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(54) Hydraulic actuator circuit

(57) This invention provides with a hydraulic actuator circuit comprising a holding valve (17) disposed in a boom extension-side pipeline (13) in the circuit an opening of which is controlled by a control valve (15) and an assist cylinder (20) for controlling an opening of the holding valve in such a way that, in a condition wherein a holding pressure drops to a valve of not larger than a given value, the opening of the holding valve is reduced, whereby the circuit can prevent an unusual sudden lowering of a boom with a load.

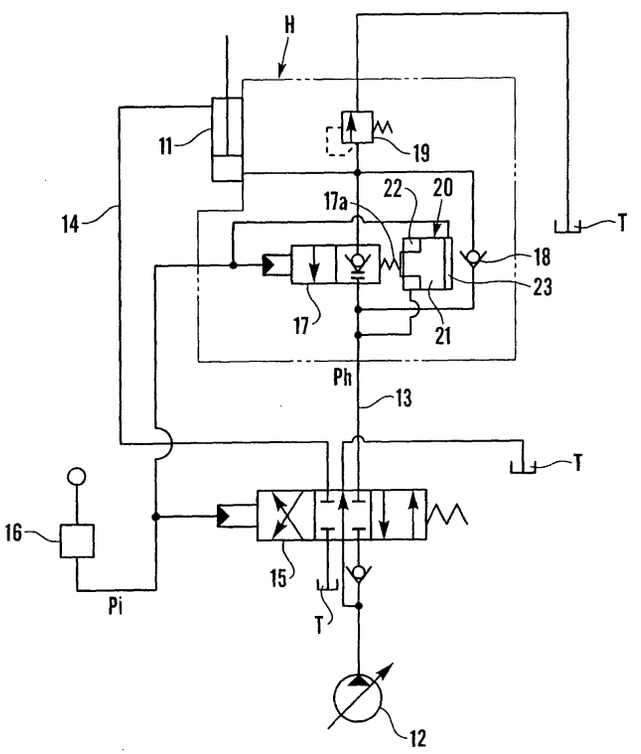

Fig. 1

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Description

BACKGROUND OF THE INVENTION

(FIELD OF THE INVENTION)

[0001] This invention relates to a hydraulic actuator circuit of a working machine.

(DESCRIPTION OF THE RELATED ART)

[0002] To a boom cylinder of a hydraulic excavator, a load on total weight of an attachment for an excavator and a load for carrying by the attachment acts in a direction of a cylinder contraction-side. In some cases, this leads to a problem of sudden lowering of the attachment on burst of a load-side pipeline in the boom cylinder and an oil leak in the control valve.

[0003] For this reason, in the load-side pipeline of a hydraulic actuator circuit in a working machine with a long span attachment, a holding valve (a safety valve) is provided (for example, Japanese Patent Application laid-open publications Hei 3-57507 and Hei 10-267009).

[0004] In Europe, with regard to the holding valve, several kinds of tests including an acceleration test defined in ISO 8643 are required to pass. The acceleration test is as follows. In the circuit with the holding valve in a load-side pipeline of the boom cylinder, a load for the test which corresponds to a half of an actual rated lifting capacity is provided and then an actuating speed of the boom cylinder is set to 200 mm/sec. In this condition, on burst of the load-side pipeline, the actuating speed is measured as test result for a check. The test requires the actuating speed of less than twice (400 mm/sec) as high as the above set value.

[0005] In a circuit with two openings connected each other in series, the openings are described as the following equation (1). Here, the opening means area of the opening (opening area).

$$1/A1^2+1/A2^2=1/A_{TOTAL}2 \quad (1)$$

A1 :meter-out opening of a control valve (hereinafter referred to as control valve opening)
A2 : holding valve opening
A_{TOTAL} : total opening in two openings in series (the opening to control an actuator)

[0006] The control valve opening A1 is determined on the basis of a standard that a target operability is accomplished in a machine without a holding valve. For this reason, in a machine with a holding valve and two openings A1, A2 connected in series, the larger A2 gets, the less the holding valve influences the operability. But, in order to pass the acceleration test, the opening A2 can not be overwhelmingly larger than the opening A1.

[0007] For this reason, it is difficult to accomplish the target operability at this situation. Accordingly, in a case of a circuit with a holding valve, a desired opening A2 had to be determined by time-consuming trial and error so as to obtain the same operability as that in only opening A2.

[0008] However, tuning the holding valve opening is hard to work, and, because of existence of inevitable manufacturing tolerances and variations arising while manufacturing the opening A2, the total opening A1+A2 is difficult to accomplish the same operability as that of only the opening A1.

SUMMARY OF THE INVENTION

[0009] It is an object of the present invention to provide a hydraulic actuator circuit capable of fulfilling a safety ensuring function inherent in a holding valve while ensuring operability (target operability) equal to that in the case of a control valve opening alone without a holding valve and wherein a holding valve opening can be set independently in a simple manner without being influenced by the control valve opening.

[0010] The hydraulic actuator circuit of the present invention comprises, as a basic construction, a control valve which is operated by an operating means, a hydraulic actuator which is controlled by the control valve in accordance with an amount of operation of the operating means, and a holding valve disposed in a load-side pipeline of the hydraulic actuator and adapted to close the pipeline in a neutral state of the control valve, thereby holding a load.

[0011] In this hydraulic actuator circuit the present invention is characterized by including a holding valve control means for controlling an opening of the holding valve during operation of the hydraulic actuator. According to the construction of the holding valve control means:

(a) in a normal condition wherein a holding pressure acting on the load-side pipeline takes a value of not smaller than a first given value, the opening of the holding valve is set to a value larger than a meter-out opening of the control valve in the normal condition; and
(b) in an unusual condition wherein the holding pressure drops to a value of not larger than a second given value, the opening of the holding valve is set to a value at which an actuating speed of the hydraulic actuator is lower than that in the absence of the holding valve.

[0012] According to this construction, when the pressure (holding pressure) of the load-side pipeline drops upon occurrence of an unusual condition such as burst, the opening of the holding valve is reduced to suppress an increase of the actuating speed or actuator speed.

[0013] Thus, by setting the opening of the holding val-

ue or the holding valve opening in the unusual condition to a value at which a desired actuating speed is obtained, it is possible to prevent a sudden lowering of load.

[0014] On the other hand, in the normal condition without the occurrence of burst or the like, the holding valve opening is set to a value larger than the control valve opening in that condition, so that there is no fear of operability being influenced by the holding valve opening.

