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

(11) Publication number: 0 428 724 A1

(12) **EUROPEAN PATENT APPLICATION published in accordance with Art. 158(3) EPC**

(21) Application number: 89905756.6

(51) Int. Cl.5: **B66D 3/18**, B66F 19/00

(22) Date of filing: **11.05.89**

(86) International application number: **PCT/JP89/00484**

(87) International publication number: **WO 90/13507 (15.11.90 90/26)**

(43) Date of publication of application: **29.05.91 Bulletin 91/22**

(84) Designated Contracting States: **DE FR GB IT**

(71) Applicant: **KABUSHIKI KAISHA KOMATSU SEISAKUSHO**
3-6, Akasaka 2-chome
Minato-ku Tokyo 107(JP)

(72) Inventor: **TAKEDA, Shyu**
18, Manda Hiratsuka-shi
Kanagawa-ken 254(JP)
Inventor: **TOMARU, Hitoshi**
505, Shinomiya Hiratsuka-shi
Kanagawa-ken 254(JP)
Inventor: **OHTSUBO, Kazuhiko**
1848-24, Minamiyana Hadano-shi
Kanagawa-ken 257(JP)

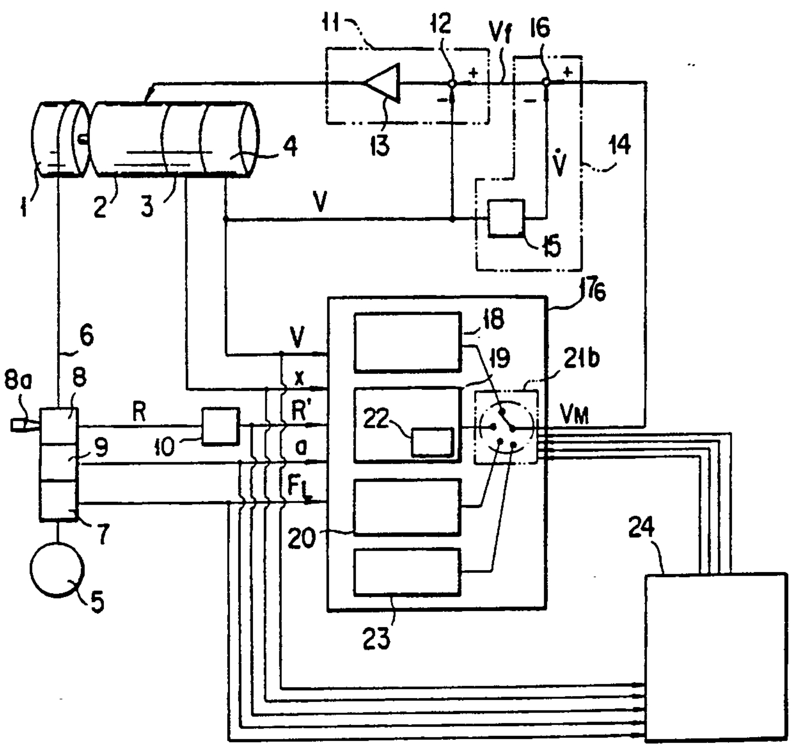
(74) Representative: **Patentanwälte Dipl.-Ing. A. Grünecker, Dr.-Ing. H. Kinkeldey, Dr.-Ing. W. Stockmair,**
Dr. rer. nat. K. Schumann, Dipl.-Ing. P.H. Jakob, Dr. rer. nat. G. Bezold
Maximilianstrasse 58
W-8000 München 22(DE)

(54) BALANCED CARGO HANDLING APPARATUS AND ITS CONTROL METHOD.

(57) This invention is directed to provide a balanced cargo handling apparatus and its control method which can rapidly bring a suspended work to halt when an operator releases his hold of the work even if there is some error in the stored weight value of the work. The balanced cargo handling apparatus includes in its operation circuit (17) a position mode operation unit (19) which keeps an operation mode in a position mode during a shift from a lever mode directed by a speed instruction (R) from an operation lever (8a) to a balance mode for accomplishing an equilibrium state of the work (5). When any abnormality such as one after a rapid change in load acting on the work (5), an abnormality mode operation unit (23) is additionally disposed in the operation circuit (17) so as to stop the work in the position in which it was first positioned with the work not swaying. A judgement circuit (24) is disposed separately in order to output a mode change-over signal in accordance with each input signal (V, X, R, F_L,a) to the mode selection circuit (21) for selecting each mode. A judgement circuit (27) for judging a mode at the time of abnormality is contained in this judgement circuit.

EP 0 428 724 A1

F I G . 22


11
12
Vf
16
13
4
14
V̇
1
2
3
V
15
17б
18
6
V
19
8a
8
x
21b
R
R'
VM
22
9
10
a
FL
7
20
24
5
23

EQUILIBRIUM CARGO HANDLING APPARATUS AND METHOD FOR CONTROLLING THE SAME

Technical Field

The present invention relates to an equilibrium cargo handling apparatus and a method for controlling the same which realize a state of equilibrium between a workpiece lifting means of the cargo handling apparatus and a workpiece being suspended having arbitrary weight by allowing a workpiece suspending and driving device to produce a force commensurate with its weight, and which makes it possible to make the workpiece to be lifted or lowered freely with an operator's light force as the operator directly touches the workpiece.

Background Art

Hitherto, methods disclosed in Japanese Patent Application Laid-Open Nos. 196495/1988 and 315497/1988 filed by the present applicant are known as conventional methods for controlling an equilibrium cargo handling apparatus of this type.

In the former publication, a controlling method using two modes, a lever mode for storing the weight of a workpiece and a balance mode for realizing a state of equilibrium between a workpiece lifting means and the workpiece, is disclosed, and the controlling method provided is such that immediately upon stopping the operation of the lever, the mode shifts to the balance mode.

In addition, in the latter publication, a controlling method is disclosed in which signals of a load detector during a fixed period of time after the operation of the lever is averaged.

In the former conventional controlling method described above, in the balance mode, unless the stored value of the weight of the workpiece is accurate, the workpiece cannot be made stationary when the operator has loosened his or her hold of the workpiece.

In addition, with the latter conventional controlling method, it is necessary to average the signals of the detector for a fixed period of time after the operation of the lever in order to accurately store the weight of the workpiece. For this reason, it is necessary to make the workpiece positively stationary during this period of time, so that there is a problem in the operating efficiency.

In addition, in an equilibrium cargo handling apparatus of this type, the arrangement provided is such that when the load acting on the workpiece has changed suddenly and the load detector has detected this sudden change in load, a brake is applied to stop the sudden movement (rapid fall or rapid rise) of the workpiece.

However, with such a conventional equilibrium cargo handling apparatus, since the rapid fall or rapid rise (springing up) of the workpiece is prevented by applying the brake after the sudden change in the load acting on the workpiece is detected, there are undesirable problems in that (1) there is a time lag until the brake begins to work, and the movement of the workpiece cannot be stopped at the point of time when the sudden change in load is detected, and (2) with respect to the cancellation of the brake or restarting due to the sudden change in load, a power source must be reset on each such occasion.

SUMMARY OF THE INVENTION

The present invention has been devised in view of the above-described circumstances, and its object is to provide an equilibrium cargo handling apparatus and a method for controlling the same in which, in order to ensure that a workpiece being suspended can be made stationary speedily when the operator has loosened his or her hold of the workpiece even if there is a slight error in the stored value of the weight of the workpiece, a position mode is provided while the mode shifts from the lever mode to the balance mode, the weight of the workpiece is stored at this position mode, and this position mode is held until the operator subsequently applies an operating force, so as to make the workpiece stationary.

Another object of the present invention is to provide an equilibrium cargo handling apparatus which, at a time when an abnormality is detected such as a sudden change in the load acting on a workpiece being suspended, is capable of stopping workpiece at an initially placed position without swinging the workpiece, and allows a normal controlling operation to be continued by simply effecting the operation of a lever at the time of restarting after the stopping of the workpiece.

To attain the above-described objects, in accordance with a first aspect of the present invention, there is provided a method for controlling an equilibrium cargo handling apparatus, comprising the steps of: storing the weight of a workpiece in position-mode control provided between lever-mode control for controlling a work suspending operation by the operation of an operation lever by an operator on the one hand, and balance-mode control for controlling a driving device for lifting the workpiece at the time of a work lifting/lowering operation by the operator on the other; holding the position-mode control until the operator applies an operating force to the workpiece, so as to maintain a stationary state of the workpiece, whereby the workpiece can be made stationary speedily even if there is a slight error in a stored value of the weight of the workpiece.

To attain the above-described objects, in accordance with a second aspect of the present invention, there is provided a method for controlling an equilibrium cargo handling apparatus according to the first aspect, wherein when a speed command signal is inputted by the operation of the operation lever, the mode is preferentially set to the lever-mode control, and when this speed command signal has become zero, the mode is set to the position-mode control.

To attain the above-described objects, in accordance with a third aspect of the present invention, there is provided a method for controlling an equilibrium cargo handling apparatus according to the first aspect, wherein when the storage of the weight of the workpiece is completed, and an absolute value of a difference between a load detection signal and the stored value of the weight of the workpiece exceeds a preset threshold, the mode is changed over to the balance-mode control, while when the absolute value has reached the threshold or below, the mode is changed over to the position-mode control.

To attain the above-described objects, in accordance with a fourth aspect of the present invention, there is provided an equilibrium cargo handling apparatus including work lifting means for lifting or lowering a workpiece being suspended, driving means for driving the work lifting means, load detecting means for detecting load acting on the workpiece, position detecting means for detecting a position of the workpiece lifting means, speed commanding means for outputting a speed command signal in accordance with the operation of an operation lever by an operator, and weight storing means for storing the weight of the workpiece, the apparatus comprising: a lever mode calculating unit for negatively feeding back a work lifting/lowering speed with the speed command signal from the speed commanding means set as a targeted value; a position mode calculating unit which sets as a targeted value the position of the work lifting means at a moment when the speed command value has become very small and which negatively feeds back the position and the work lifting/lowering speed at that time; a balance mode calculating unit for negatively feeding back a load detection signal from the load detecting means with the weight of the workpiece set as a targeted value, and for positively feeding back the speed detecting signal; and a calculation circuit for outputting one of the respective modes to the driving means via a mode selecting circuit.

To attain the above-described objects, in accordance with a fifth aspect of the present invention, there is provided an equilibrium cargo handling apparatus according to the fourth aspect, wherein the calculation circuit is a digital-type calculation circuit including an A/D converter, a digital calculation unit, a timer, and a D/A converter.

To attain the above-described objects, in accordance with a sixth aspect of the present invention, there is provided an equilibrium cargo handling apparatus according to the fourth aspect, wherein the calculation circuit further comprises a balance stationary mode calculating unit, whereby load feedback is applied to positional control of the workpiece, and a large change occurring between an output value of calculation and a motor speed command value at the time of the balance mode is prevented.

To attain the above-described objects, in accordance with a seventh aspect of the present invention, there is provided an equilibrium cargo handling apparatus according to the sixth aspect, wherein a shift to the balance stationary mode is effected when a relationship $|F_L - W_0| \leq F_0$ between an absolute value ($|F_L - W_0|$) of a work operating force of the operator and a threshold (F_0) has continued for a preset period of time (Td).

To attain the above-described objects, in accordance with an eighth aspect of the present invention, there is provided an equilibrium cargo handling apparatus according to the fourth aspect, wherein an acceleration signal from an acceleration detector for detecting lifting/lowering acceleration of the workpiece at the time of operation of the workpiece by the operator is inputted to the calculation circuit.

To attain the above-described objects, in accordance with a ninth aspect of the present invention, there is provided an equilibrium cargo handling apparatus according to the fourth aspect, further comprising a determining circuit for outputting a changeover signal to the mode selecting circuit in accordance with an input signal from each of the means, wherein the calculation circuit further includes an abnormality mode calculating unit for stopping the driving means at a position corresponding to a position signal of the work lifting means by outputting an abnormality mode command to the driving means by negatively feeding back the position signal, wherein the determining circuit includes a determining circuit for an abnormality mode for outputting a signal for changing over the mode selecting circuit to the abnormality mode calculating unit by detecting a sudden change of the load acting on the work, wherein when the load acting on the work changes suddenly, on the basis of signals outputted from the load detecting means, the speed detecting means, and the speed commanding means at that time, absolute values of the respective signals and their thresholds are respectively compared and calculated by the determining circuit for the abnormality mode, the mode selecting circuit is changed over to the abnormality mode calculating unit by an output signal from the determining circuit, and the driving means is stopped by an output signal from the abnormality mode calculating unit.

Three modes, i.e., the lever-mode control based on a speed command from the operation lever, the balance-mode control for realizing a state of equilibrium of the workpiece, and the position-mode control for making the workpiece stationary, can be realized. Even if there is a slight error in the stored value of the weight of the workpiece, the workpiece can be made stationary when the operator has released his or her hold of the workpiece.

Furthermore, the workpiece can be stopped at an initial position without swinging the workpiece after detection of an abnormality such as a sudden change of the load acting on the workpiece. At the same time, it is possible to continue a normal controlling operation by simply operating the lever at the time of restarting after the workpiece is stopped.

The other objects, modes and advantages of the present invention will become apparent to those skilled in the art by the following description in which the preferred specific examples conforming with the basic principle of the present invention are illustrated as embodiments when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a basic schematic explanatory diagram concerning a first embodiment of the present invention;

Figs. 2 to 4 are schematic explanatory diagrams of a lever mode, a position mode, and a balance mode in a calculation circuit of the first embodiment, respectively;

Fig. 5 is a basic schematic explanatory diagram concerning a second embodiment of the present invention;

Fig. 6 is a flowchart for selecting a mode concerning the first and second embodiments;

Fig. 7 is a diagram of transition between the modes concerning the first and second embodiments;

Fig. 8 is a schematic explanatory diagram of an example in which a parallelogrammic link-type workpiece lifting machine;

Fig. 9 is a basic schematic explanatory diagram concerning a third embodiment of the present invention;

Fig. 10 is a schematic explanatory diagram of the balance stationary mode in the calculation circuit of the third embodiment;

Figs. 11A and 11B are diagrams illustrating relationships between a motor speed command value and an operator's operating force at the time of changeover of a motor in a case where only positional feedback is operated;

Figs. 12A and 12B are diagrams illustrating relationships between the motor speed command value and the operator's operating force at the time of changeover of the motor in a case where only load feedback is operated;

Fig. 13 is a mode transition diagram concerning the third embodiment;

Fig. 14 is a flowchart at a time when the modes concerning the third embodiment are selectively determined;

Fig. 15 is a mode transition diagram concerning a fourth embodiment;

Fig. 16 is a flowchart at a time when the modes concerning the fourth embodiment are selectively determined;

Fig. 17 is a basic schematic explanatory diagram concerning a fifth embodiment of the present invention;

Figs. 18 and 19 are schematic explanatory diagrams of the lever mode and the position mode in the calculation circuit in the fifth embodiment, respectively;

Fig. 20A is a diagram illustrating a load detector signal in a case where acceleration feedback in the fifth embodiment is not operated;

Fig. 20B is a diagram illustrating a load detector signal in a case where acceleration feedback in the fifth embodiment is operated;

Fig. 21 is a basic schematic explanatory diagram concerning a sixth embodiment of the present invention;

Fig. 22 is a basic schematic explanatory diagram concerning a seventh embodiment of the present invention;

Figs. 23 to 26 are schematic explanatory diagrams of the lever mode, position mode, balance mode, and abnormality mode in the calculation circuit of the seventh embodiment, respectively;

Fig. 27 is a flowchart at a time when the modes concerning the seventh embodiment are selectively determined; and

Fig. 28 is a schematic explanatory diagram of a determination circuit for the abnormality mode concerning the seventh embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the accompanying drawings, a description will be given of several embodiments of the present invention.

