Europäisches Patentamt
European Patent Office
Office européen des brevets

(19)

(11) Publication number: **0 487 725 A1**

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

(21) Application number: **90909368.4**

(22) Date of filing: **15.06.90**

(86) International application number: **PCT/JP90/00784**

(87) International publication number: **WO 91/19665 (26.12.91 91/29)**

(51) Int. Cl.5: **B66C 13/46**, B66C 23/90

(43) Date of publication of application: **03.06.92 Bulletin 92/23**

(84) Designated Contracting States: **AT BE CH DE DK ES FR GB IT LI LU NL SE**

(71) Applicant: **KATO WORKS CO., LTD.**
1-9-37, Higashiooi Shinagawa-ku
Tokyo140(JP)

(72) Inventor: **ICHIBA, Akinori**
4-25-41, Naka
Satte-shi, Saitama 340-01(JP)
Inventor: **TSUTSUMI, Yukio**
450-114, Ohaza Kuzume, Washimiya-cho
Kita Katsushika-gun, Saitama 340-02(JP)

(74) Representative: **Wright, Peter David John et al**
R.G.C. Jenkins & Co. 26 Caxton Street
London SW1H 0RJ(GB)

(54) HOOK LIFT DISPLAY APPARATUS OF CRANE.

(57) Rope movement is detected through a rope movement change quantity at predetermined time intervals and the rope movement quantity is obtained by the accumulated value of the change quantities. When a hook structure reaches a spiral length position, the accumulated rope movement value is reset automatically to zero to update the reference position of rope movement, and measurement error of rope movement is corrected. The hook structure suspension length from the tip of a boom or jib is determined from the rope movement quantity thus obtained, and the hook lift is calculated. The hook lift or hook structure position thus calculated is displayed on a display with reference to a fixed index or pattern and the operator can monitor the behavior of the hook structure on the display.

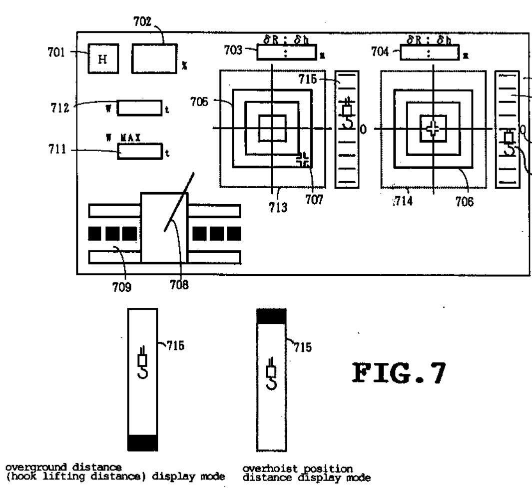


FIG.7

EP 0 487 725 A1

Field of the Invention

The present invention relates to an apparatus for calculating and displaying a crane hook lifting distance.

Background of the Invention

A crane safety apparatus has been proposed (in Japanese Patent Publication No.56-47117) in which various operation parameters (such as boom length, boom angle, outrigger extension, and jibbing) of a crane are detected by sensors, a digital memory storing rated loads for various operation states determined by the specification of the crane is accessed to retrieve the rated load specific to the detected operation parameters, the retrieved rated load is compared with the actual load, and warning is issued when the actual load reaches a value near the rated load or the crane is automatically stopped when the actual load reaches the rated load.

A conventional crane safety apparatus does not have a function of correctly indicating a hook lifting distance. The hook lifting distance is known from the present state of the hook structure. However, there is no practical method of correctly knowing particularly how long a hook structure is hung from the boom or jib top by released rope. Furthermore, an apparatus has not been proposed which schematically displays a hook structure on a display within a target or operation range fixedly set by an operator, and allows the operator to monitor the hoisting and lowering operation of the hook structure.

Summary of the Invention

In the method of calculating a hook lifting distance according to the present invention, a rope extension is detected as a roe shift distance at a predetermined time interval, and the accumulated value of rope shift distance is used as a rope extension amount. In accordance with the accumulated value of rope shift distances, a hanging length of the hook structure is obtained. In response to a detection that the hook structure is at the maximum hook lifting position, the accumulated value of rope shift distance is reset to renew the reference position of the rope extension amount. According to the method of the present invention, the reference position is automatically renewed so that a correct hanging length of the hook structure can be obtained and a correct hook lifting distance can be calculated from the obtained hanging length.

According to one aspect of the present invention, an apparatus is provided for displaying the hook lifting distance or hook structure position calculated by the above method together with an operation range limit pattern, on a display screen. According to another aspect of the present invention, a crane operator places the hook structure on an actual target position and pushes a key. Then, the target position is set to the reference point (e.g., 0) fixedly displayed on the screen. The actual distance between the target and hook structure is displayed on the screen in correspondence with the distance on the screen between the schematic hook structure graphic image and reference point.

Brief Description of the Drawings

Fig.1A is a block diagram showing the fundamental structure of the apparatus according to the present invention;

Fig.1B is a graph showing an example of rated total load data curves whose data is stored in the apparatus of the present invention;

Fig.2 is a block diagram showing a particular structure of the apparatus of the present invention;

Fig.3 is a diagram showing the crane mechanism and hook lifting distance; Fig.6 is a diagram showing a graphical image in an automatic crane safety monitor mode of the apparatus of the present invention;

Fig.7 is a diagram showing a graphical image in a target mode of the apparatus of the present invention;

Fig.8 shows the crane mechanism explaining an crane operation using a primary hoist and subhoist;

Fig.9 and 10 are diagrams showing graphical images in an operation range limit mode; and

Fig.11 to 16 are flow charts showing the operation sequences of the apparatus of the present invention.

Description of the Embodiment

The fundamental structure of a crane safety apparatus according to the present invention is shown in Fig.1A. The apparatus is constructed of a main unit A and a display unit B. During the operation of the apparatus, a main unit CPU and a display unit CPU always exchange commands and data.

When power is turned on, first a crane operation state (such as the number of outrigger stages, and the number of jib stages) is set at the display unit. An operator selects an operation state setting mode from a plurality of display modes displayed on a display B'', by manipulating a predetermined key in a setting key group. The display unit has a memory which stores the operation state setting mode display as graphics data. CPU reads the display data in accordance with a display control program in ROM, and writes the data in a video RAM to display a display mode graphic image on the display B''. Data such as the number of outrigger stages set by the operator using a setting key is fetched by the display unit CPU. The display unit CPU modifies the display mode graphic image in accordance with the setting data, and sends the setting data to the main unit A as data D_B, to thereafter complete the settings for the operation state mode. The operator then selects a monitor mode necessary for the crane operation, and reads the display data from the memory to display it on the screen.

The main unit A receives the crane operation state setting data D_B sent from the display unit B, and fetches from a sensor group A' operation parameter data (boom length 1, boom angle 8, swing angle ϕ, rope extension amount, jib offset angle, and the like) representative of the state of the crane mechanism changing from time to time as the crane is operated. The operation parameter data is, directly or after processed by CPU, sent to the display unit B as data D_A. In accordance with the data D_A, the display unit B modifies the display data on the display B'' from time to time so that the present operation state of the crane can be monitored as a schematic graphic image.

The main unit A stores data determined by the specification of the crane. Typical data is maximum rated loads at various crane operation states. For example, Fig.1B shows rated load data curves under the operation state settings of a middle outrigger (5.9 m), extension (side), and no jib, with the boom length of 8.9 m. Rated total load curves of the crane are determined for each of various operation state settings and boom lengths. Such a great amount of data is stored in ROM of the main unit A.

In accordance with the crane operation state setting data D_B from the display unit B and the operation state parameter data from the sensor group A' of the crane changing from time to time, the main unit A accesses the maximum rated load data stored in ROM corresponding to the crane operation state at that time. The maximum rated load data obtained or processed is compared with an actual load. If the present crane operation state is within a danger range, the main unit sends a signal for controlling the crane mechanism A'' so that warning is issued and/or the crane is automatically stopped.

The memory of the display unit B stores a plurality of display data for a plurality of display modes. A desired display mode is selected from a plurality of display modes including a hook lifting display mode by using a setting key. An operator can set the operation state and monitor the crane operation while referring to the display mode graphic image on the screen including the above-described and conventionally used automatic crane safety monitor mode graphic image.

The main unit A and display unit B run on their own programs. Transfer of commands and data between the main unit A and display unit B is carried out by an interrupt process.

Particular Structure of Apparatus

Referring to Fig.2, the main unit CPU 200 is inputted with actual load data from a pressure sensor 201, and other crane operator parameter data from a swing angle sensor 202, boom length sensor 203, boom angle sensor 204, boom overground top angle sensor 205, jib overground angle sensor 206, wire rope extension amount sensor 207, and pressure sensor 208 respectively mounted on various positions of the crane mechanism. The data from the sensors 205 to 208 at the boom top is collected at a top terminal 209, and sent to a cord reel 210 at the boom bottom via optical fibers. The data is then converted into electric signals which are sent to the main unit CPU 200. The display unit CPU 211 is powered by the main unit CPU 200 via lines 217. Commands and data are transferred via bidirectional serial lines 214 and 215 between the main unit CPU and display unit CPU. A display 212 is a matrix type, dynamically driven liquid crystal display (LCD). LCD is more preferable from the viewpoint of easy-to-monitor than CRT, LED, plasma display and the like because a crane is generally used outdoors and exposed to strong light. LCD 212 is back-lighted in the night. The setting key switch group has a plurality of touch keys corresponding to a plurality of setting items. Signals for controlling the crane mechanism are outputted to plungers 218, electromagnetic valves and the like.

