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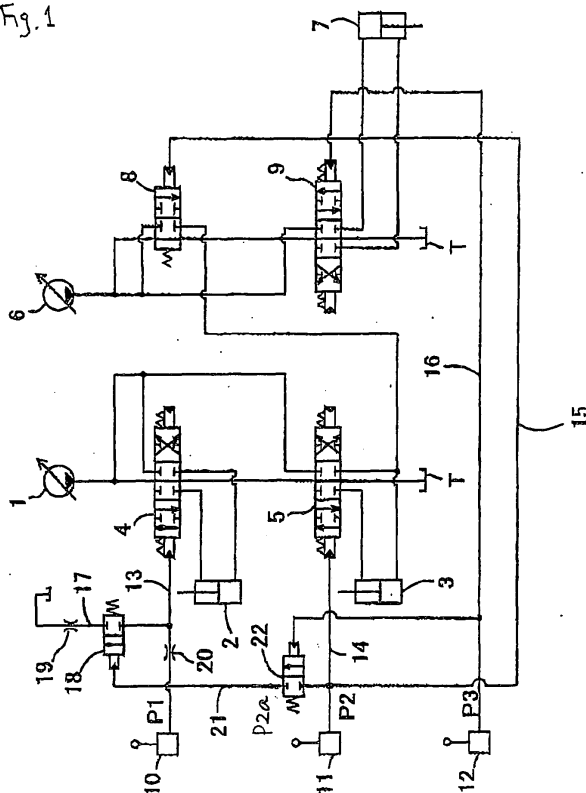
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(54) **Hydraulic circuit of hydraulic excavator**

(57) This invention provides with a hydraulic circuit in a hydraulic excavator which, on composite or simultaneous operations of a boom raising, a bucket digging, and an arm pulling, a stroke throttling of a bucket control valve (4) by decreasing a pilot pressure (13) of the valve through a throttle valve can make a pump pressure in-

creased by a throttling action of the control valve itself, thereby capable of ensuring a boom raising operation at the time of the composite operations with no fear of occurrence of cavitation, easy to be installed later, and easy to adjust an increase or decrease of the bucket weight.

Fig. 1



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Description

BACKGROUND OF THE INVENTION

(FIELD OF THE INVENTION)

[0001] This invention relates to a hydraulic circuit of a hydraulic excavator.

(DESCRIPTION OF THE RELATED ART)

[0002] In a hydraulic excavator with a two-pump type hydraulic circuit, when simultaneous operations of a boom raising, an arm pulling, and a bucket digging are performed in the air, pressure oil provided from both pumps are fed to a bucket cylinder and an arm cylinder in preference to a boom cylinder since a boom raising operation is an operation with heavy load than a bucket digging or an arm pulling of which its own weight in itself acts in a direction of working. As a result, there is a problem that an operation can not operate working attachments according to his will.

[0003] In this regard, with a flow rate control valve provided at an inlet-passage of a control valve for a bucket cylinder, Japanese Patent Application Publication No. Hei 8-13547 discloses that a pump pressure is increased to more than a load pressure of the boom cylinder by throttling a flow rate for supply to the bucket cylinder on composite operations including the above three operations.

[0004] In this case, on a condition of a full stroke of control valve for bucket, its inlet flow rate is throttled but a returning flow rate to a tank is not throttled. This causes problems that, especially, rotation speed of an engine as pump driving source is lowered due to a work load, a pump flow rate decreases and shortage of an inlet flow rate leads to cavitation.

[0005] Since a main flow rate is throttled, a later installation of the flow rate control valve to the existing machine is difficult to handle and the installation like this is costly. Furthermore, it is difficult to deal with an adjustment with regard to an increase and decrease of a bucket weight (a load of the bucket cylinder).

SUMMARY OF THE INVENTION

[0006] It is an object of the present invention to provide a hydraulic circuit in a hydraulic excavator capable of ensuring a boom raising operation at the time of simultaneous operation of working attachments, including a boom, with no fear of occurrence of cavitation, easy to be installed later, and easy to adjust against an increase or decrease of the bucket weight.

[0007] The hydraulic circuit of the present invention has the following basic constructions.

[0008] A hydraulic circuit in one aspect of the present invention comprises a boom, an arm, a bucket, a boom cylinder for actuating the boom, an arm cylinder for ac-

tuating the arm, a bucket cylinder for actuating the bucket, and a hydraulic pump, and is constructed so as to supply pressure oil from the hydraulic pump in parallel to both boom cylinder and bucket cylinder through a boom control valve and a bucket control valve, wherein each of the control valves is a hydraulic pilot switching valve adapted to operate by a pilot pressure proportional to the amount of operation of an operating means. This hydraulic circuit is characterized by further comprising a pilot pressure control means which, in accordance with the amount of a boom raising operation, reduces a pilot pressure fed to a bucket digging-side pilot port of the bucket control valve when both boom raising operation and bucket digging operation are performed substantially simultaneously.

[0009] A hydraulic circuit in another aspect of the present invention comprises a boom, an arm, a bucket, a boom cylinder for actuating the boom, an arm cylinder for actuating the arm, a bucket cylinder for actuating the bucket, a first hydraulic pump, and a second hydraulic pump, and is constructed such that pressure oil provided from the first hydraulic pump is fed in parallel to both boom cylinder and bucket cylinder through a boom control valve and a bucket control valve, while pressure oil provided from the second hydraulic pump is fed in parallel to both boom cylinder and arm cylinder through a boom control valve for confluence and a control valve for the arm, wherein each of the control valves is a hydraulic pilot switching valve adapted to operate in accordance with the amount of operation of an operating means, the hydraulic circuit further comprising a pilot pressure control means which, in accordance with the amount of an arm pulling operation and that of a boom raising operation, reduces a pilot pressure fed to a bucket digging-side pilot port of the bucket control valve when boom raising, arm pulling, and bucket digging operations are performed substantially simultaneously.