Fig. 1 shows a first embodiment explaining a basic principle of the present invention, in which reference numeral 1 denotes a drum rotatively driven by a motor 2; 3, a position detector for detecting the rotational position of the motor 2; and 4, a speed detector for detecting the rotational speed of the motor 2. Meanwhile, numeral 5 denotes a workpiece which is wound up onto the drum 1 via a rope 6. A load detector 7 and a speed commanding device 8 are provided for the rope 6 for suspending this workpiece 5. Reference character 8a denotes an operation lever of the speed commanding device 8.

The speed commanding device 8 is adapted to output a speed command signal R corresponding to an amount of the operation lever 8a operated, and the load detector 7 is adapted to detect the load (force) acting on the workpiece 5 and output its signal F_L. Furthermore, the position detector 3 and the speed detector 4 are adapted to output a rotational position signal x of the motor and a speed signal V, respectively.

Reference numeral 11 denotes a drive circuit for driving the motor 2, and this drive circuit 11 comprises an adder 12 for calculating a difference between a command value Vf and the speed signal V of the motor 2, as well as a drive circuit 13, and is adapted to drive the motor 2 in accordance with the difference Vf - V.

Reference numeral 14 denotes a motor acceleration feedback circuit, and this circuit 14 has a differential device 15 for obtaining an acceleration signal $\dot{V}$ of the motor 2 by differentiating the speed signal V outputted from the speed detector 4 of the motor 2 as well as an adding point 16, and is adapted to output a motor speed command value Vf by calculating at the adding point 16 a difference between the aforementioned acceleration signal $\dot{V}$ and a speed command value V_M from a calculation circuit 17_1 which will be described later.

The reference numeral 17_1 denotes the calculation circuit which outputs the aforementioned speed command value V_M, and this calculation circuit 17_1 is provided with a lever mode calculating unit 18, a position mode calculating unit 19, and a balance mode calculating unit 20. Reference numeral 21 denotes a mode selecting circuit for selecting the aforementioned mode calculating units 18, 19, 20, as necessary. In addition, numeral 22 denotes a weight storage calculating unit, and this calculating unit 22 is adapted to output a weight command W_0 by storing the weight W of the workpiece.

The aforementioned mode selecting circuit 21 is adapted to effect a selecting operation shown in each flowchart which will be described later.

Referring now to Figs. 2 to 4, a description will be given of the operation in each mode and the configuration of each calculating unit.

(1) Lever Mode (Fig. 2)

First, the operation lever 8a of the speed commanding device 8 is operated. The speed command signal R outputted from the speed commanding device 8 is inputted to the lever mode calculating unit 18 of the calculation circuit 17_1. Meanwhile, the speed signal V is also inputted from the speed detector 4 to the lever mode calculating unit 18 for the purpose of stabilization.

In the lever mode calculating unit 18, a gain K_R is multiplied, and its result is inputted to the drive circuit 11 of the motor 2 via the adding point 16. At this time, the speed signal V of the motor is multiplied by a gain Kvn, is negatively fed back, and is inputted to the drive circuit 11 so as to stabilize the motor speed command value Vf.

It should be noted that the lever mode takes precedence over the other modes, and when there is a lever input, the mode selecting circuit 21 is forcedly changed over to a lever mode position $\underline{a}$.

(2) Position Mode (Fig. 3)

Immediately after the operation lever 8a is stopped and the speed command signal R due to this operation lever 8a disappears, i.e., when the formula $|R| <$ threshold R_0 has become valid, the mode selecting circuit 21 is changed over to a position mode position b so as to start the position mode. At the same time as this, the load storage calculating unit 22 also begins to operate. After the starting of the position mode, unless the operator effects an operation after the lapse of a stored time T_M, the following formula becomes valid:

$$|\text{load signal } F_L - \text{stored value } W_0| \leqq \text{threshold } F_0$$

whereupon the position mode is maintained.

In addition, if the accuracy of the stored value W_0 of the weight is within the threshold V_0, the mode does not shift to the balance mode and the position mode is maintained, so that the workpiece remains stationary. It should be noted that the threshold R_0 and the threshold F_0 are set in advance.

In the above-described position mode, positional feedback is effected so as to make the workpiece 5 stationary and, in practice, a difference $x - x_0$ from the motor signal x at the moment when the position mode is set is multiplied by a gain Kx so as to effect negative feedback. Meanwhile, the motor speed signal V is multiplied by the gain Kvn for the purpose of stabilization, thereby effecting negative feedback.

(3) Balance Mode (Fig. 4)

After the lapse of T_M upon the setting of the position mode, and when the absolute value $|F_L - W_0|$ of the operating force acting on the workpiece 5 has become greater than the threshold F_0, the mode shifts to the balance mode.

A detected value F_L from the load detector 7 is compared with the stored value W_0 of the weight from the weight storage calculating unit 22 at an adding point 25, and this difference $(W_0 - F_L)$ is multiplied by a predetermined gain K_F. In addition, for the purpose of stabilization, the motor speed signal V is multiplied by a gain Kvp so as to effect positive feedback, and its result is inputted to the adder 16 of the acceleration feedback circuit 14 via the mode selecting circuit 21.

The weight W of the workpiece 5 at the time when it is stationary is stored in advance in the aforementioned weight storage calculating unit 22.

Now, if it is assumed that the operator has applied an upward operating force (load) F to the workpiece 5, the detected value F_L of the load detector 7 at this time is inputted to the adding point 25. The adding point 25 compares the output W_0 from the weight storage calculating unit 22 with the aforementioned detected value F_L. Then, its difference is multiplied by the gain K_F so as to be amplified. After the operating force signal at this time is positively fed back to a value in which the motor speed signal V is multiplied by the gain Kvp, the operating force signal is inputted to the acceleration feedback circuit 14. In this case, since the detected value F_L of the load detector 7 decreases due to the upward operating force F, the difference $W_0 - (W - F)$ outputted from the adder 25 increases by the operating force F as compared to the difference $W_0 - W$ at the time when the workpiece is stationary, with the result that the motor torque increases and the work 5 moves upward. In other words, at the time when the force begins to be applied to the workpiece from the state of equilibrium, if only the load detector 7 senses this operating force F, a difference for moving the workpiece 5 vertically is produced at the adding point 25, so that if the gain constant K_F is made sufficiently large, the operator is capable of raising or lowering the workpiece 5 without practically feeling the stationary friction.

Fig. 5 illustrates a second embodiment of the present invention in a case where a digital-type calculation circuit 17_2 is used.

In this case, the four signals, the motor speed signal V, motor position signal x, load detection signal F_L, and speed command value R, are inputted to the calculation circuit 17_2, and this calculation circuit for its part converts the signals to digital form via an A/D converter.

In the aforementioned digital calculation circuit 17_2, the mode is first determined by the flowchart sown in Fig. 6.

In the drawing, since the threshold R_0 falls in a nonsensitive zone for the operation lever 8a, the threshold R_0 is preferably a very small value. Meanwhile, the threshold F_0 acts like the stationary frictional force in the balance mode. If this value is set to be large, when the operator effects an operation, he or she feels the force to be heavy, so that it is difficult to effect fine control. On the other hand, if the value is set to a small value, in a case where the stored value W_0 is not accurate, the mode soon shifts to the balance mode, so that even if the operator has loosened his or her hold, the workpiece does not become stationary and moves in an inching manner.

Upon determination of the mode, the following calculation expressions are calculated, and the motor speed command value V_M is outputted in analog form via the D/A converter:

Lever Mode:

$$V_{M1} = K_R \cdot R - Kvp \cdot V$$

Position Mode:

$$V_{M2} = -Kx(x - x_0) - Kvn \cdot V$$

Balance Mode:

$$V_{M3} = -K_F(F_L - W_0) + Kvp \cdot V$$

In the above expressions, x_0 represents the position of the motor at the moment when the position mode is set. In addition W_0 represents the stored value of the weight of the workpiece, and is obtained from an average value of the force signal F_L for a duration of a T_M second by the calculation unit in the position mode. In addition, the speed signal V is differentiated through the differential circuit 15, is constantly subtracted from the aforementioned V_{M1} - V_{M3}, is negatively fed back, and is inputted to the motor driving circuit 11.

It should be noted that Fig. 7 shows a state of transition between the respective modes.

In addition, in the foregoing embodiments, an AC or DC motor is used as the motor 2. In addition, as the speed commanding device 8, an angle of inclination of the operation lever 8a is detected by a potentiometer and, as the speed detector 4, a resolver, a tachogenerator, or the like is used. Furthermore, as the load detector 7, a general load cell or the like is used and, as the position detector 3, an encoder, a resolver, or the like is used.

In addition, as the means for suspending the workpiece 4, it is possible to use a link-type lifting machine of a paralellogrammic type such as the one shown in Fig. 8 may be used instead of the aforementioned drum 1 and the rope 6.

In a method of controlling the equilibrium cargo handling apparatus in accordance with the invention shown in the first and second embodiments, it is possible to realize the three modes, i.e., the lever mode based on a speed command using the operation lever 8a, the balance mode for realizing a state of equilibrium, and the position mode for making the workpiece stationary. It is possible to demonstrate an advantage in that even if there is a slight error in the stored value of the weight of the workpiece 5, when the hold is released, the workpiece 5 can be made stationary.

Figs. 9 to 14 illustrate a third embodiment of the present invention. In this third embodiment, once the mode is set to the balance mode and the operator has loosened his or her hold, the mode does not immediately return to the position mode, and the balance stationary mode is provided separately, in which mode it becomes possible to prevent the occurrence of large variations in the calculation output value and the motor speed command value during the balance mode by adding load feedback to the position control.

Fig. 9 explains the basic principle of this third embodiment, the same members as those of the first embodiment shown in Fig. 1 are denoted by the same reference numerals, and a description thereof will be omitted.

A calculation circuit 17_3 is provided with a balance stationary mode calculating unit 26 in addition to the lever mode calculating unit 18, the position mode calculating unit 19, and the balance mode calculating unit 19, and these modes are adapted to be selected by a mode selecting circuit 21a.

A description will now be given of the operation in the balance stationary mode and the calculating units.

(4) Balance Stationary Mode (Fig. 10)

Positional feedback is effected so as to make the workpiece 5 in the same way as in the position mode. Now, it is assumed that only positional feedback is being effected.

If there is an error in the stored value W_0 of the weight during the balance mode, the speed and the acceleration at this time are small and can be ignored, so that the calculated output value V_{M3} becomes

$$V_{M3} = -K_F(F_L - W_0)$$

so that even if hold is released, the workpiece is raised or lowered at slow speed. However, since the relationship between the absolute value $|F_L - W_0|$ and the threshold F_0 becomes

$$|F_L - W_0| \leqq F_0,$$

so that the mode is set to the balance stationary mode. Hence, the motor speed command value changes from V_{M3} to

$$V_{M4} = -Kx(x - x_0).$$

However, since the position x at the moment of which the mode is set to the balance stationary mode is set as the targeted value x_0, the moment when the mode is set to the balance stationary mode is

$$V_{M4} = 0.$$

The difference between this V_{M3} and V_{M4} constitutes a shock for the motor, and the load cell of the load detector 7 momentarily changes, with the result that the operating force becomes

$$|F_L = W_0| > F_0,$$

so that the mode returns to the balance mode. This state is shown in Figs. 11A and 11B.

For this reason, the same load feedback as at the time of the balance mode is applied during the balance stationary mode, and the setting provided is as follows:

$$V_{M4} = -Kx(x - x_0) - K_F(F_L - W_0).$$

As a result, the variation of the motor speed command value V_M at the time of mode changeover can be controlled, allowing the mode to settle down in the balance stationary mode. This state is shown in Figs. 11A and 11B.

The logic of mutual changeover of the balance mode and the balance stationary mode is similar to the logic of mutual changeover of the balance mode and the position mode in the above-described first embodiment. In addition, the mode transition in this third embodiment is shown in Fig. 13.

In this third embodiment, when the mode is determined in a similar manner to that of the aforementioned first embodiment, the lever mode V_{M1}, the position mode V_{M2}, and the balance mode V_{M3} are respectively calculated and, in addition, a calculation of the balance stationary mode

$$V_{M4} = -Kx(x - x_0) - K_F(F_L - W_0)$$

is made, and the result is outputted in analog form via the D/A converter. The remaining operation is similar to that of the first embodiment. Fig. 14 is a flowchart of the third embodiment.

In this third embodiment, even in a case where there is a slight error in the stored value of the weight of the workpiece, the workpiece is made stationary when the hold is released.

It should be noted that in the above-described third embodiment the workpiece 5 does not move unless the operator imparts a force (load) of not less than the threshold F_0, i.e., the mode cannot shift to the balance mode. For this reason, the nonsensitive zone F_0 occurs, so that the operation for effecting fine positioning, such as a pin fitting operation, has been difficult. However, this problem can be overcome by a fourth embodiment which will be described below.

That is, although in the above third embodiment the balance mode is shifted to the balance stationary mode at the moment when the formula $|F_L - W_0| \leqq F_0$ has become valid, in this fourth embodiment, as shown in the mode transition diagram of Fig. 15, the mode is shifted to the balance stationary mode only when the formula $|F_L - w_0| \leqq F_0$ has continued for a predetermined period of time Td.

In accordance with this fourth embodiment, when a fitting operation is being carried out, the operating force need not be below the threshold for the period of time Td. Hence, while the operation is being carried out, the mode does not shift to the balance stationary mode, nor the nonsensitive zone appears, and it is easy to effect the aforementioned fine control. In addition, if the operator releases his or her hold, the operating force continuously falls below the threshold F_0, and the mode is set to the balance stationary mode after Td, making the workpiece stationary.

In this fourth embodiment, the mode is first determined by the digital calculator shown in Fig. 5. Its flowchart is shown in Fig. 16. In the drawing, since the threshold RO falls in the nonsensitive zone of the lever, the threshold RO is preferably as small as possible. Meanwhile, F_0 constitutes stationary friction at the time when the mode shifts from the stationary state (position mode, balance position mode) to the balance mode. If this value is large, there are cases where the mode shifts to the balance stationary mode even while the fitting operation is being carried out, thereby making it difficult to effect fine control. On the other hand, if this value is made too small, it becomes difficult to shift the mode to the balance stationary mode, and the workpiece is difficult to be set stationary when the hold is released.

