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

(11) EP 0 406 419 B2

(12) **NEW EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the opposition decision:
28.08.2002 Bulletin 2002/35

(45) Mention of the grant of the patent:
28.06.1995 Bulletin 1995/26

(21) Application number: **89904237.8**

(22) Date of filing: **06.04.1989**

(51) Int Cl.[7]: **B66C 23/90**

(86) International application number:
PCT/JP89/00368

(87) International publication number:
WO 90/007465 (12.07.1990 Gazette 1990/16)

(54) Crane safety apparatus

SICHERHEITSANORDNUNG FÜR KRÄNE

DISPOSITIF DE SECURITE POUR GRUES

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

(30) Priority: **27.12.1988 JP 33019788**

(43) Date of publication of application:
09.01.1991 Bulletin 1991/02

(60) Divisional application:
94201063.8 / 0 614 845

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- **"LICCON" operating instructions**

Remarks:
Divisional application 94201063.8 filed on 06/04/89.

EP 0 406 419 B2

Description

Detailed Description of the Invention

Field of the Invention

[0001] The present invention relates to a crane safety apparatus, and more particularly to a crane safety apparatus having a plurality of image display modes and capable of providing an operator with crane operation status settings and safe operation in accordance with a selected image display mode.

Background of the Invention

[0002] A conventional crane safety apparatus (such as disclosed in document GB-A-2 050 294) has a function wherein various operation parameters (boom length, boom angle, outrigger projection, jib setting, and the like) for determining the operation status of a crane are inputted, a specific load for the operation status determined by these operation parameters is accessed from previously stored specific loads for various operation status determined in accordance with the specification of a crane, the accessed specific load is compared with the current actual load, if the actual load becomes near the specific load, a warning is issued, and if it becomes equal to the specific load, the crane operation is automatically stopped. A conventional crane safety apparatus of this type has an indication panel such as shown in Fig. 12. The operation status such as crane outrigger projection, jib setting and the like is set by using switches mounted on the indication panel so that values representative of the current boom length, angle and the like are displayed from time to time. A safety meter is mounted on the upper portion of the indication panel. The safety meter displays in the form of bar graph the safety degree of an actual load relative to the specific load for the current crane operation status.

[0003] A problem associated with such conventional technique is that only the safety degree of an actual load relative to the specific load, i.e., the safety degree of actual operation, is provided. As a result, an operator cannot recognize sufficiently the danger for the next possible stage and operation.

[0004] Further, although there are provided warning and automatic stop for the possible overturn, or collapse of a crane, there is not provided a function to regulate the operation range of a crane when considering other buildings or the like.

[0005] Furthermore, there is not provided a function to ensure proper and safe operation at the operation site which an operator cannot visually recognize.

Brief Description of the Drawings

[0006]

Fig. 1 is a schematic diagram showing the apparatus of this invention mounted on a crane;
Fig. 2A is a block diagram showing the fundamental structure of the apparatus according to this invention;
Fig. 2B shows an example of a specific load data curve stored in the apparatus of this invention;
Fig. 2C is a block diagram showing a particular structure of the apparatus of this invention;
Fig. 3 shows a display pattern on the screen during an operation status setting mode according to the apparatus of this invention;
Fig. 4A shows a display pattern on the screen during an ACS mode according to the apparatus of this invention;
Fig. 4B shows illustrative representations of the causes of automatic stop to be displayed on the screen according to the apparatus of this invention;
Fig. 5 shows a display pattern on the screen during an operation range setting mode according to the apparatus of this invention;
Fig. 6 shows a display pattern on the screen during a target mode according to the apparatus of this invention;
Fig. 7 shows a display pattern on the screen during a limit load - slewing angle mode according to the apparatus of this invention;
Fig. 8 shows a display pattern on the screen during a performance curve display mode according to the apparatus of this invention;
Fig. 9A shows a part of the crane total specific load table;
Fig. 9B shows a display pattern on the screen during a performance table display mode according to the apparatus of this invention;
Fig. 10 shows the operation sequence of the main unit;
Fig. 11 shows the operation sequence of the display unit; and
Fig. 12 shows an ACS apparatus according to the prior art.

〈Description of Reference Numerals for Main Elements〉

[0007]

Main CPU ... 200
Sensor ... 201, 202, 205, 206, 208
Display CPU ... 211
Display ... 212
Setting key switch group ... 213

Summary of the Invention

[0008] The crane safety apparatus of this invention as set out in claim 1 has a memory which stores therein display images for a plurality of crane operation modes. The display image selected by an operator is controlled to indicate the current crane operation status in accordance with the crane operation parameters and operator setting data.

