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(54) **Method for controlling stretching and contracting operations of telescopic multistage boom.**

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(73) Proprietor: **KABUSHIKI KAISHA KOBE SEIKO**
SHO
3-18 1-chome, Wakinohama-cho Chuo-ku
Kobe 651 (JP)

(72) Inventor: **Fujioka, Jun**
947-1, Ohkubo-machi Ohkubo-cho
Akashi Hyogo-ken (JP)

(74) Representative: **Wright, Hugh Ronald et al**
Brookes & Martin 52/54 High Holborn
London WC1V 6SE (GB)

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Description

This invention relates to a method for controlling the telescopic extension and contraction of a multistage boom of a crane or the like in an efficient manner.

Multistage booms generally used on cranes or the like are of the telescopic type, (see for example Japanese patent specifications, 56—75388 and 56—78795) which has its modulus of section reduced gradually toward the fore ends of the telescopic boom portions and which is designed to extend firstly a boom portion with the largest modulus of section having the greatest boom strength and to contract firstly a boom portion with the smallest modulus of section during the contracting operation. Therefore, in controlling the extension and contraction of a three stage boom, for example, the ideal procedure is to extend and contract the telescopic boom portions successively, extending the fore boom portion after the intermediate boom portion is fully extended during extension, and contracting the intermediate boom portion after complete contraction of the fore boom portion during contraction.

With such a multistage boom, it has been the conventional practice to resort to a method of detecting the fully extended state of the intermediate boom portion of the fully contracted state of the fore boom portion by means of a limit switch and switching an electromagnetic valve in a hydraulic control circuit of boom operating cylinders in response to a signal produced by the position of an operating lever, or a method which, in order to preclude the errors in the switching operation of the boom operating cylinders, feeds the fluid pressure also to the cylinder of the intermediate boom portion (normally at the end of its stroke) at the time of extension of the fore boom portion, feeding the fluid pressure even to the cylinder of the fore boom portion (normally at the end of its stroke) when contracting the intermediate boom portion. Of these conventional methods, the former method is costly since it necessitates to provide a take-up reel for winding the electrical cables which connect the limit switches to the electromagnetic valve in relation with the telescopic operation of the boom, in addition to the above-mentioned two limit switches for detecting the fully extended state of the intermediate boom portion and the fully contracted state of the distal boom portion, respectively. On the other hand, the latter method has a problem that it likewise requires provision of costly boom operating cylinders and a complicated hydraulic control circuit.

There is also known from U.S. Patent Specification 4,286,386 a detector for measuring the length of a boom on a tractor.

The present invention provides a method for controlling the boom operating cylinders during expansion and contraction of a multistage telescopic boom including a base boom portion, an

intermediate boom portion and a fore boom portion, said method being characterised by:

detecting the length of said boom by means of a boom length detector;

5 permitting extension or contraction of a cylinder of said intermediate boom portion when the value (1) of the detected length of the boom is smaller than a first preset reference value (L-b) which reference value is determined by subtracting a preset arbitrary length (b) from the actual length L of said boom when said intermediate boom portion and said fore boom portion is fully contracted relative to said intermediate boom portion;

10 permitting extension or contraction of a cylinder of said fore boom portion alone when the detected boom length (1) is greater than a second preset reference value (L+b);

15 detecting variation per unit time (V) of said detected boom length (1) when said detected boom length (1) is in the range between said first and second reference values (L-b) and (L+b);

20 continuing the boom extension or contraction by means of a currently operating cylinder while said variation (V) is greater than a predetermined value; and

25 switching the boom extending or contracting operation to a cylinder of the next stage when said variation (V) becomes smaller than said predetermined value.

30 The present invention also provides apparatus for controlling the boom operating cylinders during expansion and contraction of a multistage telescopic boom including a base boom portion, an intermediate boom portion and a fore boom portion, said apparatus being characterised by:

35 a boom length detector for detecting the length (1) said boom;

40 means for permitting extension or contraction of a cylinder of said intermediate boom portion when the value (1) of the detected length of the boom is smaller than a first preset reference value (L-b) which reference value is determined by subtracting a preset arbitrary length (b) from the actual length L of said boom when said intermediate boom portion is fully extended relative to said base boom portion and said fore boom portion is fully contracted relative to said intermediate boom portion;

45 means permitting extension or contraction of a cylinder of said fore boom portion alone when the detected boom length (1) is greater than a second preset reference value (L+b);

50 means detecting variation per unit time (V) of said detected boom length (1) when said detected boom length (1) is in the range between said first and second reference values (L-b) and (L+b);

55 means for continuing the boom extension or contraction by means of a currently operating cylinder while said variation (V) is greater than a predetermined value and for switching the boom extending or contracting operation to a cylinder of the next stage when said variation (V) becomes smaller than said predetermined value.

60 The above and other features and advantages

of the present invention will become apparent from the following description and the appended claims, taken in conjunction with the accompanying drawings which show by way of example some illustrative embodiments of the invention.

In the accompanying drawings:

Figure 1 is a schematic sectional view of a multistage telescopic boom;

Figure 2 is a diagram of an hydraulic circuit employed for carrying out the present invention;

Figure 3 is a logic circuit of the operation of preferred electric circuit for controlling the operation of an electromagnetic circuit in the hydraulic circuit of Figure 2;

Figure 4 is a diagram of a relay control system: and

Figure 5 is a modified logic circuit similar to Figure 3.

Referring to Figure 1, there is shown an example of a multistage (three-stage) boom including a fore boom portion 3 which is telescopically fitted in an intermediate boom portion 2 which is in turn telescopically fitted in a base boom portion 1. A first cylinder 4 for operating the intermediate boom portion 2 is provided between the base and intermediate boom portions 1 and 2, and a second cylinder (5) for operating the fore boom portion 3 is provided between the base and intermediate and fore boom portions 2 and 3.

Ideally, in the operation of this sort of multistage boom, the first and second cylinders 4 and 5 are sequentially actuated to (a) extend the boom, by switching from the first cylinder 4 to the second cylinder 5 exactly at the point when the intermediate boom portion 2 is fully extended relative to the base boom portion 1 and (b) contract the boom, by switching from the second cylinder 5 to the first cylinder 4 exactly at the point when the fore boom portion 3 is fully contracted relative to the intermediate boom portion 2 as shown by solid line in Figure 1. In this regard, it is to be noted that the actual boom length L at this time point is constant.