In the measurement of the delay time Td for shifting to the balance stationary mode, a timer or a sampling time may be used instead. The flowchart shown in Fig. 16 illustrates a case where the timer is used. By resetting the timer when the absolute value $|F_L - W_0|$ of the operating force is F_0 or more, it is possible to measure the time elapsing after the formula $|F_L - W_0| \leqq F_0$ has become valid.

It should be noted that if the delay time Td is too long, the workpiece moves substantially due to the error in the stored value of the weight by the time the balance stationary mode is set. On the other hand, if the delay time Td is too short, the mode shifts soon to the balance stationary mode, and the nonsensitive zone of the load occurs during the time when the fitting operation is being carried out, making it difficult to effect fine control.

In accordance with this fourth embodiment, since the stationary characteristic at the time when the hold is released is satisfied, and the nonsensitive zone at the time of the balance mode is eliminated, fine control is facilitated.

A fifth embodiment of the present invention is shown in Fig. 17. This embodiment is an example in which the acceleration detector 9 at the time of operation of the workpiece 5 is provided to the first embodiment shown in Fig. 1.

Referring now to Figs. 18 and 19, a description will be given of the operation of each mode and the configuration of each calculating unit. It should be noted that as for the same members as those of the first embodiment a description thereof will be omitted.

(5) Lever Mode (Fig. 18)

In addition to the embodiment shown in Fig. 2, the acceleration signal a is multiplied by a gain Kan and is negatively fed back to avoid swinging.

(6) Position Mode (Fig. 19)

In addition to the first embodiment shown in Fig. 3, the acceleration signal a is multiplied by a gain Kan and is negatively fed back to avoid swinging in the same way as the lever operation mode.

When the speed command signal R becomes smaller than the threshold RO, the mode shifts to the position mode. Load signals are averaged for a fixed period of time starting with the moment when the mode is shifted to the position mode.

When a mechanism portion is soft, in the case of the first embodiment, the workpiece 5 swings, as shown in Fig. 20A, so that the load cannot be stored accurately unless an average value is taken for a long period of time.

In this fifth embodiment, in a case where acceleration feedback is provided, the swing becomes small, as shown in Fig. 20B, so that the weight can be stored accurately even by an average taken for a short period of time.

Although not shown, in this fifth embodiment as well, the balance mode is operated in the same way as in the first embodiment.

Fig. 21 illustrates a sixth embodiment in a case where a digital calculation circuit 17_5 is used instead of the calculation circuit 174. In this digital calculation circuit 17_5, the mode is first determined in accordance with the flowchart shown in Fig. 6.

In the drawing, the threshold RO falls in the nonsensitive zone of the operation lever 8a, the threshold RO is preferably a very small value. Meanwhile, the threshold F_0 acts like the stationary frictional force at the time of the balance mode. If this value is set to be large, the workpiece is felt to be heavy by the oprerator when he or she engages with the operation, makes it difficult to effect fine control. On the other hand, if this value is set to be small, in a case where the stored value W_0 of the weight is not accurate, the mode shifts soon to the balance mode, so that even if the operator loosens his or her hold, the workpiece does not become stationary and moves in an inching manner.

Upon determination of the mode, the following calculation expressions are calculated, and the motor speed command value V_M is outputted in analog form via the D/A converter:

Lever Mode:

$$V_{M1} = K_R \cdot R - Kvp \cdot V - Kan \cdot a$$

Position Mode:

$$V_{M2} = -Kx(x - x_0) - Kvn \cdot V - Kan \cdot a$$

Balance Mode:

$$V_{M3} = -K_F(F_L - W_0) + Kvp \cdot V(+Kan \cdot a)$$

In the above expressions, x_0 represents the position of the motor at the moment when the position mode is set. In addition W_0 represents the stored value of the weight of the workpiece, and is obtained from an average value of the force signal F_L for a duration of a T_M second by the calculation unit in the position mode. In addition, the speed signal v is differentiated through the differential circuit 15, is constantly subtracted from the aforementioned V_{M1} - V_{M3}, is negatively fed back, and is inputted to the motor driving circuit 11.

Fig. 22 explains a basic principle of a seventh embodiment of the present invention, in which reference numeral 1 denotes the drum rotatively driven by the motor 2; 3, the position detector for detecting the rotational position of the motor 2; and 4, the speed detector for detecting the rotational speed of the motor 2. Meanwhile, numeral 5 denotes the workpiece which is wound up onto the drum 1 via the rope 6. The load detector 7, the speed commanding device 8, and the acceleration detector 9 are provided for the rope 6 for suspending this workpiece 5. Reference character 8a denotes the operation lever of the speed commanding device 8.

The speed commanding device 8 is adapted to output the speed command signal R corresponding to an amount of the operation lever 8a operated, the load detector 7 is adapted to detect the load (force) acting on the workpiece 5 and output its signal F_L, and the acceleration detector 9 is adapted to output the acceleration signal $\underline{a}$. Furthermore, the position detector 3 and the speed detector 4 are adapted to output the rotational position signal x of the motor and the speed signal V, respectively. A primary delay circuit 10 is interposed in the output circuit of the aforementioned speed commanding device 8, and this primary delay circuit 10 is provided with the aforementioned speed command signal R and adapted to output a primary delay signal R'.

Reference numeral 11 denotes the drive circuit for driving the motor 2, and this drive circuit 11 comprises the adder 12 for calculating a difference between the command value Vf and the speed signal V of the motor 2, as well as the drive circuit 13, and is adapted to drive the motor 2 in accordance with the difference Vf - V.

Reference numeral 14 denotes the acceleration feedback circuit, and this circuit 14 has the differential device 15 for obtaining the acceleration signal $\dot{V}$ of the motor 2 by differentiating the speed signal V outputted from the speed detector 4 of the motor 2 as well as the adding point 16, and is adapted to output the motor speed command value Vf by negatively feeding back at the adding point 16 a difference between the aforementioned acceleration signal $\dot{V}$ and the speed command value V_M from a calculation circuit 17_6 which will be described later.

The reference numeral 17_6 denotes the calculation circuit which outputs the aforementioned speed command value V_M, and this calculation circuit 17_6 is provided with the lever mode calculating unit 18, the position mode calculating unit 19, the balance mode calculating unit 20, and an abnormality mode calculating unit 23. Reference numeral 21b denotes a mode selecting circuit for selecting the aforementioned mode calculating units 18, 19, 20, 23, as necessary. In addition, numeral 22 denotes the weight storage calculating unit, and this calculating unit 22 is adapted to output the weight command W_0 by storing the weight W of the workpiece. Reference numeral 24 denotes a determining circuit for operating the aforementioned mode selecting circuit 21b to operate in accordance with the flowchart shown in Fig. 27.

Referring now to Figs. 23 to 26, a description will be given of the operation in each mode and the configuration of each calculating unit.

(1) Lever Mode (Fig. 23)

First, the operation lever 8a of the speed commanding device 8 is operated. The speed command signal R outputted from the speed commanding device 8 is inputted to the lever mode calculating unit 18 of the calculation circuit 17_6 as the primary delay signal R' via the primary delay circuit 10 Meanwhile, the speed signal V is also inputted from the speed detector 4 to the lever mode calculating unit 18 for the purpose of stabilization. Furthermore, the acceleration signal $\underline{a}$ is inputted to the aforementioned calculating unit 18 for the purpose of prevention of swinging.

In the lever mode calculating unit 18, the primary delay signal R' is multiplied by the gain K_R, and its result is inputted to the drive circuit 11 of the motor 2 via the adding point 16. At this time, the speed signal V of the motor is multiplied by the gain Kvn, and the acceleration meter signal $\underline{a}$ is multiplied by the gain Kan, and they are respectively negatively fed back and are inputted to the drive circuit 11 so as to stabilize the motor speed command value Vf.

It should be noted that the lever mode takes precedence over the other modes owing to the determining circuit 24, and when there is a lever input, the mode selecting circuit 21b is forcedly changed over to the lever mode position $\underline{a}$.

(2) Position Mode (Fig. 24)

Immediately after the operation lever 8a is stopped and the speed command signal R due to this operation lever 8a disappears, i.e., when the formula $|R|$ < threshold R_0 has become valid, the mode selecting circuit 21b is changed over to the position mode position b by means of the determining circuit 24 so as to start the position mode. At the same time as this, the weight storage calculating unit 22 also begins to operate. After the starting of the position mode, unless the operator effects an operation after the lapse of the stored time T_M, the following formula becomes valid:

$$|\text{load signal } F_L - \text{stored value } W_0| \leq \text{threshold } F_0$$

whereupon the position mode is maintained.

In addition, if the accuracy of the stored value W_0 of the weight is within the threshold V_0, the mode does not shift to the balance mode and the position mode is maintained, so that the workpiece remains stationary. It should be noted that the threshold R_0 and the threshold F_0 are set in advance.

In the above-described position mode, positional feedback is effected so as to make the workpiece 5 stationary and, in practice, the difference $X - X_0$ from the motor signal x at the moment when the position mode is set is multiplied by the gain Kx so as to effect negative feedback. Meanwhile, the motor speed signal V is multiplied by the gain Kvn for the purpose of stabilization, thereby effecting negative feedback. In addition, the acceleration signal a is negatively fed back by being multiplied by the gain Kan for the purpose of prevention of swinging.

(3) Balance Mode (Fig. 4)

After the lapse of T_M upon the setting of the position mode, and when the absolute value $|F_L - W_0|$ of the operating force acting on the workpiece 5 has become greater than the threshold F_0, the mode shifts to the balance mode.

A detected value F_L from the load detector 7 is compared with the stored value W_0 of the weight from the weight storage calculating unit 22 at the adding point 25, and this difference $(W_0 - F_L)$ is multiplied by the predetermined gain K_F. In addition, for the purpose of stabilization, the motor speed signal V is multiplied by the gain Kvp so as to effect positive feedback, and its result is inputted to the adder 16 of the acceleration feedback circuit 14 via the mode selecting circuit 21.

The weight W of the workpiece 5 at the time when it is stationary is stored in advance in the aforementioned weight storage calculating unit 22.

Now, if it is assumed that the operator has applied an upward operating force (load) F to the workpiece 5, the detected value F_L of the load detector 7 at this time is inputted to the adding point 25. The adding point 25 compares the output W_0 from the weight storage calculating unit 22 with the aforementioned detected value F_L. Then, its difference is multiplied by the gain K_F so as to be amplified. After the operating force signal at this time is positively fed back to a value in which the motor speed signal V is multiplied by the gain Kvp, the operating force signal is inputted to the acceleration feedback circuit 14. In this case, since the detected value F_L of the load detector 7 decreases due to the upward operating force F, the difference W_0 - (W - F) outputted from the adder 25 increases by the operating force F as compared to the difference W_0 - W at the time when the workpiece is stationary, with the result that the motor torque increases and the work 5 moves upward. In other words, at the time when the force begins to be applied to the workpiece from the state of equilibrium, if only the load detector 7 senses this operating force F, a difference for moving the workpiece 5 vertically is produced at the adding point 25, so that if the gain constant K_F is made sufficiently large, the operator is capable of raising or lowering the workpiece 5 without practically feeling the stationary friction.

(4) Abnormality Mode (Fig. 26)

The signal $\bar{a}$ from the acceleration detector 9 is multiplied by the acceleration gain Kan, the signal V from the speed detector 4 is multiplied by the acceleration gain Kvn, and the difference X - X_0 between the position X at the moment when the abnormality is detected and the signal X_0 from the position detector 3 is multiplied by a gain Kxn, and they were added together. The result is set as a command value for the abnormality mode, and is outputted as a command value to the motor driving circuit 11 in a case where the abnormality mode is selected by the mode selecting circuit 21b. Each gain of the acceleration, speed, and position is negative, and the motor 2 is stopped at its position by the aforementioned command value.

The aforementioned respective modes are selectively determined by the determining circuit 24 in accordance with the flowchart shown in Fig. 27.

That is, in a case where the absolute value (operating angle of the operation lever) |R'| from the speed commanding device 8 is greater than the threshold RO, the lever mode is automatically selected, but in a case where |R'| < RO, a determination is made by an abnormality mode portion of the determining circuit 24 as to whether or not there is any abnormality. If in the event of an abnormality, the abnormality mode is selected by the mode selecting circuit 21b, and if not, the operation proceeds to a normal operation pattern.

According to this mode selection and determination, the lever mode takes precedence over the abnormality mode, so that even if the abnormality mode has been selected, the mode returns to the lever mode by operating the lever.

Fig. 28 shows an example of the determining circuit 27 for the abnormality mode which is one of the determining circuits for the respective modes in the above-described determining circuit 24.

In the drawing, reference numeral 28 denotes a differentiator for differentiating the load signal F_L from the load detector 7; numeral 29 denotes an absolute value comparator for comparing the absolute value $|\dot{F}_L|$ of the differential value $\dot{F}_L$ differentiated by this differentiator with its threshold F_0, and outputs the following signals:

$|\dot{F}_L| > F_0$ 1

$|\dot{F}_L| < F_0$ ..... 0.

Numeral 30 denotes an absolute value comparator for comparing the absolute value |V| of the speed signal V from the speed detector 4 and its threshold V_0, and outputs the following signals:

$|V| > V_0$ 1

$|V| < V_0$ ..... 0.

Numeral 31 denotes an absolute value comparator for comparing the absolute value |R'| of a signal from the speed commanding device 8, i.e., a delay signal R' transmitted via the primary delay circuit 10, with the threshold RO of the speed command signal, and outputs the following signals:

$|R'| > R_0$ 0

$|R'| < R_0$ ..... 1.

Numeral 32 denotes an AND circuit for outputting a signal "1" as both signals "1" of the load detector-side absolute value comparator 29 and the speed detector-side absolute value comparator 30 are inputted thereto; numeral 32 denotes a latch circuit which latches the signal from this AND circuit 32 during the time when the signal "1" is transmitted from the speed commanding device-side absolute value comparator 31 and is reset by the signal "0".

As the signal from the aforementioned determining circuit 27 is inputted to the mode selecting circuit 21b, the mode is changed over to the abnormality mode, and the command value for the abnormality mode is inputted to the drive circuit 11 via the acceleration feedback circuit 14, thereby stopping the motor 2 at its position.

The control of stopping and holding by means of the aforementioned calculation circuit 176 may be effected by negatively feeding back the position signal X of the motor; however, in a case where the rigidity of the rope 6 (or arm) for connection between the motor 2 and the workpiece 5 is soft, if the workpiece 5 is stopped suddenly, there are cases where the workpiece 5 is swung when it is stopped. Accordingly, by negatively feeding back the acceleration signal a of the workpiece 5 together with the speed signal V of the motor 2 for the purpose of stabilizing the control system in addition to the position signal X of the motor 2, the dynamic movement of the workpiece 5 is suppressed, so that the workpiece 5 can be stopped at the position where the abnormality was detected.

It should be noted that in the above-described seventh embodiment the primary delay circuit of the lever may not be particularly provided.