An embodiment of the hook lifting distance displaying apparatus of the present invention is used as realizing one display mode of the above-described crane safety apparatus. The constitution of the present invention will further be described with reference to Fig.3. A crane main frame 31 is supported by a fixedly mounted outrigger. Mounted within an operation cabinet of the crane main frame are the main unit CPU 200, display unit CPU 211, display 212, and setting switch key group 213. The sensors are mounted on the crane mechanism at predetermined positions. A hook structure 34 is hung by a wire rope 33 from the top of a boom 32. The hook structure 34 is hoisted or lowered when the rope 33 is wound about or released from a winch 35. In Fig.3, a jib 37 is additionally mounted. An overhoist sensor 36 or 38 detects that the hook structure 34 was hoisted to the position lower than the top of the boom by a predetermined distance (overhoist length), and causes the winch-hoisting to automatically stop in order to prevent collision of the hook structure against the boom top. The predetermined distance from the boom top and hook structure is called an overhoist length which takes a value specific to the crane mechanism. The overground height of the hook structure at the overhoist length is a maximum lifting distance. A hook lifting distance is given by the following equation:

Hook lifting distance = maximum lifting distance - (rope extension amount - rope extension amount caused by boom length shift - rope extension amount caused by jib offset angle shift)/number of ropes on hook

As described above, the maximum lifting distance is the length between the position (overhoist position) lower than the boom or jib top by the predetermined distance) and ground. This maximum lifting distance is calculated by the main unit CPU 200 shown in Fig.2 in accordance with the setting state of the boom and jib measured with the various sensor.

In order to obtain the present hook lifting distance, it is necessary to calculate the length of the rope hanging down from the boom or jib top. This length is calculated by the terms within the parentheses of the above equation, these terms being influenced by the setting state of the boom and jib and the rope extension amount. In the embodiment shown in Fig.3, a pulse type rope extension amount sensor 39 is mounted on the boom at the upper position thereof. Specifically, each time the rope moves by a predetermined distance, the sensor 39 generates one pulse which is supplied to the main unit CPU 200. The main unit CPU 200 forms therein a software up/down counter to count pulses from the sensor. The up/down counter is switched to an up counter when an operation lever is manipulated to cause the winch 35 to lower the hook structure, and to a down counter when it is manipulated to cause the winch 35 to hoist the hook structure. When the sensor 36 detects that the hook structure 34 is at the overhoist position, it outputs a signal in response to which the up/down counter is automatically reset to "0". The rope extension amount, i.e., rope winding or releasing amount, is determined using as a reference the state that the hook structure 34 is at the overhoist position.

Even if the winch 35 does not positively wound or release the rope and hence there is no rope extension, the rope length below the overhoist position will change with the boom length.

Referring to Fig.4, as the boom length changes, the maximum lifting distance or overhoist position will change and the rope length from the overhoist position to the hook structure changes from a to b, because the rope is hung down by the amount corresponding to the boom length change.

Even if there is no rope extension, if the jib offset angle θ changes as shown in Fig.5, the rope length below the overhoist position will change.

One or more ropes are extended from the boom or jib top to the hook structure 34. The rope length from the overhoist position to the hook structure 34 can be calculated by dividing the rope length by the number of ropes.

Data from the various sensors 201 to 208 and setting switch key group 213 shown in Fig.2 is supplied from the display unit CPU 211 to the main unit CPU 200 to calculate the hook lifting distance.

The amount of winding the wire rope about or releasing it from the winch is not given as an absolute value, but it is given as a relative rope extension amount from the reference position by the pulse sensor 207. This relative rope extension amount is supplied to the main unit CPU 200. In this embodiment, the overhoist position sensor 36 or 38 detects that the hook structure is overhoist at the boom angle 30° or more and stays above the overhoist position several seconds or more and then the overhoist state is released. This overhoist position is used as the reference position for calculating the rope extension amount caused by the rope winding or releasing.

The reason why the overhoist position of the hook structure is used as the reference position is that this position can be easily set under any condition with less error. The reason why the boom angle is set to 30° or more is that it is preferable to determine the reference position at the running state (normally the boom angle is set to 30° or less) of the crane. The reference position is therefore set immediately after starting crane operation. The reason of introducing the condition that the hook structure stays several seconds or more, is to exclude the case where the hook structure swings and becomes in contact with the overhoist sensor.

It is difficult in practice to correctly measure the rope extension amount, and there is some play in mechanical components. Therefore, even if an operator once manually sets the reference position, after continuous crane operation the software register within CPU 200 may sometimes store "+3" for example instead of "0" as the rope extension amount. In this embodiment, when the hook structure takes the reference position, the register is automatically reset to "0". Namely, the reference position is automatically renewed to eliminate the accumulated error. When an operator sets the hook structure at the overhoist position during the crane operation, particularly immediately after starting crane operation (this hook structure setting of the crane is always tried immediately after starting crane operation), the reference position for the rope extension amount is automatically updated to a correct position.

Hook Lifting Distance Display in Automatic Safety Monitor Mode

The crane safety apparatus uses the hook lifting distance calculated by CPU 200, in the following manner. The hook lifting distance calculated at a predetermined time period is supplied to the display unit CPU 211.

After setting the operation state mode, the display unit CPU 211 automatically enters an automatic crane safety monitor mode for displaying a graphic image such as shown in Fig.6. In accordance with the information supplied from the main unit CPU 200, the display unit CPU 211 displays the present crane operation state, including an outrigger setting 604, swing position 605, operation radius 606, boom angle 607, lifting load 610, hook lifting 609, boom length 602, and maximum lifting 614. The boom length is schematically shown as an expansion bar 603.

The present crane operation state is indicated by a bar graph 611 showing the safety limit of the crane. The numerical value representing the safety is indicated at 613. A limit (maximum) load for a given crane operation state is numerically shown at 608. When the crane operation state enters near the limit range (when the bar graph 611 expands to the yellow zone), warning is issued. When the crane operation state enters the danger range, the crane is automatically stopped. The present crane operation state is monitored by the main CPU 200 using data from the various sensors. The main unit CPU 200 accesses the memory to retrieve the maximum load for the crane operation state at that time and checks whether the actual load is equal to or less than the maximum load. The main unit CPU 200 outputs a signal for locking the crane operation mechanism when the actual load becomes the maximum load of the crane operation at that time. During the automatic crane safety monitor mode, similar warning and automatic stop are effected by the display unit CPU 211 not only when the actual load becomes the maximum load but alto when the actual operation range enters the limit operation range set by the operator.

One of the unique graphic images of this embodiment is an automatic stop cause 612. When the crane is automatically stopped during the automatic crane safety monitor mode, it is difficult for an operator to quickly locate the cause of the automatic stop. It is difficult to locate the cause particularly when the crane is tumbled down or broken due to an overload or when the crane operation range is set in the monitor mode. If the rope having a predetermined length is wound in an idle state in excess of the rope length during the crane operation, a reverse winding will occur. Even in such a case, an automatic stop is carried out and its cause is illustratively shown at 612.

In this embodiment, when the hook lifting distance becomes 0 +/- 1 m or - 1 m of the maximum lifting distance is flushed.

Hook Lifting Distance in Target Mode

Upon actuation of the mode selection key, the display unit CPU enters the target mode showing a graphic image such as shown in Fig.7. The target mode is used when an operator sitting on the seat cannot see a hanging load. Target index marks 705 and 706 indicated by solid lines in Fig.7 are used for setting two target points on the horizontal plane. One side of the innermost target index mark corresponds to an actual distance of 15 cm in the radial direction, that of the next mark corresponds to 40 cm, and that of the outermost mark corresponds to 60 cm. The sides correspond respectively to +/- 5°, +/-10°, and +/- 15° in the circumferential direction. Indices 715 and 716 indicate the lifting distance of the hook structure in the vertical direction of the two target points in the horizontal plan. A mark 718 represents the overhoist position, a mark 719 represents the target position (0 point) in the vertical direction, and a mark 717 represents the actual position of the hook structure. A hanging load is placed at the target position in the vertical and horizontal directions by operating the crane, and then the setting key is actuated to set the target position as the first target. The target position is set as the 0 point of the coordinate system. The position of the hanging load in the horizontal plane is displayed on the target index mark display area as a distance from the 0 point. The target position of the hook structure in the vertical direction corresponds to the mark 719, and the actual position of the hook structure is indicated by the mark 717. After setting the target position, the operator can know the position of the hanging load relative to the target position without directly looking at the hanging load. The crane operation often includes an operation of moving a hanging load from the first point to second point by swinging the boom. In this case, the target index marks 705 and 716 are used for setting the first point, and the target index marks 706 and 716 are used for setting the second point. On the display screen, the index marks 705 and 715, and the index marks 706 and 716 are used for displaying different and independent coordinate systems. The two sets of index marks 705 and 715, and 706 and 716 show the effective display area of the coordinate systems of the first and second points, and correspond to the actual size, e.g., of 100 cm square. A hanging load within the effective area is represented by a + mark. For a hanging load outside of the effective area, the + mark moves onto a broken line as indicated at 707 so that the operator can know the direction of the hanging load. While referring to the mark displayed relative to the target index mark, the operator can carry out repetitive operations of moving the hanging load between the first and second points in the horizontal and vertical directions, even if the operator cannot visually confirm the actual position of the hanging load. Distance of the hanging load to the first and second points in the horizontal and vertical directions are displayed at the upper area of the display screen at 703 and 704. Displayed for convenience sake at the lower left of the display screen area an outrigger setting 709 and a boom swing position 708. Displayed for reference sake are a load 712 and a maximum load 711. Reference numeral 701 represents a mode, and reference numeral 702 represents a numerical value of safety degree.

An actual hanging load position is calculated by the main unit CPU from data of the various sensors and crane setting data, and is given to the display unit CPU as the hanging load position data and crane lifting distance. When a certain position is designated as a target position within the target index marks 705 and 715 by actuating the touch keys, the display unit CPU sets the lifting position data at that time as the 0 point of the index marks 705 and 715.

In addition to the mode of displaying the hook structure position relative to the target position (0 point), an overground distance (hook lifting distance) display mode is switchably provided wherein the lower area of the index 715 is displayed in different color. In the overhoist position distance display mode, the upper area of the index 715 is displayed in different color.