[0009] According to this invention, the crane safety apparatus comprises a main unit controller and a display unit controller each having a CPU. CPUs of the main and display unit controllers run independently from each other on sequence programs for the display control. Commands and data transfer between CPUs of the main and display unit controllers is activated by an interrupt. According to the present invention, jobs are assigned properly to the main and display unit controller CPUs so that the crane operation status can be displayed without any time delay to allow quick control of the crane and display of a schematic diagram of complicated crane operation status.

Description of the Embodiment

- Mounts of Apparatus on Crane -

[0010] As shown in Fig. 1, an ACS main unit 2 and display unit 3 are installed within a crane operation room 1. An operator sets crane operation conditions and operates the crane while viewing a display selected from a plurality of display modes and displayed on the screen. The crane operation status (boom length ℓ, boom angle θ, slewing angle ϕ, actual load W and the like) is detected with various sensors including a stress sensor 4, boom angle sensor 5, slewing angle sensor 6, front jack setting sensor 7, counterweight sensor 8, spiral sensor 9 and the like. The sensor output data are sent to the ACS main unit. The ACS main unit checks when the crane operation status reaches a predetermined danger zone to issue a crane stop command to an automatic stop apparatus.

- Fundamental Structure of Apparatus -

[0011] The fundamental structure of the ACS apparatus of this invention is shown in Fig. 2A. The ACS apparatus is constructed of a main unit and a display unit. During the operation of the apparatus, commands and data are transferred between a main unit controller A and a display unit controller B.

[0012] Upon power-on, the crane operation status (outrigger projection step, jib step and the like) is first required to be set. This setting is carried out at the display unit. An operator selects an operation status setting mode from a plurality of display modes to display a display indication such as shown in Fig. 3 on a display B" screen, and operates predetermined keys on a setting key group B' while monitoring the display B" screen. The display unit controller B has a memory which stores therein, in the form of a bit map, graphics data for display images such as shown in Fig. 3. In accordance with a display control program in a ROM, CPU selectively reads a display image shown in Fig. 3 from the memory, writes it in a video RAM, and displays the display image on the display B" screen in accordance with the data read from the video ram. The display unit controller B fetches the data of outrigger step setting and the like entered from a setting key by an operator, modifies the display image so as to match the setting data, and supplies the setting data as data B to the main unit controller A. Upon setting completion in the operation status setting mode, the display unit controller B enters an ACS mode and displays a display image such as shown in Fig. 4A on the display B" screen. The graphics data for the display image such as shown in Fig. 4A have already been stored in the memory, so CPU executes a selective read and display of the graphics data.

[0013] In addition to the crane operation status setting data B supplied from the display unit controller B, the main unit controller A obtains from a sensor group A' the operation parameter data (such as boom length ℓ, boom angle θ, slewing angle ϕ) representative of the operation status of the crane mechanism which changes from time to time as the crane is operated. These operation parameters are sent directly, or after processed by CPU, to the display unit controller B as data A. The display unit controller B modifies from time to time the display image on the display B" screen in accordance with the data A, to thereby display the current operation status of the crane.

[0014] The main unit controller A stores various data in accordance with each crane specification. Such data are typically maximum specific loads for various crane operation status. For example, a total specific load curve shown in Fig. 2B is used for the operation status settings such as with outrigger intermediate projection of (5.0 m - side direction), without jib, and with boom length of 8.9 m. Such a total specific load curve is determined for each of different operation status settings and boom lengths, in accordance with each crane specification. A great number of these data are stored in ROM of the main unit controller A.

[0015] In accordance with the crane operation status setting data B supplied from the display unit controller B and the crane operation status parameters changing with time supplied from the sensor group A', the main unit controller A accesses ROM to obtain the maximum specific load data for the crane operation status at that time, or compares the maximum load value obtained by processing the data with the actual load and if the current crane operation status is in La danger zone, a warning is issued, or/and delivers a signal for controlling the crane mechanism A" for automatic stop of the crane operation.

[0016] In the bit map memory of the display unit controller B, there are stored a plurality of display image graphics data corresponding to a plurality of display modes. A display image such as shown in Figs. 5 to 9 is selected in accordance with the display mode selected by a setting key. In addition to the ACS mode shown in Fig. 4 conventionally provided in general, an operator can use other display modes to set the operation contents of a crane and monitor it for the effective crane operation. The operation of other display modes will be later detailed.

[0017] The main unit controller A and display unit controller B each have a processor (CPU), and they run independently on its own program. Transmission/reception of commands and data between the main unit controller A and display unit controller B is allowed by an interrupt process.