[0015] That is, if the valve opening is set on the basis of the target operability, it is possible to ensure a desired operability and it is no longer required to perform such a troublesome work as adjusting the holding valve opening for attaining the target operability.

[0016] In other words, adjusting or tuning of the holding valve opening can be done independently without being influenced by the control valve opening and in a simple manner such that in the normal condition the holding valve opening is set sufficiently larger than the control valve opening, while in the unusual condition the holding valve opening is set only on the basis of only fulfilling the function as a safety valve.

[0017] It is preferable that in the normal condition the holding valve opening be set to a value sufficiently larger than the control valve opening.

[0018] The holding valve control means may be constructed such that the holding valve opening in the unusual condition is set to a value at which the actuator speed is lower than twice as high as that in the normal condition.

[0019] In this case, the holding valve opening can be set so that the foregoing desired actuator speed is lower than twice as high as that in the normal condition in conformity with the ISO Standard.

[0020] Preferably, the holding valve is constructed so that its opening varies depending on the amount of operation of the operating means, and the holding valve control means is constructed to make control such that the amount of change in the opening of the holding valve based on the amount of operation of the operating means is varied in accordance with the holding pressure.

[0021] In this case, in a circuit configuration wherein the opening of the holding valve changes together with the control valve opening in accordance with the amount of operation (pilot pressure) of the operating means, the amount of change in the holding valve opening relative to the amount of operation varies in accordance with the holding pressure.

[0022] The holding valve may be constructed as a hydraulic pilot valve whose opening changes in accordance with a pilot pressure based on operation of the operating means, while the holding valve control means may be constructed such that by adding to the holding valve the holding pressure in a direction in which the holding pressure is added to the pilot pressure, the amount of change in the holding valve opening relative to a command signal inputted from the exterior is changed on the basis of the holding pressure.

[0023] Preferably, the holding valve control means is constructed such that the holding pressure is applied in a direction in which the pressure set for a return spring in the holding valve is decreased.

[0024] Preferably, the holding valve control means is constructed so as to apply the holding pressure to a pilot port of the holding valve.

[0025] Preferably, the holding valve control means has a pressure reducing valve disposed in a pilot line of the holding valve and is constructed so as to change the output of the pressure reducing valve in accordance with the holding pressure.

[0026] Preferably, as the pressure reducing valve there is used a hydraulic pilot type pressure reducing valve, and the holding valve control means is constructed so as to supply the holding pressure as a pilot pressure to the pressure reducing valve.

[0027] In this construction, the holding pressure is applied to the hydraulic pilot type holding valve in a direction in which the holding pressure is added to the external pilot pressure and the change of the holding pressure is directly linked with the change of the holding valve opening, so that the operation of the holding valve is performed quickly and positively in comparison with a later-described construction wherein a holding pressure is detected by a sensor and the detected signal is converted to an oil pressure signal and applied to the holding valve, thus resulting in the apparatus reliability becoming higher.

[0028] Besides, since the opening of the holding valve can basically be controlled by the operating means, it is possible to carry out for example an operation such that, after an unusual suspension of working attachment at a high position in the air, the actuator is operated while opening the holding valve gradually by operation of the operating means to bring down the attachment to a lower position.

[0029] The holding valve control means may include an electromagnetic proportional type pressure reducing valve disposed in the pilot line of the holding valve, a holding pressure sensor for detecting a holding pressure, and a controller which provides a command signal to the pressure reducing valve in accordance with a signal fed from the holding pressure sensor.

[0030] In this case, in what manner the holding valve opening is to be changed relative to the change in holding pressure can be selected arbitrarily by a signal processing in the controller and thus it becomes possible to widen the control range.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031]

Fig. 1 is a boom cylinder circuit with a function for holding a load according to a first embodiment of

the present invention;

Fig. 2 is a view disclosing characteristics of pilot pressure of a holding valve in Fig. 1 to a holding valve opening;

Fig. 3 is a view disclosing characteristics of pilot pressure of a holding valve in Fig. 1 to a spool stroke of the holding valve;

Fig. 4 is a boom cylinder circuit with a function for holding a load according to a second embodiment of the present invention;

Fig. 5 is a view disclosing characteristics of pilot pressure of a holding valve in Fig.4 to a spool stroke of the holding valve;

Fig. 6 is a boom cylinder circuit with a function for holding a load according to a third embodiment of the present invention;

Fig. 7 is a view disclosing characteristics of an amount of operation of a remote control valve in Fig. 6 to a spool stroke of the holding valve;

Fig. 8 is a boom cylinder circuit with a function for holding a load according to a fourth embodiment of the present invention; and

Fig. 9 is a view disclosing a control flow of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0032] A load holding function (apparatus) in hydraulic actuator circuits embodying the present invention will be described hereinunder with reference to Figs. 1 to 9 in illustration of, but not in limitation of, the present invention.

[0033] The present invention is applicable to a hydraulic actuator circuit used in a hydraulic excavator and a working machine constituted using the hydraulic excavator as a matrix or a main body such as a dismantling machine or a deep hole excavator.

[0034] In each of the following embodiments reference will be made to a boom cylinder circuit in a hydraulic excavator or a work machine using the hydraulic excavator as a matrix.

First Embodiment (see Figs. 1 to 3)

[0035] Numeral 11 denotes a boom cylinder as a hydraulic actuator, numeral 12 denotes a hydraulic pump as an oil pressure source, numeral 13 denotes a boom extension-side (load-side) conduit or pipeline, numeral 14 denotes a contraction-side conduit or pipeline, numeral 15 denotes a control valve, and T denotes a tank. With a pilot pressure Pi provided from a remote control valve 16, the control valve 15 operates strokewise to control both operating direction and speed of the boom cylinder 11.

[0036] In the extension-side pipeline 13 is provided a holding valve circuit H in a mounted state to the boom cylinder 11, the holding valve circuit H comprising a hydraulic pilot type holding valve 17, a check valve 18, a relief valve 19, and an assist cylinder 20. The assist cylinder 20 is a holding valve control means disposed on a return spring 17a side of the holding valve 17.

[0037] With the pilot pressure Pi provided from the remote control valve 16, the opening of the holding valve 17 changes together with that of the control valve 15 in accordance with the amount of operation of the remote control valve 16. For example, upon burst of the extension-side pipeline 13 in a neutral state of the control valve 15, the outflow of oil from the boom cylinder 11 to the extension-side pipeline 13 is inhibited by closure of the holding valve 17. As a result, contraction (load lowering) of the cylinder 11 is prevented.