We control the timing of the switching operation of the cylinders 4 and 5 according to an output signal from a detector 6 which is provided on the multistage boom to detect its length. Travelling cranes with a rated lifting capacity greater than 3 tons are normally required to be equipped with an overload indicator system, and so a boom length detector is provided on most cranes as part of said overload detector system (not shown) and this boom length detector can be used as the length detector 6. For example, the boom length detector 6 may comprise a potentiometer which is mounted, via gears, on the axis of a wire winding drum of a spring-loaded wire retractor 6a which thereby measures the length of wire 6b pulled out from the drum when the boom is extended, the front end of the wire 6b being securely fixed to a base end portion of the fore boom member 3.

In this instance, the boom length detector 6 detects the extended boom length with a good degree of accuracy in most cases, but the de-

tected value inevitably contains an error of about plus or minus 10 cm. If the error is expressed by (a), the detected boom length (1) of the boom which has actually a length L when in the position indicated in solid line in Figure 1, is

$$L-a \leq 1 \leq L+a$$

Therefore, the switching operation of the cylinders 4 and 5, if based solely on the detected boom length (1), will be too early or too late as a result of the error (a). In order to eliminate this problem, an arbitrary length (b) (eg of 20—50 cm) which is greater than the error (a) is preselected to determine a first reference value ($L-b$) which is the actual length of the boom in the position of Figure 1 minus the preselected value (b), and a second reference value ($L+b$) which is the actual length L of the boom plus the preselected value (b). The first cylinder 4 alone is actuated to extend or contract only the intermediate boom portion 2 of the detected boom length (1) of the detector 6 is smaller than ($L-b$) and the second cylinder 5 alone is actuated to extend or contract the fore boom portion 3 if the output value (1) of the detector 6 is greater than ($L+b$).

When the detected boom length (1) is in the range S between the first and second reference values ($L-b$) and ($L+b$), the switching of the cylinders 4 and 5 is controlled on the basis of the variation per unit time (V) of the detected boom length (1).

The boom length or the detected boom length (1) of the boom length detector 6 changes due to the telescopic motion of the boom at a velocity (v) which is expressed by

$$v = \lim_{dt \rightarrow 0} \frac{1(t+dt) - 1(t)}{dt}$$

At the switching point of the cylinders 4 and 5, one cylinder which has been in operation comes to the end of its stroke and the telescopic velocity of the boom becomes zero. The cylinders 4 and 5 should be switched when the telescopic velocity becomes zero.

Thus, the variation per unit time (V) of the detected boom length (1), which represents the telescopic velocity (v) of the boom, need only be detected when the detected boom length (1) of the boom length detector 6 is in the range S between the first reference value ($L-b$) and the second reference value ($L+b$).

When the detected boom length (1) is less than ($L+b$) or greater than ($L-b$) and the variation per unit time of the detected boom length value (1) is greater than a predetermined value, it is assumed that the cylinder 4 or 5 which is currently in operation has not yet reached the end of its stroke. As soon as the variation per unit time (V) of the detected boom length (1) becomes smaller than a predetermined value (preferably equal to zero), the currently operating cylinder 4 or 5 is assumed to have reached the end of its stroke,

and the telescopic operation is switched to the other cylinder (ie the cylinder of the next stage).

More particularly, the above described control of the telescopic operation of the multistage boom can be attained by the use of a hydraulic circuit as shown in Figure 2 and a logic circuit as shown in Figures 3 and 4.

As shown in Figure 2, boom extending fluid chambers 4a and 5a of the first and second cylinders 4 and 5 are separately connected to conduits 9 and 10 through counterbalance valves 7 and 8, respectively, and the conduits 9 and 10 are selectively connected to a main conduit 12 by a pilot change-over valve 11. On the other hand, the boom contracting oil chambers 4b and 5b of the first and second cylinders 4 and 5 communicate with each other through an intermediate conduit 13 and are connected to a main circuit 14 in parallel relation with each other. The main circuits 12 and 14 are selectively connectable either to a hydraulic pump P serving as a pressure source or to a tank T by the operation of a boom extension/contraction control valve 15 which switches the flow direction of the pressure medium thereby to extend or contract the cylinders 4 and 5. Indicated at 16 is an operating lever of the control valve 15.

As seen in the same figure, the pilot change over valve 11 is connected to an accumulator 18 through an electromagnetic valve 17 which is actuated by an electric change-over signal from an electric control circuit operated according to the logic circuit shown in Figure 4 thereby to supply the pilot pressure from the accumulator 18 to the pilot change over valve 11. Whereupon, the change-over valve 11 is switched to select either the extension or contraction of the cylinder 4 or 5.

The control circuit operated according to the logic circuit of Figure 3 receives the detected boom length (1) of the boom length detector 6 as the telescopic boom expands or contracts and compares it with the above mentioned preset first and second reference values (L-b) and (L+b), turning on or off a relay R according to the results of the comparison.

The control circuit includes a microprocessor 20 as shown in Figure 4 and the logic circuit of Figure 3 is provided in the form of a programme in the microprocessor 20. In this connection, it is advantageous to utilise the microprocessor which is already provided on the crane for the control of the overload detector system. Such a microprocessor is already supplied with the detected boom length (1) from the boom length detector 6 sequentially at predetermined time intervals, and it can easily perform the operations of comparing the detected boom length (1) with the respective reference values and detecting the variation per unit time of the detected boom length (1), for the on-off control of the relay R, by incorporating a programme corresponding to the logic circuit of Figure 3. Further, by the logic circuit of Figure 4, the switch Rs is turned on and off according to the on-off control of the relay R to energise and de-energise the solenoid 17', accurately switching

the position of the electromagnetic valve 17 of Figure 12.

The telescopic boom expanding and contracting operations will now be explained more particularly case by case.

(i) Extending the boom from the fully contracted state:

In this case, the boom extension/contraction control valve 15 of Figure 2 is switched to the right position 15A by manipulating the lever 16, whereupon the output fluid pressure of the hydraulic pump P is fed in the direction of arrow A1 and admitted into the pilot change-over valve 11. On the other hand, the detected boom length (1) from the boom length detector 6 is fed to the control circuit, more particularly, to a discriminator 21 (see Figure 3) of the control circuit to make a judgement as to whether the boom is to be extended or contracted. In this instance, the boom is to be extended, so that the detected boom length (1) is fed to a discriminator 22 through YES circuit of the discriminator 21 for comparison with the first reference value (L-b).