- Particular Structure of Apparatus -

[0018] Referring to Fig. 2C, the main unit CPU 200 receives the actual load data from a stress sensor 201, and other crane operation parameter data from a slewing angle sensor 202, boom length sensor 203, boom angle sensor 204, boom top v. angle sensor 205, jib v. angle sensor 206, and stress sensor 208 respectively disposed at various positions of the crane. The data from the sensors 205 and 206 disposed at the top of the boom are collected to a top terminal 207 at the boom distal end, sent to a cord reel 210 at the boom distal end via an optical fiber cable 209, subjected to photoelectric conversion at the cord reel, and sent to the main unit CPU 200. The display unit CPU 211 is powered from the main unit CPU via a line 217. Commands and data are transferred via bilateral serial lines 214 and 215 between the display unit CPU and main unit CPU 200. The display 212 is a matrix type dynamic drive liquid crystal display (LCD). An LCD is more preferable than other CRT, LED, plasma display and the like because the crane is generally used in outdoors and because it allows a clear display image even under strong sun light. During the night, LCD 212 is provided with back illumination. The setting key switch group 213 includes a plurality of numbered touch keys corresponding to a plurality of items to be set. Signals for controlling the crane mechanism are outputted to a plunger 218, magnetic value or the like.

- Modes of Display Unit -

(1) Operation Status Setting Mode

[0019] Referring to Fig. 3, after the power is turned on, the display unit CPU automatically enters the operation status setting mode, and displays the image such as shown in Fig. 3. This mode is indicated at 301. Numerals generally indicated at 302 represent the boom status and they are flashing. When an operator sets desired numerals, they stop flashing and become always illuminated. First, in order to select a desired boom operation status, one of the ten keys on a touch panel 310A is depressed. Numeral 0 stands for the case of using only the main boom without using the jib and rooster, numeral 1 stands for the case of using the jib with one step, numeral 3 stands for the case of using the jib with two steps. After completion of the boom operation status setting, numerals will flash to indicate the rightside outrigger status 303. Numeral 3 represents a maximum projection, numeral 2 an intermediate projection, numeral 1 a small projection, numeral 0 a minimum projection, numeral 4 no outrigger mounting, and numeral 5 a status setting, an operator selects a desired numeral upon activation of the ten keys on the touch panel 310A. Following the rightside outrigger setting, the leftside outrigger status 304 is set.

[0020] The display unit CPU causes the set numeral to change its display status from flashing to continuous illumination, and sends the set boom and outrigger status data to the main unit CPU.

(2) ACS Mode

[0021] After completion of the input operation for the operation status mode, the display unit CPU automatically

enters the ACS (Automatic Crane Stopper) for displaying an image such as shown in Fig. 4. In accordance with the information supplied from the main unit CPU, the display unit CPU displays the current crane operation status, i.e., an outrigger setting 404, slewing position 405, operation radius 406, boom angle 407, lifting load 410, lifting distance 409, and boom length 402. The boom length is schematically displayed in the form of bar 403 whose length changes in correspondence with the actual length of the boom.

[0022] The safety limit of the current crane operation status is indicated at 411 in the form of bar graph. The numerical representation of the safety limit is indicated at 413. The limit (maximum) load at the current crane operation status is indicated at 408. When the crane operation status becomes near the limit zone (when the bar graph 411 extends to the yellow zone), a warning is issued. When the status reaches the limit, the crane is automatically stopped. the main unit CPU monitors the actual crane operation status by using the data from various sensors, accesses the memory to obtain the maximum limit load for that operation status, and checks if the accessed maximum limit load is equal to or smaller than the actual load. If the actual load becomes the maximum limit load for the current crane operation status, the main unit CPU delivers a signal for locking the crane operation mechanism. During the ACS mode display, the display unit CPU visually provides an operator a crane operation status. The crane operation status reaches a limit when it has a maximum limit load, or when it has an operation range limit set by an operator (described later with reference to Fig. 5). Also in the latter case, a warning is issued and the crane is automatically stopped.

[0023] One of distinctive features of this embodiment is to display an automatic stop cause 412. If the crane stops automatically during the ACS mode, it is difficult for an operator to find at once the cause of automatic stop. The cause of automatic stop is difficult to be found especially for the case of crane turnover or failure caused by overload during the operation, and for the case of crane operation during the ACS mode while setting the crane operation range or zone (described later with Fig. 5). Further, if a predetermined length of wire continues to be released over the range of its length, then a reverse winding of the wire occurs during the crane operation. In such a case, an automatic stop is also effected. In the ACS mode of this embodiment, the cause of automatic stop is illustratively displayed at 412 on the screen.