[0038] The assist cylinder 20 comprises a piston rod 21 which contacts the return spring 17a and controls the pressure (a force resisting to the pilot pressure Pi, "spring set pressure" hereinafter) of the return spring, a first pressure chamber 22, and a second pressure chamber 23. The pilot pressure Pi is introduced into the second pressure chamber 23, while a holding pressure Ph acting on the extension-side pipeline 13 is introduced into the first pressure chamber 22. The first pressure chamber 22 pressurizes the piston rod 21 in a direction to weaken the spring set pressure, while the second pressure chamber 23 pressurizes the piston rod 21 in a direction to strengthen the spring set pressure.

[0039] In the normal condition wherein the holding pressure Ph takes a value (determined by weight of the load of the boom cylinder 11) of not smaller than a first given value, the spring set pressure becomes low, so that the opening of the holding valve 17 becomes larger. In contrast therewith, in the unusual condition wherein the holding pressure Ph drops to a value (almost zero in a completely burst state of the extension-side pipeline 13 for example) of not larger than a second given value, the spring set pressure becomes high, so that the opening of the holding valve 17 becomes smaller.

[0040] In the normal condition the opening of the holding valve is set to a sufficiently larger value relative to a meter-out opening ("control valve opening" hereinafter) of the control valve 15. In the unusual condition the opening of the holding valve is set to a value at which the cylinder speed becomes lower than that without the holding valve.

[0041] In the case of a machine conforming to ISO standard, the opening of the holding valve is controlled so that, when the boom cylinder operating speed under a test load which corresponds to a half of an actual rated lifting capacity is set to 200 mm/sec, the cylinder speed in bursting the extension-side pipeline 13 of a boom cylinder 11 takes a value of less than twice (400 mm/sec) as high as the set value.

[0042] The holding valve opening A2 is controlled such that in the foregoing equation (1), when the speed of 200 mm/sec is ensured at the total opening A_{TOTAL} and when there remains only the holding valve opening A2 due to burst of the load-side pipeline, the speed does

not exceed the two-fold speed (400 mm/sec).

[0043] Therefore, the holding valve opening A2 does not become an overwhelmingly larger opening relative to the control valve opening A1.

[0044] This controlling condition for the holding valve opening is illustrated in Figs. 2 and 3.

[0045] Fig. 2 illustrates how the control valve opening and the holding valve opening vary as the pilot pressure Pi changes and Fig. 3 illustrates a spool stroke of the holding valve 17 relative to changes of the pilot pressure Pi.

[0046] In Fig. 2, a dash-dot line I represents a holding valve opening characteristic in the normal condition, a dash-double dot line II represents a holding valve opening characteristic upon occurrence of burst, and a solid line III represents a control valve opening characteristic. Further, the symbol A represents a value (the amount of operation of the remote control valve 16) of the pilot pressure Pi at which the cylinder speed becomes 200 mm/sec in the normal condition. In the normal condition, the holding valve opening takes the value at point x and the control valve opening takes the value at point z both in Fig. 2, and with the total opening at this time, the cylinder speed becomes 200 mm/sec.

[0047] Upon occurrence of burst, the holding valve opening decreases to the point y in Fig. 2, and with the total opening at this time, the cylinder speed is suppressed to a value of smaller than 400 mm/sec.

[0048] There may be adopted a construction wherein upon occurrence of burst the cylinder speed is suppressed to the normal condition speed (200 mm/sec) or lower.

[0049] Thus, when the holding pressure Ph decreases upon occurrence of an unusual condition such as burst in the cylinder extension-side pipeline 13, the holding valve opening is narrowed to prevent an increase of the actuator speed. Therefore, by setting this holding valve opening in the unusual condition to a value which affords a desirable actuator speed (e.g., lower than twice as high as that in the normal condition), it is possible to prevent a sudden lowering of the working attachment in the working machine.

[0050] On the other hand, in the normal condition without the occurrence of burst or the like, the holding valve opening takes a sufficiently larger value than the control valve opening at that time. Thus, there is no fear of the operability being influenced by the holding valve opening.

[0051] That is, tuning of the holding valve opening can be done independently without being influenced by the control valve opening and in a simple manner such that in the normal condition the holding valve opening is set sufficiently larger than the control valve opening, while in the unusual condition the holding valve opening is set on the basis of only fulfilling the safety valve function.

[0052] Besides, the holding valve opening can be controlled by the remote control valve 16. Therefore, for example when the attachment is suspended at a high position in the air upon occurrence of burst, the holding valve opening is expanded gradually by operation of the remote control valve 16, allowing the boom cylinder 11 to operate to its contraction side, whereby the attachment can be let down to a lower position.

[0053] Further, the holding pressure Ph is applied to the holding valve 17 in a direction (spring set pressure weakening direction) in which it is added to the pilot pressure Pi to expand the holding valve opening, and thus a change of the holding pressure Ph is directly linked with a change of the holding valve opening. Consequently, the operation of the holding valve 17 is performed quickly and positively in comparison with for example the construction wherein the holding pressure Ph is detected with a sensor and the detected signal is converted to an oil pressure signal and applied to the holding valve, thus resulting in the apparatus reliability becoming higher.

Second Embodiment (see Figs. 4 and 5)

[0054] In the following second embodiment the same portions as in the first embodiment will be denoted by the same reference numerals to omit tautological explanations thereof.

[0055] In this second embodiment, as shown in Fig. 4, a pressure reducing valve 24 is provided in the holding valve circuit H. The pressure reducing valve 24 functions as a holding valve control means whose secondary pressure changes in accordance with the pilot pressure Pi. The holding pressure Ph is reduced by the pressure reducing valve 24 and is then applied together with the pilot pressure Pi to the holding valve 17.

[0056] According to this construction, in basically the same manner as in the first embodiment, the holding pressure Ph is added to the pilot pressure Pi and acts in a direction to expand the holding valve opening. In the normal condition, therefore, the holding valve opening is set to a value sufficiently larger than the control valve opening, while in the unusual condition the holding valve opening is reduced.

[0057] Fig. 5 shows how the holding valve opening changes.

[0058] As shown in the same figure, in the normal condition, from the time when the pilot pressure Pi reaches a preset value PiS (when the spool stroke reaches the point e), the secondary pressure in the pressure reducing valve is added to the pilot pressure Pi, resulting in the degree of increase of the holding valve opening (spool stroke) becoming larger. For example, the cylinder speed becomes 200 mm/sec at point A. At this time the holding valve opening takes a value sufficiently larger than the control valve opening.