As another display mode, the index 7115 is used for displaying the primary hoisting hook structure position, and the index 716 is used for the sub-hoisting hook structure position (refer to Fig.8). The symbols representing the hook structure in the indices 715 and 716 display a difference between the positions of the primary hoisting and sub-hoisting. For example, if the primary hoisting hook is higher than the sub-hoisting hook by 1 m, then the symbol of the primary hoisting hook is displayed higher than the middle position of the index. In this case, the hooks are made horizontal by hoisting the primary hoisting hook or by lowering the sub-hoisting hook.

Hook Lifting Distance Display in Operation Range Limit Mode

Apart from the tumbling or breakage limit of the crane, in the operation range limit mode of this embodiment, preset is the operation range of the hook structure within which the hook structure and hanging load do not become in contact with nearby building or the like. If the boom or rope extension exceeds the preset range, warning is issued or the crane is automatically stopped. When the display unit CPU enters the operation range limit mode, graphic images such as shown in Fig.9 and 10 are displayed. The boom and jib are illustrated at A on the display screen and the position of the hook structure is indicated at F. This graphical illustration changes as the crane moves. In setting the operation limit of the hook structure, an operator moves the hook structure with an actual lifting load to limit points (upper and lower limits). Under this condition, the operator pushes a limit setting switch so that upper and lower lines indicated at U and L are drawn on the display screen as shown in Figs.9 and 10. Fig.9 illustrates the absolute upper and lower limit positions of the hook structure. Fig.10 illustrates the limits of distance of the hook structure from the overhoist position near the boom or jib top. As the boom angle changes, the limit lines U and L are changed and displayed correspondingly. While monitoring such graphic illustrations, a crane operator manages the F mark not to move outside of the limit range.

In setting the limit range, the hook structure is actually moved to the limit points and the setting key is actuated at that time. This setting is carried out not by entering limit values an operator determined, but by actually moving the hook structure. This setting is advantageous in that the operation range can be set by actually moving the hook structure on site.

Operation Sequence of Apparatus

The operation sequence of the apparatus according to the embodiment of the present invention is controlled by programs independently running on the main unit and display unit CPUs. The main unit CPU receives the operation parameters from the various sensors and the operation range setting data from the display unit CPU, calculates the actual load, operation range radius, limit load, maximum lifting distance, hook lifting distance, and the like, automatically stops the crane mechanism, and sends the data to the display unit CPU. The display unit CPU displays a graphic image of the selected mode in accordance with the data from the main unit CPU, modifies the graphic image in accordance with the data inputted from setting keys, and transmits the inputted setting data to the main unit CPU. The sequences of the main unit and display unit CPUs run independently from each other, while transferring commands and data upon occurrence of an interrupt.

Programs for sequence control of the main unit and display unit CPUs are stored in ROM. The display unit has a video RAM which stores display graphic data of a selected display mode. The contents of the graphic data are modified as the crane operation state changes. The graphic data in the video RAM is transferred to the display at an interval of 150 ms for example to update the graphic image.

Data D_A and D_B are transferred between the main unit and display unit by start-stop synchronization of data communication. Each time data to be transmitted to display unit is generated at the main unit, the main unit CPU receives a transmission request interrupt to transmit data. The display unit then receives a reception request interrupt to receive the data. Data is transmitted from the display unit and received by the main unit in a similar manner.

Data from the various sensors representative of the crane operation state is received by the main unit CPU via an A/D converter. In response to a sensor data read request interrupt issued at a predetermined operation timing of the A/D converter, the main unit CPU reads the sensor data.

A key input at the display unit is checked at a predetermined cycle to execute the process suitable for a depressed key.

A timer interrupt is received by the main unit and display unit CPUs to execute a process at a predetermined time interval.

The display unit CPU writes graphic data in the video RAM in accordance with the data received at the display unit to display a graphic image, and supplies the operation limit setting data and the like to the main unit.

The main unit CPU calculates a boom radius, lifting distance, actual load, and limit load in accordance with the data received at the main unit, compares them with the performance data defined by the crane specification, and outputs a control signal for automatically stopping the crane and other control signals.

(1) Main Unit Operation Sequence

In response to powering or resetting the apparatus, the main unit performs the main flow sequence at steps S_{1a} to S_{6a}. The first step S_{1as} checks whether the apparatus is in a proper state and initializes the CPU settings for achieving the proper execution at the following steps. Prior to this initializing, an interrupt is inhibited, and after completion of the initializing, an interrupt inhibition is released at step S_{2a}. At step S_{3a}, it is checked whether data to be transmitted to the display or data received from the display is present. If present, the data is subjected to transmission/reception. Data transmitted to the main unit is received upon execution of a hardware interrupt similar to the case of receiving data from sensors.

At step S_{4a}, various calculation processes are executed for the received and processed data. Specifically, parameters representative of the crane operation state including an actual load, boom radius, maximum lifting distance, hook lifting distance, and the like are obtained from data such as a boom length, boom angle, pressure, rope extension amount, and the like. A limit load is obtained from the parameters and a preset limit load data defined by the crane specification. At step S_{5a}, the safety degree of the crane operation is calculated from the results obtained at the step S_{4a}, the crane operation state is compared with the operation limit value, and an automatic stop process is executed by generating a stop signal if the crane operation state is in the danger range or over the operation limit.

After the above sequence steps, the main unit CPU enters a stop (HALT) state at step S_{6a}. When a hardware interrupt request (IREQ) for receiving data is received from the external component, the main unit CPU in the stop state executes the interrupt process and thereafter returns to the loop start point. If there is no hardware interrupt, the main unit CPU remains at step S_{6a}. In Fig.11, although a hardware interrupt is set between step S_{6a} and the loop start point, this interrupt may be set at a desired point in the sequence at steps S_{3a} to S_{6a}. In the main flow, data reception at the main unit and data transmission to the display unit are activated by an interrupt. After transmission/reception of new data, the data is processed and the automatic stop process is executed.

(2) Display Unit Operation Sequence

Fig.12 shows the main flow of the display unit. The first step S_{1b} initializes the display unit CPU settings for achieving the proper execution at the following steps. At step S_{2b}, an interrupt inhibition is released. In displaying the crane operation state changing from time to time on the display in a certain display mode, the graphic image for the crane operation state is first written in the video RAM. The graphic image data is read from the video RAM at a predetermined time interval, e.g., 150 ms and displayed on the display. In this manner, the contents of the graphic image on the display are updated at the interval of 150 ms. In this embodiment, coordinate values of each line segment constituting an image are stored as the graphic image data. If a display update flag is being set at step S_{3b},then at step S_{4b} the graphic image data is transferred from the video RAM to the display to update the displayed image.

In response to powering or resetting the apparatus, the initial display data stored in the video RAM set at step S_{1b} is displayed. Thereafter, CPU enters in a stop (HALT) state at step S_{5b} and maintains as it is until a hardware interrupt is received.

A hardware interrupt to the display unit CPU includes a timer interrupt and a data transmission/reception interrupt relative to the main unit CPU. The display unit CPU transmits or receives the data for a given type of hardware interrupt. In the main flow after an interrupt, a process for a selected mode is executed at step S_{6b}. Specifically, a graphic image for the selected mode is written in the video RAM in accordance with new data. This process for a selected mode is activated always by a hardware interrupt. A hardware interrupt is allowed also during this graphic image processing, but it is not allowed during a short time period while a hardware interrupt is processed. The updated graphic image in the video RAM is displayed on the display at steps S_{3b} and S_{4b}.

(3) Calculation of Hook Lifting Distance

Calculation of a hook lifting distance by CPU 200 is carried out by the routine shown in Fig.13 which is activated at a predetermined time interval. The pulse sensor generates a pulse each time the rope is extended by a predetermined amount. There is a counter buffer for counting these pulses. At step S_{1c}, the count in the counter buffer is read as a new pulse number. At step S_{2c} the new pulse number is subtracted from an old pulse number read at the previous count time and stored in a software register. The resultant pulse count is the number of pulses generated during the period from the previous count time and present count time as the rope is extended. If the resultant pulse count is 0 at step S_{3c},it means that the rope was not extended during this period. Therefore, the rope shift distance is set to 0 at step S_{4c}. If the pulse count is not 0, at step S_{5c} the new pulse number is replaced by the old pulse number stored in the software register. At step S_{6c}, the rope shift distance is calculated from (pulse count) × (rope extension amount per one pulse). At step S_{7c} it is checked if the winch lever is for winding or releasing. If not winding, at step S_{8c} the present rope extension amount is obtained by adding this rope shift distance to an old rope extension amount calculated at the previous count time and stored in a software register. If winding, at step S_{9c} the present rope extension amount is obtained by subtracting this rope shift distance from the old rope extension amount. This present rope extension amount is replaced by the old rope extension amount stored in the software register. At the next step S_{10}, a boom length shift amount is obtained by subtracting the old boom length detected at the previous count time from the present boom length. At step S_{10c}, the rope extension amount obtained at step S_{8c} or S_{9c} is subtracted by the rope extension amount corresponding to the boom length shift amount and by the rope extension amount corresponding to the jib offset angle shift. The resultant rope extension amount is divided by the number or ropes on hook to obtain $\underline{m}$ representing the rope length hanging down from the overhoist position described before. Therefore, the hook lifting distance is obtained at step S_{11c} by subtracting $\underline{m}$ from the maximum lifting distance calculated from the crane operation state.