[0010] According to the present invention constructed as above, when two operations of both boom raising operation and bucket digging operation or three operations of these two operations plus an arm pulling operation are performed at a time, the pilot pressure fed to the bucket control valve is reduced to diminish the stroke of the same valve, whereby a throttling effect of the control valve itself is exerted to increase the pump pressure and there is ensured a boom raising operation.

[0011] That is, the boom raising operation is ensured not by throttling an inlet-side passage (main passage) in the bucket control valve, but by reducing the pilot pressure fed to the same valve. Therefore, even if the pump flow rate decreases due to a decrease of engine speed, there is no fear of occurrence of cavitation because the tank flow rate is also throttled at the same time.

[0012] Besides, since the pilot pressure for the bucket control valve is reduced, the construction of the hydraulic circuit is simpler and the cost thereof is lower than in the technique wherein the main flow rate is throttled, and

a later installation of the hydraulic circuit becomes easier.

[0013] Preferably, the pilot pressure control means is constructed such that the pilot pressure fed to the bucket digging-side pilot port of the bucket control valve is reduced by a throttle means.

[0014] Preferably, the pilot pressure control means is constructed such that a tank line communicating with a tank is connected a bucket digging-side pilot line, and a bucket digging-side switching valve whose degree of opening changes in accordance with a boom raising pilot pressure, as well as a first throttle means, are provided in the tank line, further, a second throttle means is provided in the pilot line upstream of the tank line.

[0015] Preferably, a boom raising switching valve whose degree of opening changes in accordance with an arm pulling pilot pressure is connected to a boom raising pilot line, and a boom raising pilot pressure as an output of the boom raising switching valve is fed to a pilot port of the bucket digging-side switching valve.

[0016] As the first and second throttle means there may be used variable throttle means whose degree of opening can be adjusted.

[0017] The pilot pressure control means may comprise an electromagnetic proportional pressure reducing valve disposed in the bucket digging-side pilot line of the bucket control valve, an arm pulling detector means for detecting the amount of the arm pulling operation, a boom raising detector means for detecting the amount of the boom raising operation, and a controller which issues to the electromagnetic proportional pressure reducing valve a command of a secondary pressure proportional to the amount of the arm pulling operation and that of the boom raising operation detected by both detector means.

[0018] Further, the pilot pressure control means may comprise a boom raising pressure detector means for detecting a boom raising-side pressure of the boom cylinder and a pump pressure detector means for detecting an operating pressure of the first hydraulic pump, wherein the command of the secondary pressure to the electromagnetic proportional pressure reducing valve may be issued on condition that the operating pressure of the first hydraulic pump is higher than the boom raising-side pressure.

[0019] In this case, since there is performed feedback of the pump pressure, there is no fear of the bucket digging operation speed decreasing to a greater extent than necessary with consequent impairment of operability.

[0020] In the above construction provided with the throttle means, since pressure is reduced by the throttle means, there can be attained a simpler construction, a lower cost of parts, and a still easier later installation of the hydraulic circuit.

[0021] It also becomes easy to increase or decrease the weight of the bucket and adjust the degree of pressure reduction according to an operator's taste in operation characteristics.

This adjustment is further facilitated by the construction which uses a variable throttle means.

[0022] On the other hand, in the construction using a pressure reducing valve adapted to operate in accordance with a command provided from the controller, the selection and change of a characteristic with respect to each of boom raising, bucket digging, and arm pulling operations can be done more easily by adjustment using the controller.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023]

Fig. 1 is a view of a hydraulic circuit according to a first embodiment of the present invention;

Fig. 2 is a view of a hydraulic circuit according to a second embodiment of the present invention;

Fig. 3 is a view of a hydraulic circuit according to a third embodiment of the present invention;

Fig. 4 is an explanatory flow chart of an operation of the third embodiment;

Fig. 5 is a view of a hydraulic circuit according to a fourth embodiment of the present invention; and

Fig. 6 is an explanatory flow chart of an operation of the fourth embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0024] Working attachments in a hydraulic excavator are composed of a boom, an arm, a bucket, and hydraulic cylinders (boom cylinder, arm cylinder, bucket cylinder) for actuating those components. Various works, including excavating and loading works, are carried out by various operations, including boom raising/boom lowering, arm pushing/arm pulling, and bucket digging or bucket-in/bucket dump or bucket-out operations.

[0025] In this case, as to a hydraulic pump - cylinder combination, both a boom cylinder which requires a large flow rate and a bucket cylinder for which a small flow rate will do, are actuated usually by a common hydraulic pump.

[0026] In each of the following embodiments, reference will be made to a two-pump type hydraulic circuit as an example. According to this construction, a boom cylinder and a bucket cylinder are actuated by a first hydraulic pump, while an arm cylinder is actuated by a second hydraulic pump, and in this state a portion of pressure oil fed from the second hydraulic pump is allowed to join the pressure oil in the boom cylinder to ensure a required boom operation speed.

First Embodiment (see Fig. 1)

[0027] The numeral 1 denotes a first hydraulic pump. A bucket cylinder 2 and a boom cylinder 3 are connected

to the first hydraulic pump 1 in parallel through a bucket control valve 4 and a boom control valve 5, respectively.

[0028] Numeral 6 denotes a second hydraulic pump. The boom cylinder 3 and an arm cylinder 7 are connected to the second hydraulic pump 6 in parallel through a boom control valve 8 for confluence and an arm control valve 9, respectively. The mark T denotes a tank.

