively pass through the pressure compensation spools 11,12 and are fed to the controls spools of the left established actuator circuit 5 and the right established actuator circuit 6.

[0047] Given that the hydraulic pressures at the A1 port and the B1 port are PA1 and PB1 respectively; the degree of aperture of the variable throttle 39 of the flow dividing control spool 10 (shown in Fig. 2) is Ax; and that the flow rate of the hydraulic fluid flowing from the P1 port to the A1 port is QA1, the following equation (1) results;

$$QA1 = K \cdot Ax \cdot (PB1\text{-}PA1)^{1/2} \quad (1),$$

wherein K is a constant.

[0048] When the differential pressure (PB1-PA1) exceeds a given, constant differential pressure (ΔP) set by the spring 16, the pressure compensation spool 11 shifts from position 21 to position 21 against the constant force applied by the spring 16, and, when the differential pressure increases further, it further shifts to position 23.

[0049] Therefore, when the flow dividing control spool 10 is at position 43, the differential pressure is much greater than ΔP, i.e. (PB1-PA1)» ΔP, so that the pressure compensation spool 11 is at position 23. As a result, all the hydraulic fluid flows towards the B1' port.

[0050] Now, cases where the flow dividing control spool 10 is at position 44 or position 45 are explained. When the pressure at the B1' port exceeds the pressure at the A1' port (PB1' > PA1'), a greater amount of hydraulic fluid tends to flow towards the A1' port. At that time, should the differential pressure (PB1-PA1) exceed ΔP, the pressure compensation spool 11 shifts towards position 23, in other words in such a direction as to limit the flow of the hydraulic fluid towards the A1' port.

[0051] On the contrary, in case of PB1' < PA1', a greater amount of hydraulic fluid tends to flow towards the B1' port. At that time, should the differential pressure (PB1-PA1) become less than ΔP, the constant force of the spring 16 causes the pressure compensation spool 11 to shift towards position 21, in other words in such a direction as to limit the flow of the hydraulic fluid towards the B1' port.

[0052] In other words, the pressure compensation spool 11 functions so as to maintain the differential pressure between the inlet and the outlet of the variable throttle 39 (PB1 - PA1) at a constant level (ΔP) regardless of the pressure at the A1' port (PA1') or the pressure at the B1' port (PB1'). Therefore, it is evident from the equation (1), the hydraulic fluid is fed from the A1' port to the independent attachment circuit 7 at the flow rate of QA1 that corresponds to the degree of aperture Ax of the variable throttle 39.

[0053] In the same manner as above, the right-side-travel pressure compensation spool 12 compensates the pressure of the hydraulic fluid passing through the variable throttle 40 of the flow dividing control spool 10 in accordance with the same working principle as that for the left-side-travel pressure compensation spool 11.

[0054] The oil channel of the flow dividing control spool 10 that extends from the P1 port and communicates with the A1 port through the internal oil channel 36 is ensured to have the same aperture characteristics as those of the oil channel of the flow dividing control spool 10 that extends from the P2 port and communicates with the A2 port through the internal oil channel 38. Therefore, the hydraulic fluid is constantly fed to the A1' port and the A2' port at an equally divided flow rate, while the hydraulic fluid is simultaneously fed to the B1' port and the B2' port at an equally divided flow rate. As the flow rate of the working fluid fed to the left established actuator circuit 5 is always the same as that of the working fluid fed to the right established actuator circuit 6, the flow rate of the working fluid fed to the left-side travel motor, too, is always the same as that of the working fluid fed to the right-side travel motor. In other words, the vehicle will not deviate from running straight.

[0055] When there is no excessively high pressure in the independent attachment line 31, the controller 53, which has received electric signals from the attachment operation lever 54, outputs electric signals in proportion to the degree of operation of the lever to the solenoid 58 of the electromagnetic proportional control valve 57, thereby controlling the stroke of the flow dividing control spool 10 by using the electromagnetic proportional control valve 57.