[0059] On the other hand, upon occurrence of burst, the secondary pressure in the pressure reducing valve is not added. Consequently, the holding valve opening expands slowly to a narrower extent than in the normal condition while depending on only the pilot pressure Pi,

whereby the cylinder speed for example at point A is suppressed to lower than 400 mm/sec.

Third and Fourth Embodiments (see Figs. 6 to 9)

[0060] In both third and fourth embodiments, the pilot pressure Pi introduced into the holding valve 17 is controlled in accordance with the holding pressure Ph.

[0061] More specifically, in the third embodiment, as shown in Fig. 6, a pressure reducing valve 25 is disposed in the pilot line of the holding valve 17. The pressure reducing valve 25 functions as a holding valve control means whose secondary pressure varies depending on the holding pressure Ph. In this case, as shown in Fig. 7, the pilot pressure Pi drops upon lowering of the holding pressure Ph (upon occurrence of a trouble), whereby the ratio of an increase of the holding valve spool stroke relative to the amount of operation of the remote control valve decreases and the holding valve opening is reduced.

[0062] On the other hand, in the fourth embodiment, as shown in Fig. 8, an electromagnetic proportional type pressure reducing valve 26 is disposed in the pilot line of the holding valve 17. Further provided are pressure sensors 27 and 28 for detecting the holding pressure Ph and the pilot pressure Pi, respectively. A secondary pressure Pi2 in the pressure reducing valve 26 is controlled a command signal provided from a controller 29 in accordance with pressure signals provided from both pressure sensors 27, 28.

[0063] The contents of this control will now be described in more detail. As shown in Fig. 9, when the detected holding pressure Ph exceeds a preset value PhS (NO in step S1 namely normal condition) and also when the pilot pressure Pi is not more than a preset value PiS (NO in step S2), the controller 29 sends a signal to the electromagnetic proportional valve 26 to set Pi equal to Pi2 (proportional valve secondary pressure) (step S3).

[0064] On the other hand, when the answer in step S1 is YES (Ph<PhS, namely unusual condition) and the answer in step S2 is also YES (Pi≧PiS), the controller 29 sends a signal to the electromagnetic proportional valve 26 to reduce the secondary pressure Pi2 (step S4).

[0065] As a result, as indicated with a solid line in step S4, the ratio of a change in the proportional valve secondary pressure Pi2 relative to the pilot pressure Pi becomes gentler or smaller than in the normal condition (indicated with a dash-double dot line in the same step) and the holding valve opening is reduced.

[0066] Also in both third and fourth embodiments, as in the first and second embodiments, it is possible to prevent an increase of the cylinder speed in the unusual condition while ensuring the target operability. Besides, the setting of the holding valve opening can be done in a simplified manner with the holding valve 17 alone.

[0067] Further, according to the fourth embodiment, a desired way of change of the holding valve opening relative to the change of the holding pressure Ph can be selected arbitrarily by a signal processing in the controller 29. Consequently, it becomes possible to enlarge the control range.

[0068] In each of the above embodiments there basically is adopted a construction wherein the holding valve opening is controlled in accordance with the pilot pressure Pi of the remote control valve 16. However, there may be adopted a construction wherein the holding valve opening is controlled (expanded in the normal condition and reduced in the unusual condition) in accordance with the holding pressure Ph alone independently of the pilot pressure Pi.

[0069] In this case, the holding valve 17 may be an electromagnetic valve which is controlled with an electric signal provided from the controller.

[0070] The present invention is applicable not only to the boom cylinder circuit but also to an arm cylinder circuit and the hydraulic actuator circuits (including a hydraulic motor circuit) in working machines (e.g., crane) other than the working machine and those using the hydraulic excavator as a matrix.

[0071] Thus, according to the present invention, there is provided a hydraulic actuator circuit comprising a control valve which is operated by an operating means and which controls the operation of a hydraulic actuator in accordance with the amount of operation of the operating means, and a holding valve disposed in a load-side pipeline of the hydraulic actuator and whose opening varies in accordance with a signal inputted from its exterior such as a controller, the holding valve being closed in a neutral state of the control valve to hold a load, the hydraulic actuator circuit further comprising a holding valve control means for controlling the opening of the holding valve during operation of the hydraulic actuator, the holding valve control means being constructed such that:

(a) in a normal condition wherein a holding pressure acting on the load-side pipeline takes a value of not smaller than a first given value, the opening of the holding value is set to a value sufficiently larger than a meter-out opening of the control valve; and

(b) in an unusual condition wherein the holding pressure drops to a value of not larger than a second given value, the opening of the holding valve is set to a value at which the actuator speed is lower than that in the absence of the holding valve.

[0072] According to the present invention it is possible to set the holding valve opening sufficiently larger than the control valve opening in the normal condition and thereby ensure the target operability while fulfilling the safety ensuring function inherent in the holding valve, that is, preventing a sudden lowering of load upon occurrence of a trouble such as burst in the load-side pipeline.

[0073] Besides, tuning of the holding valve opening

can be done independently without being influenced by the control valve opening and in a simplified manner such that in the normal condition the holding valve opening is set sufficiently larger than the control valve opening, while in the unusual condition the holding valve opening is set only on the basis of fulfilling the function as a safety valve.

[0074] Although embodiments of the present invention have been described above, the scope of protection of the present invention is not limited thereto.

Claims

1. A hydraulic actuator circuit comprising a control valve which is operated by an operating means, a hydraulic actuator which is controlled by said control valve in accordance with an amount of operation of said operating means, and a holding valve disposed in a load-side pipeline of said hydraulic actuator and adapted to close said pipeline in a neutral state of said control valve to hold a load,

   characterized in that said hydraulic actuator circuit further comprises a holding valve control means for controlling an opening of said holding valve during operation of said hydraulic actuator, said holding valve control means:

   (a) in a normal condition wherein a holding pressure acting on said load-side pipeline takes a value of not smaller than a first given value, setting the opening of said holding valve to a value larger than a meter-out opening of said control valve in the normal condition; and
   (b) in an unusual condition wherein said holding pressure drops to a value of not larger than a second given value, setting the opening of said holding valve to a value at which an actuating speed of said hydraulic actuator is lower than that in the absence of the holding valve.