[0029] The control valves 4, 5, 8, and 9 are constructed as hydraulic pilot valves (hydraulic pilot switching valves) adapted to operate switching in accordance with pilot pressures provided from remote control valves 10, 11, and 12 for bucket, boom, and arm, respectively, which serve as operating means. In a composite operation of three such motions as bucket digging, boom raising, and arm pulling, the bucket control valve 4 and the boom control valve 5 are set to respective left-hand positions (bucket digging position and boom raising position) in the figure, while the boom control valve 8 for confluence and the arm control valve 9 are set to respective righthand positions (confluent position, arm pulling position) in the figure.

[0030] According to this construction, pressure oil is fed from the first hydraulic pump 1 to both bucket and boom cylinders 2, 3 and from the second hydraulic pump 6 to both boom and arm cylinders 3, 7 at flow rates proportional to control valve operation quantities, whereby the cylinders 2, 3, and 7 extend.

[0031] In Fig. 1, as pilot lines for the supply of a pilot pressure to each of the control valves 4, 5, 8, and 9, there are shown only a bucket digging-side pilot line 13, a boom raising-side pilot line 14, a confluent pilot line 15 connected in parallel with the pilot line 14, and an arm pulling-side pilot line 16. On the other hand, bucket dump-side, boom lowering-side, confluence stop-side, and arm pushing-side pilot lines are not shown.

[0032] In this hydraulic circuit, a tank line 17 is connected to the pilot digging-side pilot line 13. A bucket digging-side switching valve 18 as a hydraulic pilot valve whose degree of opening changes in accordance with a pilot pressure, and a first throttle 19 (throttle valve), are provided in the tank line 17. Further, a second throttle 20 (throttle valve) is provided in the pilot line 13 upstream (on the hydraulic pump side) of the tank line 17. A pilot pressure control means is constituted by these components.

[0033] A pilot port of the bucket digging-side switching valve 18 is connected to the boom raising-side pilot line 14 through a control line 21. In the control line 21 is provided a boom raising-side switching valve 22 as a hydraulic pilot valve whose degree of opening changes in accordance with an arm pulling pilot pressure.

[0034] In this construction, when there is performed a composite operation of bucket digging, boom raising, and arm pulling, pilot pressures P1, P2, and P3 proportional to operation quantities are exerted on pilot lines 13, 14, 15, and 16.

[0035] In this case, when the arm pulling pilot pressure P3 is fed to a pilot port of the boom raising-side

switching valve 22, the switching valve 22 opens at a degree of opening proportional to the pilot pressure P3. Further, a pilot pressure P2a proportional to the degree of opening of the switching valve 22 is fed to the pilot port of the bucket digging-side switching valve 18, whereby the switching valve 18 opens at a degree of opening proportional to the pilot pressure P2a.

[0036] On the other hand, the bucket digging-side pilot pressure P1 is reduced to an intermediate pressure (e.g., one half or so) by the second throttle 20. As a result, by the action of the first throttle 19 upon opening of the bucket digging-side switching valve 18, a further reduced pilot pressure is fed to a bucket digging-side pilot port of the bucket control valve 4.

[0037] With this action, the stroke of the bucket control valve 4 is diminished and the pump pressure of the first hydraulic pump 1 increases by a throttling action of the valve 4. Consequently, pressure oil is fed also to the boom cylinder 3 whose load pressure is high, whereby a boom raising operation is ensured. That is, a composite operation of bucket digging, boom raising, and arm pulling, can be done at an operator's will.

[0038] Besides, the valve stroke is diminished not by throttling an inlet-side passage of the bucket control valve 4 but by reducing the pilot pressure fed to the valve 4, to ensure a boom raising operation. Consequently, even in the event of decrease of the pump flow rate due to a lowering of the engine speed which is a pump drive source, the tank flow rate is also throttled at the same time by the valve 4. As a result, there no longer is any fear of occurrence of cavitation.

[0039] Moreover, because of the construction wherein the pilot digging-side pilot pressure is reduced, the construction can be made simpler than in case of providing a throttle means in the main passage. Accordingly, the cost of parts and that of assembly can be reduced and it becomes easy to later install the hydraulic circuit to an existing machine.

[0040] When both boom raising and arm pulling operations are not performed substantially simultaneously, the bucket digging-side switching valve 18 does not operate, so that there is no throttling action for the bucket digging-side pilot pressure and a bucket digging operation is performed at a normal speed.

Second Embodiment (see Fig. 2)

[0041] In the following embodiments, reference will be made to only different points from the first embodiment.

[0042] It is preferable that the degree of reduction in the bucket digging-side pilot pressure be adjustable in accordance with the weight of the bucket and the operator's taste in operation characteristic. In the previous first embodiment, adjustment of the degree of pressure reduction can be made by the selection and replacement of both throttles 19 and 20.

[0043] In this second embodiment, variable throttles are used as both first and second throttles 19' and 20'.

[0044] With the variable throttles, when the bucket is replaced or the operator is changed in a single machine, the degree of pressure reduction can be adjusted freely by adjusting the degree of opening of both throttles 19' and 20'.

Third Embodiment (see Figs. 3 and 4)

[0045] In this third embodiment, as a pilot pressure control means, an electromagnetic proportional pressure reducing valve (hereinafter referred to simply as "pressure reducing valve") 23 is disposed in the bucket digging-side line 13, as shown in Fig. 3. There also are provided pressure sensors 25 and 26 for detecting the boom raising pilot pressure P2 and the arm pulling pilot pressure P3 and sending them to a controller 24. Secondary pressure command signals proportional to both pilot pressures P2 and P3 are sent to the pressure reducing valve 23 from the controller 24 to reduce the bucket digging-side pilot pressure.

[0046] The operation on this regard will now be described with reference to Fig. 4. In steps S1 and S2, the boom raising pilot pressure P2 and the arm pulling pilot pressure P3 are read. Next, in steps S3 and S4, it is respectively determined whether a boom raising operation and an arm pulling operation are being performed.