Since the boom length is short in the initial stage of the boom extension and the detected boom length (1) is smaller than the first reference value (L-b), its signal is fed to a relay-off circuit 26 through a YES circuit of the discriminator 22 to turn off the relay R of Figure 4, de-energising the solenoid 17' and maintaining the electromagnetic valve 17 and the pilot change-over valve 11 in the positions shown in Figure 2. Therefore, the fluid pressure which is fed in the direction of arrow A1 is fed in the direction of arrow A2 and admitted into the extending oil chamber 4a of the cylinder 4, while the fluid pressure in the contracting oil chamber 4b of the cylinder 4 is led in the direction of arrow A3 for return to the tank T. As a result, the first cylinder 4 extends the intermediate boom portion 2 out of the base boom portion 1. At this time, the conduit 10 which is connected to the extending oil chamber 5a of the second cylinder 5 is blocked by the pilot change over valve 11, so that the second cylinder 5 does not extend or contract and the fore boom portion 3 is held in its contracted state in the intermediate boom portion 2 which is being extended out of the base boom portion 1.

As the boom is extended to a certain point, and the detected boom length (1) becomes greater than the first reference value (L-b), so that the detected boom length (1) is fed to the discriminator 23 for comparison with the second reference value (L+b). However, the detected boom length (1) is still smaller than the second reference value (L+b) at this time and the detected boom length (1) is fed to the discriminator 24 through the NO circuit of the discriminator 23 to determine if the variation (V) of the detected boom length (1) per unit time is greater than a predetermined value. Thus, as this stage the control treats the discriminator 23 as if it were not included in the control sequence. As long as the variation (V) of the detected boom length (1) exceeds a predetermined value (which means

that the first cylinder 4 has not yet reached the end of its stroke), the signal is returned to the initial point of control through the NO circuit of the discriminator 24. Thus, there is substantially no change in the control sequence, and the electromagnetic valve 17 and pilot change over valve 11 are continuously maintained in the position shown, permitting further extension of the intermediate boom portion 2 by the first cylinder 4 alone.

Then, if the variation per unit time (V) of the detected boom length (1) becomes smaller than the predetermined value (ie the first cylinder 4 is at the end of its stroke), the signal is fed to a relay-on circuit 26' through the YES circuit of the discriminator 24, turning on the relay R of Figure 4 and energising the solenoid 17' through the switch Rs to shift the electromagnetic valve 17 to the right position in Figure 2. Consequently, the fluid pressure from the accumulator 18 is led in the direction of arrow A4 to shift the pilot change-over valve 11 into the upper position in the same figure, stopping the supply of fluid pressure to the first cylinder 4 and instead feeding the fluid pressure in the direction A5 from the main circuit 12 for admission into the extending fluid chamber 5a of the second cylinder 5. The fluid pressure in the contracting chamber 5b of the second cylinder 5 is drained in the direction of arrow A6 for return to the tank T. As a result, the first cylinder 4 is stopped with the intermediate boom portion 2 held in a fully extended position relative to the base boom portion 1, while the fore boom portion 3 alone is extended out of the intermediate boom portion 2 by the extension of the second cylinder 5.

If the detected boom length (1) becomes greater than the second reference value (L+b) by further extension of the boom, the detected boom length (1) is fed to the relay-on circuit 26' through the YES circuit of the discriminator 23, holding the electromagnetic valve 17 in the right position in the figure to permit the extension of the fore boom portion 3 by the second cylinder 5 alone.

Thus, in the boom extending operation, the intermediate boom portion 2 is firstly extended out of the base boom portion 1 by the first cylinder 4, and the electromagnetic valve 17 shifted when the first cylinder 4 comes to its stroke end, that is to say, when the intermediate boom portion 2 is fully extended, thereby stretching the second cylinder 2 to extend the fore boom portion 3 out of the intermediate boom portion 2.

(II) Contracting the boom from a fully extended state:

In this case, the boom extension/contraction control valve 15 is shifted to the left position 15B in the figure to supply the output fluid pressure of the hydraulic pump P in the direction of arrow B1 into the contracting fluid chamber 4b of the first cylinder 4 to contract same. However, since the boom is to be contracted in this instance the output boom length (1) of the boom length

detector 6 is fed to the discriminator 22' through the NO circuit of the discriminator 21 as shown in Figure 3. The detected boom length is large and its detected boom length (1) is greater than the first reference value (L-b) and the second reference value (L+b) in the initial stage of the boom contracting operation, so that the detected boom length (1) is fed to the relay-on circuit 26' through the NO and YES circuits of the discriminators 22' and 23', respectively, to turn on the relay R. Whereupon, the solenoid 17' is energised to shift the electromagnetic valve 17 into the right hand position in Figure 2, and the fluid pressure from the accumulator 18 is fed in the direction of arrow B2 to shift the pilot change-over valve 11 into the upper position, blocking the conduit 9 and instead connecting the conduit 10 to the main circuit 12.

Therefore, the fluid pressure flowing in the direction of arrow B1 is fed in the direction of arrow B3 and admitted into the contracting fluid pressure in the extending chamber 5a of the second cylinder 5 is drained in the direction of arrow B4 and returned to the tank T. Consequently, the first cylinder 4 remains stationary without expanding or contracting holding the intermediate boom portion 2 in the fully extended state relative to the base boom portion 1, so that only the fore boom portion retracts into the intermediate boom portion by the contraction of the second cylinder 5.

If the boom is contracted to a certain extent and the detected boom length (1) becomes smaller than the first reference value (L+b), the detected boom length (1) is fed to the discriminator 24' through the NO circuit of the discriminator 23' to check if the variation per unit time (V) of the detected boom length (1) is greater than a predetermined value. If the variation (V) is greater than the predetermined value (implying that the second cylinder 5 has not yet reached the end of its stroke), the signal is returned to the initial point of control through the NO circuit of the discriminator 24'. Therefore, the electromagnetic valve 17 is retained in the current position, so that the fore boom portion 3 is still retracted by the second cylinder 5.

As soon as the variation per unit time (V) of the detected boom length (1) becomes smaller than the predetermined value (with the second cylinder 5 coming to the end of its stroke), the signal is fed to the relay-off circuit 26 through the YES circuit of the discriminator 24', returning the electromagnetic valve 17 to its initial change-over position. As a result, the conduit 10 is blocked by the change-over valve 11 to stop the fluid in the contracting chamber 5b of the second cylinder 5 from draining into the tank T, holding the second cylinder 5 still. Then the fluid pressure which is led in the arrowed direction B1 is admitted into the contracting chamber 4b of the first cylinder 4, while the fluid pressure in the extending chamber 4a of the first cylinder 4 is led out in the direction of arrow B5 for return to the tank T. Thus, the first cylinder 4 starts to contract

to retract the intermediate boom portion 2 into the base boom portion 1, along with the fore boom portion 3 which is held in a fully retracted position in the intermediate boom portion 2.