2. The hydraulic actuator circuit according to claim 1, wherein said holding valve control means sets the opening of said holding valve in the unusual condition to a value at which the actuating speed is lower than twice as high as that in the normal condition.

3. The hydraulic actuator circuit according to claim 1 or claim 2, wherein the opening of said holding valve changes according to the amount of operation of said operating means, and said holding valve control means causes an amount of change in the opening of said holding valve to be varied on the basis of the holding pressure.

4. The hydraulic actuator circuit according to claim 3, wherein said holding valve is constructed as a hydraulic pilot valve whose opening changes in accordance with a pilot pressure based on operation of said operating means, said holding valve control means causes the amount of change in the opening said holding valve to be varied on the basis of the holding pressure by applying the holding pressure to the holding valve in a direction in which the holding pressure is added to said pilot pressure.

5. The hydraulic actuator circuit according to any of claims 1 to 4, wherein said holding valve is provided with a return spring.

6. The hydraulic actuator circuit according to claim 5, wherein said holding valve control means applies the holding pressure in a direction to decrease a set pressure for said return spring.

7. The hydraulic actuator circuit according to claim 5, wherein the holding pressure is applied to a pilot port of said holding valve.

8. The hydraulic actuator circuit according to claim 5, wherein said holding valve control means comprises a pressure reducing valve disposed in a pilot line of said holding valve and causes an output of said pressure reducing valve to be varied in accordance with the holding pressure.

9. The hydraulic actuator circuit according to claim 8, wherein said pressure reducing valve is a hydraulic pilot type pressure reducing valve, and said holding valve control means supplies the holding pressure as a pilot pressure to said pressure reducing valve.

10. The hydraulic actuator circuit according to claim 8, wherein said holding valve control means further comprises:

    an electromagnetic proportional type pressure reducing valve disposed in the pilot line of said holding valve;
    a holding pressure sensor for detecting the holding pressure; and
    a controller adapted to provide a command signal to said pressure reducing valve in accordance with a signal provided from said holding pressure sensor.

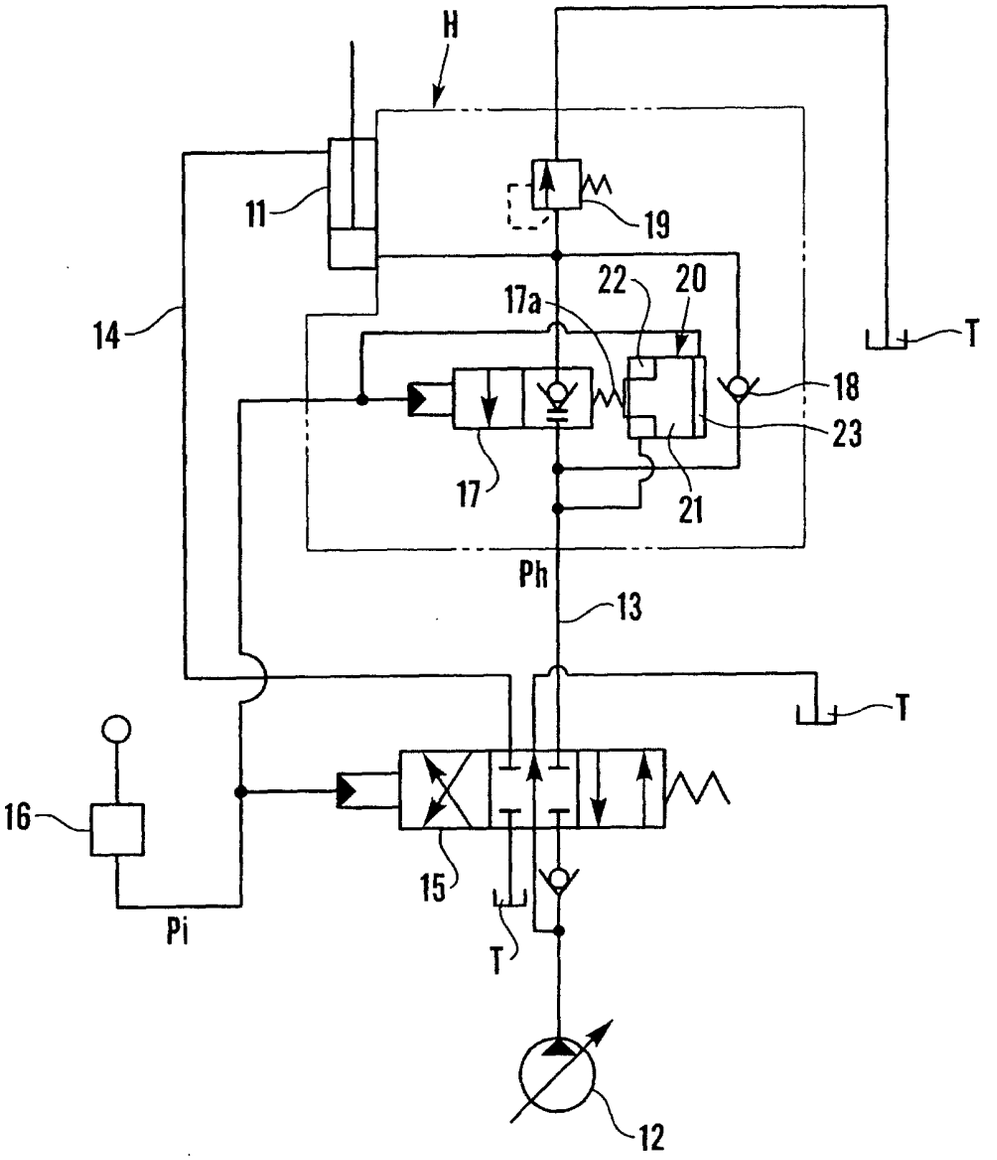

Fig. 1

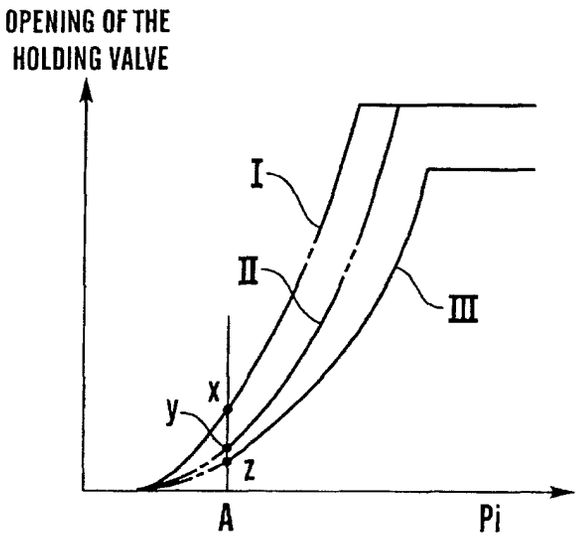
OPENING OF THE
HOLDING VALVE
I
II
III
x
y
z
A
Pi

