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(71) Applicant: **SHIN CATERPILLAR MITSUBISHI LTD.**
Tokyo (JP)

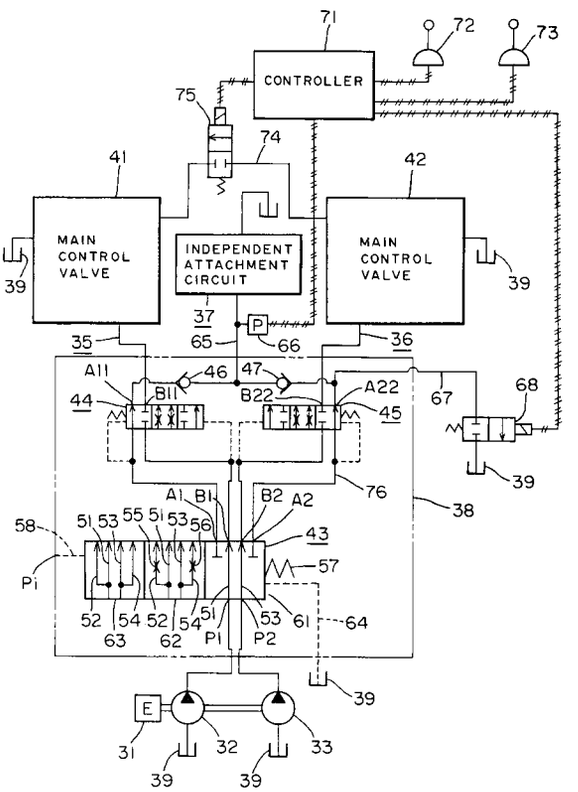
(72) Inventor: **Shimada, Yoshiyuki**
Setagaya-ku, Tokyo (JP)

(74) Representative: **Kemp, Paul Geoffrey et al**
Brookes Batchellor
102-108 Clerkenwell Road
London EC1M 5SA (GB)

(54) Hydraulic circuit of construction machine

(57) To provide a way to prevent sharp decrease in the speed of main body actuators by ensuring a sufficient amount of hydraulic fluid to be fed to the main body actuators even if the pressure in the attachment circuit of a hydraulic shovel approaches the relief pressure. When the pressure in an independent attachment circuit 37, which is adapted to control an attachment of a hydraulic shovel, approaches a given relief pressure in the course of operating the attachment together with other main body actuators, a controller 71 detects the increase of the pressure by means of a pressure sensor 66 and shifts an electromagnetic selector valve 68 to the channel-communicating position so that priority hydraulic fluid branching off from a pressure compensation flow dividing valve 38 to an external channel 67 flows through the electromagnetic selector valve 68 into a tank 39. As a result, the discharge rate of a pump 33 is increased by the amount equivalent to the decrease in the discharge pressure so that a greater amount of hydraulic fluid is fed from the independent attachment circuit 37 into a main circuit 36 of the main body actuators. Therefore, sharp decrease in the speed of the main body actuators is prevented.

FIG. 1



EP 1 193 400 A2

Description

TECHNICAL FIELD

[0001] The present invention relates to a hydraulic circuit which is installed in a construction machine and includes a pressure compensation flow dividing valve.

BACKGROUND OF THE INVENTION

[0002] As shown in Fig. 3, a hydraulic circuit of a construction machine disclosed in Japanese Patent provisional Publication No. 2000-73409 is provided with a pressure compensation flow dividing valve 8 disposed between a group of components consisting of a first pump 2 and a second pump 3, which are adapted to be driven by an engine 1 mounted on a hydraulic shovel, and a group of components consisting of a left-side travelling circuit 5, a right-side travelling circuit 6 and an independent attachment circuit 7.

[0003] The left-side travelling circuit 5 includes a left-side travelling control spool 11a of a main control valve 11 which is adapted to control hydraulic fluid fed from the first pump 2. The right-side travelling circuit 6 includes a right-side travelling control spool 12a of a main control valve 12 which is adapted to control hydraulic fluid fed from the second pump 3. Thus controlled hydraulic fluid drives hydraulic motors (not shown) of the right and left crawler belt type travelling systems mounted on the hydraulic shovel.

[0004] The aforementioned independent attachment circuit 7 includes an attachment control valve (not shown) for controlling the hydraulic fluid fed from the first pump 2 and the second pump 3. By means of the hydraulic fluid controlled by the attachment control valve, 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.

[0005] When simultaneously running the hydraulic shovel and operating its attachment, the pressure compensation flow dividing valve 8 compensates the pressure of the hydraulic fluid that is fed from the first pump 2 and divided so as to flow into the left-side travelling circuit 5 and the independent attachment circuit 7 and also compensates the pressure of the hydraulic fluid that is fed from the second pump 3 and divided so as to flow into the right-side travelling circuit 6 and the independent attachment circuit 7. In order to serve for this purpose, the pressure compensation flow dividing valve 8 contains a flow dividing control spool valve 13, a pressure compensation valve 14 for constantly maintaining the differential pressure between a B1 port and an A1 port of the flow dividing control spool valve 13 (FB1 - PA1) at a given level, a pressure compensation valve 15 for constantly maintaining the differential pressure between a B2 port and an A2 port of the flow dividing control spool valve 13 (PB2 - PA2) at a given level, and check valves 16,17 respectively disposed in the output circuits extending from the two pressure compensation valves 14,15 to the independent attachment circuit 7.