Claims

1. A method for controlling an equilibrium cargo handling apparatus, comprising the steps of:
storing the weight of a workpiece in position-mode control provided between lever-mode control for controlling a work suspending operation by the operation of an operation lever by an operator on the one hand, and balance-mode control for controlling a driving device for lifting the workpiece at the time of a work lifting/lowering operation by the operator on the other;
holding said position-mode control until the operator applies an operating force to the workpiece, so as to maintain a stationary state of the workpiece,
whereby the workpiece can be made stationary speedily even if there is a slight error in a stored value of the weight of the workpiece.

2. A method for controlling an equilibrium cargo handling apparatus according to Claim 1, wherein when a speed command signal is inputted by the operation of said operation lever, the mode is preferentially set to said lever-mode control, and when this speed command signal has become zero, the mode is set to said position-mode control.

3. A method for controlling an equilibrium cargo handling apparatus according to Claim 1, wherein when the storage of the weight of the workpiece is completed, and an absolute value of a difference between a load detection signal and the stored value of the weight of the workpiece exceeds a preset threshold, the mode is changed over to said balance-mode control, while when said absolute value has reached said threshold or below, the mode is changed over to said position-mode control.

4. An equilibrium cargo handling apparatus including work lifting means for lifting or lowering a workpiece being suspended, driving means for driving said work lifting means, load detecting means for detecting load acting on the workpiece, position detecting means for detecting a position of said workpiece lifting means, speed commanding means for outputting a speed command signal in accordance with the operation of an operation lever by an operator, and weight storing means for storing the weight of the workpiece, said apparatus comprising:
a lever mode calculating unit for negatively feeding back a work lifting/lowering speed with the speed command signal from said speed commanding means set as a targeted value;
a position mode calculating unit which sets as a targeted value the position of said work lifting means at a moment when the speed command value has become very small and which negatively feeds back said position and the work lifting/lowering speed at that time;
a balance mode calculating unit for negatively feeding back a load detection signal from said load detecting means with the weight of the workpiece set as a targeted value, and for positively feeding back the speed detecting signal; and
a calculation circuit for outputting one of said respective modes to said driving means via a mode selecting circuit.

5. An equilibrium cargo handling apparatus according to Claim 4, wherein said calculation circuit is a digital-type calculation circuit including an A/D converter, a digital calculation unit, a timer, and a D/A converter.

6. An equilibrium cargo handling apparatus according to Claim 4, wherein said calculation circuit further comprises a balance stationary mode calculating unit, whereby load feedback is applied to positional control of the workpiece, and a large change occurring between an output value of calculation and a motor speed command value at the time of the balance mode is prevented.

7. An equilibrium cargo handling apparatus according to Claim 6, wherein a shift to the balance stationary mode is effected when a relationship $|F_L - W_0| \leq F_0$ between an absolute value ($|F_L - W_0|$) of a work operating force of the operator and a threshold (F_0) has continued for a preset period of time (Td).

8. An equilibrium cargo handling apparatus according to Claim 4, wherein an acceleration signal from an acceleration detector for detect-

ing lifting/lowering acceleration of the workpiece at the time of operation of the workpiece by the operator is inputted to said calculation circuit.

9. An equilibrium cargo handling apparatus according to Claim 4, further comprising a determining circuit for outputting a changeover signal to said mode selecting circuit in accordance with an input signal from each of said means, wherein said calculation circuit further includes an abnormality mode calculating unit for stopping said driving means at a position corresponding to a position signal of said work lifting means by outputting an abnormality mode command to said driving means by negatively feeding back said position signal, wherein said determining circuit includes a determining circuit for an abnormality mode for outputting a signal for changing over said mode selecting circuit to said abnormality mode calculating unit by detecting a sudden change of the load acting on the work, wherein when the load acting on the work changes suddenly, on the basis of signals outputted from said load detecting means, said speed detecting means, and said speed commanding means at that time, absolute values of the respective signals and their thresholds are respectively compared and calculated by said determining circuit for the abnormality mode, said mode selecting circuit is changed over to said abnormality mode calculating unit by an output signal from said determining circuit, and said driving means is stopped by an output signal from said abnormality mode calculating unit.

F I G . 1

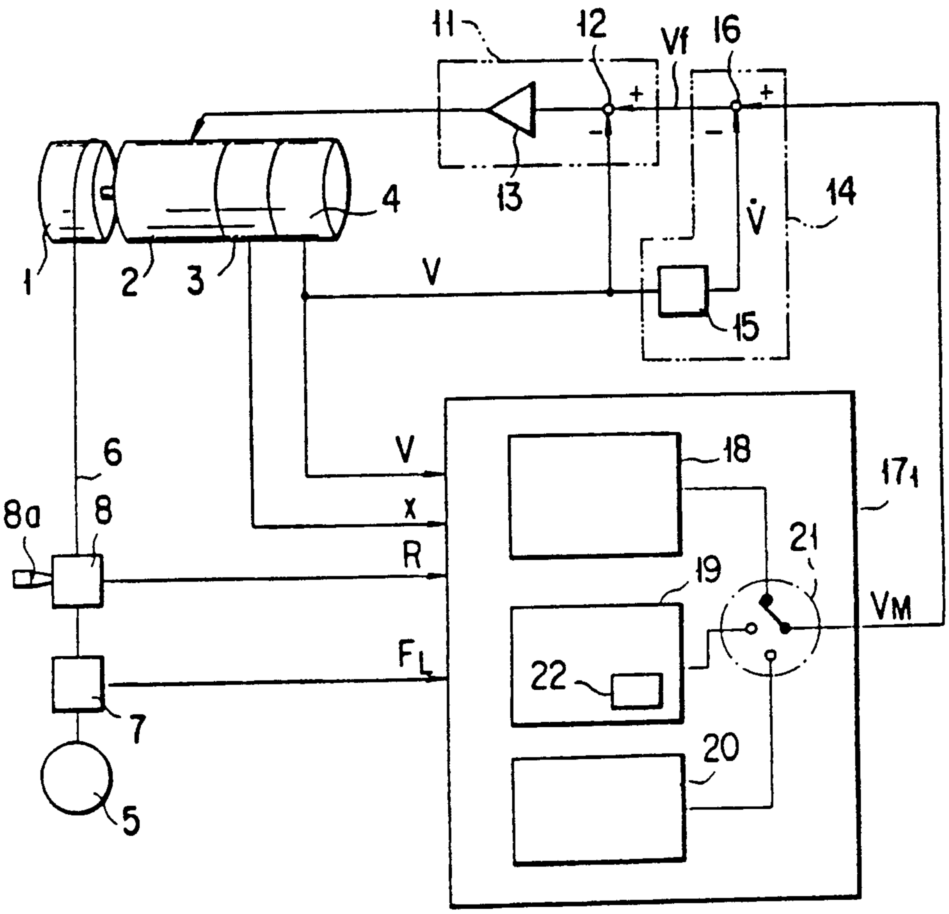


FIG. 2

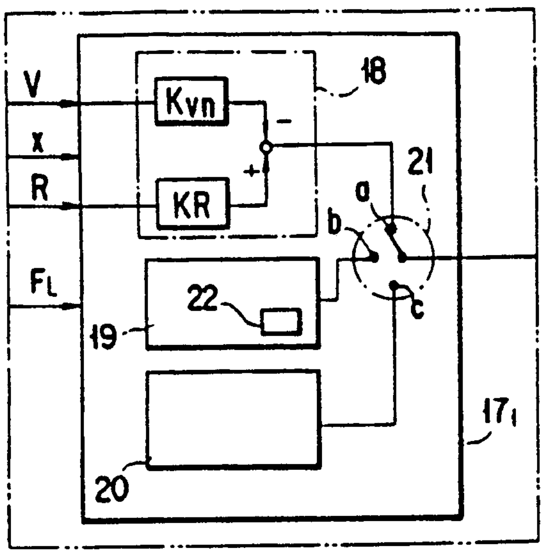


FIG. 3

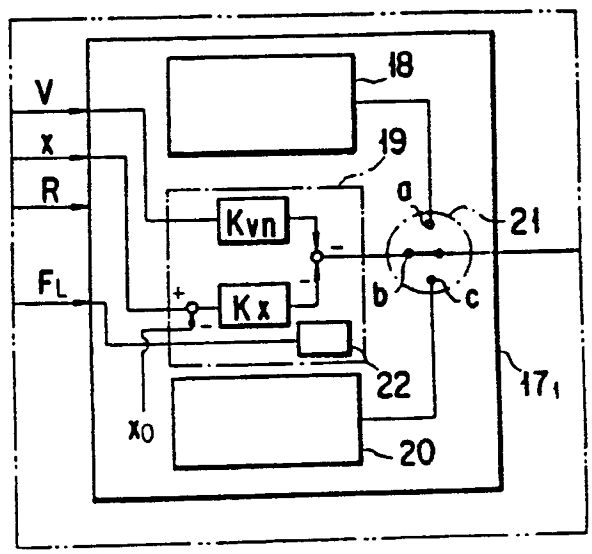
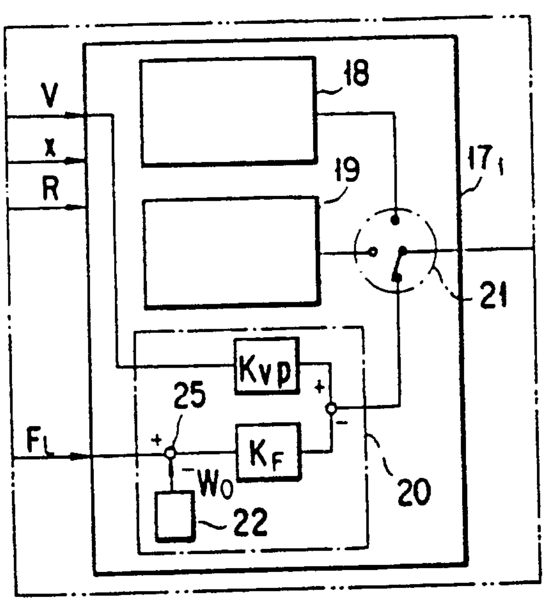
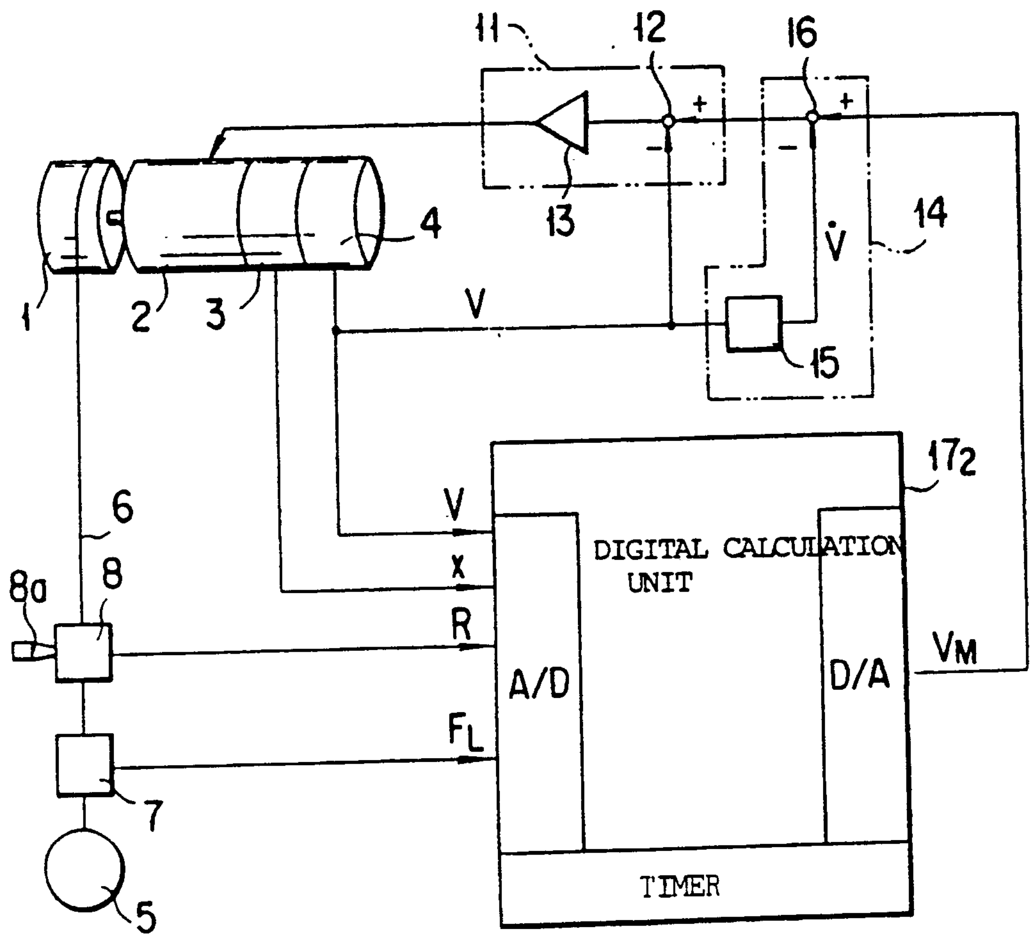