When the hook structure reaches the overhoist position and the overhoist position sensor turns on, an interrupt routine shown in Fig.14 starts running. At step S_{1d}, it is checked if the boom angle is 30° or more. If lower than 30°, the timer is reset at step S_{2d}. At step S_{3d} if 30° or more and the timer is not operating (that the timer is operating means that the overhoist position sensor was turned on and its process is being executed), the timer is caused to start at step S_{3d}. Upon time-out of the timer, at step S_{1e} an interrupt routine shown in Fig.15 starts to forcibly reset to 0 the rope extension amount calculated by the process shown in Fig.13 and stored in the software register. In this manner, the reference point for the rope extension amount is automatically modified. If the hook structure moves away from the overhoist position and the sensor turns off before time-out of the timer, the timer is reset by an interrupt routine shown in Fig.16 at step S_{12f}. Namely, only when the hook structure remains at the overhoist position during the predetermined time period, the reference point of the rope extension amount is modified.

Claims

1. In a method of obtaining a maximum hook lifting distance L in accordance with crane mechanism setting state, obtaining a hanging length $\underline{1}$ of a hook structure hung by a rope from the crane mechanism, and obtaining a hook lifting distance (l - 1), said method comprising:

detecting a rope shift distance at a predetermined time interval to obtain a rope extension amount as an accumulated value of said rope shift distances;

determining said hanging length 1 in accordance with said rope shift distance accumulated value; and

resetting said accumulated value when said hook structure is at a maximum hook lifting position to renew the reference position of said rope extension amount.

2. A method of obtaining a hook lifting distance according to claim 1, wherein said rope extension is detected as a movement of said rope relative to said boom structure.

3. A method of obtaining a hook lifting distance according to claim 2, wherein a boom length shift amount is detected at a predetermined time interval to modify said hanging length 1 by said boom length shift amount.

4. A method of obtaining a hook lifting distance according to claim 2, a jib offset angle shift amount is detected at a predetermined time interval to modify said hanging length 1 by said jib offset angle shift amount.

5. A method of obtaining a hook lifting distance according to claim 1, wherein said maximum hook lifting distance is defined under the condition that said hook structure is at an overhoist position.

6. A method of obtaining a hook lifting distance according to claim 5, wherein said accumulated value is reset only when said hook structure is at said overhoist position and a boom angle is 30° or more.

7. A method of obtaining a hook lifting distance according to claim 5, wherein said accumulated value is reset only when said hook structure is at said overhoist position longer than a predetermined time period.

8. A hook structure display apparatus having means for receiving a signal from a sensor for detecting the operation state of a crane mechanism and display means having a two-dimensional screen, said apparatus comprising:
hook lifting distance display means for dynamically displaying a schematic illustration of said hook structure on said screen, said means responsive to said signal from said sensor, for determining the position of said schematic illustration on said screen relative to an index fixedly displayed on said screen; and

means including a key for setting a target position of said hook structure as a reference point of said index, in response to a key input by an operator when said hook structure is selected and moved to said target position.

9. A hook structure display apparatus according to claim 8, wherein said display means moves said hook structure schematic illustration on said screen relative to said index, in response to a movement of said hook structure in the vertical direction.

10. A crane safety apparatus having means for receiving a signal from a sensor for detecting the operation state of a crane mechanism and display means having a two-dimensional screen, said apparatus comprising:

hook structure schematic illustration display means for dynamically displaying a schematic illustration of a hook structure on said screen, said means responsive to said signal from said sensor, for determining the coordinates of said schematic illustration on said screen relative to the coordinate axes of said screen;

means including a key for fixedly displaying an operation limit range pattern on said screen relative to said schematic illustration on said screen, in response to a key input by an operator when said hook structure is selected and moved to said target position; and

means for detecting a rope shift distance at a predetermined time interval to obtain a rope extension amount as an accumulated value of said rope shift distances, resetting said accumulated value when said hook structure is at a predetermined position to renew the reference position of said rope extension amount,

wherein said display means determines the coordinates of said hook structure on said screen in accordance with said rope extension amount.

11. A hook structure display apparatus according to claim 10, wherein said accumulated value is reset only when said hook structure is at an overhoist position and a boom angle is 30° or more.

12. A hook structure display apparatus according to claim 10, wherein said accumulated value is reset only when said hook structure is at said overhoist position longer than a predetermined time period.

FIG. 1A

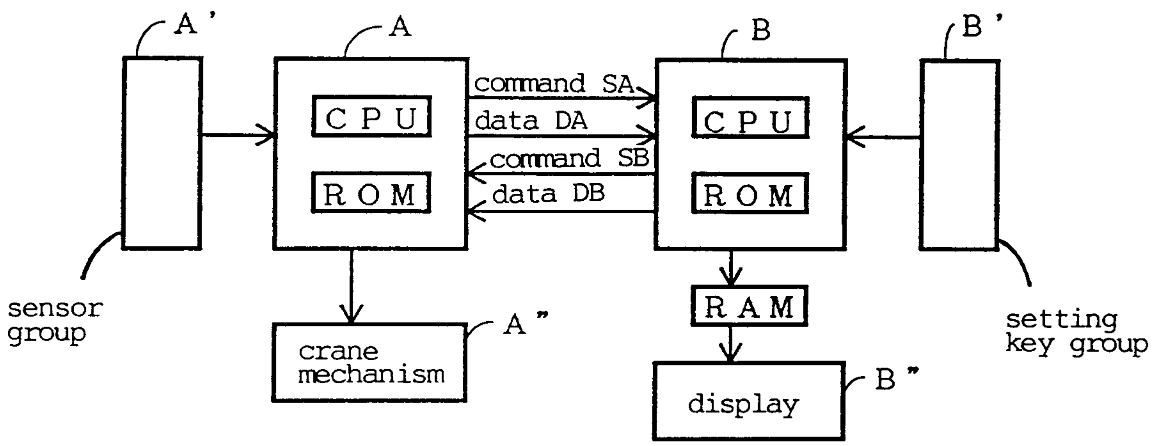
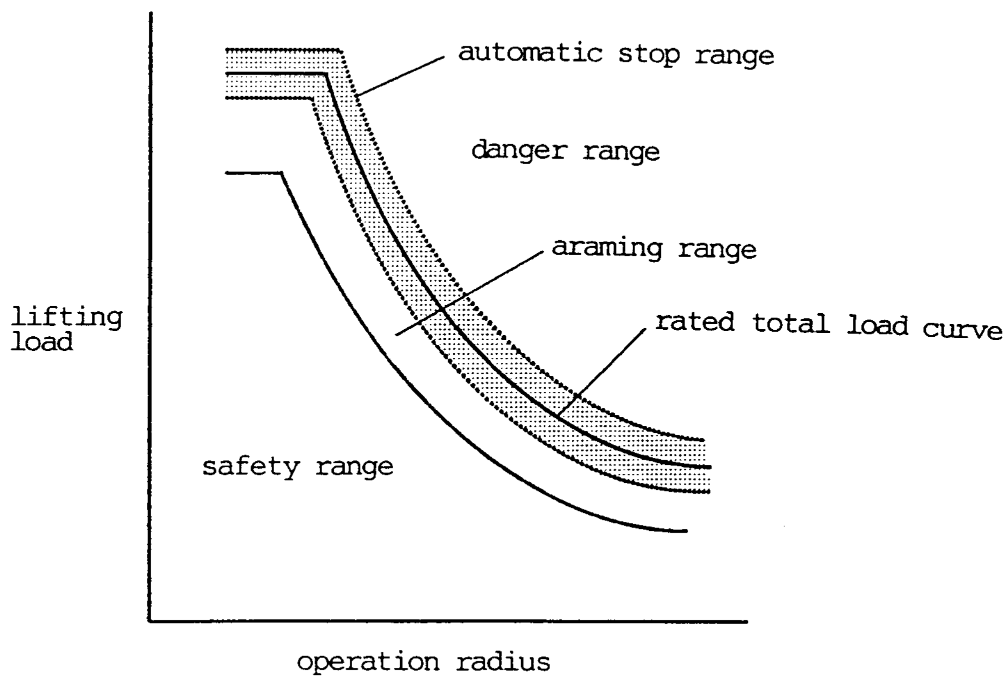

A'
A
B
B'
CPU
ROM
command SA
data DA
command SB
data DB
CPU
ROM
RAM
sensor group
crane mechanism
A"
display
B"
setting key group

FIG. 1B


automatic stop range
danger range
araming range
rated total load curve
lifting load
safety range
operation radius