[0006] The flow dividing control spool valve 13 has internal oil channels 21,22 having such aperture characteristics that the flow rate of the hydraulic fluid that is fed from the first pump 2 and branches off to the left-side travelling circuit 5 is equal to the flow rate of the hydraulic fluid that is simultaneously fed from the second pump 3 and branches off to the right-side travelling circuit 6. The flow dividing control spool valve 13 is also provided with internal oil channels 23,24 having such aperture characteristics that the flow rate of the hydraulic fluid that is fed from the first pump 2 and branches off to the independent attachment circuit 7 is equal to the flow rate of the hydraulic fluid that is simultaneously fed from the second pump 3 and branches off to the independent attachment circuit 7.

[0007] With the configuration as above, when simultaneously running the hydraulic shovel and operating its attachment, the pressure compensation flow dividing valve 8 is capable of feeding hydraulic fluid to the left-side travelling circuit 5 and the right-side travelling circuit 6 at the same flow rate regardless of the position of the flow dividing control spool valve 13 and consequently keeping the hydraulic shovel running straight.

[0008] Generally speaking, each hydraulic pump installed in such a hydraulic shovel as described above has a threshold curve between the pump discharge rate, which is determined by the engine power, and the discharge pressure. A diagram illustrating such a threshold curve (hereinafter called P-Q curve diagram) is shown in Fig. 2. In other words, the hydraulic pump is designed such that the higher the discharge pressure, the lower the pump discharge rate.

[0009] According to the structure of the conventional independent attachment circuit 7 described above and shown in Fig. 3, the pressure compensation valves 14,15 function in such a manner that the hydraulic fluid is fed to the independent attachment circuit 7 at a flow rate corresponding to the degree of aperture of the internal oil channels 23,24 of the flow dividing control spool valve 13 regardless of the pressure in the circuit. Therefore, nearly all of the hydraulic fluid discharged from the pump flows into the independent attachment circuit 7 when the pump discharge rate is reduced as shown in the P-Q curve of Fig. 2 as a result of the pressure in the attachment circuit reaching a level high enough to be nearly equal to the relief pressure, should the internal oil channels 23,24 of the flow dividing control spool valve 13 be widely open. As a result, hydraulic fluid stops flowing into main body actuators, such as hydraulic travelling motors, etc.

[0010] Therefore, the moment when the pressure in the independent attachment circuit approaches the relief pressure in the course of operating the attachment in conjunction with main body actuators, such as hydraulic travelling motors, the action of the actuators of

the main body becomes extremely slow.

[0011] In order to solve the above problem, an object of the present invention is to provide a hydraulic circuit of a construction machine, which includes a pressure compensation flow dividing valve and ensures the supply of a necessary amount of hydraulic fluid to main body actuators even if the pressure in the attachment circuit approaches the relief pressure in the course of operating the attachment in conjunction with the main body actuators, thereby preventing sharp reduction in the speed of the main body actuators.

DISCLOSURE OF THE INVENTION

[0012] The invention as claimed in claim 1 relates to a hydraulic circuit of a construction machine, said hydraulic circuit including main circuits for controlling hydraulic fluid pumped up from a tank by pumps mounted on a construction machine, thereby feeding the hydraulic fluid to main body actuators mounted on the construction machine; an attachment circuit for controlling hydraulic fluid pumped up from the tank by the pumps, thereby feeding the hydraulic fluid to an attachment mounted on the construction machine; a pressure compensation flow dividing valve adapted to compensate the pressure of the hydraulic fluid fed from the pumps and divided so as to flow into the main circuits and the attachment circuit; an external channel for returning into the tank the hydraulic fluid fed from the pressure compensation flow dividing valve to the attachment circuit; and a selector valve adapted to shift from a channel-shutting position to a channel-communicating position when the attachment circuit pressure is increased to a level nearly equal to the relief pressure in the course of operating the attachment in conjunction with the main body actuators.

[0013] With the configuration as above, when the attachment circuit pressure approaches the relief pressure during conjunctional operation of the attachment and the main body actuators, priority hydraulic fluid that has branched off from the pressure compensation flow dividing valve to the external channel flows through the selector valve into the tank and increases the pump discharge rate so that a greater amount of hydraulic fluid is fed to the main body actuators. Therefore, the invention is free from the problem of the action of the main body actuators becoming extremely slow the moment when the attachment circuit pressure approaches the relief pressure during conjunctional operation of the attachment and the main body actuators.

[0014] The invention claimed in claim 2 relates to a hydraulic circuit as claimed in claim 1, wherein the pumps comprise a first pump and a second pump; the main circuits have a first main circuit that includes a left-side travelling control spool for controlling a left-side hydraulic travelling motor of the machine body and a second main circuit that includes a right-side travelling control spool for controlling a right-side hydraulic travelling motor of the machine body; and the pressure compensation flow dividing valve includes a single flow dividing control spool valve adapted to control hydraulic fluid so that the hydraulic fluid is fed from the first pump to the first main circuit and from the second pump to the second main circuit and the attachment circuit at the same flow rate.