Fig.2

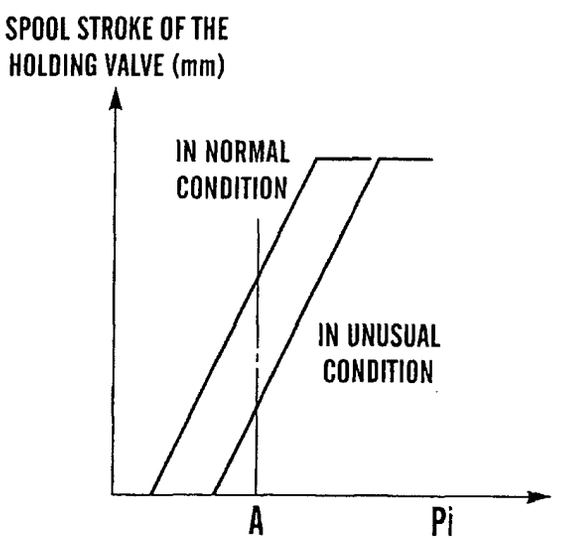
SPOOL STROKE OF THE
HOLDING VALVE (mm)
IN NORMAL
CONDITION
IN UNUSUAL
CONDITION
A
Pi

Fig.3

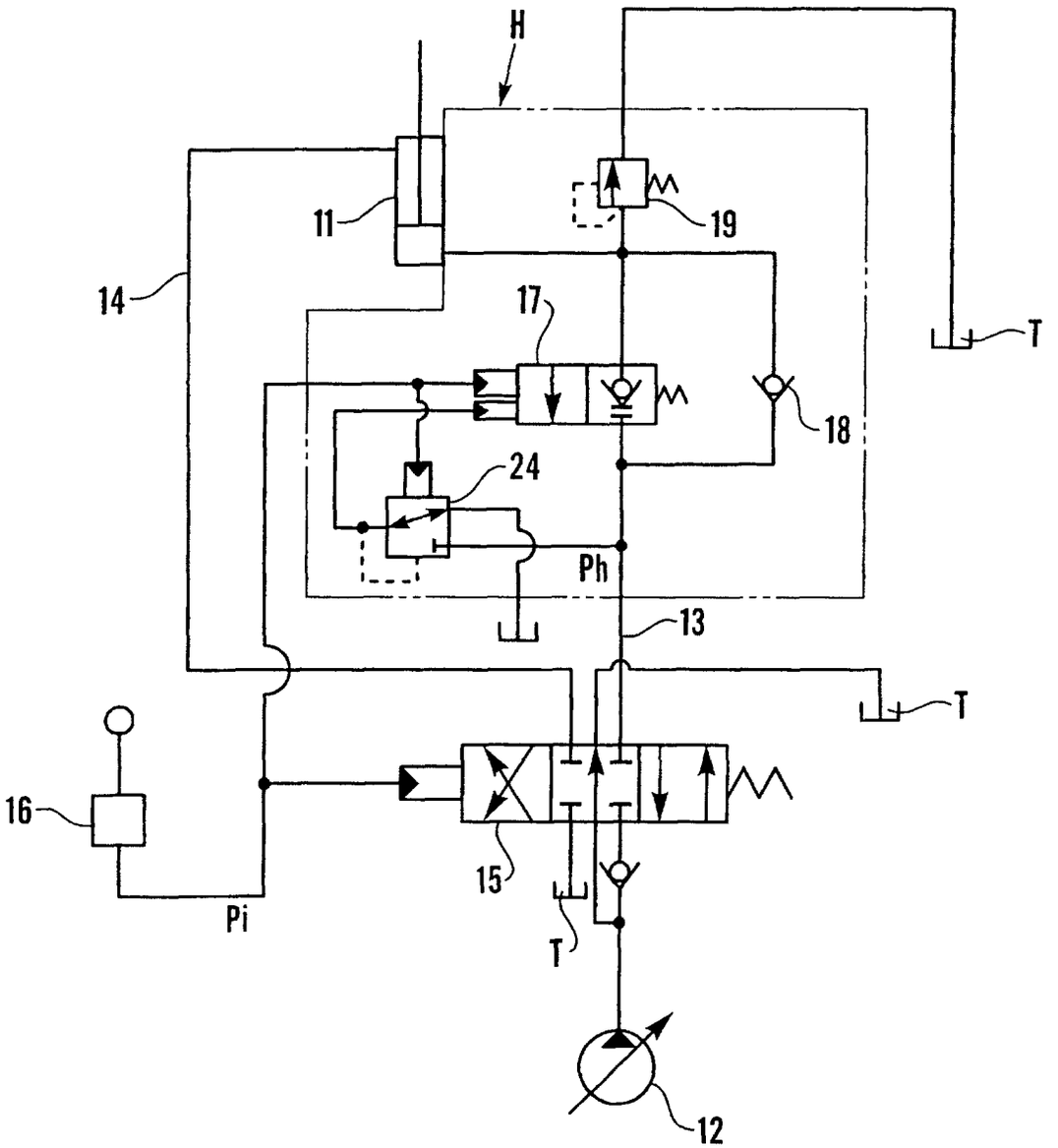

Fig.4

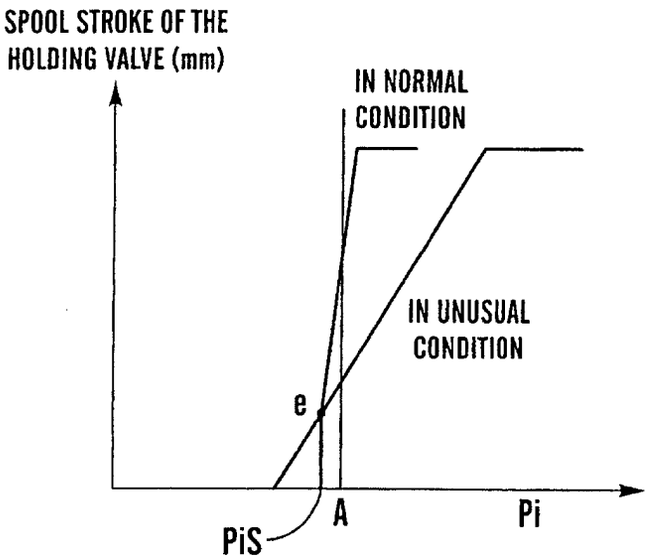
SPOOL STROKE OF THE HOLDING VALVE (mm)
IN NORMAL CONDITION
IN UNUSUAL CONDITION
e
PiS
A
Pi