[0056] In case an excessively high pressure that is in proximity to the relief pressure set by the relief valve 8 rises in the independent attachment line 31, signals indicating the overload state are input to the controller 53 from the pressure sensor 51 that has detected the aforementioned high pressure. As a result, regardless of the electric current value commanded by the operation lever 54 to be fed to the electromagnetic proportional control valve 57, the controller 53 reduced the electric current actually output to the electromagnetic proportional control valve 57, thereby automatically reducing the switching pressure output from the electromagnetic proportional control valve 57 to the flow dividing control spool 10. As a result, the aperture areas of the variable throttles 39,40 of the flow dividing control spool 10 are considerably reduced so that the amount of the hydraulic fluid fed to the independent attachment circuit 7, too, is reduced.

[0057] As described above, should pressure that is in proximity to the relief pressure rises in the independent attachment line 31, the hydraulic fluid fed to the independent attachment circuit 7 is automatically reduced. Accordingly, compared with those according to conventional art, a tremendously greater amount of oil flows into established actuators of working components mounted on the main body of the machine, i.e. hydraulic motors for travelling or swinging action, and hydraulic cylinders of a front attachment, e.g. a boom, an arm or a bucket. Therefore, during conjunctional operation of an attachment and a working component on the main body, the invention described above is free from the problem of the action of the component on the main body slowing slow the moment when the pressure in the attachment circuit approaches the relief pressure.

[0058] The term "the circuit pressure in the independent attachment circuit 7 approaches (or is in the proximity of) the relief pressure" means that the attachment is close to the state of stalling, i.e. the state where it is at a standstill due to overload. As a minimal amount of hydraulic fluid, in other words hydraulic fluid just enough to maintain the circuit pressure, is therefore sufficient, the configuration of the invention described above is rational.

[0059] According to the invention as claimed in claim 1, when there is no excessive pressure in the independent attachment circuit, the controller outputs electric signals in proportion to the attachment operation signals to the electromagnetic proportional control valve to control the stroke of the flow dividing control spool through the electromagnetic proportional control valve. In case an excessively high circuit pressure rises in the independent attachment circuit, the controller, which has detected it by means of the pressure sensor, controls the electromagnetic proportional control valve regardless of the attachment operation signals so as to reduce the aperture areas of the variable throttles, thereby reducing the hydraulic fluid fed to the independent attachment circuit. The amount of hydraulic fluid fed to the established actuator circuits can be restored by the amount equivalent to the reduction in the hydraulic fluid fed to the independent attachment circuit. Therefore, conjunctional operation of the attachment and established actuators can smoothly be performed. Thus, the invention is capable of increasing the working efficiency of the construction machine.

[0060] According to the invention as claimed in claim 2, the state where the circuit pressure in the independent attachment circuit is excessively high is defined as the state where circuit pressure in the independent attachment circuit is in the proximity of the relief pressure. When the attachment is close to the state of stalling, a minimal amount of hydraulic fluid, in other words hydraulic fluid that is just enough to maintain the circuit pressure, is sufficient. Therefore, the invention is capable of reasonably coping with the state where the circuit pressure in the independent attachment circuit is excessively high.

Claims

1. A hydraulic circuit of a construction machine, said hydraulic circuit including:

established actuator circuits for driving established actuators of the construction machine by controlling hydraulic fluid fed from hydraulic pumps;

an independent attachment circuit adapted to drive an attachment of the construction machine independently of the established actuator circuits by controlling a part of the hydraulic fluid fed from the hydraulic pumps to the established actuator circuits;

a flow dividing control valve adapted to cause a part of the hydraulic fluid fed from the hydraulic pumps to the established actuator circuits to branch off and be fed to the independent attachment circuit, the flow rate of the hydraulic fluid that undergoes branching process being controlled by means of variable throttles of the flow dividing control valve according to the stroke of the flow dividing control valve;

pressure compensation valves adapted to perform control so as to maintain a constant differential pressure between the inlet and the outlet of the variable throttles of the flow dividing control valve;

a pressure sensor for detecting circuit pressure in the independent attachment circuit;