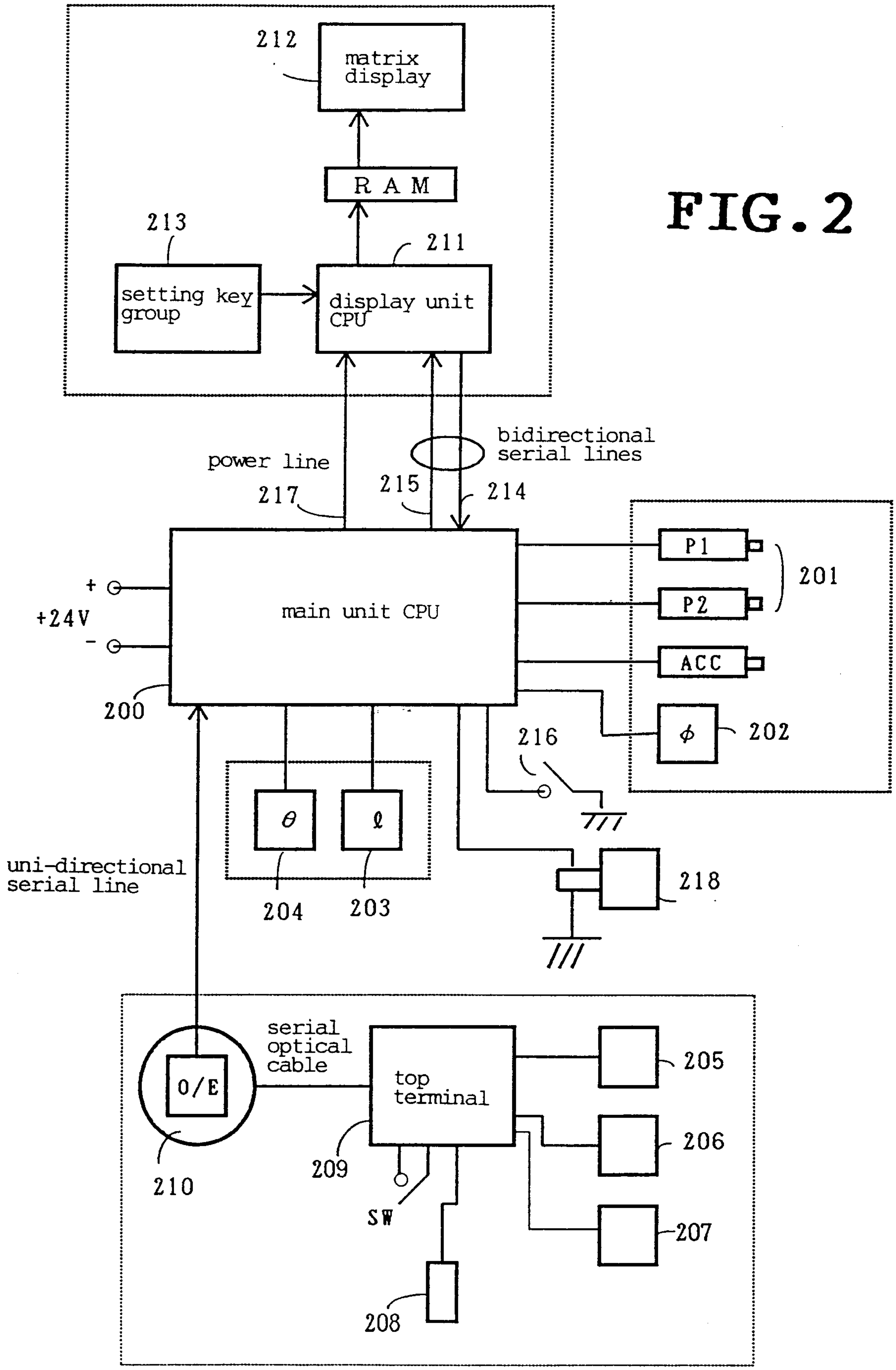
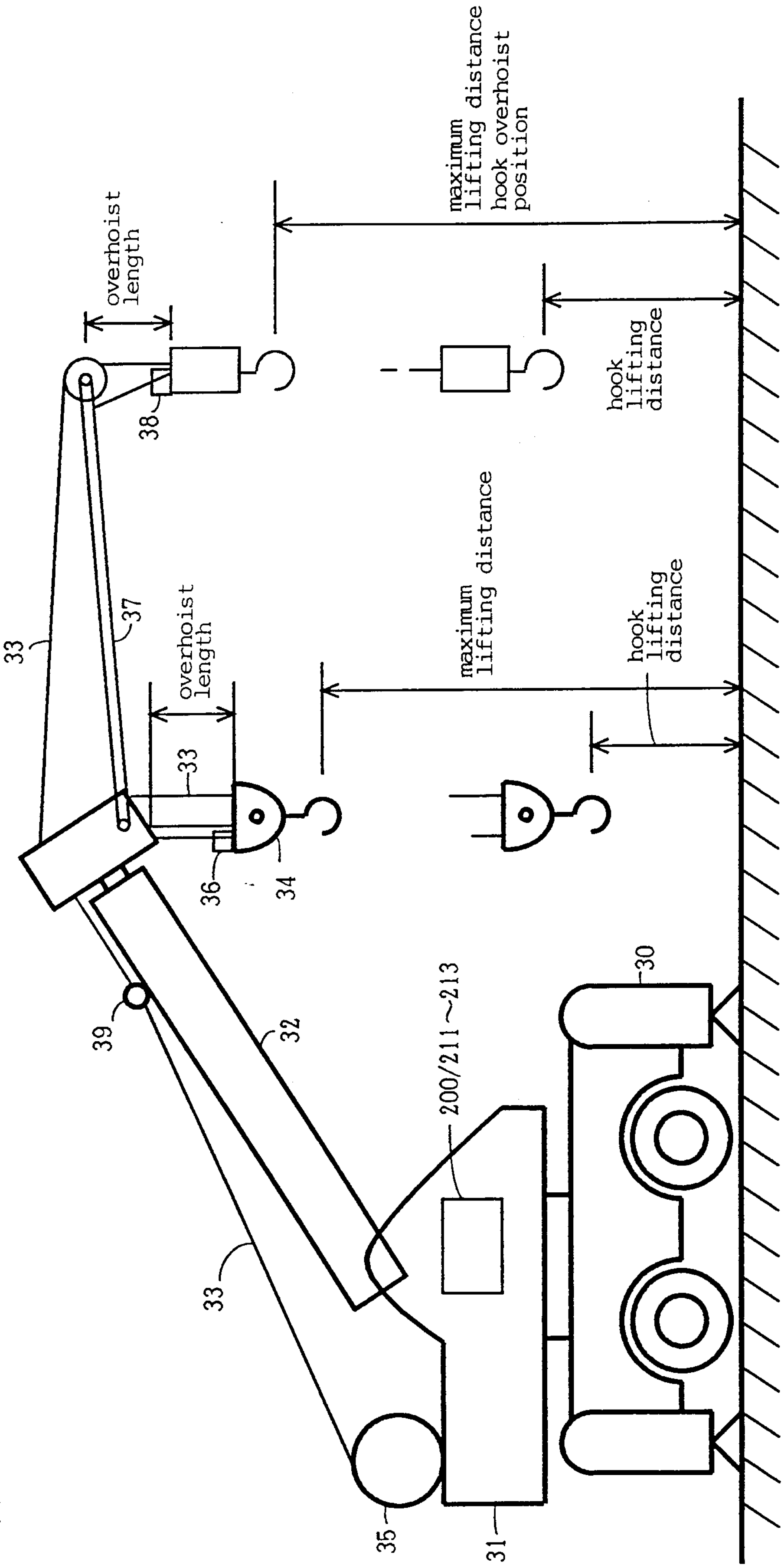

212
matrix display
R A M
213
211
setting key group
display unit CPU
bidirectional serial lines
power line
217
215
214
main unit CPU
+
+24V
-
200
P1
P2
201
ACC
202
216
204
203
218
uni-directional serial line
serial optical cable
O/E
top terminal
205
206
207
208
209
210
SW

FIG. 2

FIG.3


maximum lifting distance
hook overhoist position
overhoist length
hook lifting distance
maximum lifting distance
overhoist length
hook lifting distance
30
31
32
33
33
33
33
34
35
36
37
38
39
200/211~213