FIG. 4

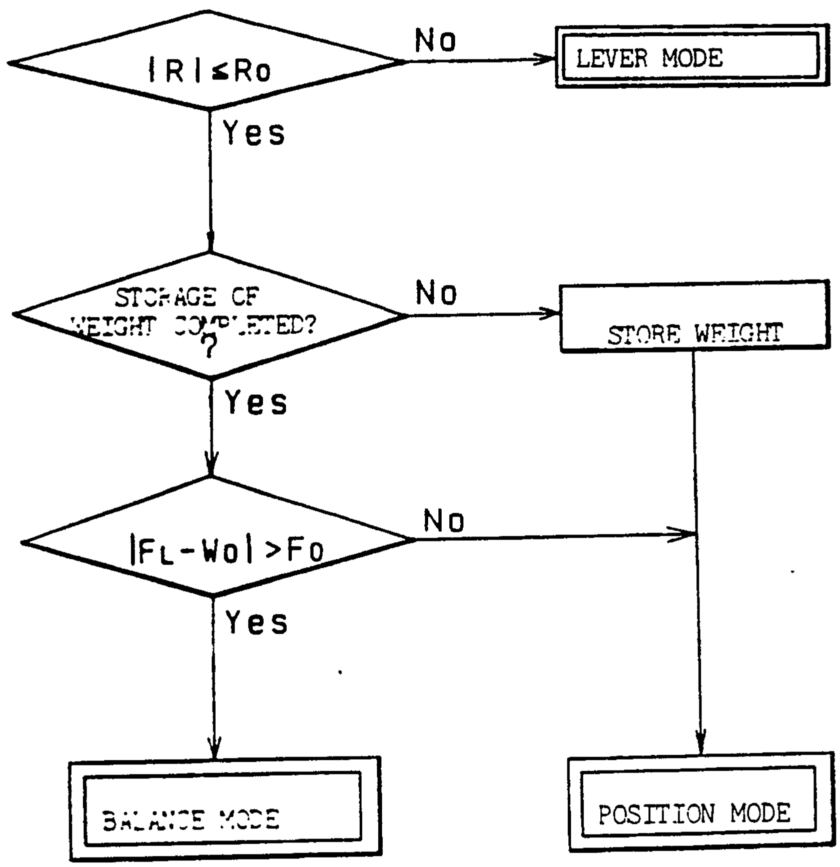


F I G . 5



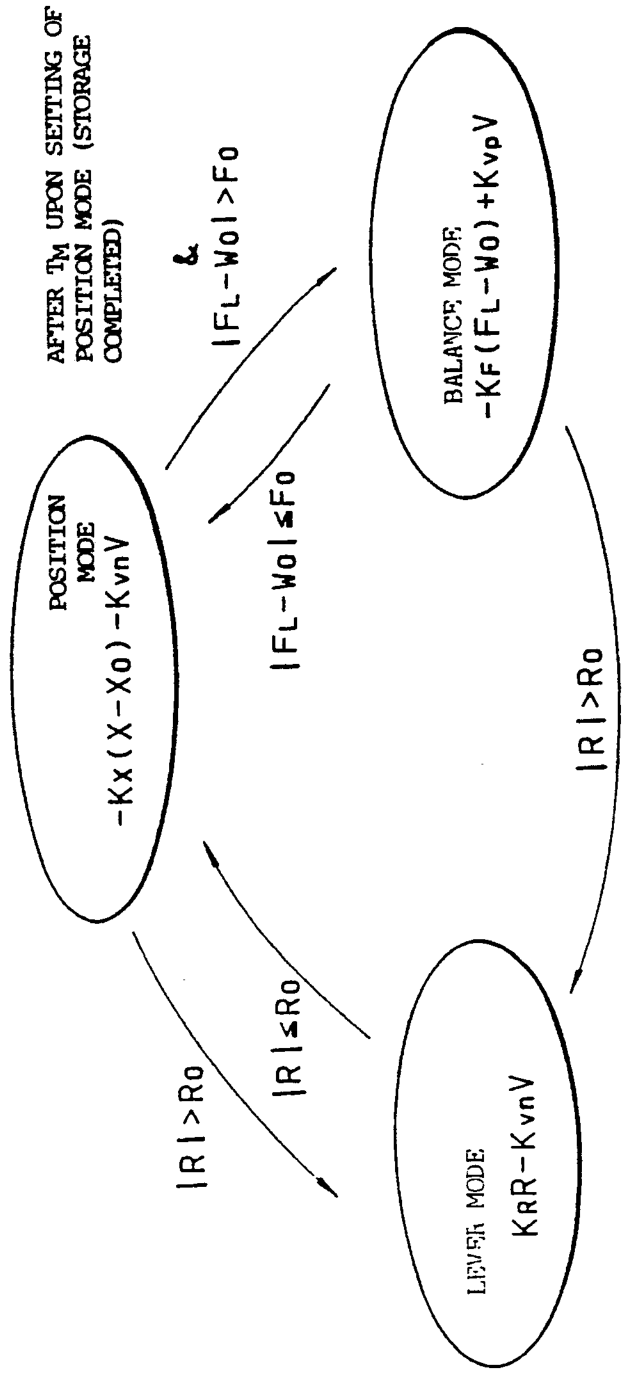
11
12
16
+
+
−
−
4
13
14
V̇
1
2
3
V
15
17₂
V
6
DIGITAL CALCULATION UNIT
x
8a
8
R
A/D
D/A
VM
FL
7
TIMER
5

F I G . 6



|R|≤Ro
No
LEVER MODE
Yes
STORAGE OF WEIGHT COMPLETED?
No
STORE WEIGHT
Yes
|FL-Wo|>Fo
No
Yes
BALANCE MODE
POSITION MODE

FIG. 7


AFTER T_M UPON SETTING OF POSITION MODE (STORAGE COMPLETED)
&
$|F_L - W_0| > F_0$
BALANCE MODE
$-K_F(F_L - W_0) + K_{vp}V$
POSITION MODE
$-K_x(X - X_0) - K_{vn}V$
$|F_L - W_0| \leq F_0$
$|R| > R_0$
$|R| \leq R_0$
$|R| > R_0$
LEVER MODE
$K_R R - K_{vn}V$

F I G . 8

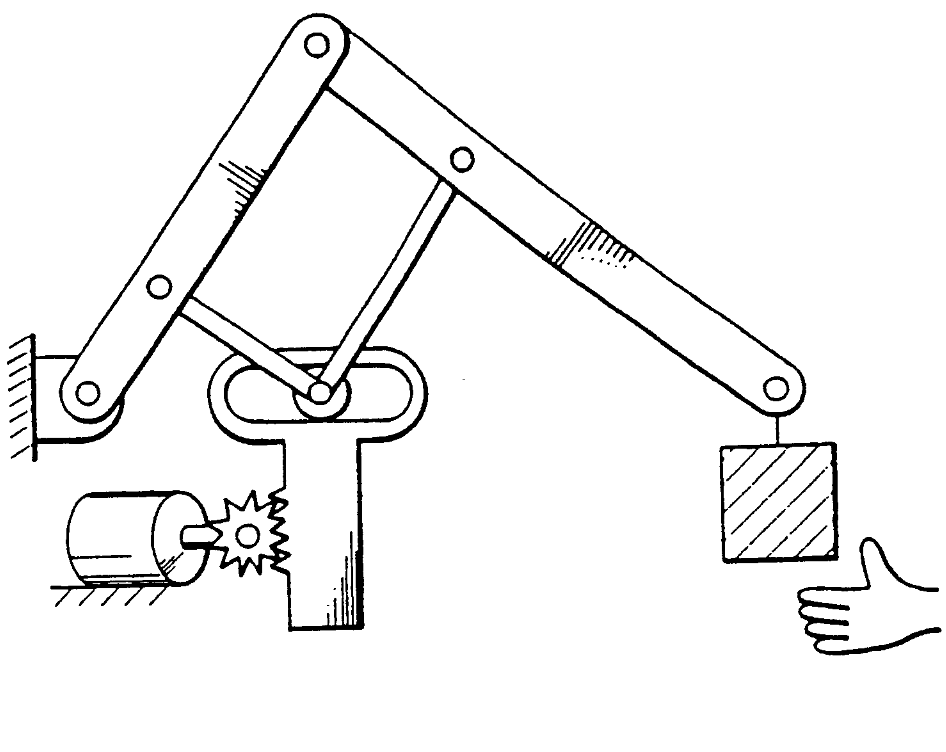
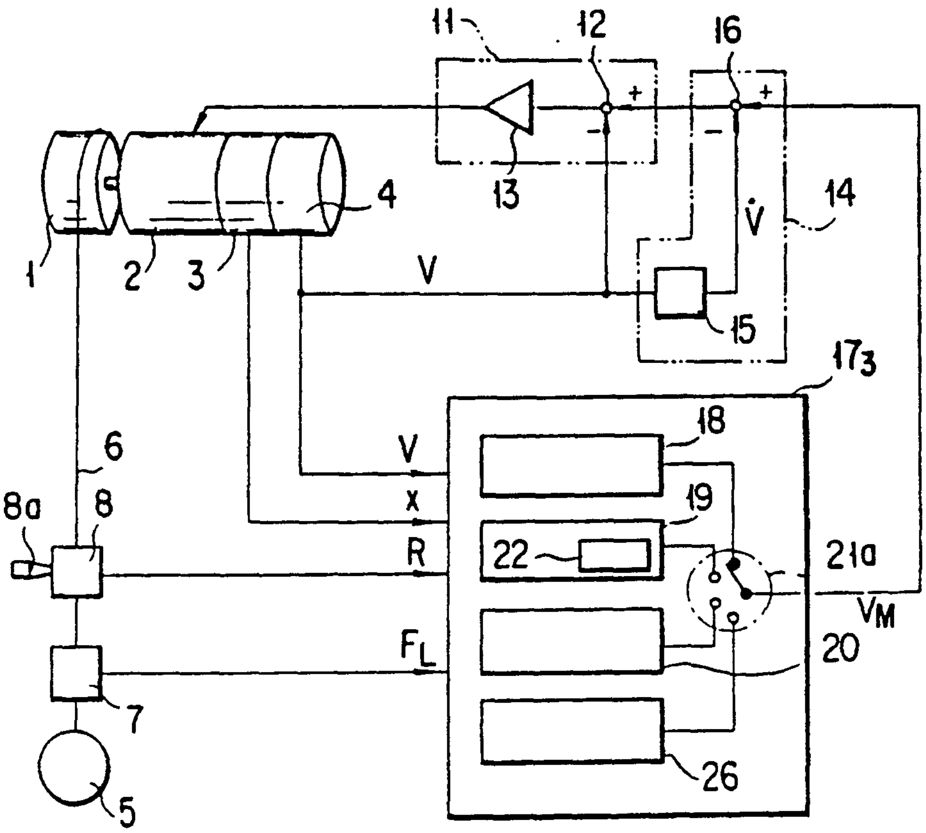
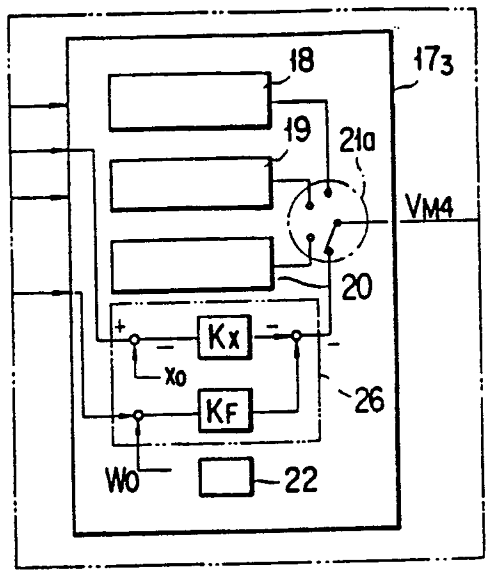


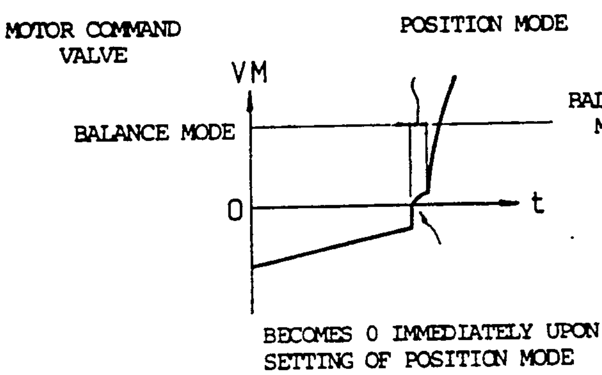
FIG. 9



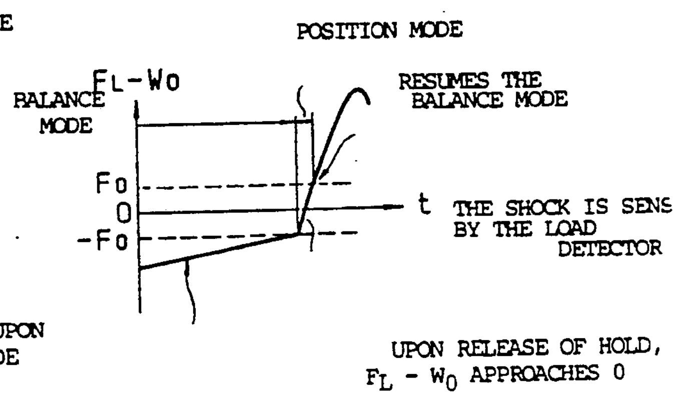
F I G . 10



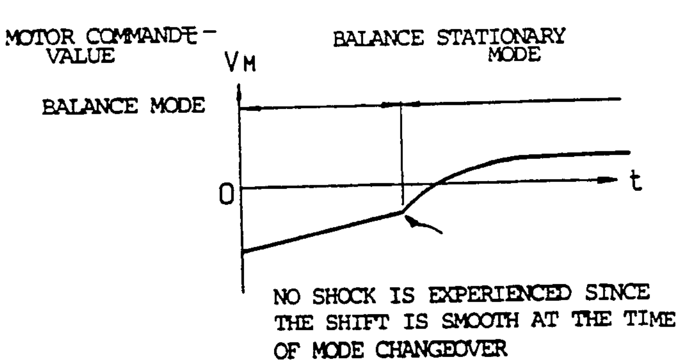
F I G . 11A



F I G . 11B



F I G . 12A



F I G . 12B

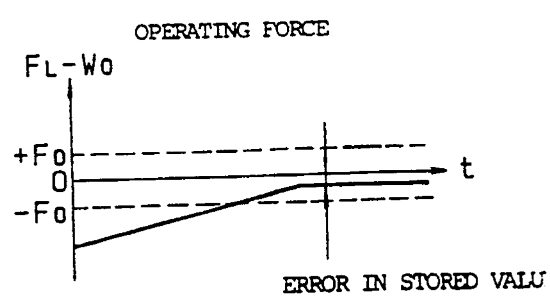


FIG. 13

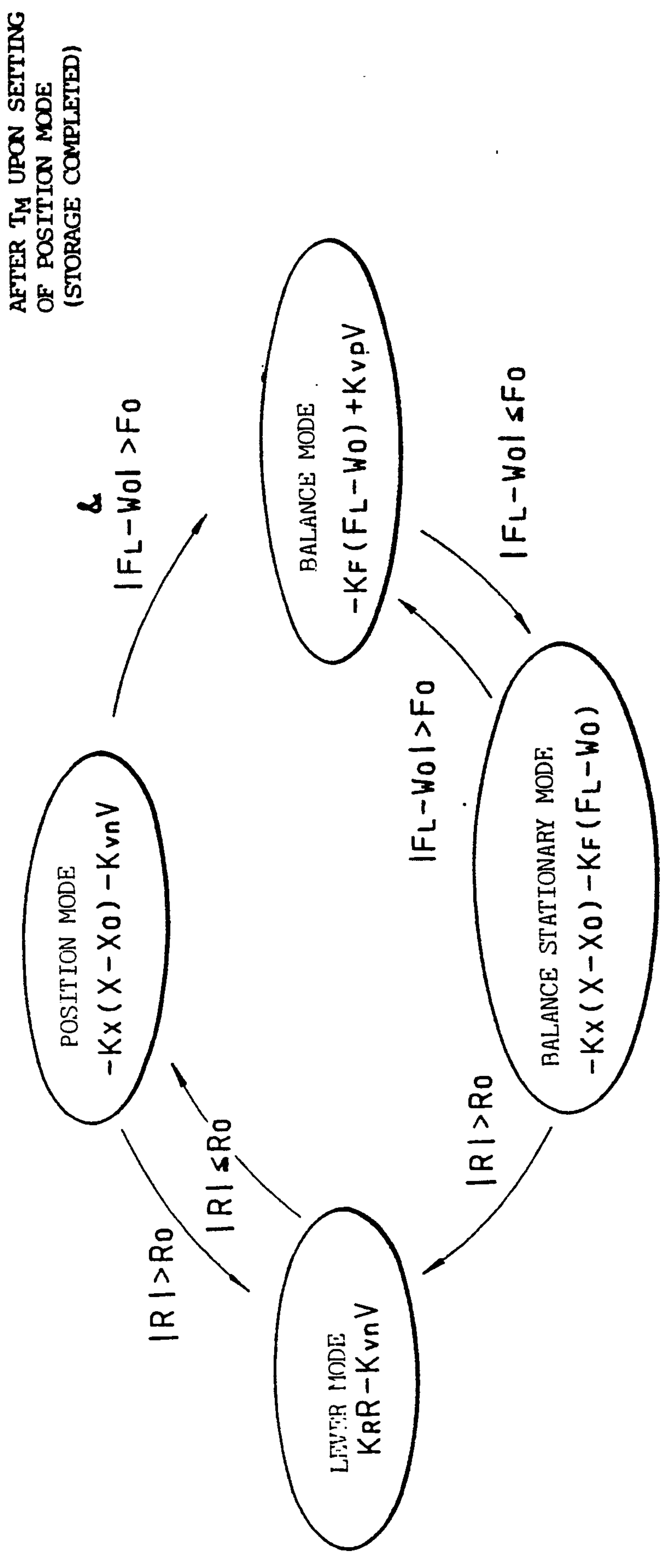

AFTER T_M UPON SETTING OF POSITION MODE (STORAGE COMPLETED)
&
$|F_L - W_0| > F_0$
BALANCE MODE
$-K_F(F_L - W_0) + K_{vp}V$
$|F_L - W_0| \leq F_0$
$|F_L - W_0| > F_0$
BALANCE STATIONARY MODE
$-K_X(X - X_0) - K_F(F_L - W_0)$
POSITION MODE
$-K_X(X - X_0) - K_{vn}V$
$|R| \leq R_0$
$|R| > R_0$
$|R| > R_0$
LEVER MODE
$K_RR - K_{vn}V$