[0047] If both answers are affirmative, then in steps S5 and S6, the sum of both pilot pressures P2 and P3 is plotted along the axis of abscissa and a secondary pressure (pressure after reduction) of the pressure reducing valve 23 is plotted along the axis of ordinate, then on the basis of a preset throttle characteristic a secondary pressure command signal is outputted to the pressure reducing valve 23 as a proportional valve.

[0048] By so doing, as in the first embodiment, it is possible to diminish the stroke of the bucket digging-side control valve in the composite three-operation mode and thereby increase the pump pressure. As a result, it is possible to ensure a boom raising operation.

[0049] Further, the selection and change of a characteristic with respect to each of boom raising, bucket digging, and arm pulling operations, can be done more easily by adjustment (e.g., using a trimmer) through the controller 24.

Fourth Embodiment (see Figs. 5 and 6)

[0050] In the fourth embodiment, in addition to the construction of the third embodiment, there are provided pressure sensors 27 and 28 for detecting a boom raising-side (cylinder head) pressure of the boom cylinder 3 and an operating pressure (pump pressure) of the first hydraulic pump 1, as shown in Fig. 5. According to the construction of this fourth embodiment, pump pressures detected by the pressure sensors 27 and 28 are inputted to the controller 24 and a bucket digging-side pilot pressure reducing action is exerted on the premise that the pump pressure is higher than the boom raising-side

pressure.

[0051] As shown in Fig. 6, the boom raising pilot pressure P2, arm pulling pilot pressure P3, boom cylinder pressure, and the pressure of the first hydraulic pump 1 are read in steps S1 to S4. In steps S5 and S6, it is determined whether a boom raising operation and an arm pulling operation are being performed or not. Thereafter, in step S7, a comparison is made between pump pressure and cylinder pressure. Only when the pump pressure is higher than the cylinder pressure, a secondary pressure of the pressure reducing valve as a proportional valve is calculated and outputted in steps S8 and S9.

[0052] By so doing, since there is performed feedback of the pump pressure, there is no fear of the pump pressure becoming lower than necessary and hence there is no fear of drop in speed of the bucket digging operation and impairment of operability.

[0053] As another embodiment, a hydraulic pilot type pressure reducing valve as a pilot control means may be provided in the bucket digging-side pilot line 13.

[0054] Further, as a modification of the first embodiment, there may be adopted a construction wherein electromagnetic switching valves are used as both bucket digging-side and boom raising-side switching valves 18, 22, and the switching valves 18 and 22 may be controlled by the controller in accordance with the boom raising-side pilot pressure and the arm pulling-side pilot pressure both detected by the pressure sensors.

[0055] According to the constructions of the above embodiments, the pressure oil provided from the first hydraulic pump 1 is used for both bucket cylinder and boom cylinder, while the pressure oil from the second hydraulic pump 6 is used for boom cylinder confluence and for the arm cylinder. However, the present invention is also applicable to the case where the pressure oil from the second hydraulic pump 6 is not used for boom cylinder confluence.

[0056] In this case, in the composite bucket digging and boom raising operation mode, the bucket digging-side pilot pressure may be reduced in accordance with the boom raising-side pilot pressure (a pressure raising operation quantity).

[0057] Although embodiments of the present invention have been described above, the scope of protection of the present invention is not limited to the above embodiments.

[0058] Although the invention has been described with reference to the preferred embodiments in the attached figures, it is noted that equivalents may be employed and substitutions made herein without departing from the scope of the invention as recited in the claims.

Claims

1. A hydraulic circuit in a hydraulic excavator, comprising:

a boom, an arm, a bucket, a boom cylinder for actuating said boom, an arm cylinder for actuating said arm, a bucket cylinder for actuating said bucket, and a hydraulic pump, wherein pressure oil provided from said hydraulic pump is fed in parallel to said boom cylinder and said bucket cylinder through a boom control valve and a bucket control valve, and each of said control valves is a hydraulic pilot switching valve adapted to operate by a pilot pressure proportional to the amount of operation of an operating means, **characterized in that** said hydraulic circuit further comprises:

a pilot pressure control means for, in accordance with the amount of a boom raising operation, reducing a pilot pressure fed to a bucket digging-side pilot port of said bucket control valve when both boom raising operation and bucket digging operation are performed substantially simultaneously.

2. A hydraulic circuit in a hydraulic excavator, comprising:

a boom, an arm, a bucket, a boom cylinder for actuating said boom, an arm cylinder for actuating said arm, a bucket cylinder for actuating said bucket, a first hydraulic pump, and a second hydraulic pump, wherein pressure oil provided from said first hydraulic pump is fed in parallel to said boom cylinder and said bucket cylinder through a boom control valve and a bucket control valve, while pressure oil from said second hydraulic pump is fed in parallel to said boom cylinder and said arm cylinder through a boom control valve for confluence and an arm control valve, and each of said control valves is a hydraulic pilot switching valve adapted to operate by a pilot pressure proportional to the amount of operation of an operating means, **characterized in that** said hydraulic circuit further comprises:

a pilot pressure control means for, in accordance with the amount of an arm pulling operation and a boom raising operation, reducing a pilot pressure fed to a bucket digging-side pilot port of said bucket control valve when boom raising, arm pulling, and bucket digging operations are performed substantially simultaneously.

3. The hydraulic circuit according to claim 2, wherein said pilot pressure control means is constructed such that the pilot pressure fed to the bucket digging-side pilot port of said bucket control valve is

reduced by a throttle means.

4. The hydraulic circuit according to claim 3, wherein said pilot pressure control means is constructed such that a tank line communicating with a tank is connected to a bucket digging-side pilot line, and a bucket digging-side switching valve of which degree of opening changes in accordance with a boom raising pilot pressure, as well as a first throttle means, are provided in said tank line, and a second throttle means is provided in said pilot line upstream of said tank line.