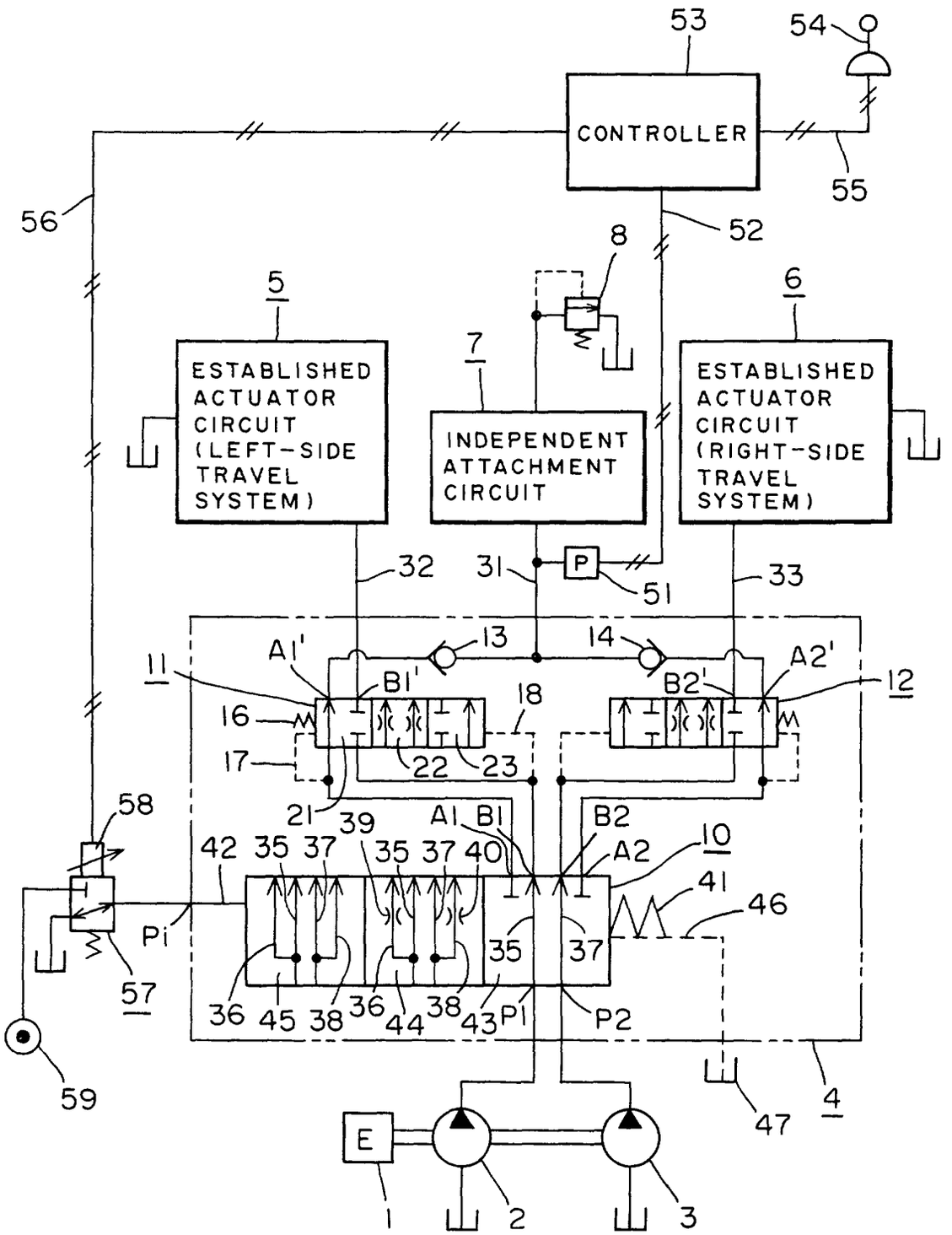
an electromagnetic proportional control valve for controlling the stroke of the flow dividing control valve by means of pilot pressure; and

a controller adapted to control the electromagnetic proportional control valve in such a manner that when the circuit pressure in the inde-

pendent attachment circuit detected by the pressure sensor is not excessively high, the controller controls the variable throttles of the flow dividing control valve by controlling the electromagnetic proportional control valve in accordance with attachment operation signals and that when the circuit pressure in the independent attachment circuit has increased to an excessively high level, the controller controls the electromagnetic proportional control valve regardless of attachment operation signals so as to reduce the aperture areas of the variable throttles of the flow dividing control valve.

2. A hydraulic circuit as claimed in claim 1, wherein the state where the circuit pressure in the independent attachment circuit is excessively high is defined as the state where circuit pressure in the independent attachment circuit is in the proximity of the relief pressure.