Fig.5

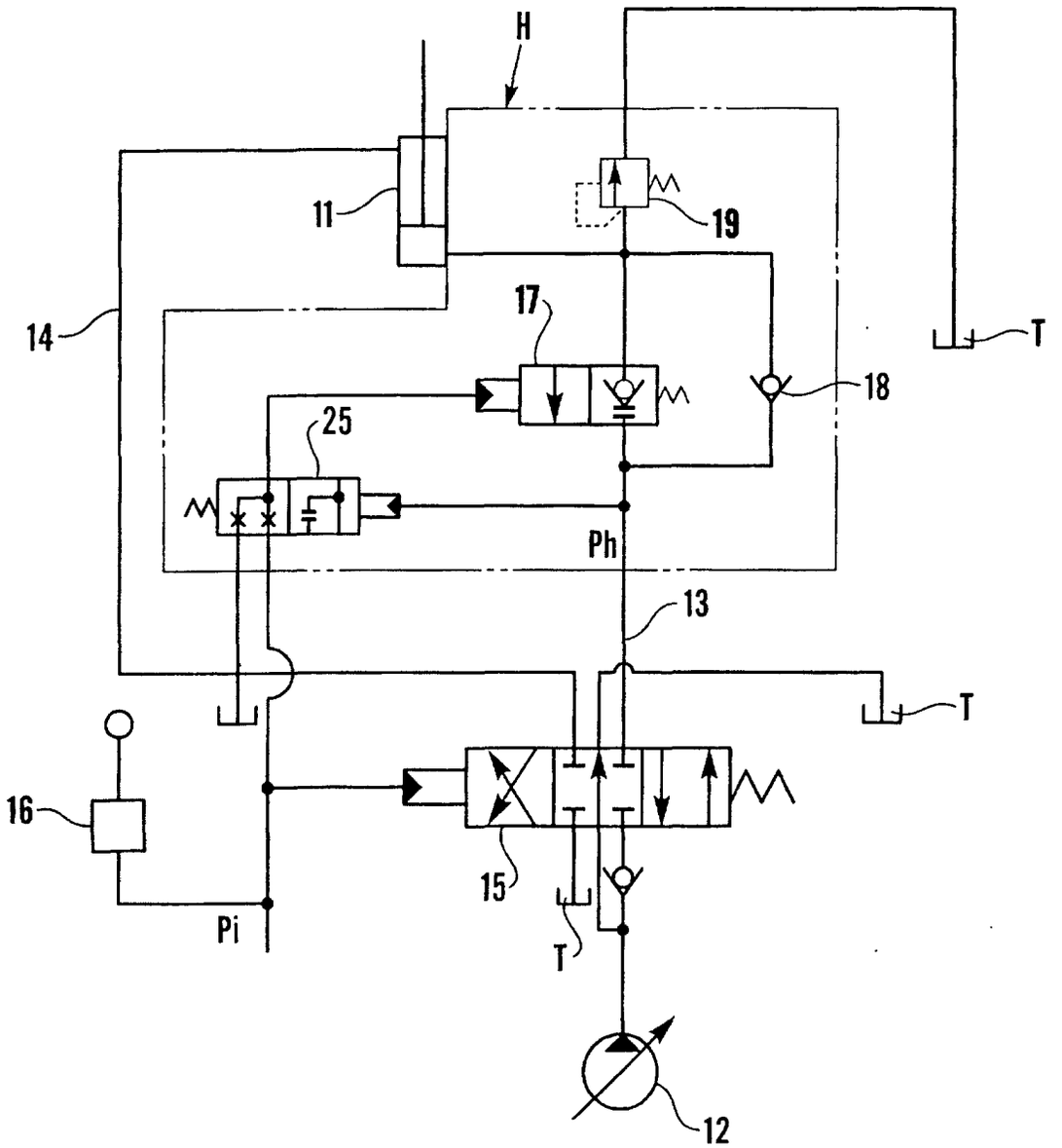

Fig.6

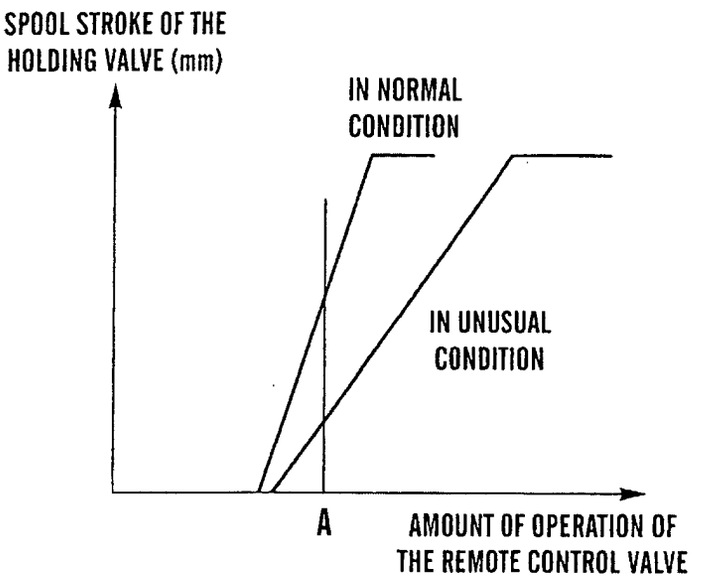
SPOOL STROKE OF THE
HOLDING VALVE (mm)
IN NORMAL
CONDITION
IN UNUSUAL
CONDITION
A
AMOUNT OF OPERATION OF
THE REMOTE CONTROL VALVE