FIG. 14

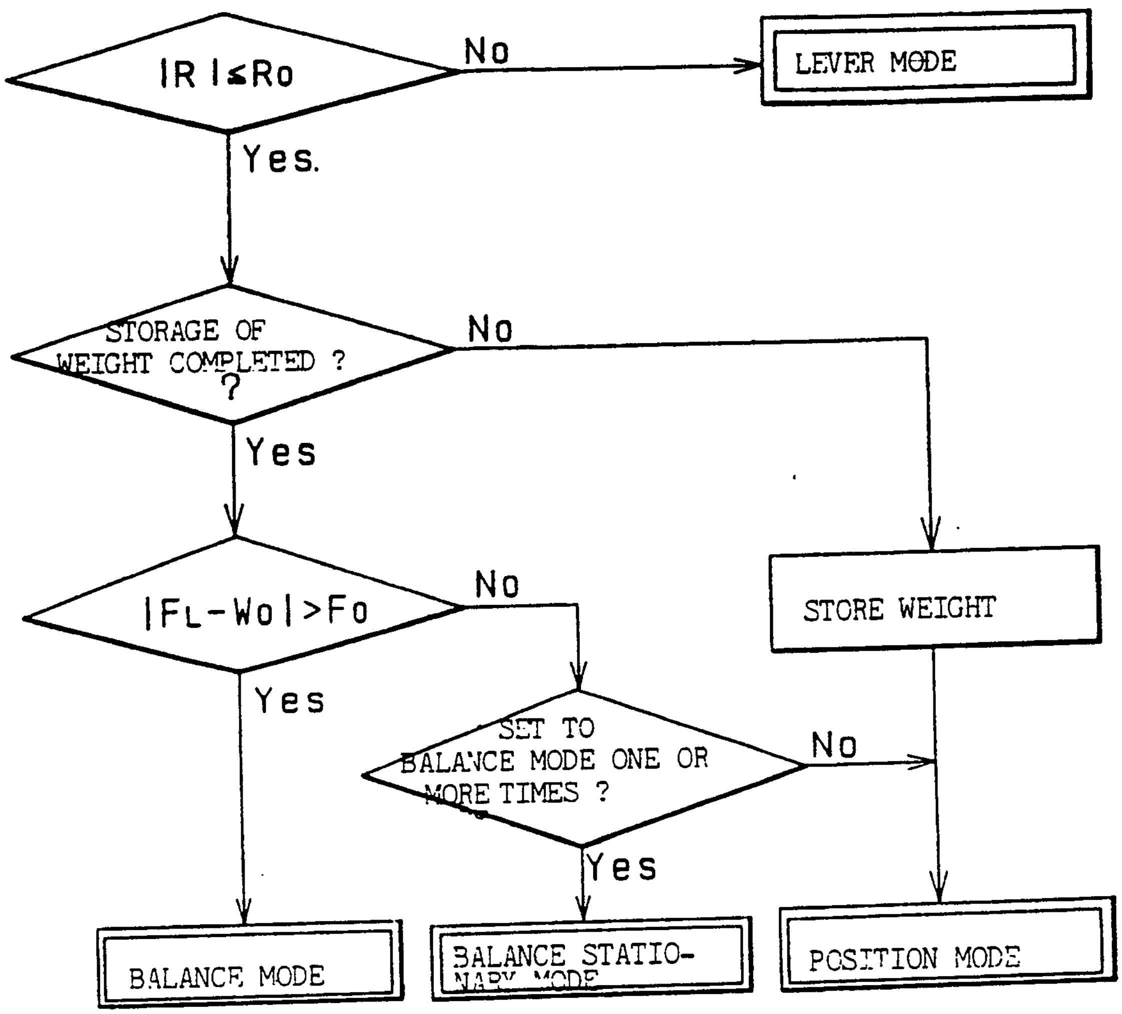
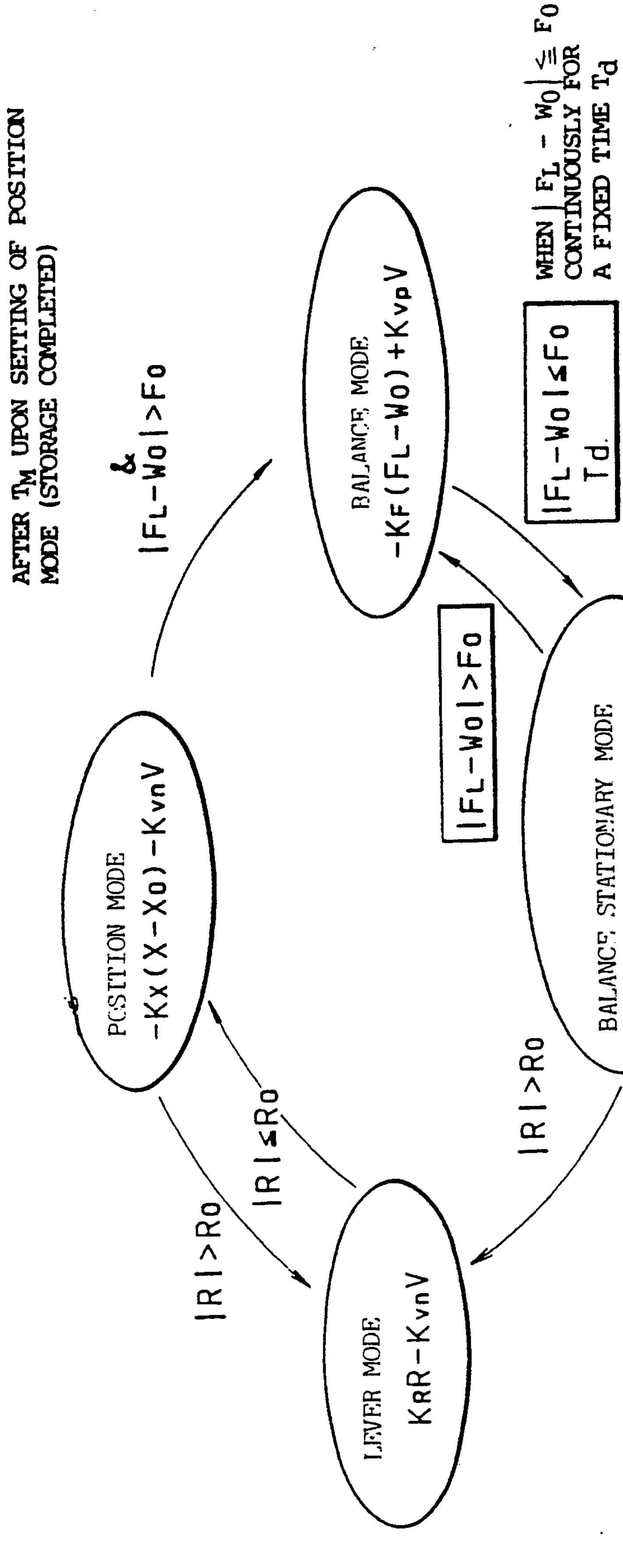
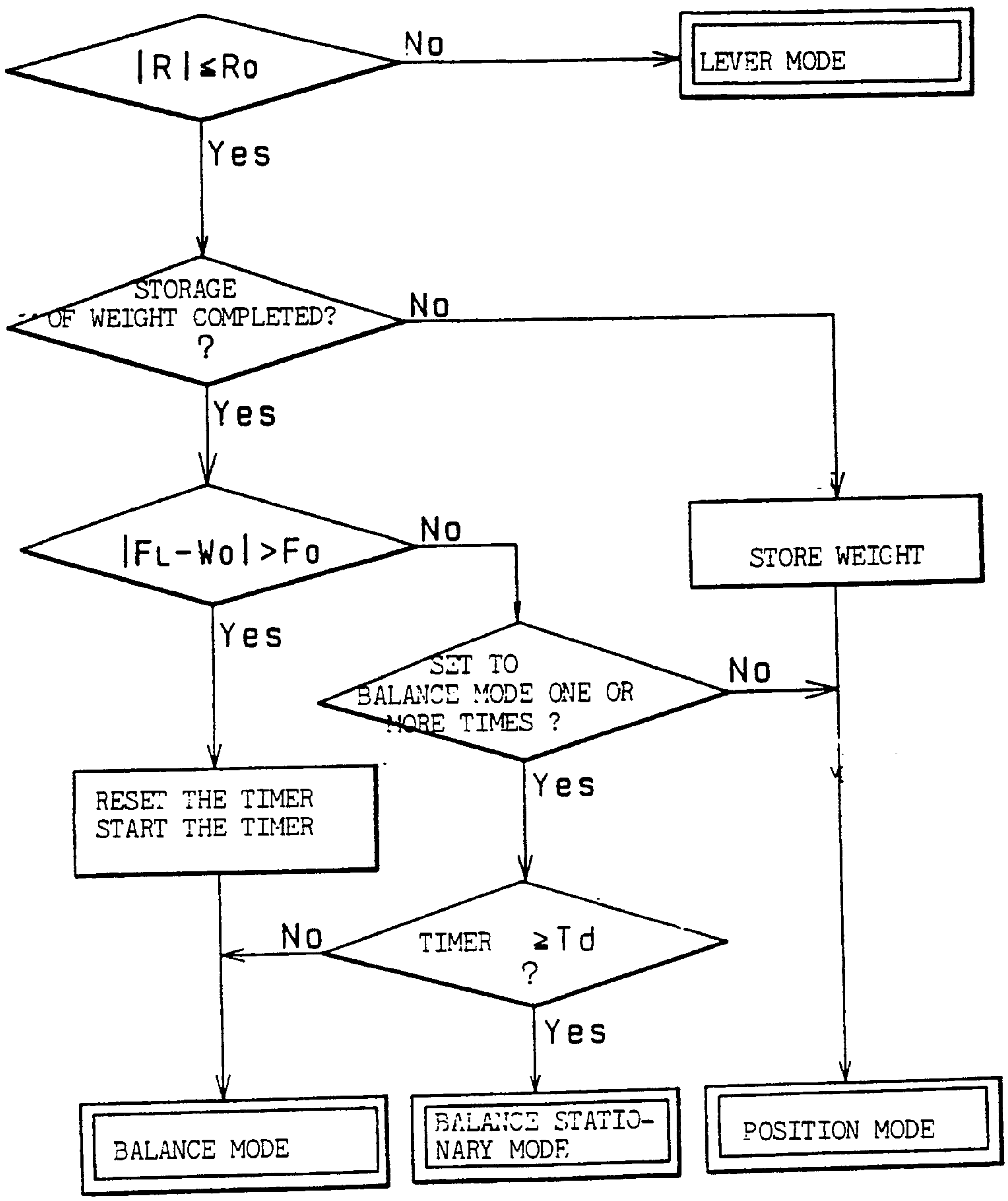

|R|≤Ro
No
LEVER MODE
Yes.
STORAGE OF WEIGHT COMPLETED ?
No
Yes
|FL-Wo|>Fo
No
STORE WEIGHT
Yes
SET TO BALANCE MODE ONE OR MORE TIMES ?
No
Yes
BALANCE MODE
BALANCE STATIONARY MODE
POSITION MODE

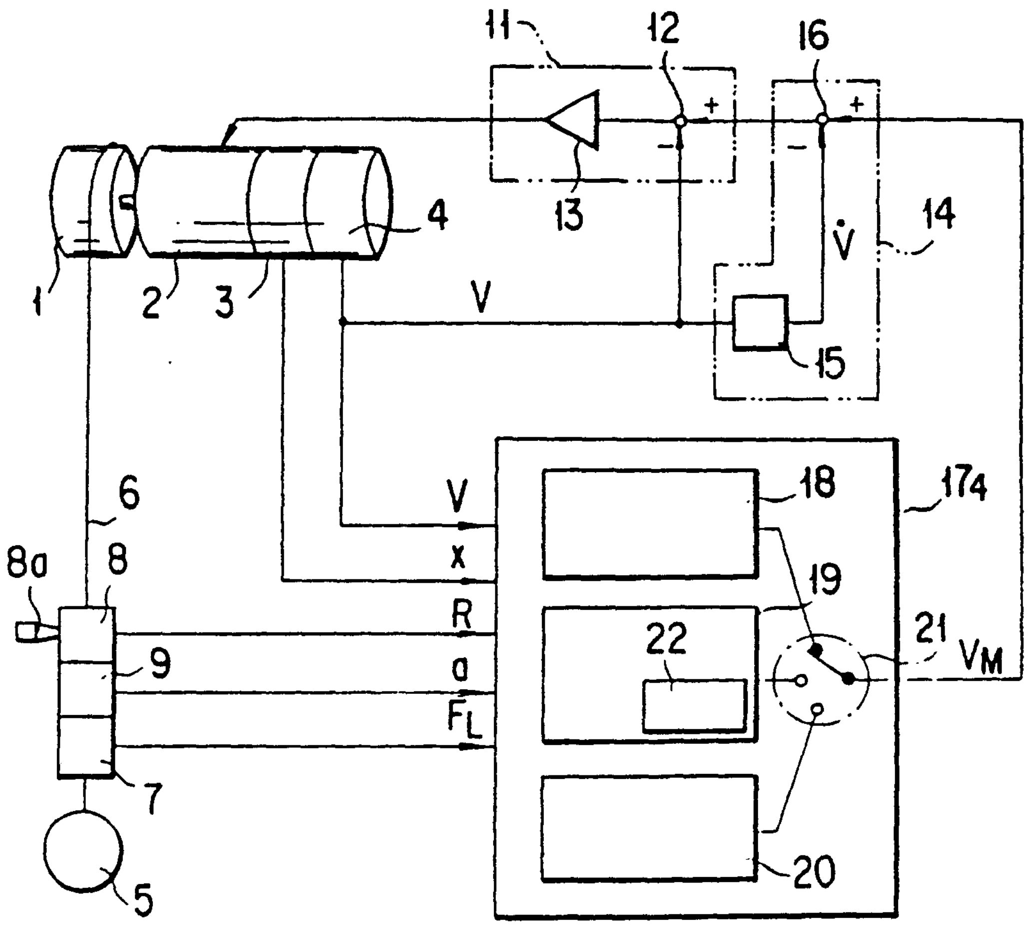
FIG. 15


AFTER T_M UPON SETTING OF POSITION MODE (STORAGE COMPLETED)
&
$|F_L-W_0|>F_0$
BALANCE MODE
$-K_F(F_L-W_0)+K_{vp}V$
$|F_L-W_0|\leq F_0$
Td
WHEN $|F_L - W_0| \leq F_0$ CONTINUOUSLY FOR A FIXED TIME T_d
$|F_L-W_0|>F_0$
BALANCE STATIONARY MODE
$-K_X(X-X_0)-K_F(F_L-W_0)$
$|R|>R_0$
POSITION MODE
$-K_X(X-X_0)-K_{vn}V$
$|R|\leq R_0$
$|R|>R_0$
LEVER MODE
$K_RR-K_{vn}V$