FIG. 1


53
54
CONTROLLER
55
56
52
8
5
6
7
ESTABLISHED ACTUATOR CIRCUIT (LEFT-SIDE TRAVEL SYSTEM)
INDEPENDENT ATTACHMENT CIRCUIT
ESTABLISHED ACTUATOR CIRCUIT (RIGHT-SIDE TRAVEL SYSTEM)
32
31
P
51
33
A1'
13
14
A2'
11
B1'
B2'
12
18
16
17
22
23
21
39
A1
B1
B2
58
42
35
37
35
37
40
A2
10
41
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Pi
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37
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36
45
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36
44
38
43
P1
P2
59
47
4
E
1
2
3

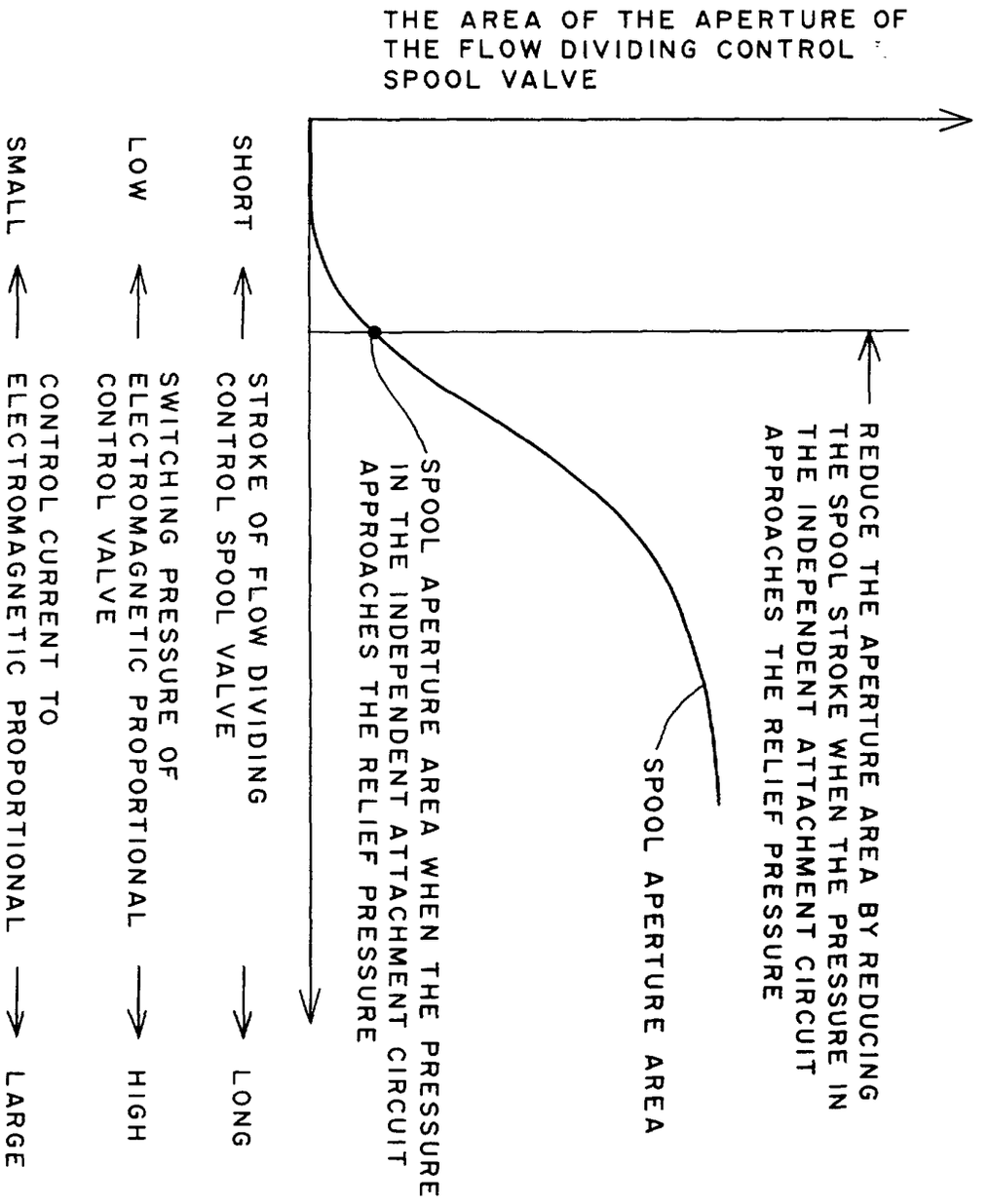
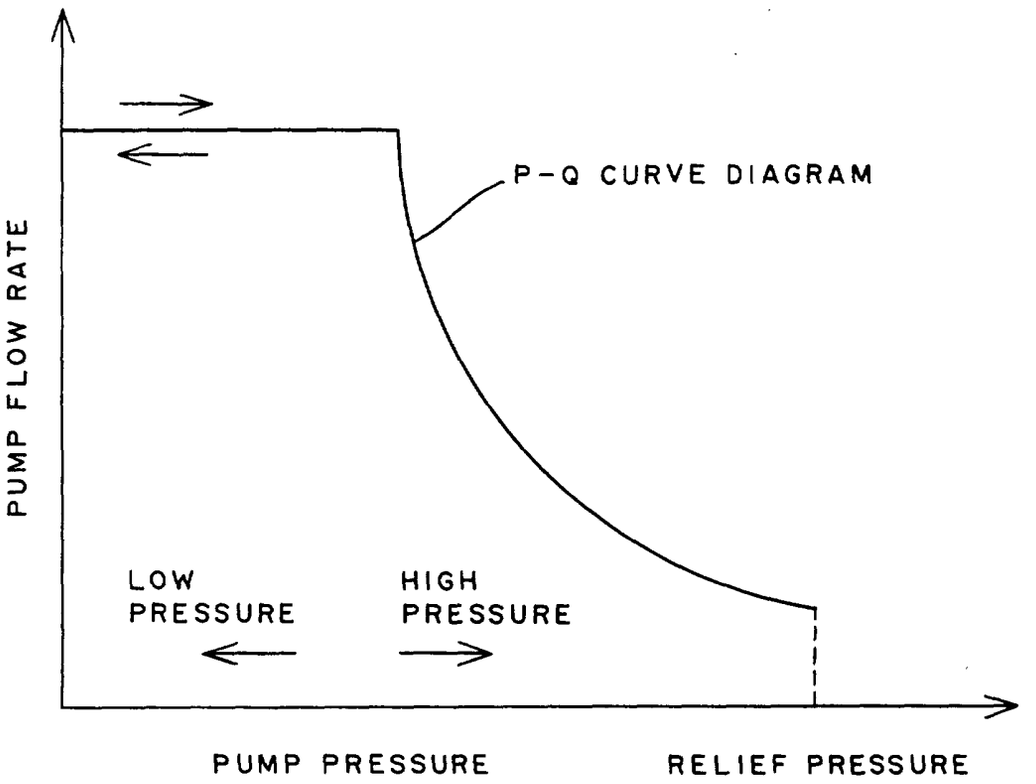

THE AREA OF THE APERTURE OF THE FLOW DIVIDING CONTROL SPOOL VALVE
REDUCE THE APERTURE AREA BY REDUCING THE SPOOL STROKE WHEN THE PRESSURE IN THE INDEPENDENT ATTACHMENT CIRCUIT APPROACHES THE RELIEF PRESSURE
SPOOL APERTURE AREA
SPOOL APERTURE AREA WHEN THE PRESSURE IN THE INDEPENDENT ATTACHMENT CIRCUIT APPROACHES THE RELIEF PRESSURE
SHORT
STROKE OF FLOW DIVIDING CONTROL SPOOL VALVE
LONG
LOW
SWITCHING PRESSURE OF ELECTROMAGNETIC PROPORTIONAL CONTROL VALVE
HIGH
SMALL
CONTROL CURRENT TO ELECTROMAGNETIC PROPORTIONAL CONTROL VALVE
LARGE

FIG. 2

FIG. 3


P-Q CURVE DIAGRAM
PUMP FLOW RATE
LOW PRESSURE
HIGH PRESSURE
PUMP PRESSURE
RELIEF PRESSURE