5. The hydraulic circuit according to claim 4, wherein a boom raising switching valve of which degree of opening changes in accordance with an arm pulling pilot pressure is connected to a boom raising pilot line, and a boom raising pilot pressure as an output of said boom raising switching valve is fed to a pilot port of said bucket digging-side switching valve.

6. The hydraulic circuit according to claim 4 or 5, wherein said first and second throttle means are variable throttle means for being adjusted in the degree of opening.

7. The hydraulic circuit according to claim 2, wherein said pilot pressure control means comprising:

an electromagnetic proportional pressure reducing valve disposed in the bucket digging-side pilot line of the bucket control valve;
an arm pulling detector means for detecting the amount of the arm pulling operation;
a boom raising detector means for detecting the amount of the boom raising operation; and
a controller adapted to give to said electromagnetic proportional pressure reducing valve a command of a secondary pressure proportional to the amount of the arm pulling operation and the boom raising operation detected by both said detector means.

8. The hydraulic circuit according to claim 7, wherein said pilot pressure control means comprising:

a boom raising pressure detector means for detecting a boom raising-side pressure of said boom cylinder; and
a pump pressure detector means for detecting an operating pressure of said first hydraulic pump, and wherein
the command of the secondary pressure to said electromagnetic proportional pressure reducing valve is issued on condition that the operating pressure of said first hydraulic pump is higher than the boom raising-side pressure.