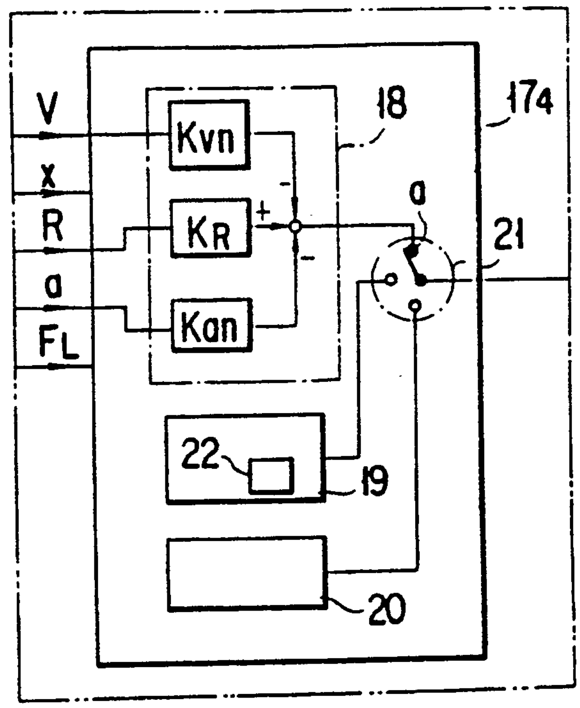
F I G . 16


|R|≤Ro
No
LEVER MODE
Yes
STORAGE OF WEIGHT COMPLETED? ?
No
Yes
|FL-Wo|>Fo
No
STORE WEIGHT
Yes
SET TO BALANCE MODE ONE OR MORE TIMES ?
No
RESET THE TIMER
START THE TIMER
Yes
No
TIMER ≥Td ?
Yes
BALANCE MODE
BALANCE STATIONARY MODE
POSITION MODE

F I G . 17



F I G . 18


V
x
R
a
FL
Kvn
KR
Kan
+
-
-
18
174
a
21
22
19
20

F I G . 19

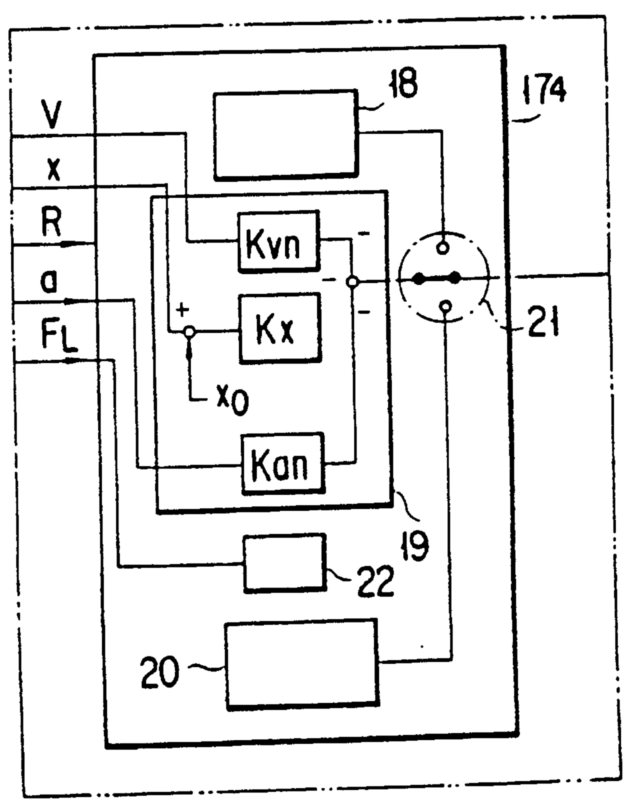

V
x
R
a
FL
18
174
Kvn
Kx
Kan
+
-
-
-
x0
21
19
22
20

FIG. 20A

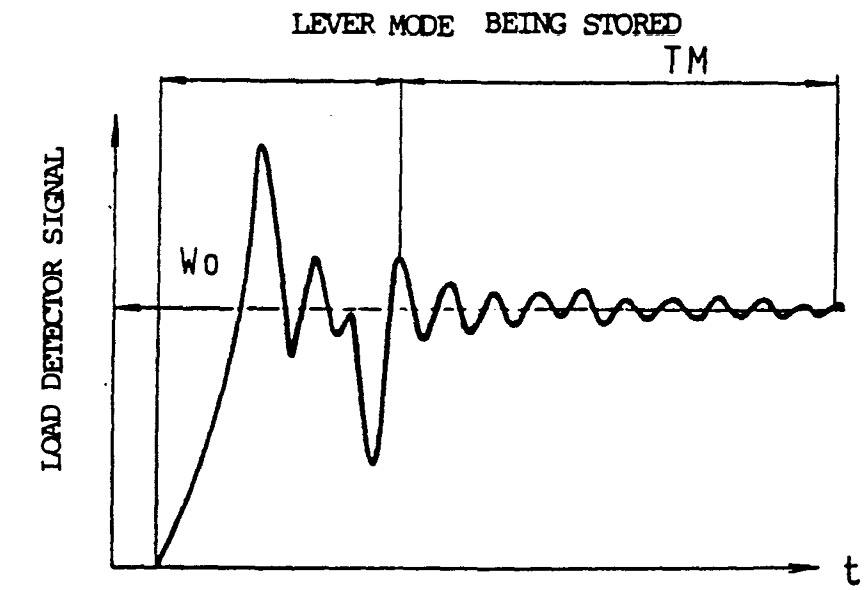
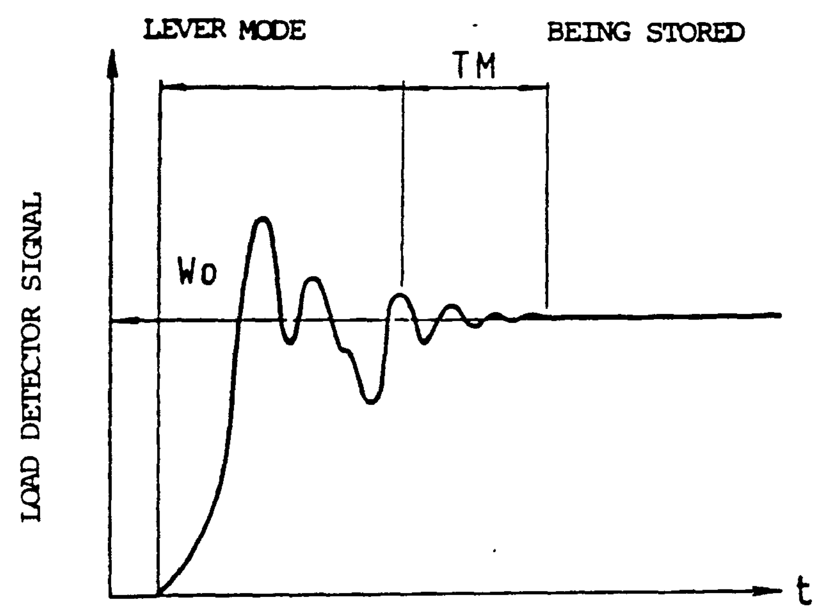
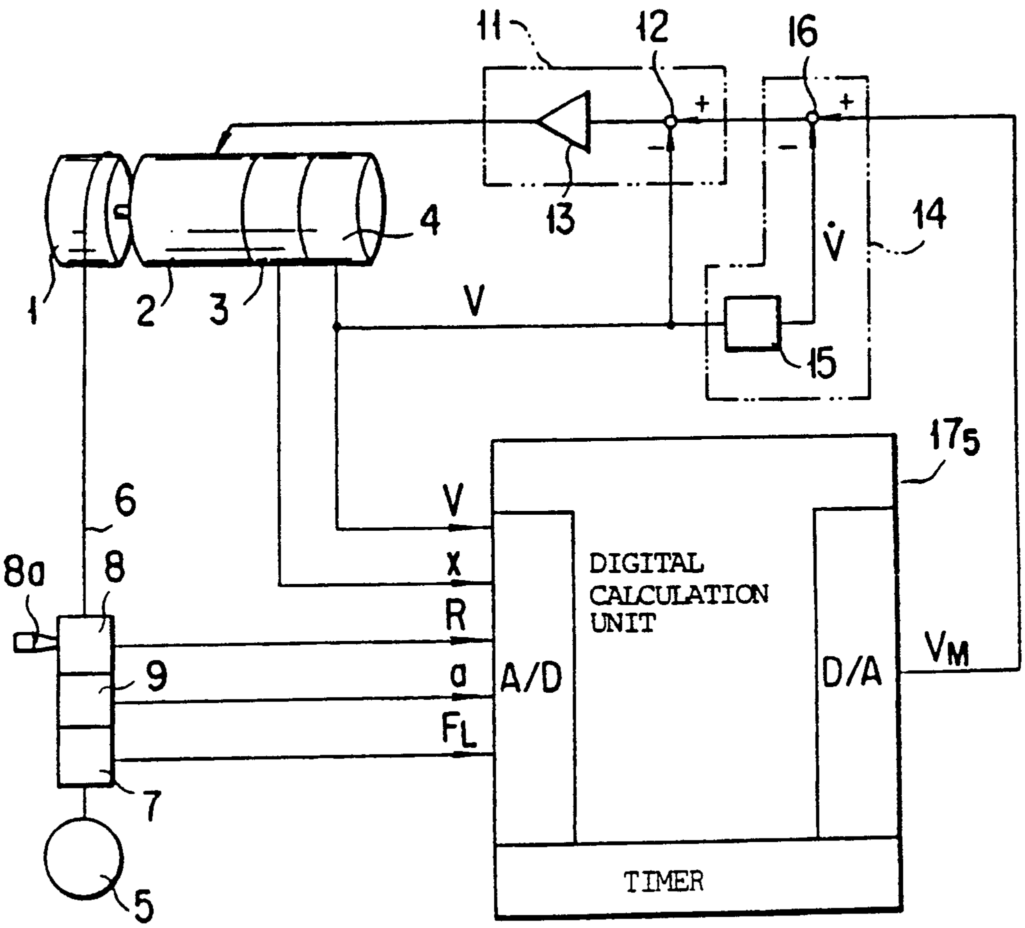