Thereafter, as the detected boom length (1) becomes smaller than the first reference value (L-b) by further contraction of the boom, the detected value (1) is fed to the relay-off circuit 26 through the YES circuit of the discriminator 22' to hold the electromagnetic valve 17 in the initial position shown, so that the intermediate boom portion 2 is retracted into the base boom portion 1 by the first cylinder 4 along with the fore boom portion 3.

It will be clear from the foregoing description that, in the boom contracting operation, the fore boom portion 3 is firstly retracted into the intermediate boom portion 2 by the second cylinder 5 with the electromagnetic valve 17 in the shifted position, and it is only when the second cylinder 5 reaches the end of its stroke, that is to say, when the fore boom portion 3 is fully retracted, that the electromagnetic valve 17 is returned to its initial position to retract the intermediate boom portion 2 into the base boom portion 1 by retraction of the first cylinder 4.

(III) Extending or contracting the boom after stopping part way to its extended operation:

Where the detected boom length (1) of the boom length detector 6 is smaller than the first reference value (L-b) at the time of re-starting the telescopic motion, the detected signal (1) is fed to the relay off circuit 26 through the YES circuit of the discriminator 22 or 22' to hold the electromagnetic valve 17 and pilot change over valve 11 in the positions shown. Therefore, the second cylinder 5 remains in a de-activated state and only the first cylinder is actuated to extend or retract the intermediate boom portion 2 relative to the base boom portion 1. On the other hand, if the detected boom length (1) is greater than the second reference value (L+b), the detected signal is fed to the relay-on circuit 26' through the YES circuit of the discriminator 23 or 23' to shift the electromagnetic valve 17 into the right-hand position and the pilot change-over valve 11 into the upper position in the Figure. Accordingly, the first cylinder remains still, and only the second cylinder is actuated to extend or retract the fore boom portion 3 relative to the intermediate boom portion 2.

During the above described telescopic boom extending or contracting operation, if an operator should stop the telescopic motion by intentionally returning the operation control valve 15 to a neutral position when the boom length is close to the cylinder switching point, namely, when the detected boom length (1) is in the range of $(L-b) \leq 1 \leq (L+b)$, the discriminator 24 or 24' of the control circuit of Figure 3 regards that there is no variation (V) in the detected boom length (1) although the operating cylinder has not yet reached the end of its stroke, turning on or off the relay R to shift the electromagnetic valve 17 to the right or left position. Therefore, upon re-starting the telescopic operation of the boom, the control would

recommence from the point at which the electromagnetic valve 17 was switched, the cylinder of the next stage extending or contracting with the cylinder of the prior stage left in a position short of the end of its stroke.

This can be prevented by providing a limit switch which detects the movement of the lever 16 of the operation control valve 15, and in particular detects whether or not the lever 16 is in its neutral position. Further, as illustrated in Figure 5, discriminators 25 and 25' which discriminate the neutral position of the lever 16 are connected to the YES circuits of the discriminators 24 and 24' which judge the variation (V) of the detected boom length (1). In this instance, even if the boom is stopped at a halfway position as described above, the electromagnetic valve 17 does not shift and the controllable state prior to the temporary stop is retained. Upon subsequently recommencing the extension or contraction of the boom, the control is started according to the situation at the time of recommencement, so that the boom stretching or contracting operation can be properly controlled to ensure an accurate operation.

It will be appreciated from the foregoing description that the respective cylinders are successively operated by an accurate switching operation to extend or contract a boom in the ideal way. The method can be economically applied since it can utilise a boom length detector which is normally already provided on a multistage boom, without necessitating changes in the construction of the booms and cylinders. The switching function is performed only in a predetermined range before and after a cylinder switching point L without resorting to a mechanical detection mechanism to guarantee accurate control of the switching operation.

Claims

1. A method for controlling the boom operating cylinders (4, 5) during expansion and contraction of a multistage telescopic boom including a base boom portion (1), an intermediate boom portion (2) and a fore boom portion (3), said method being characterised by

detecting the length of said boom by means of a boom length detector (6);

permitting extension or contraction of a cylinder (4) of said intermediate boom portion (2) when the value (1) of the detected length of the boom is smaller than a first preset reference value (L-b) which reference value is determined by subtracting a preset arbitrary length (b) from the actual length (L) of said boom when said intermediate boom portion (2) is fully extended relative to said base boom portion (1) and said fore boom portion (3) is fully contracted relative to said intermediate boom portion (2);

permitting extension or contraction of a cylinder (5) of said fore boom portion (3) alone with the detected boom length (1) is greater than a second preset reference value (L+b);

detecting variation per unit time (V) of said

detected boom length (l) when said detected boom length (l) is in the range between said first and second reference values (L-b) and (L+b);

continuing the boom extension or contraction by means of a currently operating cylinder while said variation (V) is greater than a predetermined value; and

switching the boom extending or contracting to a cylinder of the next stage when said variation (V) becomes smaller than said predetermined value.

2. The method as claimed in claim 1, characterised in that said first and second reference values (L-b) and (L+b) are chosen whereby b is greater than inevitable errors of said boom length detector (6).

3. The method as claimed in claim 1 or 2, characterised in that the cylinders (4, 5) of said fore and intermediate boom portions (3, 2) are controlled by a hydraulic control circuit including a pilot change-over valve (11) for controlling flows of fluid pressure to and from extending and contracting pressure chambers of said cylinders (4, 5) and an electromagnetic valve (17) for controlling the supply of pilot pressure to said pilot change-over valve (11), and an electric control circuit including a logic circuit connected to said boom length detector (6) to compare said detected boom length (l) with said first and second reference values (L-b) and (L+b) and adapted to energise and de-energise said electromagnetic valve (17) when said variation per unit time (V) of said detected boom length (l) becomes smaller than said predetermined value during boom extending and contracting operations, respectively.

4. The method as claimed in claim 3, characterised in that said logic circuit of said electric control circuit includes a neutral position detector (25, 25') for ensuring the correct control of the cylinders after the extension/contraction selector lever (15) has been put in a neutral position when the boom is in the range between said first and second reference values (L-b) and (L+b).