Fig. 1

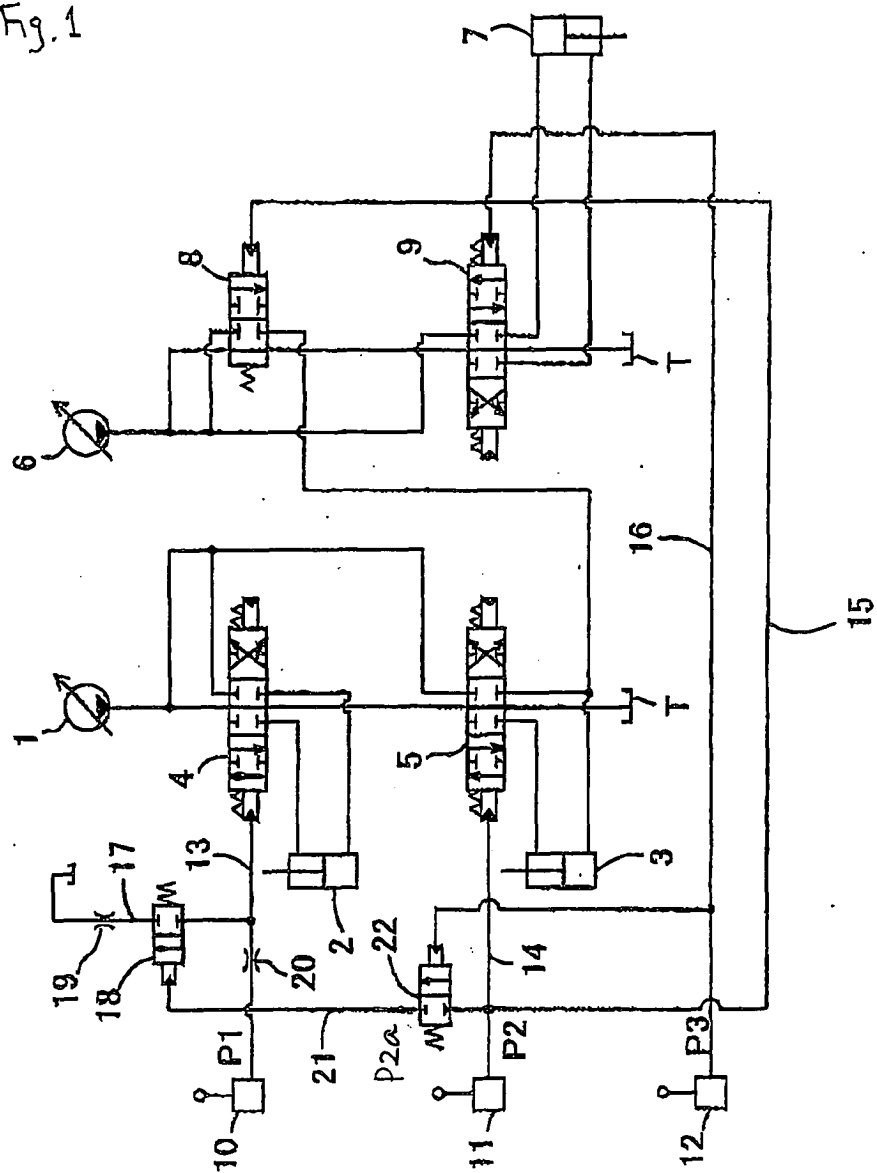


Fig. 2

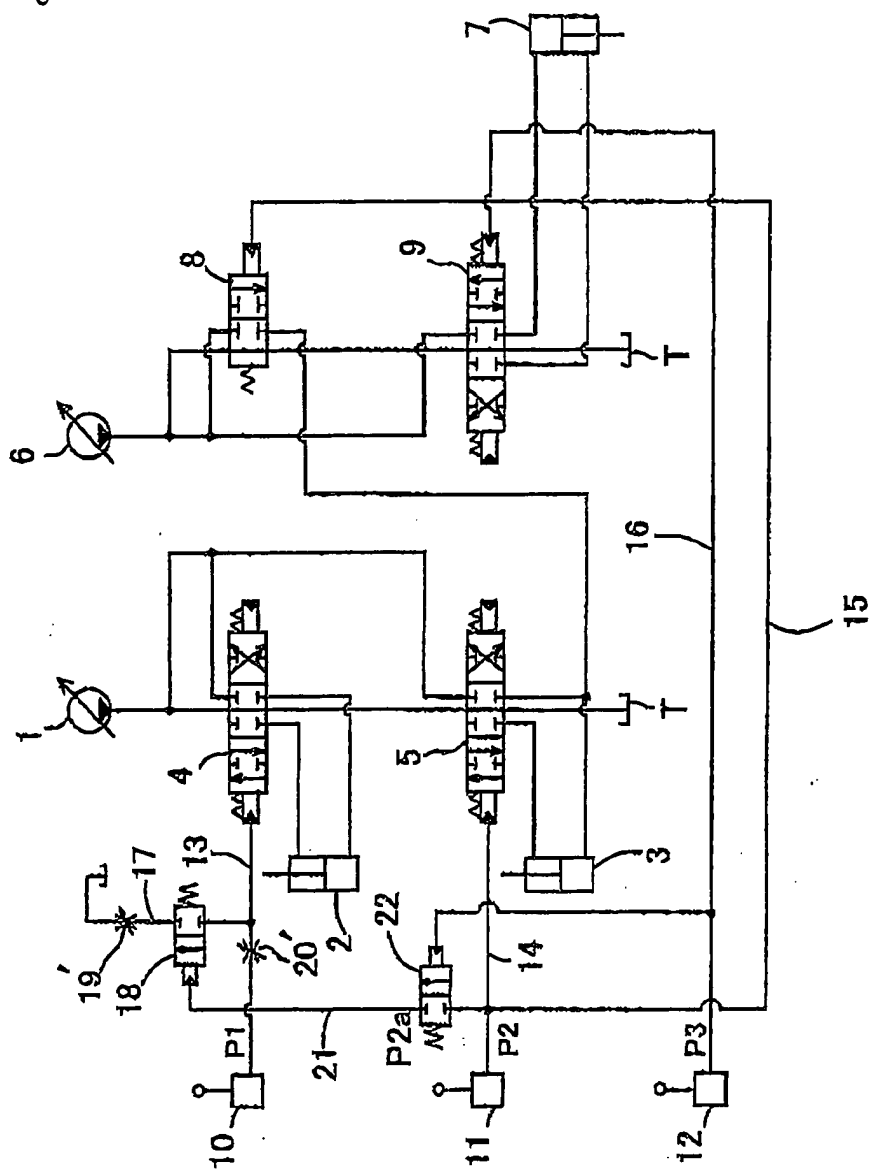


Fig. 3

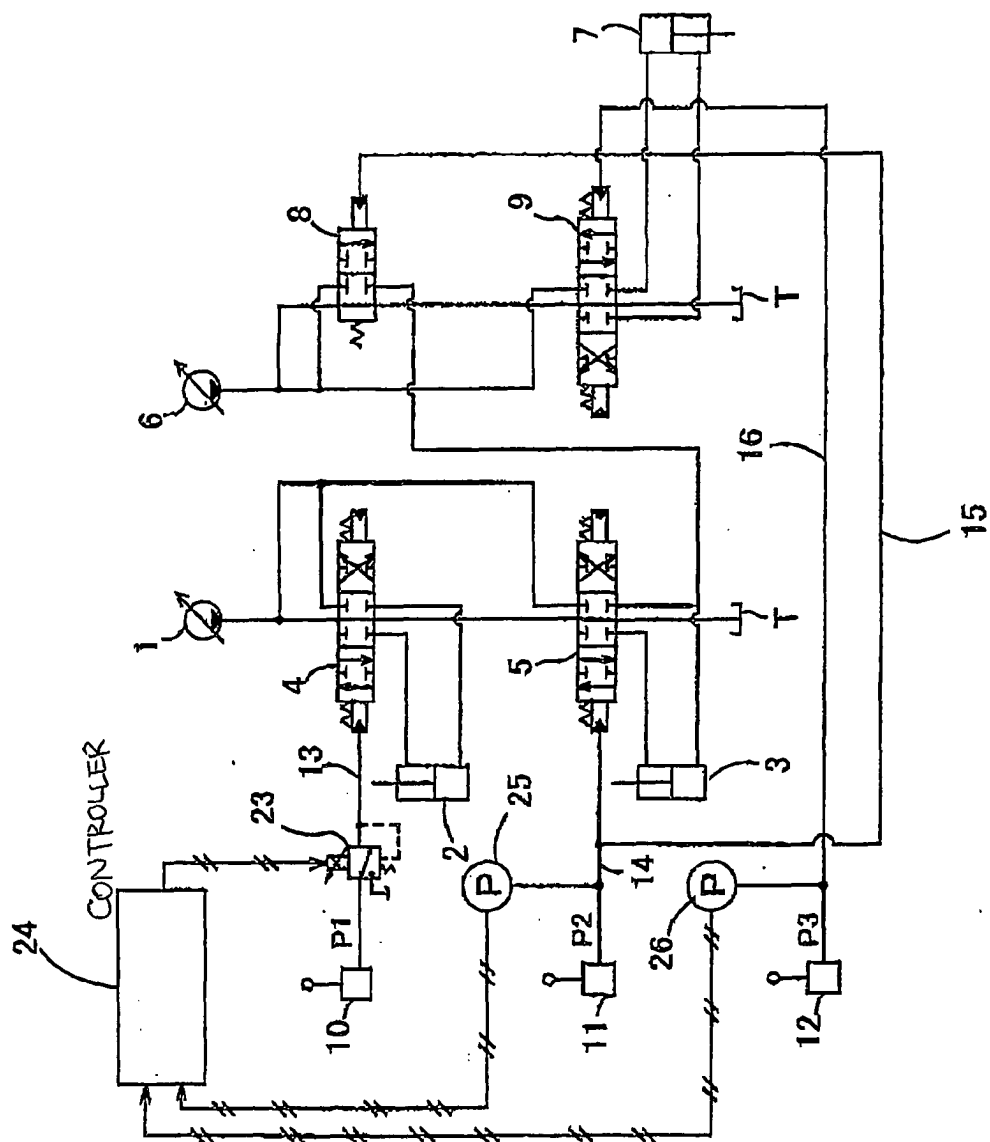


Fig. 4