[0015] With the configuration as above, when simultaneously running the hydraulic shovel and operating its attachment, the pressure compensation flow dividing valve ensures that hydraulic fluid is constantly fed into the first main circuit and the second main circuit at the same flow rate. As the flow rate of the hydraulic fluid fed from the left-side travelling control spool of the first main circuit to the left-side travelling motor is always the same as that of the hydraulic fluid fed from the right-side travelling control spool of the second main circuit to the right-side travelling motor, the invention is capable of preventing deviation of the construction machine from running straight.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

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

Fig. 2 is a P-Q curve diagram showing characteristics of the pumps representing the relationship between pump discharge pressure and discharge rate.

Fig. 3 is a circuit diagram of a conventional hydraulic circuit of a construction machine.

PREFERRED EMBODIMENT OF THE INVENTION

[0017] Next, an embodiment of the present invention is explained hereunder, referring to Figs. 1 and 2.

[0018] Fig. 1 shows an example of a hydraulic circuit, wherein_a pressure compensation flow dividing valve 38 is disposed between a group of components consisting of a first pump 32 and a second pump 33, which are adapted to be driven by an engine 31 mounted on a construction machine, i.e. a hydraulic shovel in case of the present embodiment, and a group of components consisting of a first main circuit 35, a second main circuit 36 and an independent attachment circuit 37, which is provided independently of these main circuits. The first pump 32 and the second pump 33 function to feed hydraulic fluid pumped up from a tank 39 to the first main circuit 35, the second main circuit 36 and the independent attachment circuit 37 through the pressure compensation flow dividing valve 38.

[0019] The first main circuit 35 includes a main control valve 41 for controlling hydraulic fluid fed from the first pump 32, while the second main circuit 36 includes a main control valve 42 for controlling hydraulic fluid fed

from the second pump 33.

[0020] The main control valves 41,42 function to supply the main body actuators with the hydraulic fluid that has been fed from the pumps 32,33 through the pressure compensation flow dividing valve 38 to the main control valves 41,42 while controlling directions and flow rates of the hydraulic fluid.

[0021] The main body actuators consist of hydraulic motors mounted on the lower structure, i.e. the left-side hydraulic travelling motor for driving the left-side crawler belt and the right-side hydraulic travelling motor for driving the right-side crawler belt, a hydraulic swing motor for revolving the super structure on the lower structure, and actuators for driving the boom, arm and the bucket of the front working equipment on the super structure, i. e. an arm hydraulic cylinder, a boom hydraulic cylinder and a bucket hydraulic cylinder.

[0022] The main control valve 41 of the first main circuit 35 includes a left-side travelling control spool for controlling the left-side hydraulic travelling motor of the machine body, and the main control valve 42 of the second main circuit 36 includes a right-side travelling control spool for controlling the right-side hydraulic travelling motor of the machine body. In addition, either main control valve 41 or 42 includes swing control spools for controlling the swing hydraulic motor, boom control spools for controlling the boom hydraulic cylinder(s), arm control spools for controlling the arm hydraulic cylinder, and bucket control spools for controlling the bucket hydraulic cylinder.

[0023] The aforementioned independent attachment circuit 37 includes an attachment control valve (not shown) for controlling the hydraulic fluid fed from the first pump 32 and the second pump 33. By means of the hydraulic fluid controlled by the spool of the attachment control valve, the independent attachment circuit 37 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.

[0024] When simultaneously running the hydraulic shovel and operating its attachment, the pressure compensation flow dividing valve 38 compensates the pressure of the hydraulic fluid that is fed from the first pump 32 and divided so as to flow into the first main circuit 35 and the independent attachment circuit 37 and also compensates the pressure of the hydraulic fluid that is fed from the second pump 33 and divided so as to flow into the second main circuit 36 and the independent attachment circuit 37. In order to serve for this purpose, the pressure compensation flow dividing valve 38 contains a single flow dividing control spool valve 43, a pressure compensation valve 44 for constantly maintaining the differential pressure between a B1 port and an A1 port of the flow dividing control spool valve 43 (PB1 - PA1) at a given level, a pressure compensation valve 45 for constantly maintaining the differential pressure between a B2 port and an A2 port of the flow dividing control spool valve 43 (PB2 - PA2) at a given level, and check valves 46,47 respectively disposed in the output circuits extending from the two pressure compensation valves 44,45 to the independent attachment circuit 37.

[0025] The aforementioned single flow dividing control spool valve 43 contained in the pressure compensation flow dividing valve 38 is provided with internal oil channels 51,52 extending from the first pump 32 and internal oil channels 53,54 extending from the second pump 33. The internal oil channel 51 is provided for the hydraulic fluid that branches off to the first main circuit 35, and the internal oil channel 52 is provided for the hydraulic fluid that branches off to the independent attachment circuit 37. The internal oil channel 53 is provided for the hydraulic fluid that branches off to the second main circuit 36, and the internal oil channel 54 is provided for the hydraulic fluid that branches off to the independent attachment circuit 37.