5. The method as claimed in any of claims 1 to 4, wherein said boom length detector (6) includes a wire (6b) wound on a drum of a wire retractor mounted on said base boom portion (1) and having the fore end thereof fixed to the rear end of said fore boom portion (3), and a potentiometer adapted to measure the length of said wire (6b) pulled out during the boom extending and contracting operations.

6. Apparatus for controlling the boom operating cylinders (4, 5) during expansion and contraction of a multistage telescopic boom including a base boom portion (1), an intermediate boom portion (2) and a fore boom portion (3), said apparatus being characterised by

a boom length detector (6) for detecting the length (l) of said boom; and

means (20) for permitting extension or contraction of a cylinder (4) of said intermediate boom portion (2) when the value (l) of the detected length of the boom is smaller than a first preset reference value (L-b) which reference value is

determined by subtracting a preset arbitrary length (b) from the actual length L of said boom when said intermediate boom portion (2) is fully extended relative to said base boom portion (1) and said fore boom portion (3) is fully contracted relative to said intermediate boom portion (2);

means (20) permitting extension or contraction of a cylinder (5) of said fore boom portion (3) alone when the detected boom length (l) is greater than a second preset reference value (L+b);

means (20) detecting variation per unit time (V) of said detected boom length (l) when said detected boom length (l) is in the range between said first and second reference values (L-b) and (L+b);

means (20) for continuing the boom extension or contraction by means of a currently operating cylinder while said variation (V) is greater than a predetermined value and for switching the boom extending or contracting operation to a cylinder of the next stage when said variation (V) becomes smaller than said predetermined value.

Patentansprüche

1. Verfahren zur Steuerung der Ausleger-Arbeitszylinder (4, 5) während des Ausfahrens und Einziehens eines mehrstufigen teleskopischen Auslegers, der einen Ausleger-Basisabschnitt (1), einen mittleren Auslegerabschnitt (2) und einen vorderen Auslegerabschnitt (3) aufweist, gekennzeichnet durch

das Feststellen der Länge des Auslegers mittels eines Auslegerlängendetektors (6),

das Zulassen des Ausfahrens und des Einziehens eines Zylinders (4) des mittleren Auslegerabschnitts (2), wenn der Wert (l) der festgestellten Länge des Auslegers geringer als ein erster festgesetzter Vergleichswert (L-b) ist, der bestimmt wird, indem eine vorgegebene willkürliche Länge (b) von der aktuellen Länge (L) des Auslegers abgezogen wird, wenn der mittlere Auslegerabschnitt (2) relativ zum Ausleger-Basisabschnitt (1) vollständig ausgefahren und der vordere Auslegerabschnitt (3) relativ zum mittleren Auslegerabschnitt (2) vollständig eingezogen ist,

das Zulassen des Ausfahrens und des Einziehens eines Zylinders (5) des vorderen Auslegerabschnitts (3) nur dann, wenn die festgestellte Auslegerlänge (l) größer als ein zweiter festgesetzter Vergleichswert (L+b) ist, das Feststellen der Veränderung (V) der festgestellten Auslegerlänge (l) pro Zeiteinheit, wenn die festgestellte Auslegerlänge (l) im Bereich zwischen dem ersten und dem zweiten Vergleichswert (L-b) und (L+b) liegt,

das Fortsetzen des Ausfahrens oder Einziehens des Auslegers mittels eines augenblicklich arbeitenden Zylinders, wenn die Veränderung (V) größer als ein vorbestimmter Wert ist, und

das Umschalten des Ausfahrens oder Einziehens des Auslegers auf einen Zylinder der nächsten Stufe, wenn die Veränderung (V) geringer als ein vorbestimmter Wert wird.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß der erste und der zweite Vergleichswert ($L-b$) und ($L+b$) gewählt sind, wobei b größer als die zwangsläufigen Fehler des Auslegerlängendetektors (6) ist.

3. Verfahren nach Anspruch 1 und 2, dadurch gekennzeichnet, daß die Zylinder (4, 5) des vorderen und mittleren Auslegerabschnittes (3, 2) mittels eines hydraulischen Kreislaufes, der ein Umschaltventil (11) zur Steuerung des Fluiddruckstroms zu und von Ausfahr- und Einziehdrukammern der Zylinder (4, 5) und ein elektromagnetisches Ventil (17) zur Steuerung der Zuführung von Umschaltdruck zum Umschaltventil (11) aufweist, und eines elektrischen Steuerkreises gesteuert werden, der eine Logikschaltung umfaßt, die mit dem Auslegerlängendetektor (6) verbunden ist, um die festgestellte Auslegerlänge (l) mit dem ersten und dem zweiten Vergleichswert ($L-b$ und ($L+b$) zu vergleichen, und die das elektromagnetische Ventil (17) energieren und deenergieren kann, wenn die Veränderung (V) der festgestellten Auslegerlänge (l) pro Zeiteinheit während der Ausfahr- bzw. Einziehooperationen kleiner als der vorbestimmte Wert wird.

4. Verfahren nach Anspruch 3, dadurch gekennzeichnet, daß die Logikschaltung des elektrischen Steuerkreises einen Detektor für eine neutrale Stellung (25, 25') aufweist, um die korrekte Steuerung der Zylinder sicherzustellen, nachdem der Ausfahr-/Einzieh-Wahlhebel (15) in eine neutrale Stellung gebracht wurde, wenn der Ausleger sich in einem Bereich zwischen dem ersten und dem zweiten Vergleichswert ($L-b$) und ($L+b$) befindet.

5. Verfahren nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, daß der Auslegerlängendetektor (6) einen Draht (6b), der auf eine Trommel einer Drahtrückzugsvorrichtung, die an dem Basis-Auslegerabschnitt (1) angebracht ist, gewickelt ist und dessen vorderes Ende am hinteren Ende des vorderen Auslegerabschnittes (3) befestigt ist, und ein Potentiometer aufweist, das die Länge des während der Ausfahr- und Einziehooperationen ausgezogenen Drahtes (6b) messen kann.