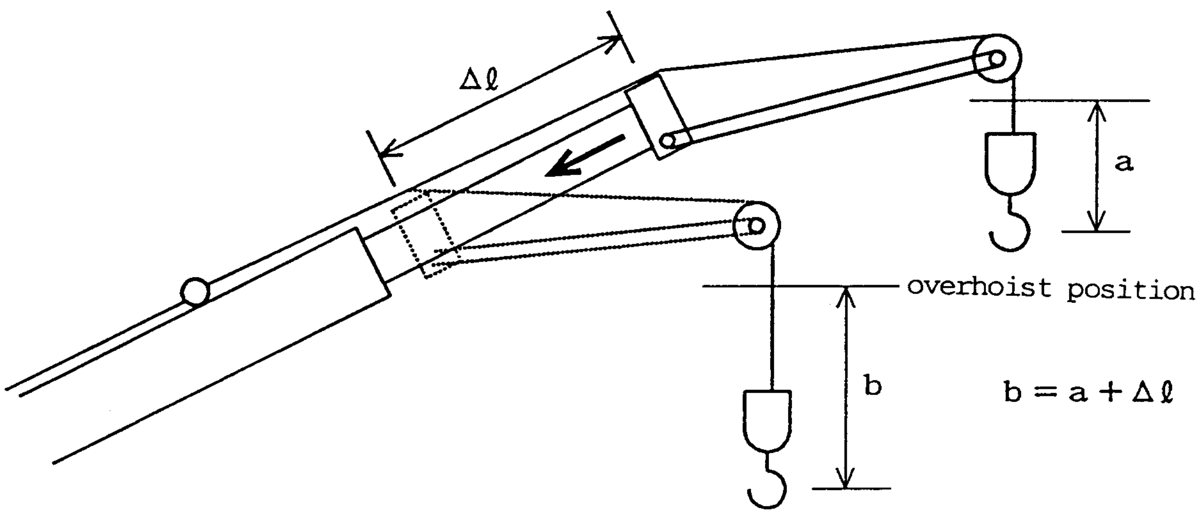


FIG.4

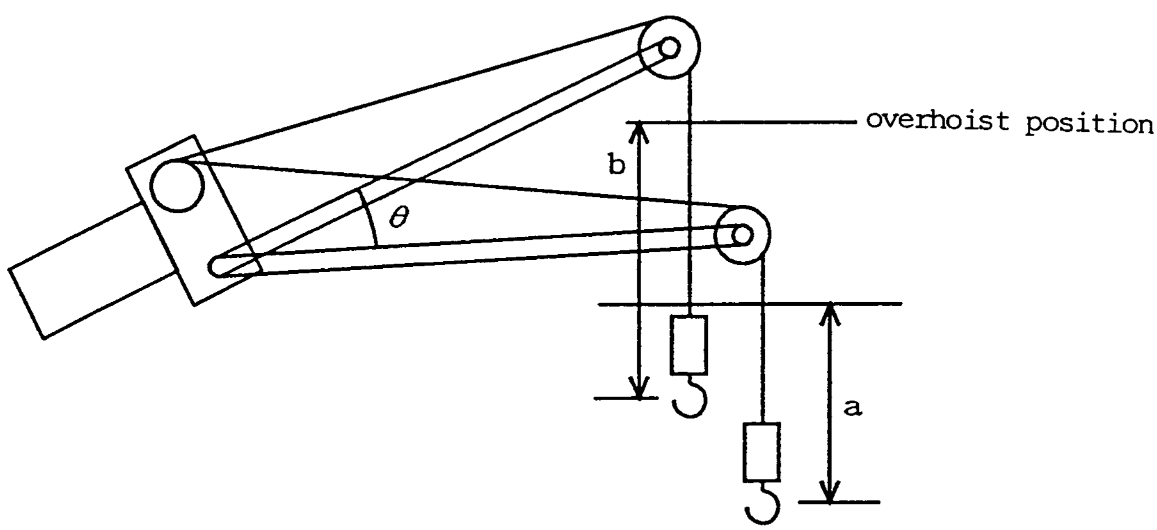


FIG.5

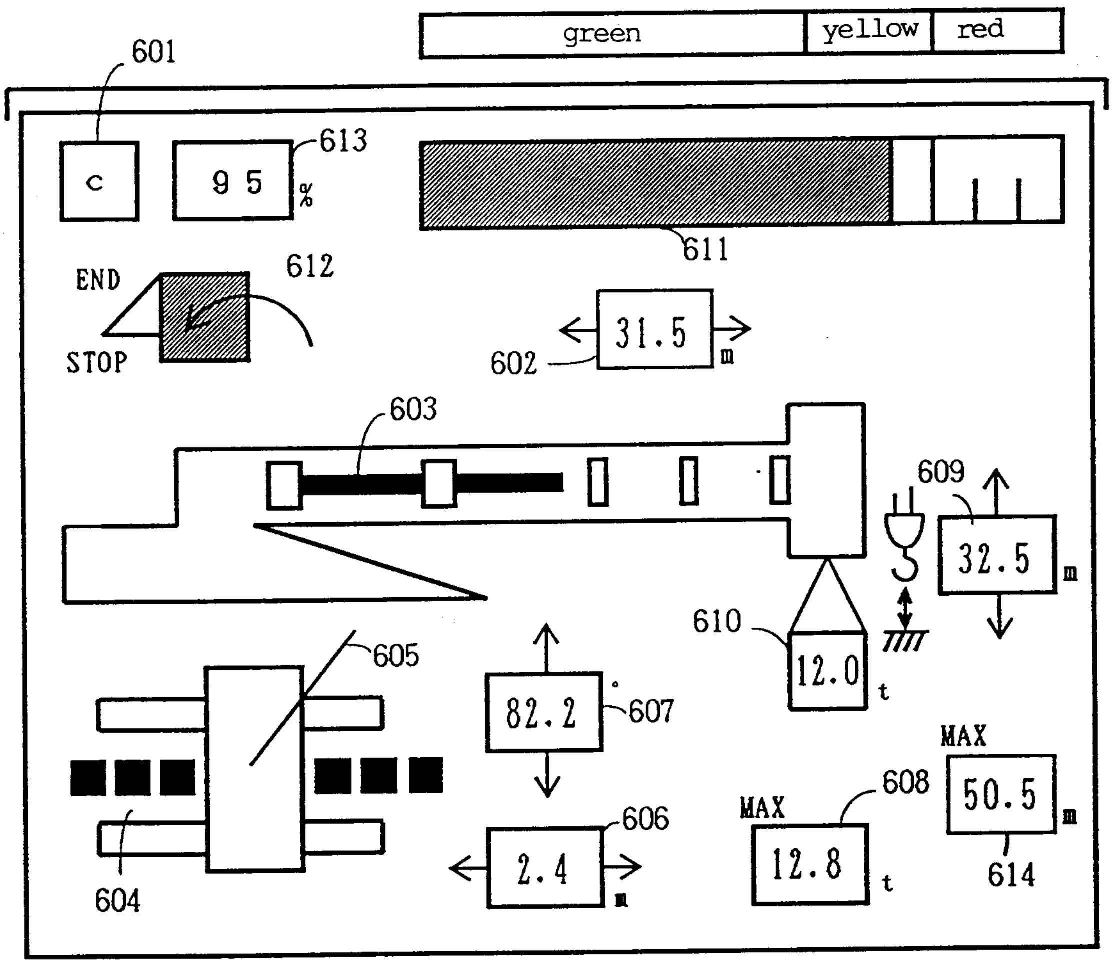

green
yellow
red
601
C
9 5
%
613
611
END
STOP
612
31.5
m
602
603
609
32.5
m
610
12.0
t
605
82.2
°
607
604
2.4
m
606
MAX
12.8
t
608
MAX
50.5
m
614

FIG.6

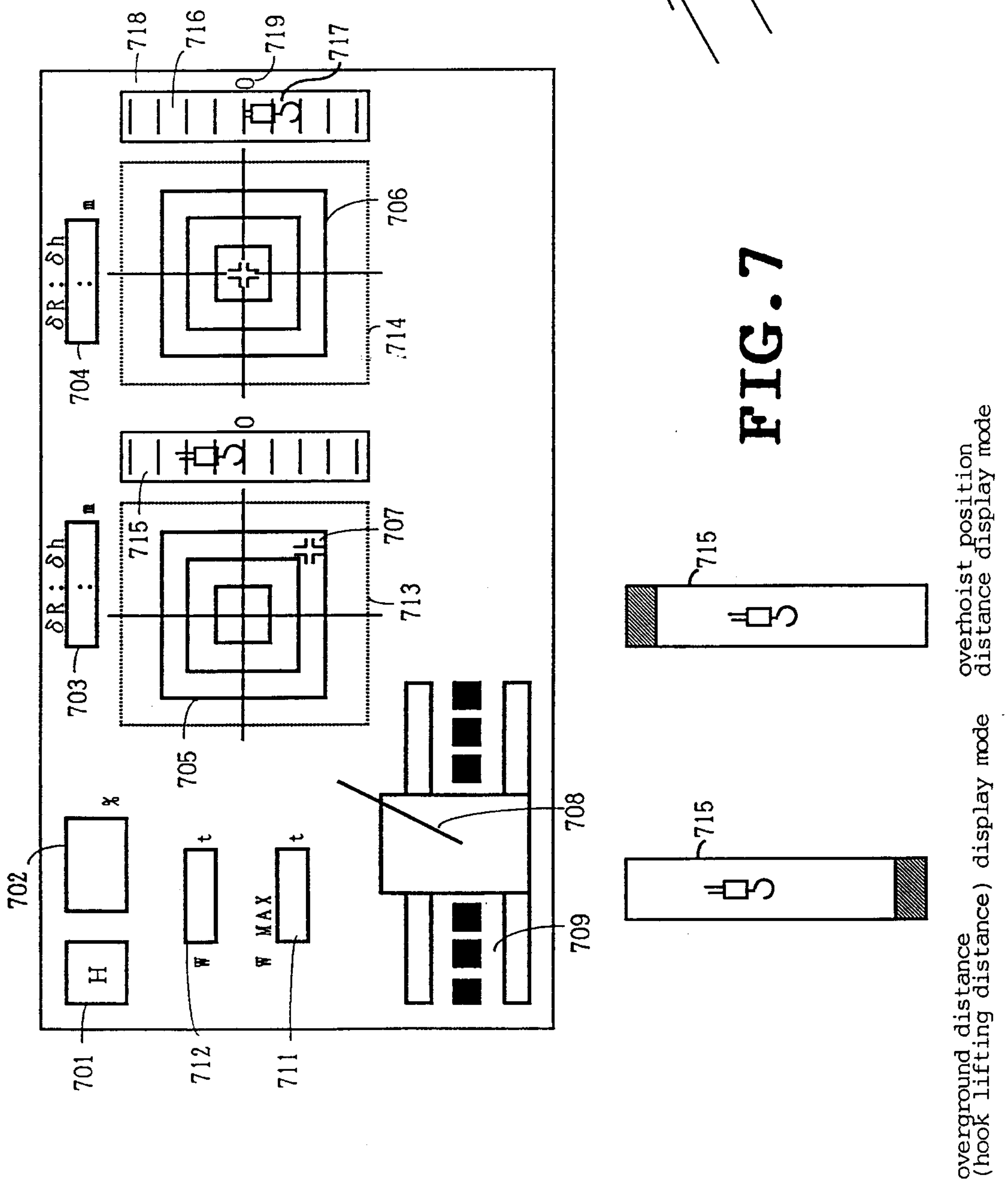

701
702
703
704
705
706
707
708
709
711
712
713
714
715
716
717
718
719
H
%
W
t
W MAX
t
δR : δh
m
0
overground distance
(hook lifting distance) display mode
overhoist position
distance display mode