[0026] The internal oil channels 51,53 of the flow dividing control spool valve 43 have such aperture characteristics as to make the flow rate of the hydraulic fluid that is fed from the first pump 32 and branches off to the first main circuit 35 equal to the flow rate of the hydraulic fluid that is simultaneously fed from the second pump 33 and branches off to the second main circuit 36. Meanwhile, the internal oil channels 52,54 have such aperture characteristics as to make the flow rate of the hydraulic fluid that is fed from the first pump 32 and branches off to the independent attachment circuit 37 equal to the flow rate of the hydraulic fluid that is simultaneously fed from the second pump 33 and branches off to the independent attachment circuit 37.

[0027] In other words, the flow dividing control spool valve 43 controls the hydraulic fluid so that the hydraulic fluid is fed from the first pump 32 to the first main circuit 35 and the attachment circuit 37 at the same flow rate as that of the hydraulic fluid fed from the second pump 33 to the second main circuit 36 and the independent attachment circuit 37.

[0028] The internal oil channels 52,54 for feeding hydraulic fluid to the independent attachment circuit 37 are respectively provided with variable throttles 55,56, of which the areas of the apertures can be changed in accordance with the spool stroke.

[0029] The flow dividing control spool valve 43 is so designed as to receive, at one end thereof, the constant force from a spring 57 and receive at the other end the pilot pressure introduced from a Pi port via a pilot pressure introducing channel 58 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 57.

[0030] To be more specific, the lower the pilot pressure at the Pi port, the closer the flow dividing control spool valve 43 to position 61. However, the higher the pilot pressure at the Pi port, the closer the flow dividing control spool valve 43 shifts through position 62 towards position 63 so that the variable throttles 55,56 open

more widely. A drain oil channel 64 is drawn out of the flow dividing control spool valve 43 and communicates with a tank 39.

[0031] A pressure sensor 66 is disposed in an independent attachment line 65, through which hydraulic fluid is fed to the independent attachment circuit 37. An external channel 67 branches off from a priority channel, which is provided between the pressure compensation valve 45 and the check valve 47 in the pressure compensation flow dividing valve 38.

[0032] An electromagnetic selector valve 68 serving as a selector valve is disposed in the external channel 67 so that the external channel 67 is connected to the tank 39 through the electromagnetic selector valve 68.

[0033] The electromagnetic selector valve 68 is a selector valve adapted to be shifted from a channel-shutting position to a channel-communicating position by the energized solenoid when the pressure in the independent attachment circuit 37, i.e. the attachment circuit pressure, is increased to a level nearly equal to the relief pressure in the course of operating the attachment in conjunction with the main body actuators.

[0034] With the configuration as above, the hydraulic fluid which is fed from the pressure compensation flow dividing valve 38 to the independent attachment circuit 37 can be returned into the tank 39 through the external channel 67 as a result of the electromagnetic selector valve 68 shifting to the channel-communicating position.

[0035] The aforementioned pressure sensor 66 is connected to an input terminal of a controller 71. The electromagnetic selector valve 68 is connected to an output terminal of the controller 71.

[0036] The controller 71 is adapted to shift the position of the spool of the control valve of the independent attachment circuit 37 based on output signals corresponding to lever signals input from an attachment operating unit 72, which may be an electric joy stick or the like. Furthermore, based on output signals corresponding to lever signals input from a main body actuator operating unit 73, which may be an electric joy stick or the like, the controller 71 shifts the aforementioned spools of the main control valves 41,42, which function to control the main body actuators.

[0037] The controller 71 is designed such that, only when signals are input from the pressure sensor 66 to the controller 71 as a result of a rise of high pressure in the proximity of the relief pressure in the independent attachment line 65 while simultaneous operation of the attachment operating unit 72 and the main body actuator operating unit 73 causes electric signals from the two operating units to be simultaneously input to the controller 71, the controller 71 transmits electric switching signals to the solenoid of the electromagnetic selector valve 68, thereby shifting the electromagnetic selector valve 68 to the channel-communicating position to cause the hydraulic fluid fed from the second pump 33 into a channel 76 to flow into the tank 39 via the external channel 67.

[0038] A bypass channel 74 is provided between the left-side main control valve 41 and the right-side main control valve 42, and a bypass valve 75 is disposed in the bypass channel 74. The bypass valve 75 is designed such that, only when high pressure nearly equal to the relief pressure rises in the independent attachment line 65 while the attachment operating unit 72 and the main body actuator operating unit 73 are simultaneously operated, the solenoid of the bypass valve 75 receives electric signals from the controller 71 so that the bypass valve 75 shifts from the channel-shutting position to the channel-communicating position, thereby opening the bypass channel 74.

[0039] Next, the function of the embodiment shown in Fig. 1 is explained hereunder, also referring to Fig. 2.