6. Vorrichtung zur Steuerung der Ausleger-Arbeitszylinder (4, 5) während des Ausfahrens und Einziehens eines mehrstufigen teleskopischen Auslegers, der einen Ausleger-Basisabschnitt (1), einen mittleren Auslegerabschnitt (2) und einen vorderen Auslegerabschnitt (3) aufweist, gekennzeichnet durch

einen Auslegerlängendetektor (6) zum Feststellen der Länge (l) des Auslegers,

eine Vorrichtung (20) zum Zulassen des Ausfahrens und des Einziehens eines Zylinders (4) des mittleren Auslegerabschnitts (2), wenn der Wert (l) der festgestellten Länge des Auslegers geringer als ein erster festgesetzter Vergleichswert ($L-b$) ist, der bestimmt wird, indem eine vorgegebene willkürliche Länge (b) von der aktuellen Länge (L) des Auslegers abgezogen wird, wenn der mittlere Auslegerabschnitt (2) relativ zum Ausleger-Basisabschnitt (1) vollständig ausgefahren und der vordere Auslegerabschnitt (3) relativ

zum mittleren Auslegerabschnitt (2) vollständig eingezogen ist,

eine Vorrichtung (20), die das Ausfahren und das Einziehen eines Zylinders (5) des vorderen Auslegerabschnitts (3) nur dann zuläßt, wenn die festgestellte Auslegerlänge (l) größer als ein zweiter festgesetzter Vergleichswert ($L+b$) ist,

eine Vorrichtung (20), die die Veränderung (V) der festgestellten Auslegerlänge (l) pro Zeiteinheit feststellt, wenn die festgestellte Auslegerlänge (l) im Bereich zwischen dem ersten und dem zweiten Vergleichswert ($L-b$) und ($L+b$) liegt,

eine Vorrichtung (20) zum Fortsetzen des Ausfahrens oder Einziehens des Auslegers mittels eines augenblicklich arbeitenden Zylinders, wenn die Veränderung (V) größer als ein vorbestimmter Wert ist, und zum Umschalten des Ausfahrens oder Einziehens des Auslegers auf einen Zylinder der nächsten Stufe, wenn die Veränderung (V) geringer als ein vorbestimmter Wert wird.

Revendications

1. Procédé pour commander les vérins (4, 5) de manoeuvre d'une flèche pendant l'extension et la rétraction d'une flèche télescopique à sections multiples, comportant un élément de flèche de base (1), un élément de flèche intermédiaire (2) et un élément de flèche avant (3), ledit procédé étant caractérisé en ce qu'il consiste à:

— détecter la longueur de ladite flèche au moyen d'un détecteur (6) de la longueur de la flèche;

— permettre l'extension ou la rétraction d'un vérin (4) dudit élément de flèche intermédiaire (2) lorsque la valeur (l) de la longueur détectée de la flèche est inférieure à une première valeur de référence préétablie ($L-b$), laquelle valeur de référence est déterminée en soustrayant une longueur quelconque préétablie (b) de la longueur réelle (L) de ladite flèche, lorsque ledit élément de flèche intermédiaire (2) est totalement déployé par rapport audit élément de flèche de base (1) et que ledit élément de flèche avant (3) est totalement rétracté par rapport audit élément de flèche intermédiaire (2);

— permettre l'extension ou la rétraction d'un vérin (5) dudit élément de flèche avant (3) seul lorsque la longueur détectée (l) de la flèche est supérieure à une seconde valeur de référence préétablie ($L+b$);

— détecter la variation par unité de temps (V) de ladite longueur détectée (l) de la flèche lorsque ladite longueur détectée (l) de la flèche se situe dans la gamme comprise entre lesdites première et seconde valeurs de référence ($L-b$) et ($L+b$);

— continuer l'extension ou la rétraction de la flèche au moyen d'un vérin, qui est alors en fonctionnement, lorsque ladite variation (V) est supérieure à une valeur prédéterminée, et

— commuter l'extension ou la rétraction de la flèche sur l'étage immédiatement suivant, lorsque ladite variation (V) devient inférieure à ladite valeur prédéterminée.

2. Procédé selon la revendication 1, caractérisé

en ce que lesdites première et seconde valeurs de référence ($L-b$) et ($L+b$) sont choisies de manière que b soit supérieure aux erreurs inévitables dudit détecteur (6) de la longueur de la flèche.

3. Procédé selon la revendication 1 ou 2, caractérisé en ce que les vérins (4, 5) desdits éléments de flèche avant et intermédiaire (3, 2) sont commandés par un circuit de commande hydraulique comportant une soupape d'inversion pilote (11) pour commander des écoulements de fluide sous pression en direction et en provenance de chambres de pression d'extension et de rétraction desdits vérins (4, 5) et une soupape électromagnétique (17) servant à commander l'admission de la pression pilote à ladite soupape d'inversion pilote (11), et un circuit de commande électrique incluant un circuit logique raccordé audit détecteur (6) de longueur de la flèche pour comparer ladite longueur détectée (l) de la flèche auxdites première et seconde valeurs de référence ($L-b$) et ($L+b$), et adapté pour exciter et desexciter ladite soupape électromagnétique (17) lorsque ladite variation par unité de temps (V) de ladite longueur détectée (l) de la flèche devient inférieure à ladite valeur prédéterminée pendant des opérations respectives d'extension et de rétraction de la flèche.

4. Procédé selon la revendication 3, caractérisé en ce que ledit circuit logique dudit circuit de commande électrique comprend un détecteur de position neutre (25, 25') permettant de garantir la commande correcte des vérins une fois que le levier (15) de sélection de l'extension/rétraction a été placé dans une position neutre, lorsque la flèche se situe dans la gamme comprise entre lesdites première et seconde valeurs de référence ($L-b$) et ($L+b$).

5. Procédé selon l'une quelconque des revendications 1 à 4, selon lequel ledit détecteur (6) de la longueur de la flèche comporte un fil (6b) enroulé sur un tambour d'un dispositif de rappel du fil, monté sur ledit élément de flèche de base (1), et dont l'extrémité avant est fixée à l'extrémité arrière dudit élément de flèche avant (3), et un potentiomètre adapté pour mesurer la longueur

audit fil (6b) dévidé pendant les opérations d'extension et de rétraction de la flèche.