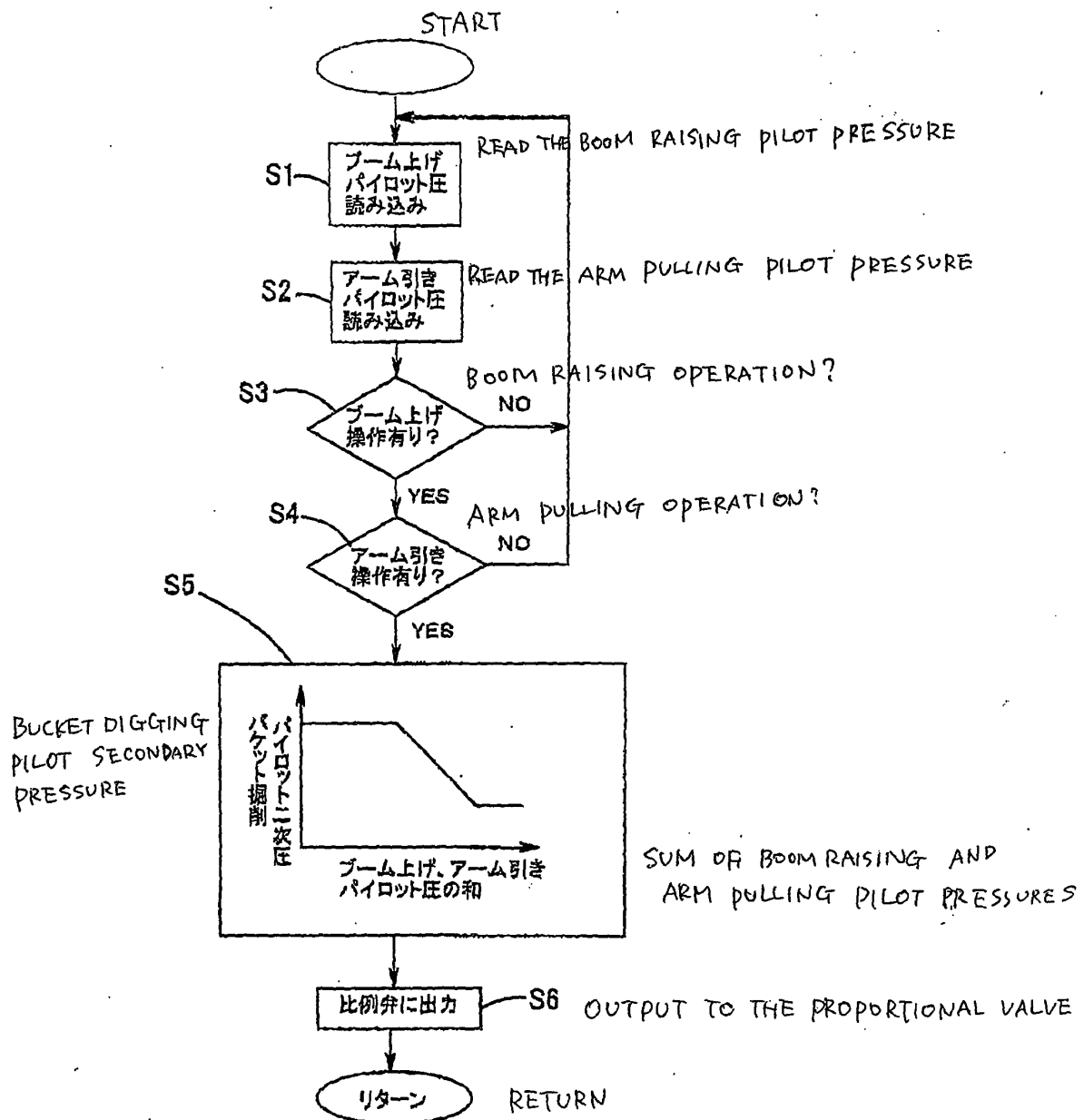


Fig. 5

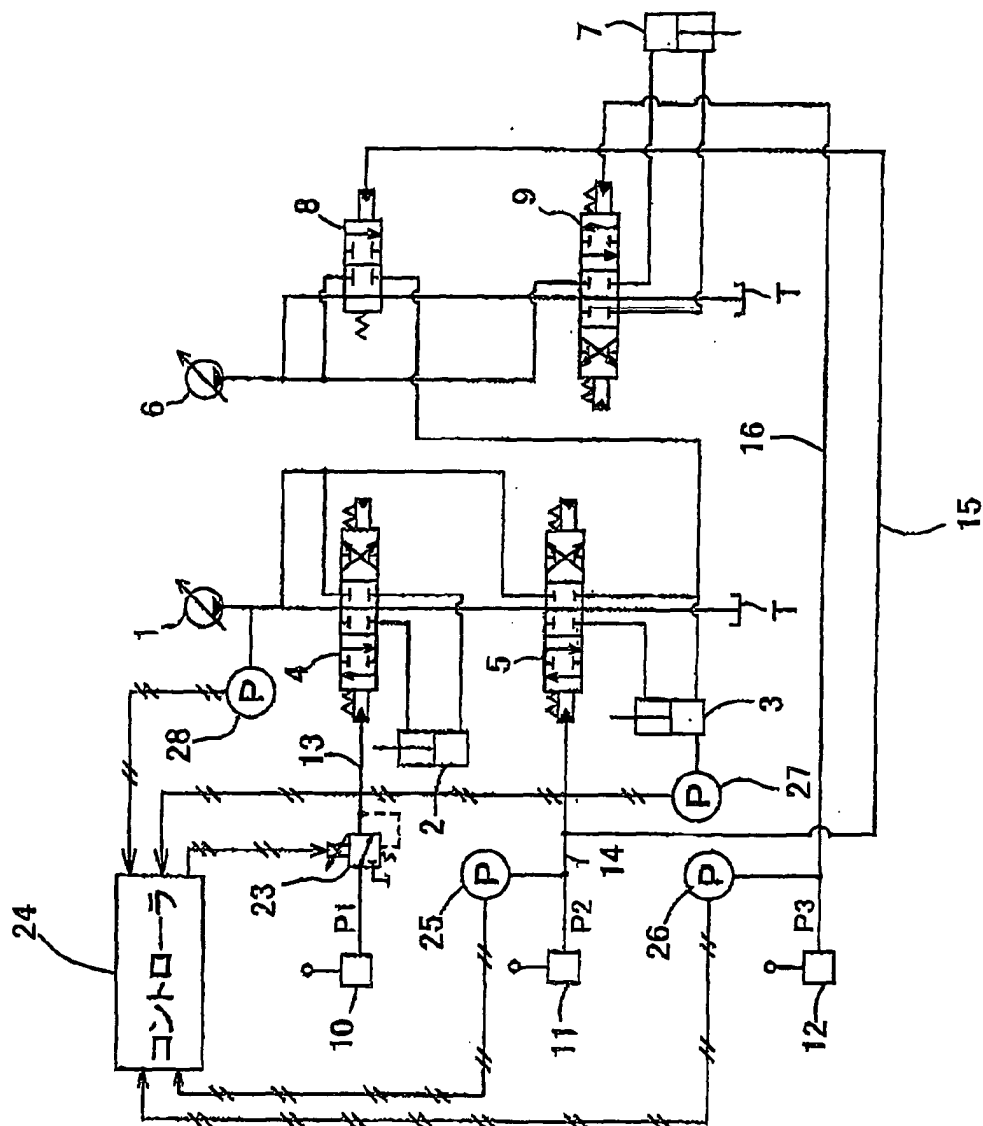
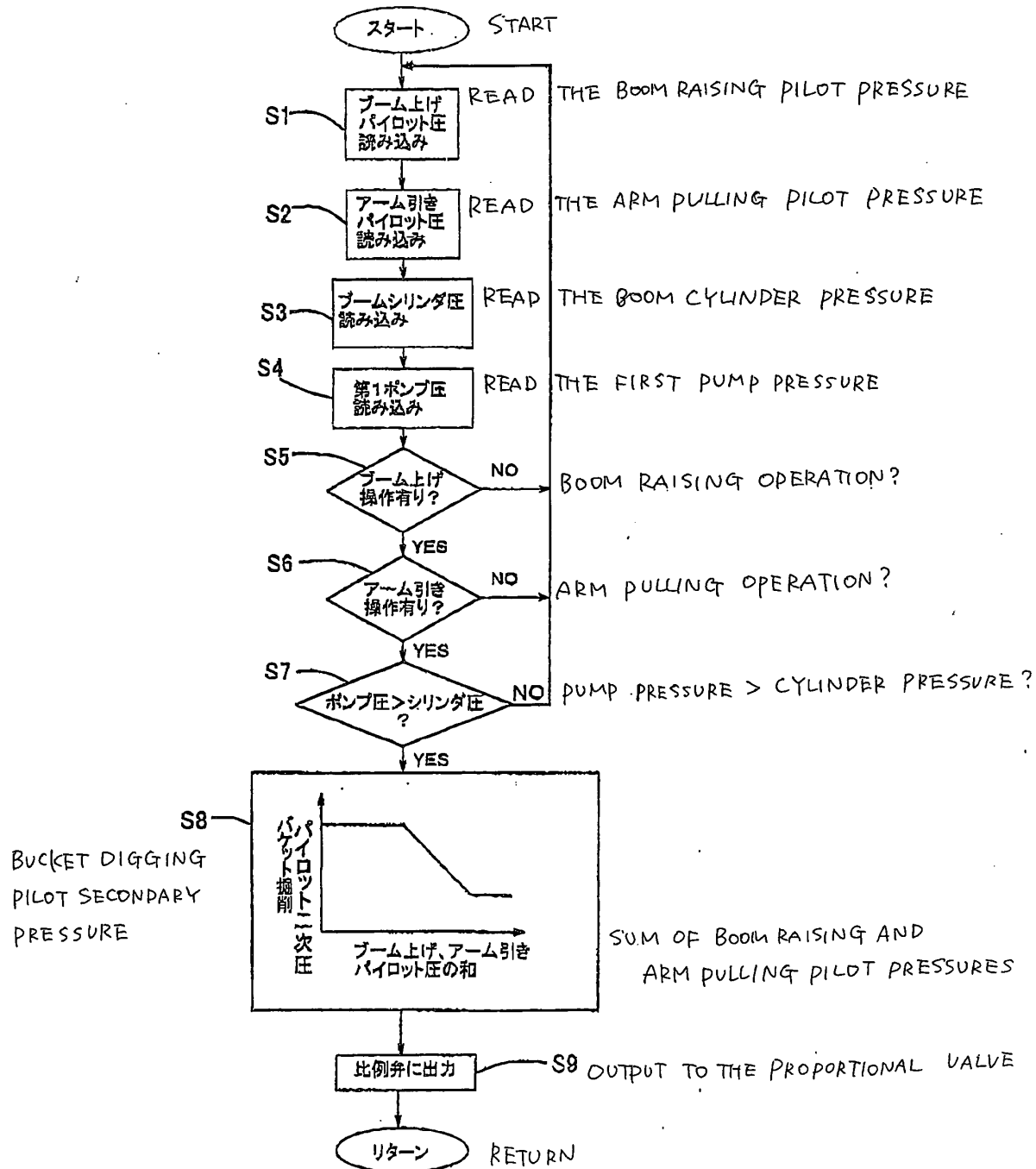


Fig. 6





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<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document</p>			

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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