Fig.7

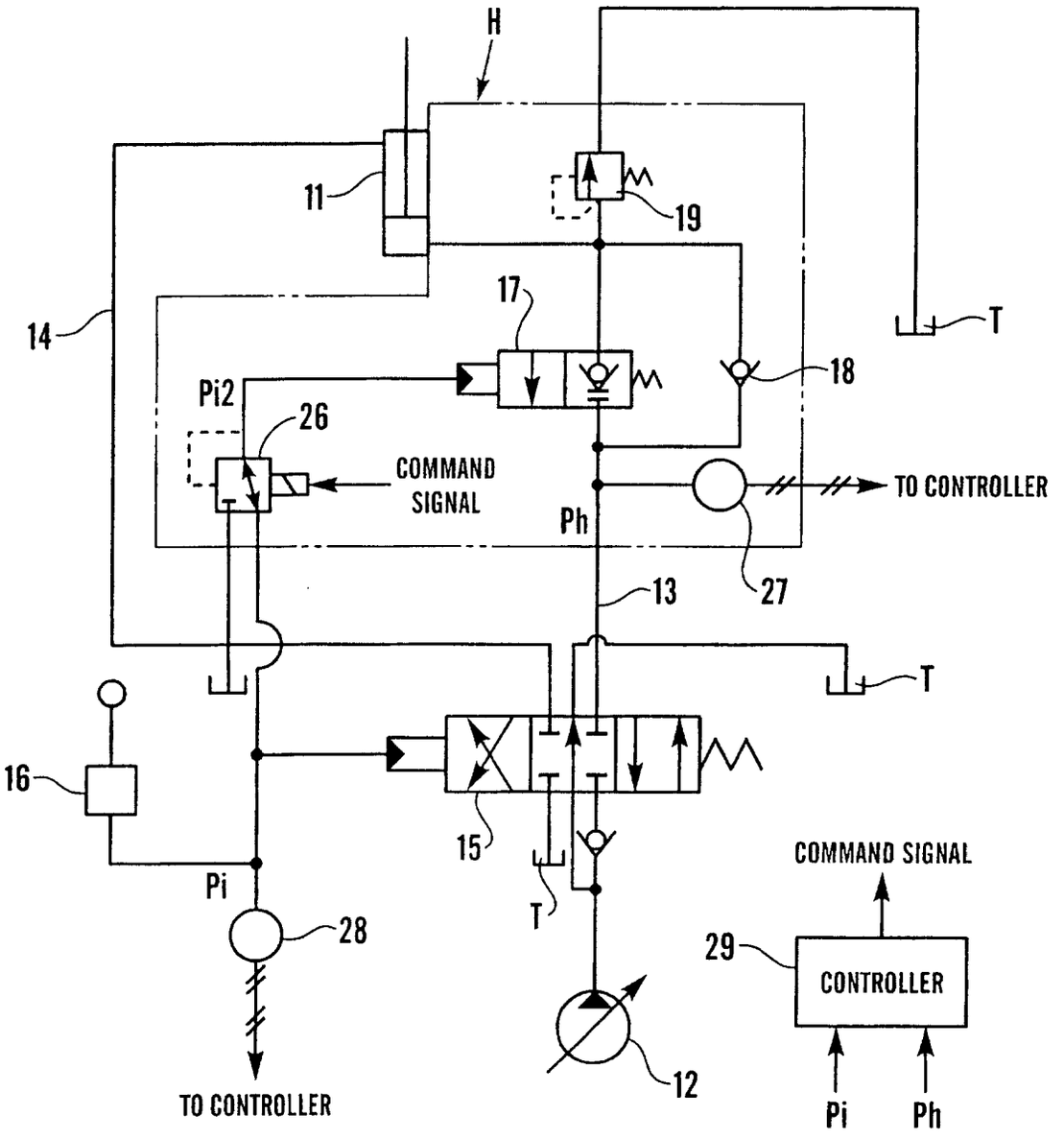
H
11
19
17
14
T
18
Pi2
26
COMMAND
SIGNAL
TO CONTROLLER
Ph
27
13
T
16
15
COMMAND SIGNAL
Pi
28
T
29
CONTROLLER
12
TO CONTROLLER
Pi
Ph

Fig.8

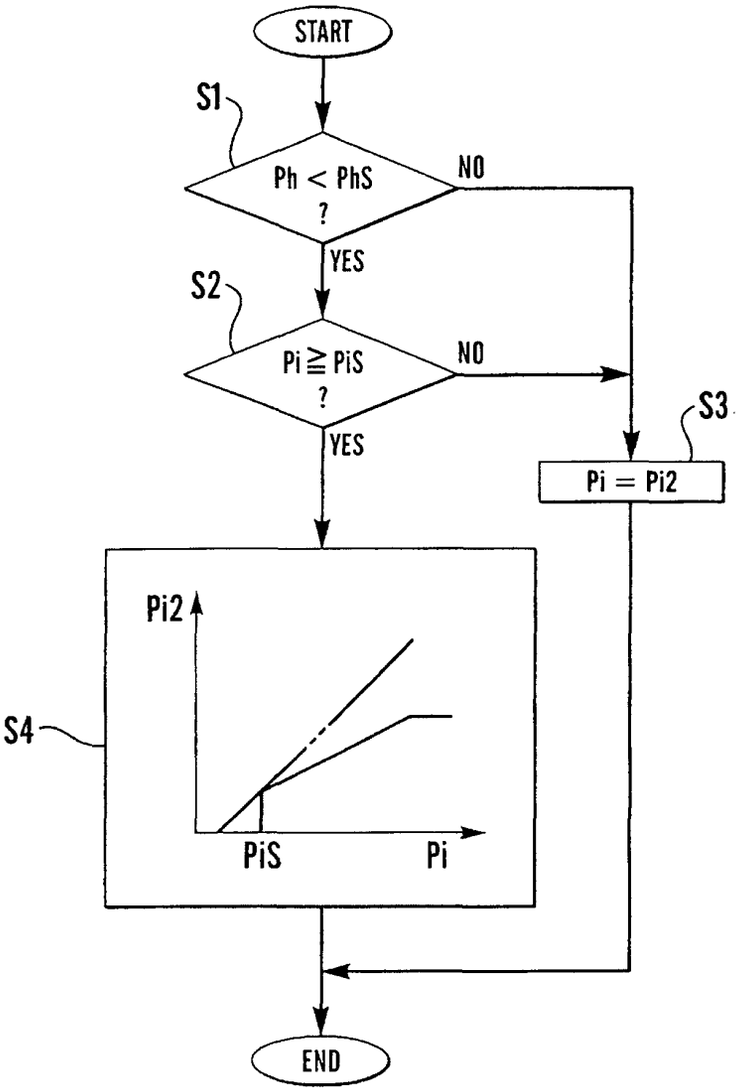

Fig.9