[0040] Should any external force be applied to the flow dividing control spool valve 43 to exert influence on its movement, the hydraulic fluid is constantly fed to an A11 port and an A22 port of the pressure compensation valves 44,45 at an equally divided flow rate, because the oil channel extending from the P1 port through the internal oil channel 52 to the A1 port and the oil channel extending from the P2 port through the internal oil channel 54 to the A2 port always have the same aperture characteristics.

[0041] When simultaneously running the hydraulic shovel and operating its attachment, the pressure compensation flow dividing valve 38 ensures that the hydraulic fluid is constantly fed from the first pump 32 and the second pump 33 to the independent attachment circuit 37 at the same flow rate so that the hydraulic fluid is constantly fed into the first main circuit 35 and the second main circuit 36 at the same flow rate. Therefore, the vehicle will not deviate from running straight, because the flow rate of the hydraulic fluid fed from the left-side travelling control spool of the first main control valve 41 to the left-side travelling motor is always the same as that of the hydraulic fluid fed from the right-side travelling control spool of the second main control valve 42 to the right-side travelling motor.

[0042] Should the circuit pressure in the independent attachment circuit 37 approaches the relief pressure in the course of simultaneously operating the attachment operating unit 72 and the main body actuator operating unit 73 to operate the attachment in conjunction with the main body actuators, the pressure sensor 66 detects the increase of pressure and inputs signals indicating it into the controller 71.

[0043] At that time, the controller 71 outputs operating signals to the electromagnetic selector valve 68 so that the electromagnetic selector valve 68 shifts to the channel-communicating position where the external channel 67 communicates with the tank 39. As a result, priority hydraulic fluid branching off from the priority channel into the external channel 67 escapes through the electromagnetic selector valve 68 into the tank 39 and reduces the pump discharge pressure of the second pump 33. The aforementioned priority channel is provided in the

pressure compensation flow dividing valve 38 in order to carry the hydraulic fluid fed from the second pump 33. The decrease in the pump discharge pressure increases the flow rate of the fluid discharged from the second pump 33, with the flow rate shown in the P-Q curve diagram of Fig. 2 shifting from the point Pa to the point Pb.

[0044] At the same time, decrease in the pressure in the channel 76 causes the pressure compensation valve 45 to shift to the right as viewed in Fig. 1 so as to reduce the supply of hydraulic fluid to the independent attachment circuit 37 while increasing the supply of hydraulic fluid to the main circuit 36. Therefore, compared with a hydraulic circuit according to conventional art, a tremendously greater amount of hydraulic fluid is fed through the main control valve 42 into the main body actuators so that the main body actuators are free from the problem of becoming extremely slow the moment when the pressure in the independent attachment circuit 37 approaches the relief pressure during conjunctional operation of the attachment and the main body actuators.

[0045] The state where "the attachment circuit pressure is in the proximity of the relief pressure" means that the attachment is close to the state of stalling. As hydraulic fluid just enough to maintain the circuit pressure is therefore sufficient, no actual problem occurs even if priority hydraulic fluid discharged from the second pump 33 flows into the tank 39. Therefore, the configuration of the invention described above is rational.

[0046] Referring to Fig. 1, when the attachment circuit pressure approaches the relief pressure, the hydraulic fluid flowing towards the main control valve 42 of the main body actuators is increased by the amount substantially greater than in the case of the conventional art. However, as the amount of the hydraulic fluid flowing towards the main control valve 41 remains small as is true in the case of the conventional art, a difference in the amount of hydraulic fluid will arise if the state described above remains unchanged.

[0047] As a result, while the actuators belonging to the main control valve 42 become faster, the actuators belonging to the main control valve 41 remain slow. In case each main control valve 41,42 is provided with a travelling spool, a difference will arise between the amount of hydraulic fluid in the right-side travelling spool and the left-side travelling spool, resulting in deviation of the vehicle from running straight.

[0048] According to the present invention, however, deviation from running straight can be prevented by using the bypass valve 75 to feed the oil flowing through the right-side travelling spool of the main control valve 42 to the left-side travelling spool of the main control valve 41 so as to achieve a balanced flow rate. As the oil flowing in the main control valve 42 is also fed to other actuators of the main control valve 41 via the bypass valve 75, the actuators can function faster than those of the conventional art.

[0049] Although the explanation is given as above referring to an example case where the external channel 67 branches off from the priority channel disposed at the side where the second pump 33 is provided, it is possible to draw an external channel from a priority channel between the pressure compensation valve 44 and the check valve 46 disposed at the side where the first pump 32 is provided and connect the external channel to the electromagnetic selector valve 68.

[0050] According to the invention as claimed in claim 1, when the attachment circuit pressure approaches the relief pressure during conjunctional operation of the attachment and the main body actuators, priority hydraulic fluid that has branched off from the pressure compensation flow dividing valve to the external channel flows through the selector valve into the tank and increases the pump discharge rate so that a greater amount of hydraulic fluid is fed to the main body actuators. Therefore, the invention is free from the problem of the action of the main body actuators becoming extremely slow the moment when the attachment circuit pressure approaches the relief pressure during conjunctional operation of the attachment and the main body actuators, and is consequently capable of increasing the working efficiency of the construction machine.