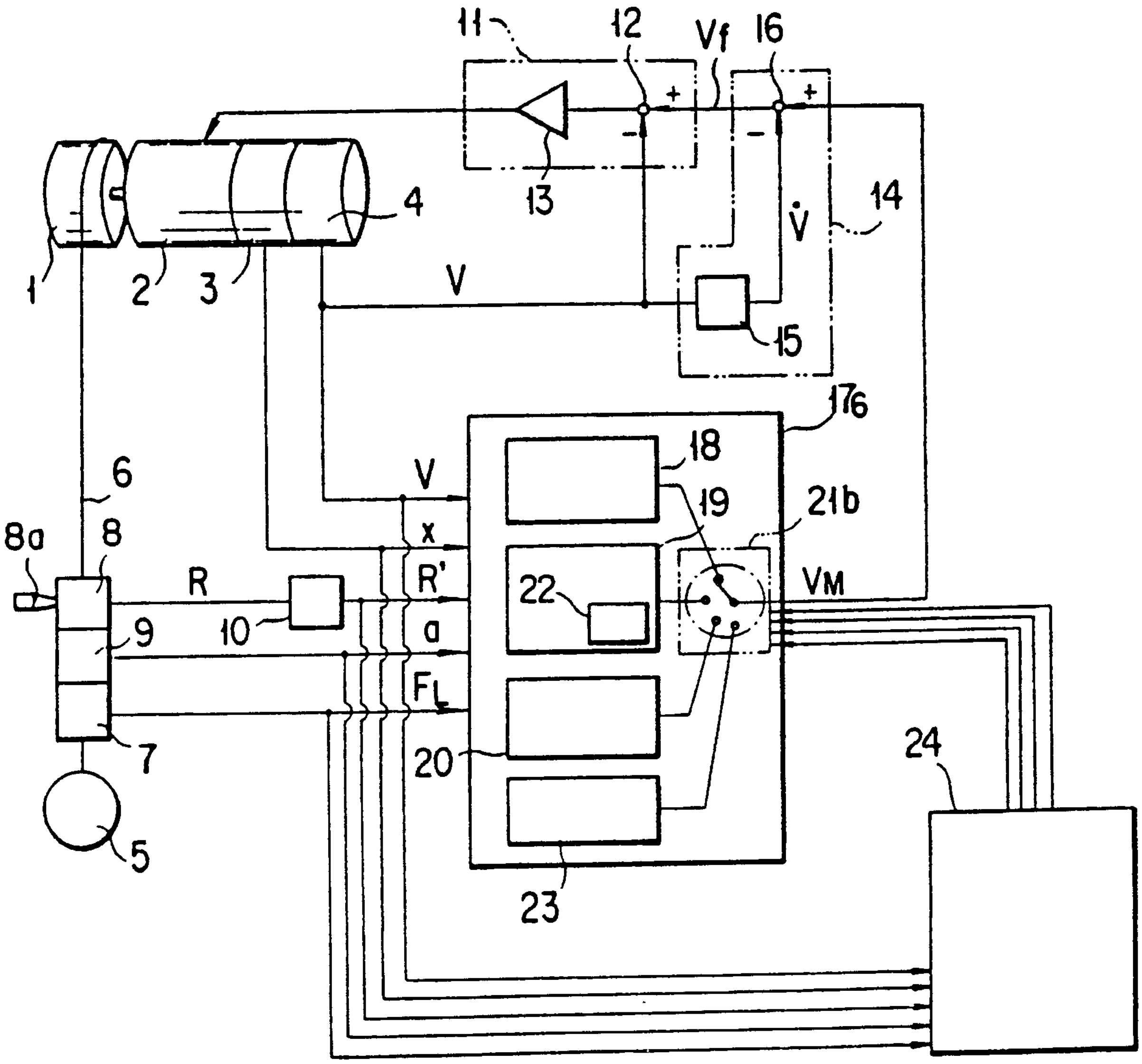
FIG. 20B



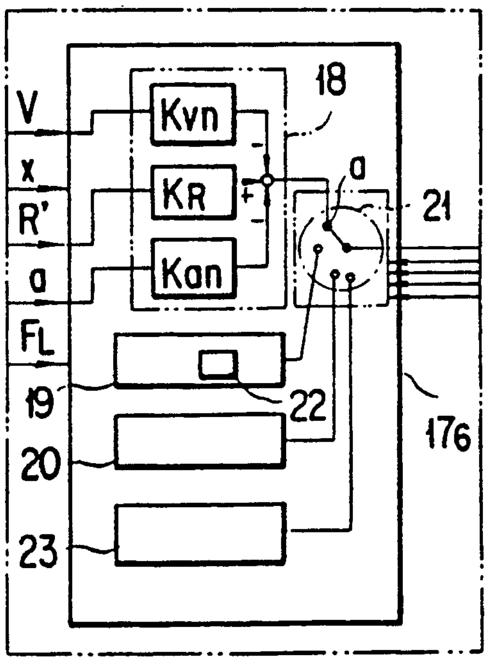
F I G . 21


11
12
16
13
4
14
V̇
1
2
3
V
15
17₅
6
V
x
8a
8
R
DIGITAL
CALCULATION
UNIT
9
a
A/D
D/A
V_M
F_L
7
TIMER
5

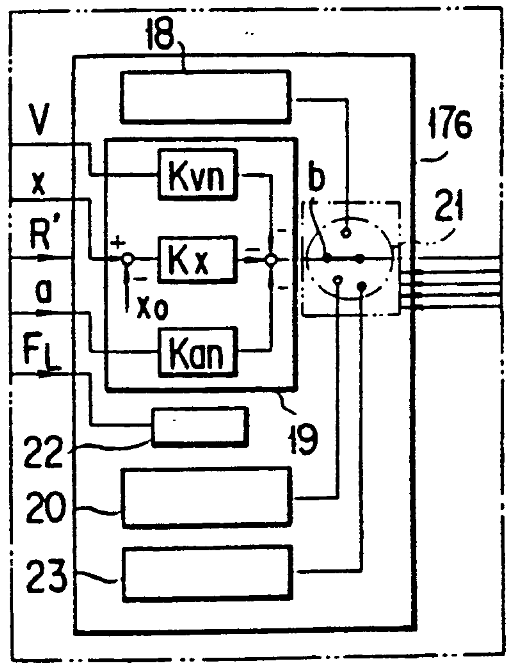
F I G . 22


11
12
Vf
16
+
+
-
-
4
13
14
V̇
1
2
3
V
15
17b
18
6
V
19
21b
8a
8
x
R
R'
22
VM
10
9
a
FL
7
24
20
5
23

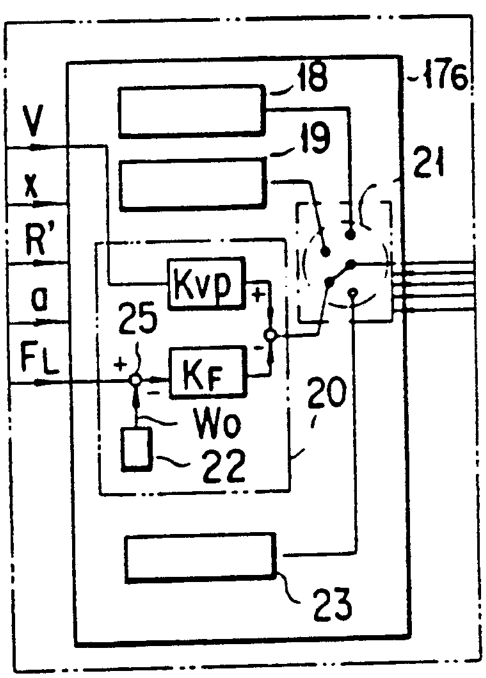
F I G . 23



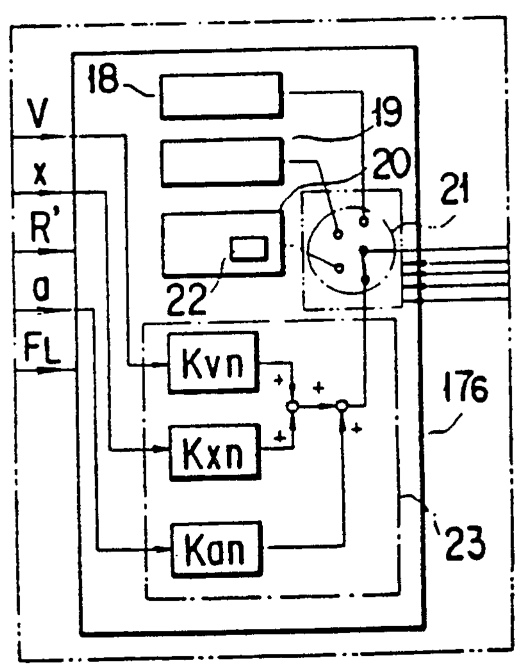
F I G . 24



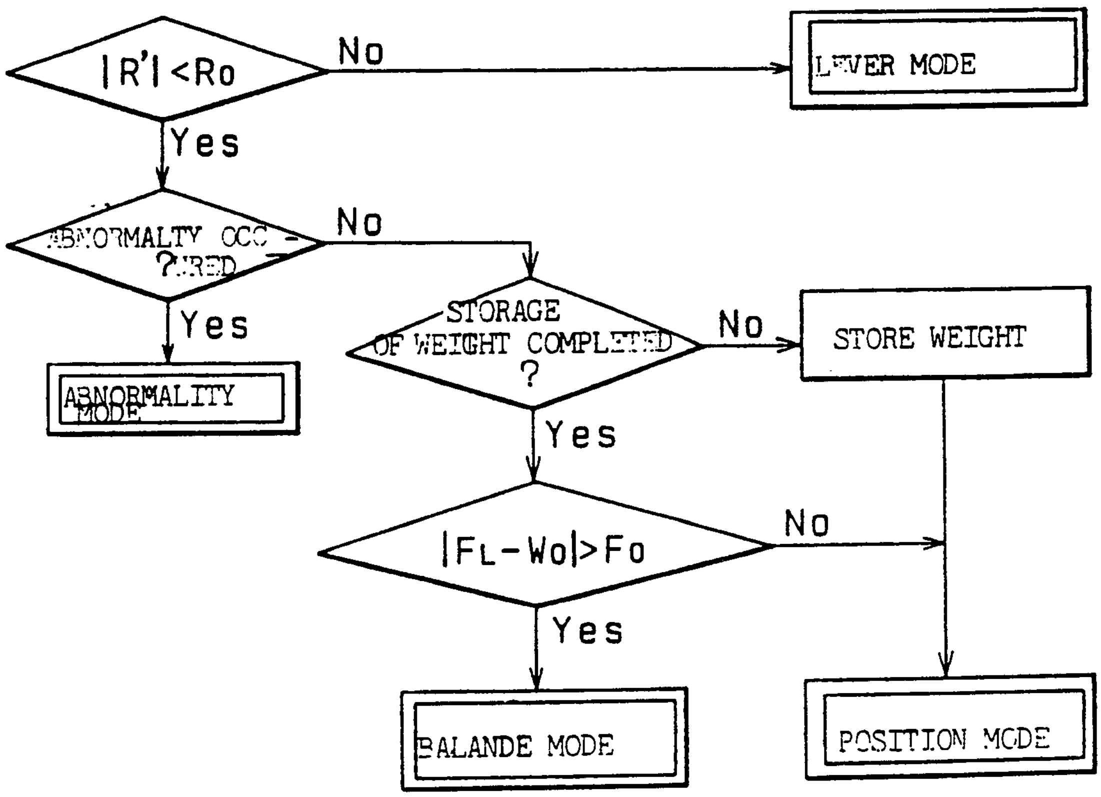
F I G . 25



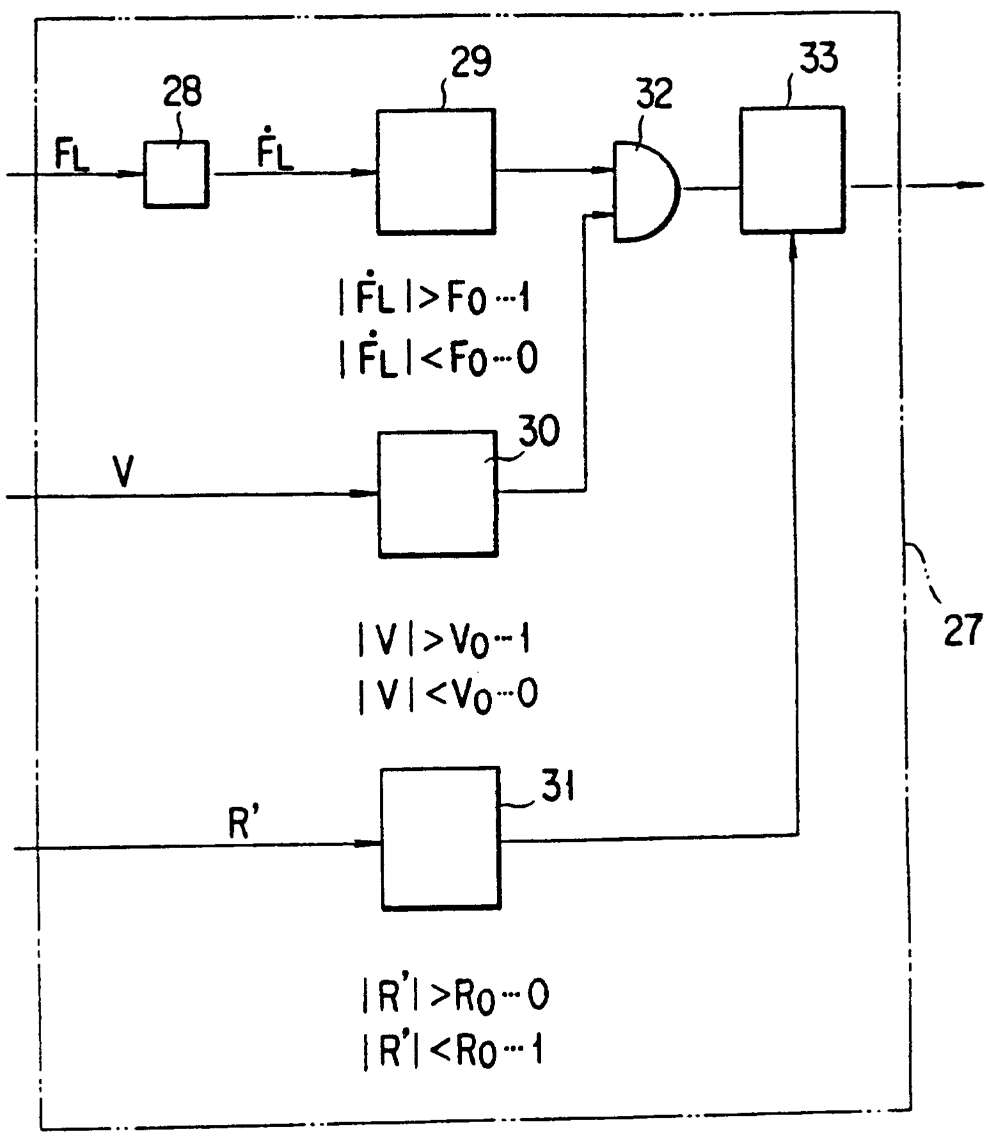
F I G . 26



F I G . 27


|R'|<Ro
No
LEVER MODE
Yes
ABNORMALTY OCCURED ?
No
Yes
ABNORMALITY MODE
STORAGE OF WEIGHT COMPLETED ?
No
STORE WEIGHT
Yes
|FL-Wo|>Fo
No
Yes
BALANDE MODE
POSITION MODE

F I G . 28



INTERNATIONAL SEARCH REPORT

International Application No PCT/JP89/00484

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl^4

B66D3/18, B66F19/00

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC	B66D3/18, B66F19/00

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

Jitsuyo Shinan Koho	1926 - 1989
Kokai Jitsuyo Shinan Koho	1971 - 1989

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
E	JP, A, 1-133900 (Komatsu Ltd.) 25 May 1989 (25. 05. 89) Page 3, upper right column, line 1 to lower right column, line 14, page 5, upper left column, line 11 to lower left column, line 9, page 6, lower left column, line 7 to lower right column, line 5 (Family : none)	1 - 8
E	JP, A, 1-127600 (Komatsu Ltd.) 19 May 1989 (19. 05. 89) Page 1, lower left column, line 5 to lower right column, line 6 (Family : none)	9
Y	JP, A, 1-8198 (Komatsu Ltd.) 12 January 1989 (12. 01. 89) Page 1, lower left column, lines 5 to 18 (Family : none)	9
A	JP, A, 63-315497 (Komatsu Ltd.) 23 December 1988 (23. 12. 88) (Family : none)	1 - 9

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
July 21, 1989 (21. 07. 89)	August 7, 1989 (07. 08. 89)
International Searching Authority	**Signature of Authorized Officer**
Japanese Patent Office	

International Application No. PCT/JP89/00484

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

Y	JP, A, 63-235299 (Komatsu Ltd.) 30 September 1988 (30. 09. 88) Page 1, lower left column, line 5 to lower right column, line 1 (Family : none)	9
A	JP, A, 63-196495 (Komatsu Ltd.) 15 August 1988 (15. 08. 88) (Family : none)	1 - 9
A	JP, A, 63-165295 (Komatsu Ltd.) 8 July 1988 (08. 07. 88) (Family : none)	1 - 9
Y	JP, A, 63-82299 (Komatsu Ltd.) 13 April 1988 (13. 04. 88) Page 1, lower left column, lines 5 to 18	4

V.☐ **OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE** [1]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1.☐ Claim numbers ...., because they relate to subject matter not required to be searched by this Authority, namely:

2.☐ Claim numbers ...., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3.☐ Claim numbers ...., because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI.☐ **OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING** [2]

This International Searching Authority found multiple inventions in this international application as follows:

1.☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2.☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3.☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4.☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

	(Family : none)	
A	JP, A, 63-82298 (Komatsu Ltd.) 13 April 1988 (13. 04. 88) (Family : none)	1 - 9
A	JP, A, 53-32550 (Motoda Kenro) 27 March 1978 (27. 03. 78) (Family : none)	1 - 9
A	JP, A, 50-113969 (Hitachi, Ltd.) 6 September 1975 (06. 09. 75) (Family : none)	9
A	JP, A, 51-35948 (Hitachi, Ltd.) 26 March 1976 (26. 03. 76) (Family : none)	1 - 9

V.☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1.☐ Claim numbers ...., because they relate to subject matter not required to be searched by this Authority, namely:

2.☐ Claim numbers ...., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3.☐ Claim numbers ...., because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI.☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [2]

This International Searching Authority found multiple inventions in this international application as follows:

1.☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2.☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3.☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4.☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.