FIG.7

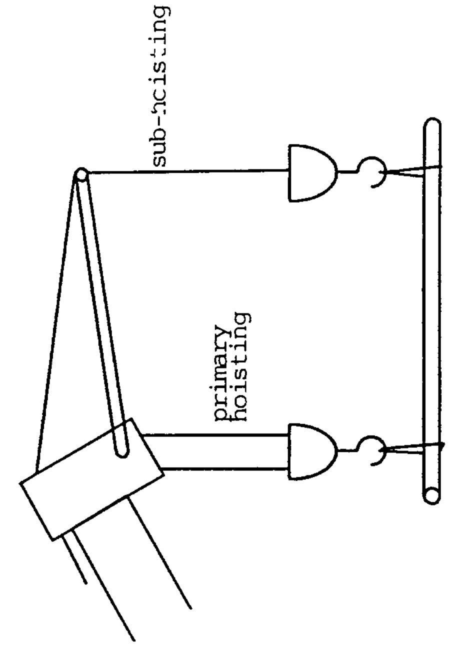

sub-hoisting
primary
hoisting

FIG.8

FIG.9

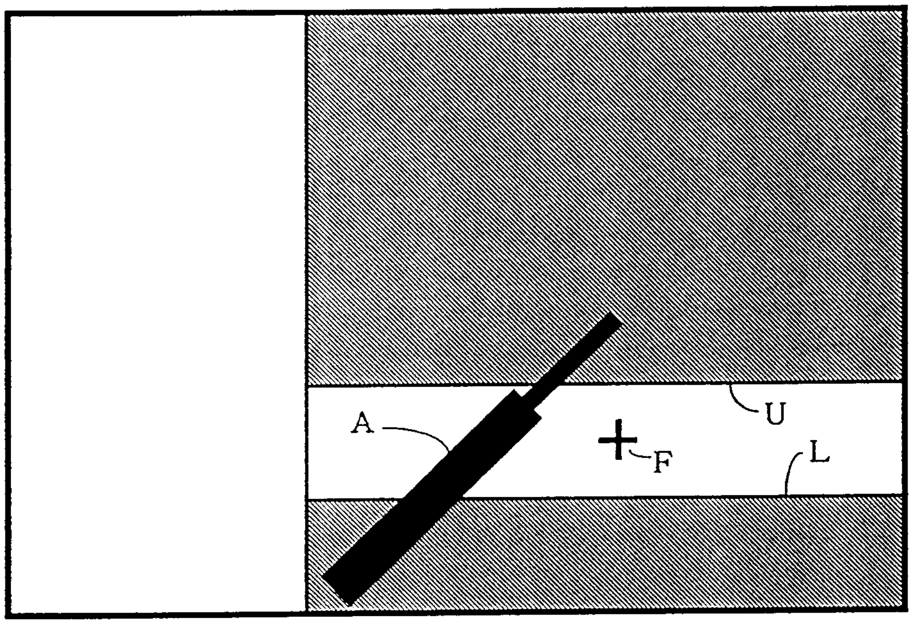


FIG.10

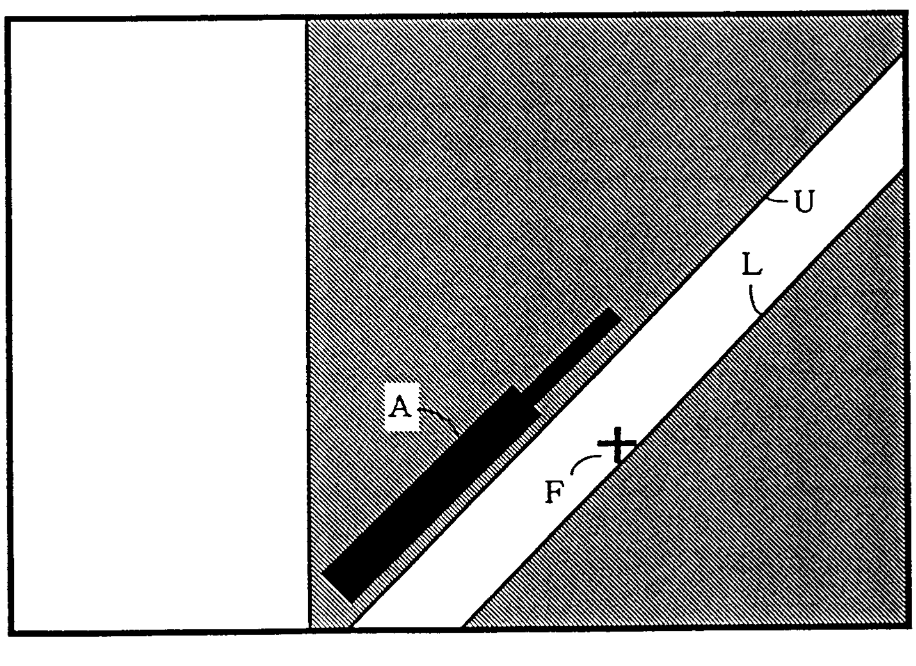


FIG.11

(main flow main unit)

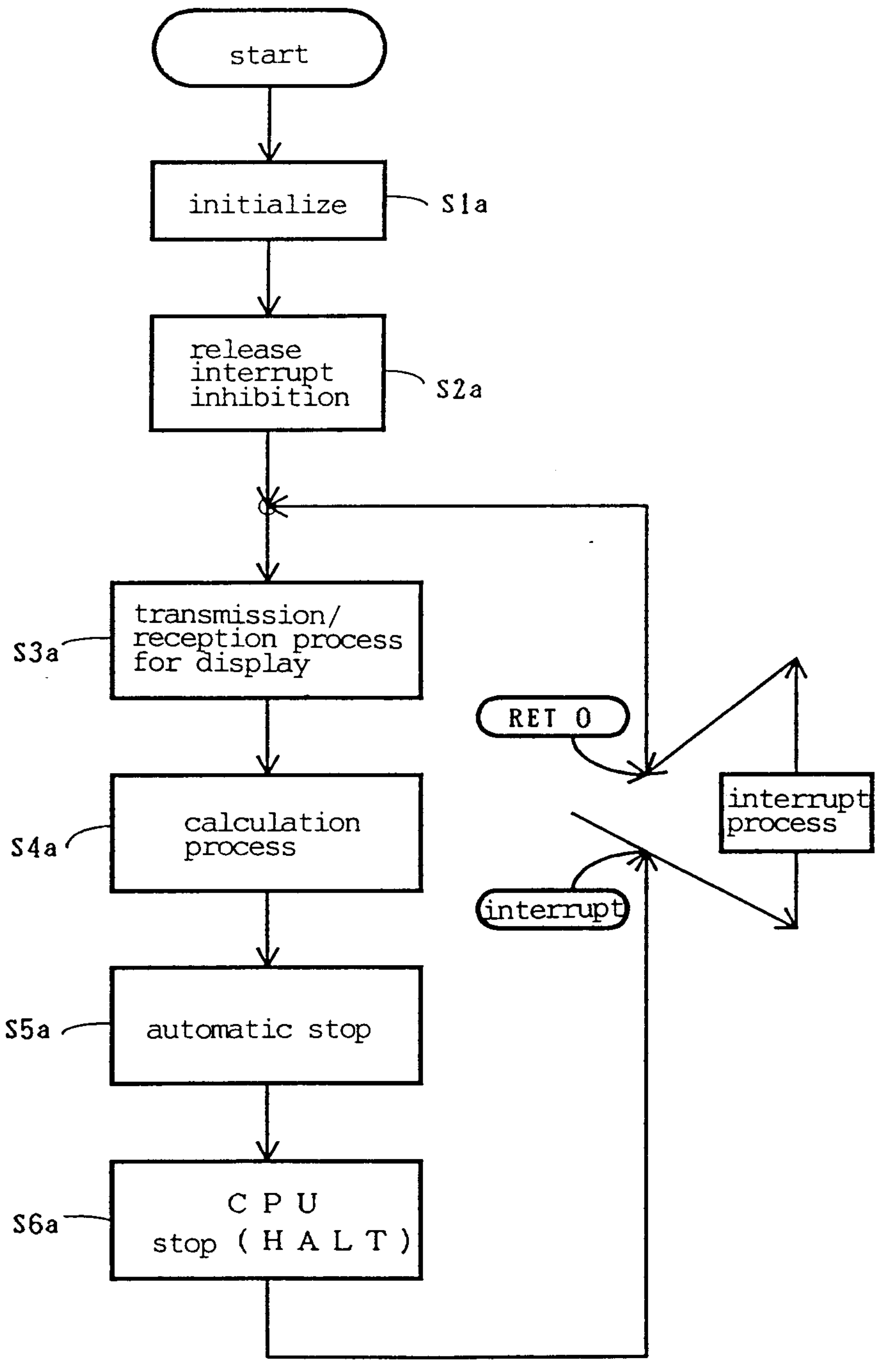


FIG.12

(main flow of display unit)