[0051] According to the invention as claimed in claim 2, when simultaneously running the hydraulic shovel and operating its attachment, the pressure compensation flow dividing valve ensures that hydraulic fluid is constantly fed into the first main circuit and the second main circuit at the same flow rate. Therefore, as the flow rate of the hydraulic fluid fed from the left-side travelling control spool of the first main circuit to the left-side travelling motor is always the same as that of the hydraulic fluid fed from the right-side travelling control spool of the second main circuit to the right-side travelling motor, the invention is capable of preventing deviation of the construction machine from running straight.

Claims

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

   main circuits for controlling hydraulic fluid pumped up from a tank by pumps mounted on the construction machine, thereby feeding the hydraulic fluid to main body actuators mounted on the construction machine;

   an attachment circuit for controlling hydraulic fluid pumped up from the tank by the pumps, thereby feeding the hydraulic fluid to an attachment mounted on the construction machine;

   a pressure compensation flow dividing valve adapted to compensate the pressure of the hydraulic fluid fed from the pumps and divided so as to flow into the main circuits and the attachment circuit;

an external channel for returning into the tank the hydraulic fluid fed from the pressure compensation flow dividing valve to the attachment circuit; and

a selector valve adapted to shift from a channel-shutting position to a channel-communicating position when the attachment circuit pressure is increased to a level nearly equal to a relief pressure in the course of operating the attachment in conjunction with the main body actuators.

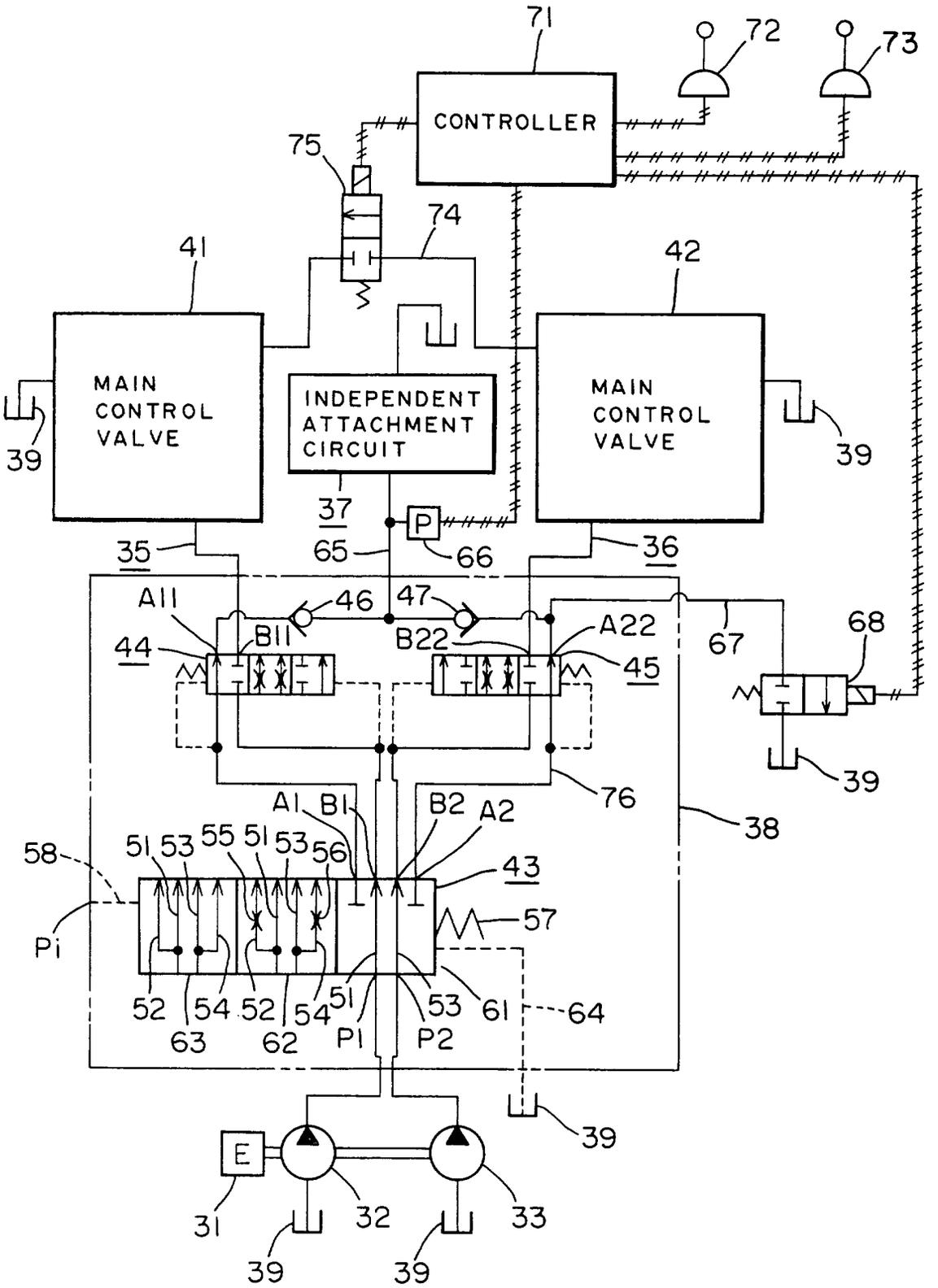
2. A hydraulic circuit as claimed in claim 1, wherein:

the pumps comprise a first pump and a second pump;

the main circuits have a first main circuit that includes a left-side travelling control spool for controlling a left-side hydraulic travelling motor of the machine body and a second main circuit that includes a right-side travelling control spool for controlling a right-side hydraulic travelling motor of the machine body; and

the pressure compensation flow dividing valve includes a single flow dividing control spool valve adapted to control hydraulic fluid so that the hydraulic fluid is fed from the first pump to the first main circuit and from the second pump to the second main circuit and the attachment circuit at the same flow rate.

FIG. 1


71
72
73
CONTROLLER
75
74
41
42
MAIN CONTROL VALVE
INDEPENDENT ATTACHMENT CIRCUIT
MAIN CONTROL VALVE
39
39
37
P
65
66
35
36
A11
46
47
B11
B22
A22
44
45
67
68
39
76
A1
B1
B2
A2
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58
51
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51
53
56
43
57
Pi
52
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62
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E
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FIG. 2

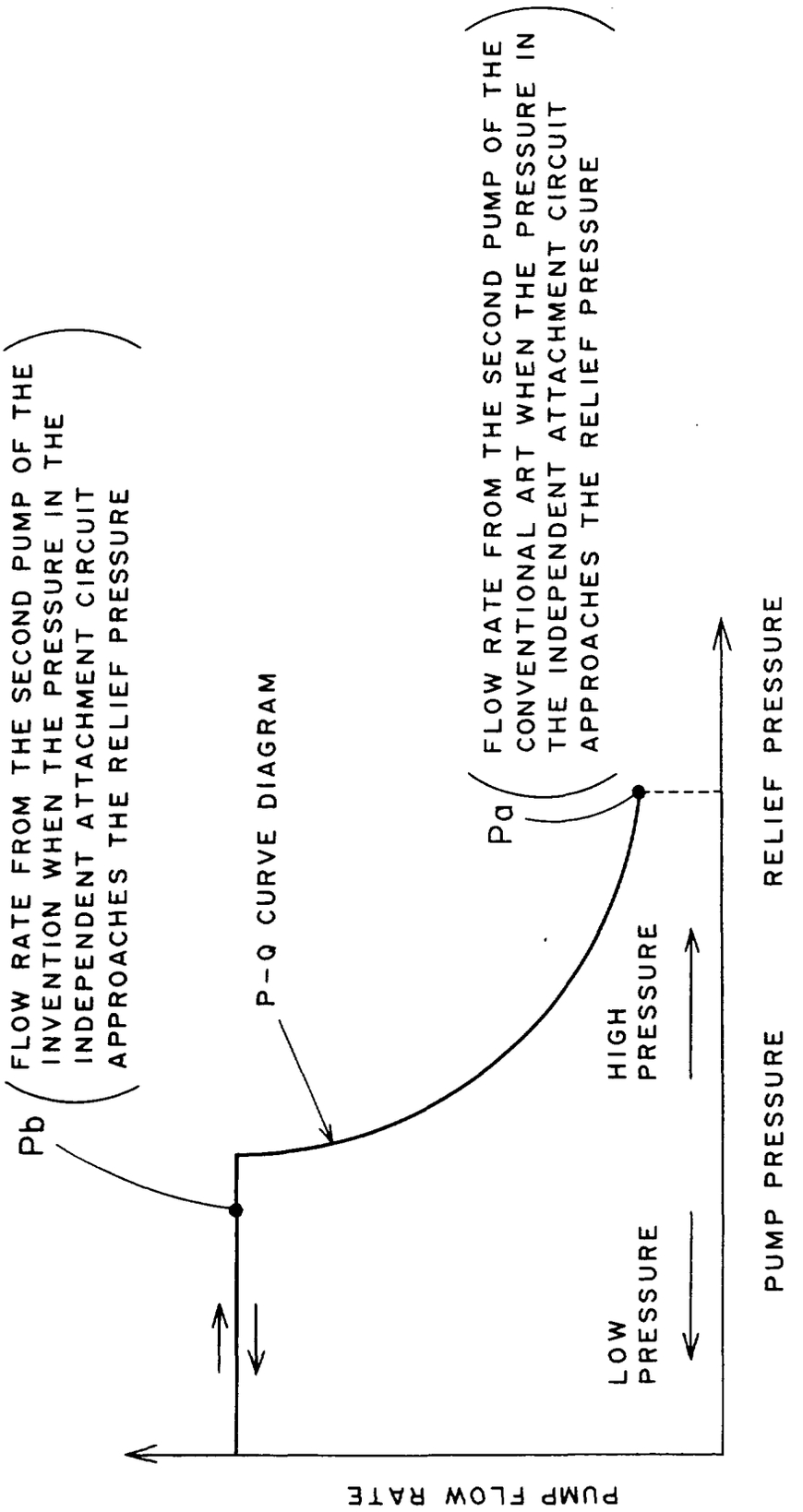
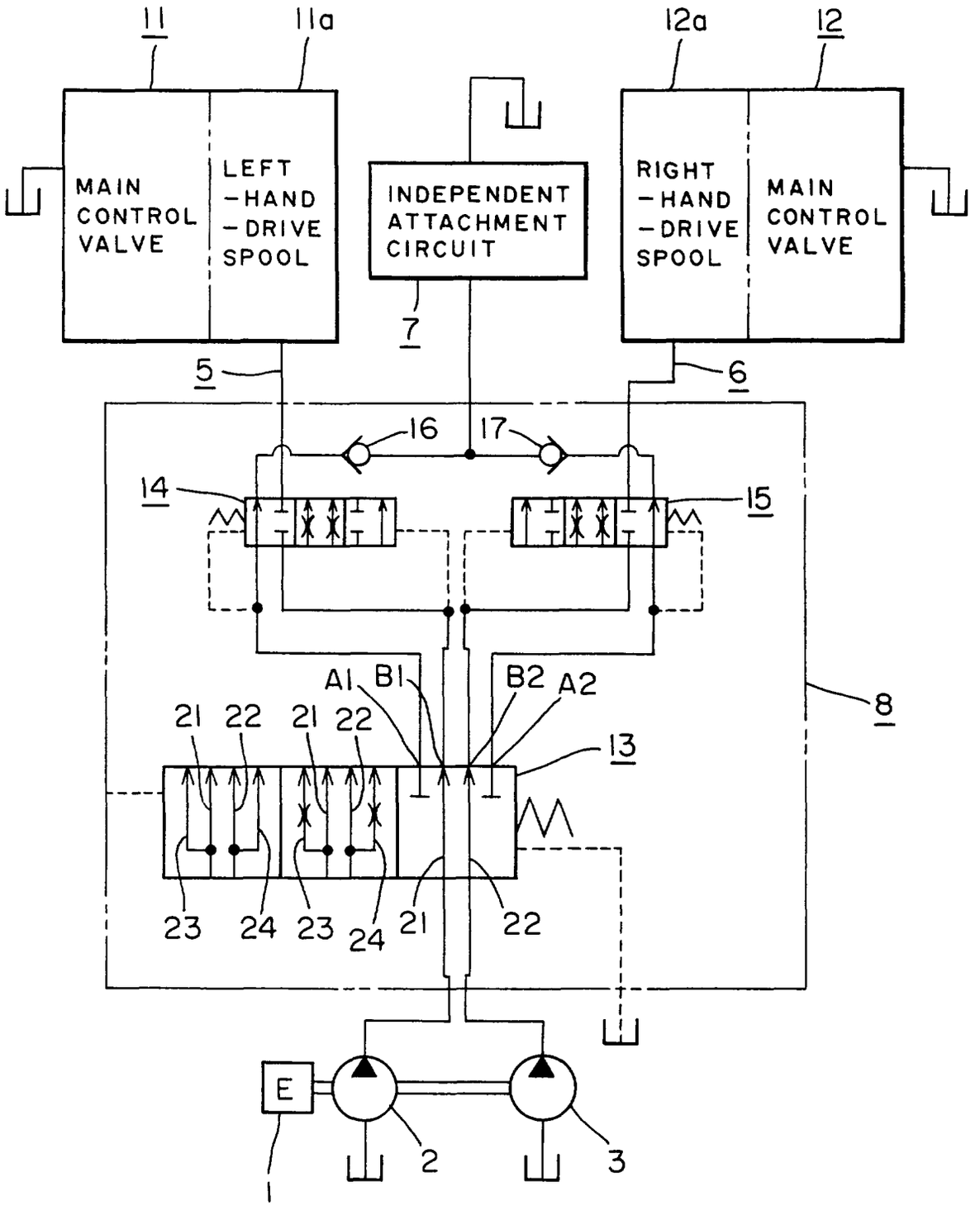

FLOW RATE FROM THE SECOND PUMP OF THE INVENTION WHEN THE PRESSURE IN THE INDEPENDENT ATTACHMENT CIRCUIT APPROACHES THE RELIEF PRESSURE
Pb
P-Q CURVE DIAGRAM
Pa
FLOW RATE FROM THE SECOND PUMP OF THE CONVENTIONAL ART WHEN THE PRESSURE IN THE INDEPENDENT ATTACHMENT CIRCUIT APPROACHES THE RELIEF PRESSURE
HIGH PRESSURE
LOW PRESSURE
PUMP PRESSURE
RELIEF PRESSURE
PUMP FLOW RATE

FIG. 3


11
11a
12a
12
MAIN CONTROL VALVE
LEFT -HAND -DRIVE SPOOL
INDEPENDENT ATTACHMENT CIRCUIT
RIGHT -HAND -DRIVE SPOOL
MAIN CONTROL VALVE
7
5
6
16
17
14
15
A1
B1
B2
A2
21
22
21
22
8
13
23
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24
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E
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1