6. Appareil pour commander les vérins (4, 5) d'actionnement de la flèche pendant l'extension et la rétraction d'une flèche télescopique à sections multiples, comprenant un élément de flèche de base (1), un élément de flèche intermédiaire (2) et un élément de flèche avant (3), ledit appareil étant caractérisé par

— un détecteur (6) de la longueur de la flèche servant à détecter la longueur (l) de ladite flèche; et

— des moyens (20) permettant l'extension ou la rétraction d'un vérin (4) dudit élément de flèche intermédiaire (2) lorsque la valeur (l) de la longueur détectée de la flèche est inférieure à une première valeur de référence préétablie ($L-b$), laquelle valeur de référence est déterminée par soustraction d'une longueur quelconque préétablie (b), de la longueur réelle (L) de ladite flèche lorsque ledit élément de flèche intermédiaire (2) est totalement déployé par rapport audit élément de flèche de base (1) et que ledit élément de flèche avant (3) est totalement rétracté par rapport audit élément de flèche intermédiaire (2);

— des moyens (20) permettant l'extension ou la rétraction d'un vérin (5) dudit élément de flèche avant (3) seul lorsque la longueur détectée (l) de la flèche est supérieure à une seconde valeur de référence préétablie ($L+b$);

— des moyens (20) détectant la variation par unité de temps (V) de ladite longueur détectée (l) de la flèche lorsque ladite longueur détectée (l) de la flèche se situe dans la gamme comprise entre lesdites première et seconde valeurs de référence ($L-b$) et ($L+b$);

— des moyens (20) pour poursuivre l'extension ou la rétraction de la flèche au moyen d'un vérin, qui est alors en fonctionnement, lorsque ladite variation (V) est supérieure à une valeur prédéterminée et de commuter l'opération d'extension ou de rétraction de la flèche sur un vérin de l'étage immédiatement suivant, lorsque ladite variation (V) devient inférieure à ladite valeur prédéterminée.