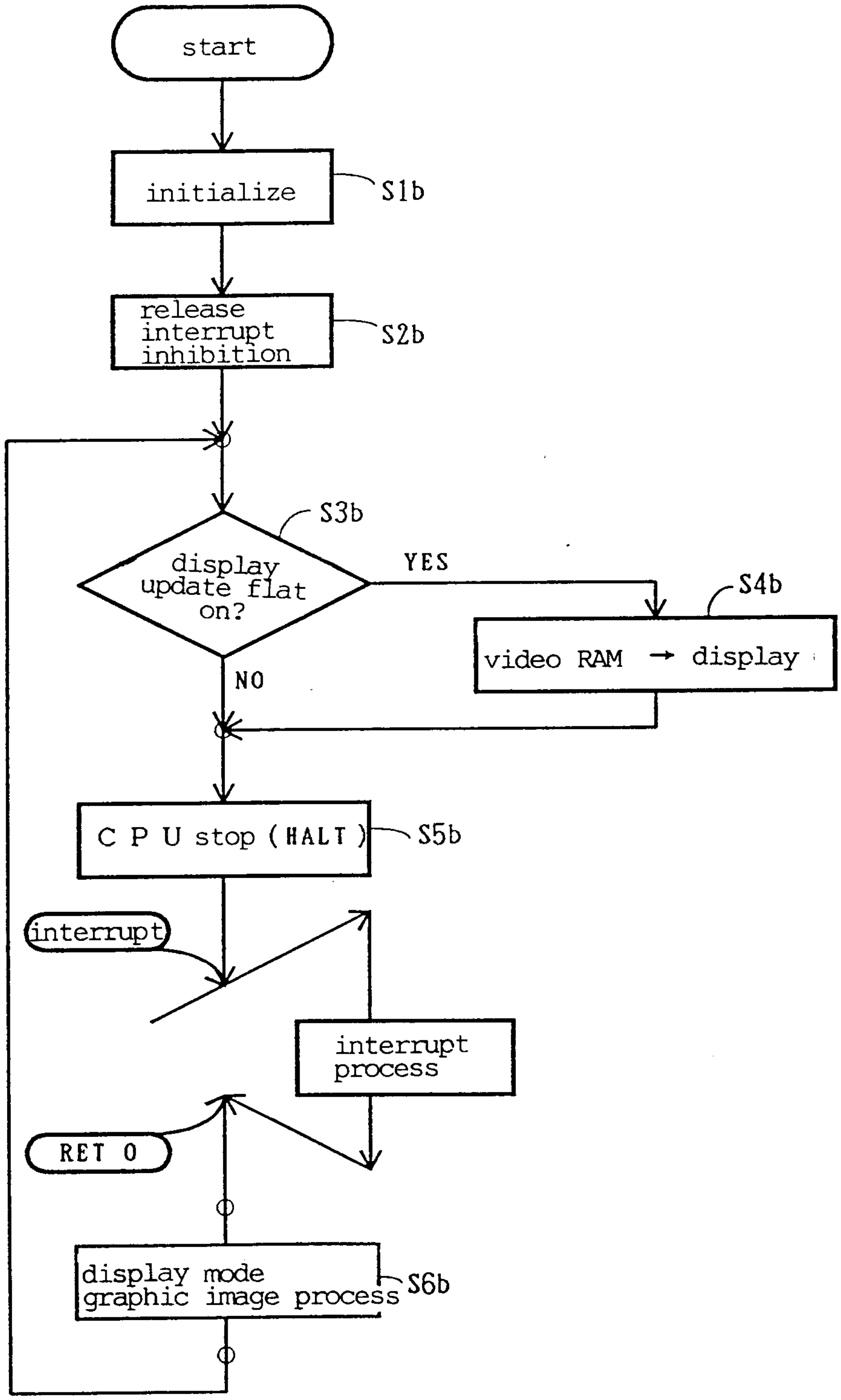
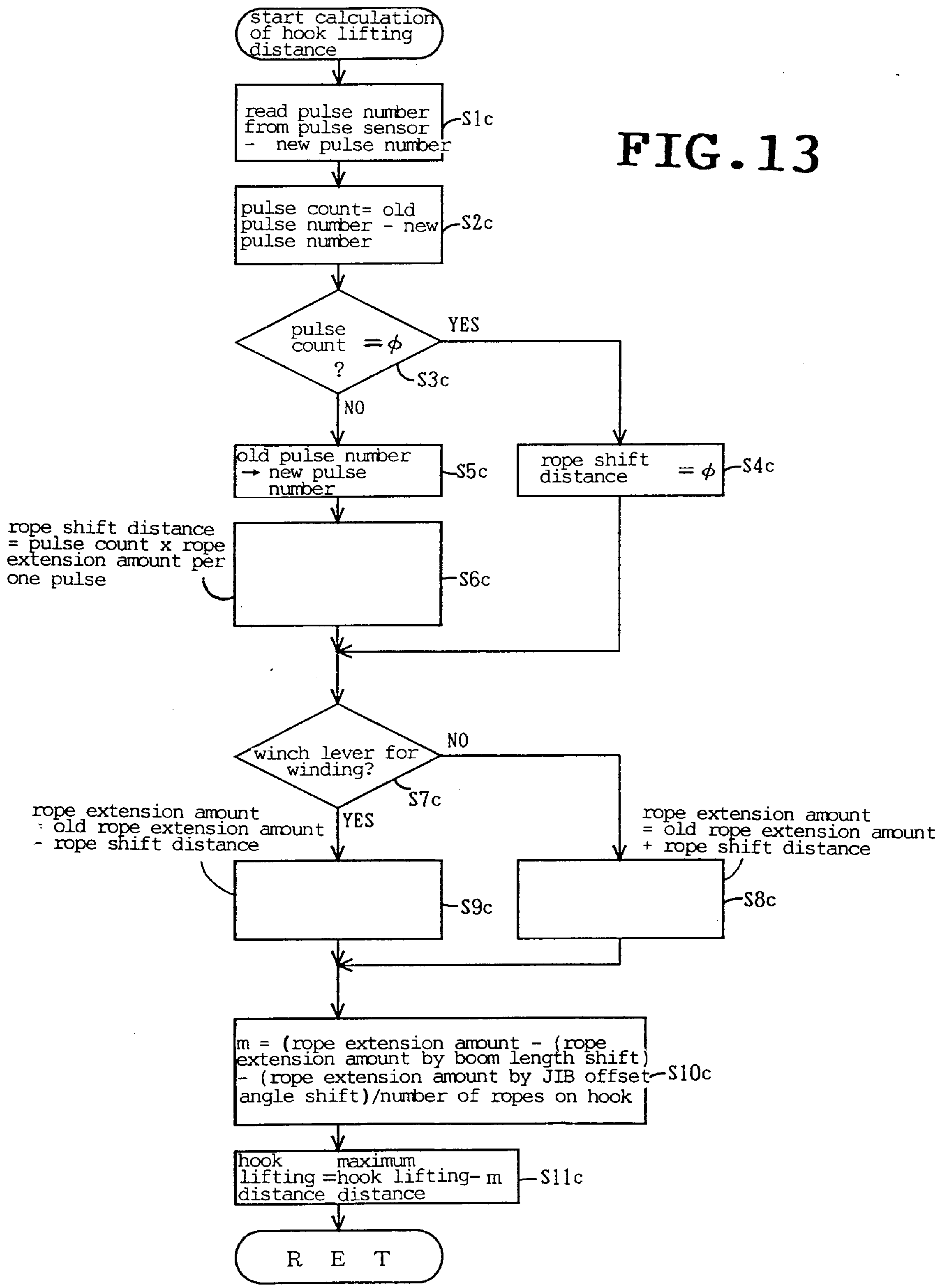


FIG.13


start calculation of hook lifting distance
read pulse number from pulse sensor - new pulse number
S1c
pulse count= old pulse number - new pulse number
S2c
pulse count =φ ?
S3c
YES
NO
old pulse number → new pulse number
S5c
rope shift distance =φ
S4c
rope shift distance = pulse count x rope extension amount per one pulse
S6c
winch lever for winding?
S7c
NO
YES
rope extension amount = old rope extension amount - rope shift distance
S9c
rope extension amount = old rope extension amount + rope shift distance
S8c
m = (rope extension amount - (rope extension amount by boom length shift) - (rope extension amount by JIB offset angle shift)/number of ropes on hook
S10c
hook lifting distance = maximum hook lifting distance - m
S11c
R E T

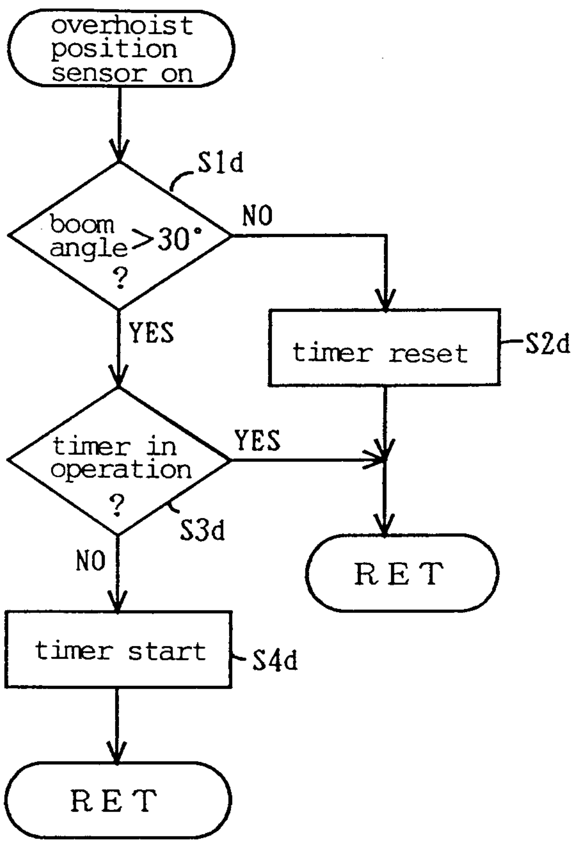


FIG.14

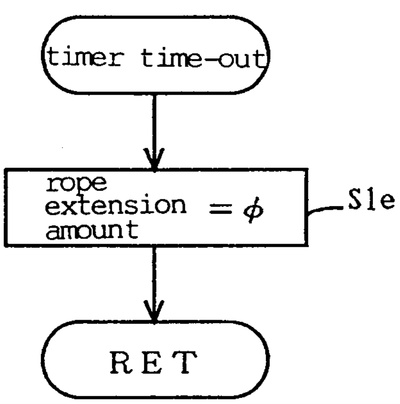


FIG.15

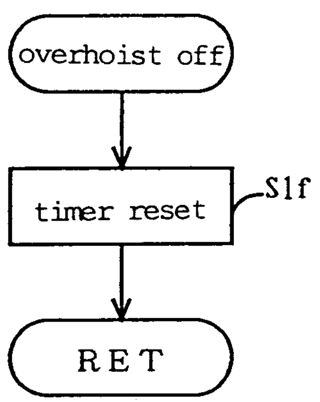


FIG.16

INTERNATIONAL SEARCH REPORT

International Application No PCT/JP90/00784

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^5 B66C13/46, B66C23/90

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC	B66C13/46, B66C23/90

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

Jitsuyo Shinan Koho	1926 - 1990
Kokai Jitsuyo Shinan Koho	1971 - 1990

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]
A	JP, U, 63-178291 (Ishikawajima Kenki K.K.), 18 November 1988 (18. 11. 88), (Family: none)	1 - 12
A	JP, A, 62-205993 (Komatsu, Ltd.), 10 September 1987 (10. 09. 87), (Family: none)	1 - 12
A	JP, U, 60-107710 (Ishikawajima-Harima Heavy Industries Co., Ltd.), 22 July 1985 (22. 07. 85), (Family: none)	1 - 12
A	JP, Y, 54-30754 (Kato Seisakusho, K.K.), 27 September 1979 (27. 09. 79), (Family: none)	1 - 12
A	JP, U, 58-23883 (Tadano Iron Works Co., Ltd.), 15 February 1983 (15. 02. 83), (Family: none)	8 - 10

* 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
August 31, 1990 (31. 08. 90)	September 17, 1990 (17. 09. 90)
International Searching Authority	**Signature of Authorized Officer**
Japanese Patent Office	