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FIGURE 1

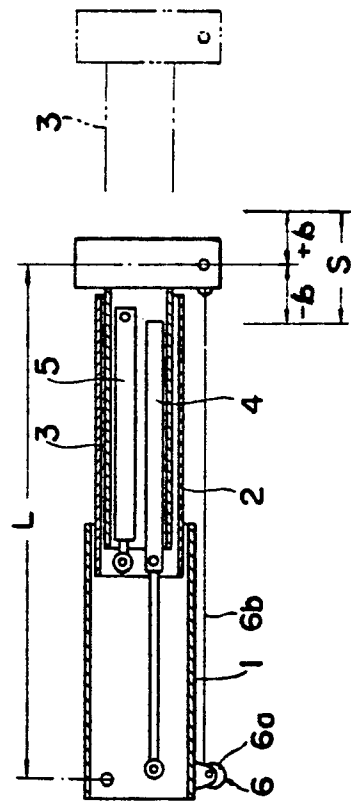


FIGURE 2

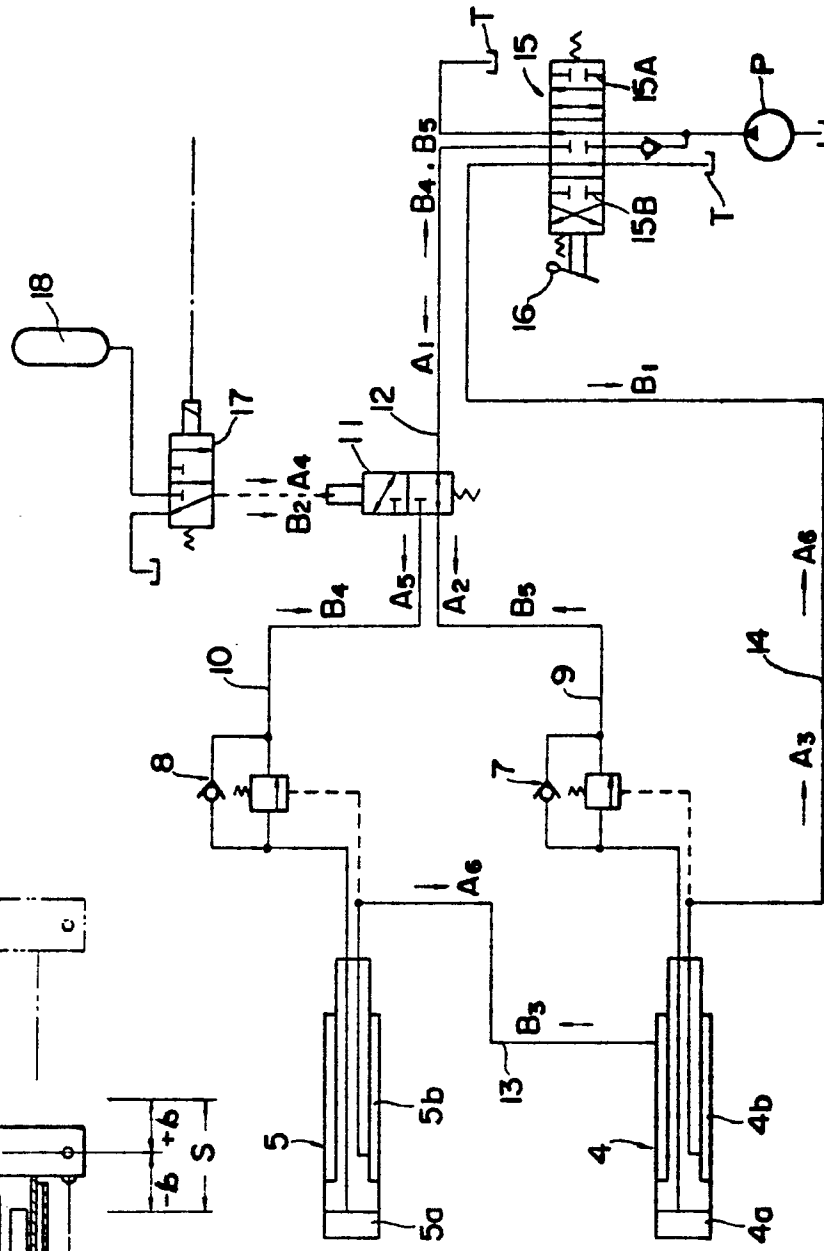


FIGURE 3

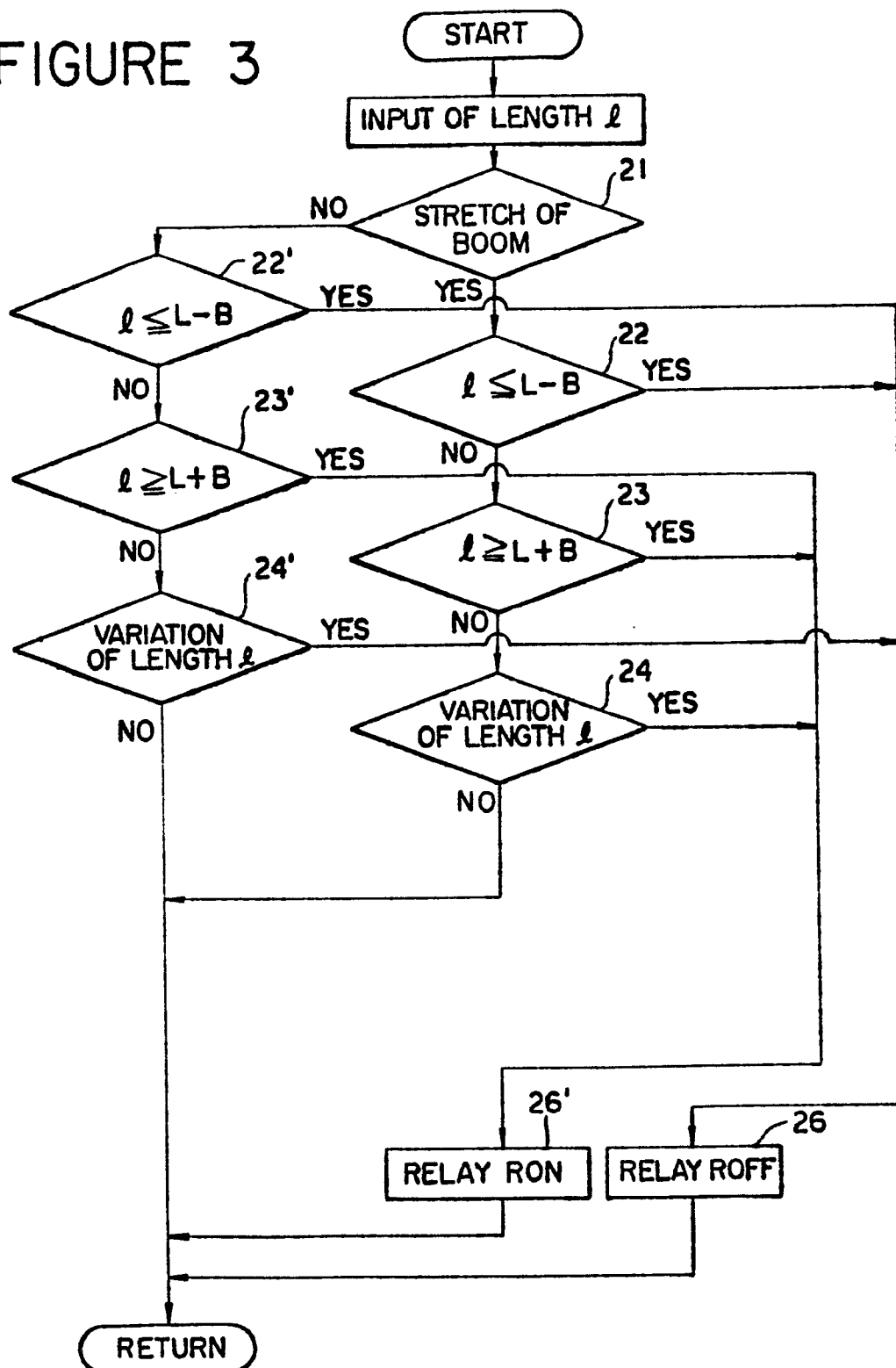


FIGURE 4

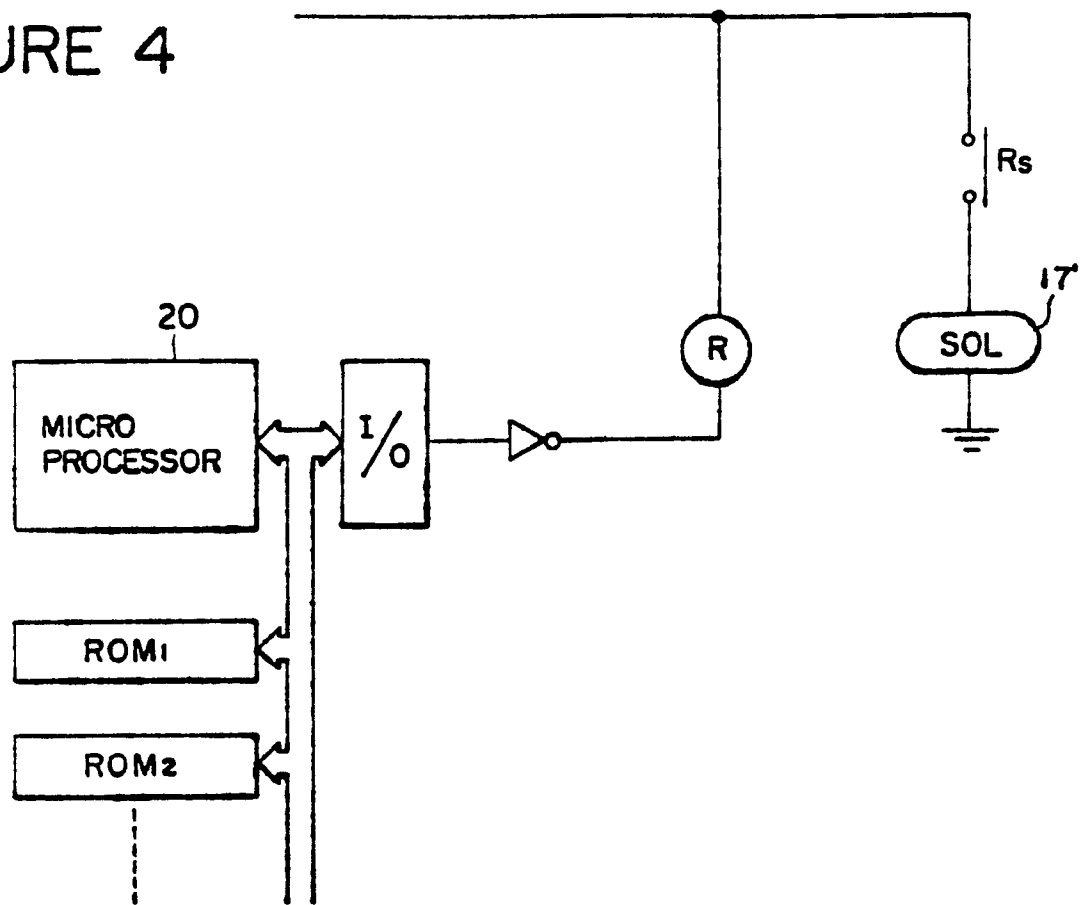


FIGURE 5