[0024] The illustrative representations of the causes of automatic stop are shown in Fig. 4B (a) to (n), the representations having the following meanings. If there are a plurality of automatic stop causes during the ACS mode, the corresponding number of representations are displayed on the screen.

Illustrative Indications	Causes of Automatic Stop
(a)	automatic stop for moment (limit load)
(b)	automatic stop for lower angle
(c)	automatic stop for higher angle
(d)	automatic stop for most straight standing of boom
(e)	automatic stop for right slewing
(f)	automatic stop for left slewing
(g)	automatic stop for spiraling
(h)	automatic stop for releasing
(i)	automatic stop for radius limit
(j)	automatic stop for lifting distance limit
(k)	automatic stop for limitation of low angle
(l)	automatic stop for limitation of high angle
(m)	automatic stop for right slewing limit
(n)	automatic stop for left slewing limit

[0025] The cause of automatic stop described above is displayed when certain conditions are satisfied. For example, the cause of automatic stop for moment is assigned, when the actual load is equal to or larger than the limit load and the lever operation is in danger side. if the actual load is near the limit load and an operator causes to turn down or extend the boom further, or causes the winch to wind up the wire, these lever operations are in danger side. The main unit CPU issues a locking signal in response to these lever operations in danger side, and the display unit CPU displays the illustrative representation (a). Upon the automatic stop, the operator recognizes from the displayed automatic stop cause illustrative representation (a) that the boom cannot be turned down or extended and that the crane can be released from the danger by other operations such as lifting the boom. As above, if the crane is turned down and the actual load exceeds the limit load, the crane enters the automatic stop, and the moment automatic stop cause representation is displayed. At this time, upon moving the crane operation lever back to the neutral position, the crane automatic stop is released and the cause representation disappears. In this condition, if the crane operation lever is

turned to the boom extension side, the automatic stop is effected again and the moment automatic stop cause is displayed. If the crane operation lever is turned not to the boom extension side but to the boom standing side, boom compression side or winch winding back side, then the automatic stop and cause display are not effected.

[0026] The crane operation in danger side is different for each automatic stop cause. The main unit CPU has stored data representative of the direction of locking the operation lever, respectively for each crane automatic stop cause. For example, if the automatic stop is effected because of the boom high limit angle, the main unit CPU supplies to the crane mechanism a signal which locks the operation lever in the direction of lifting the boom and allows it to move in the direction of turning down the boom.

[0027] In the ACS mode having a number of automatic stop causes, an operator can visually recognize the automatic stop cause so that the crane operation is made very easy.

(3) Operation Range Limit Mode

[0028] In addition to setting the crane operation range for the crane turnover and failure limit, the boom movable range is also set so as not to make the boom contact with nearby buildings and the like. It is desirous if a warning is issued or the crane is automatically stopped if the boom is moved in the direction departing from the set movable range. In response to a depression of key A on the touch panel 310B, the display unit CPU enters the operation range limit display mode and displays a screen image such as shown in Fig. 5. The operation range limit display mode is indicated at 501. At the right side of the screen, the boom is schematically shown at B, and its distal end represented by a cross is indicated at P. The schematically displayed boom B follows the actual boom motion, and is controlled by the display unit CPU in accordance with the operation parameters supplied from the main unit CPU. In setting the boom operation radius limit, an operator moves the boom to the limit point (the schematically displayed boom B also moves to the limit point). Upon depression of key B on the touch panel 310B, the non-operation range is set at the hatched area at the right of the boom distal end P. The operation radius R is displayed as the operation radius limit value at 507 within a rectangular frame. In addition to the radius limit (A), higher limit of angle (B), lower limit of angle (C), and lifting distance limit (D) may also be set. The characteristic point of this setting is that the boom is actually moved to the limit point and a key is depressed to set the non-operation range, instead of calculating and setting the numerical limit value without moving the boom to the limit point. This method of setting is advantageous in that the operation range can be determined by moving the actual boom at the field location. The total operation limit range covering all the limits (A) to (D) such as the radius limit and the like is shown as (E). The boom is allowed to move within the area not hatched. Other numerical values representative of the actual boom are also displayed on the screen, the values including boom angle 509, actual radius 508, boom length 506, and lifting distance 505.

[0029] At the left of the screen, a boom slewing angle range limit is displayed. A boom B schematically displayed within an area 511 follows the actual boom motion. The boom is moved to a boom slewing angle limit point and the boom slewing angle range limit is set upon activation of a setting key on the touch panel. As the slewing angle range limit, one side of the boom may be set as indicated by (F) or both sides thereof may be set as indicated by (G). The outrigger setting status 512 previously set is also displayed on the boom slewing display area.

[0030] For reference purpose, a lifting load 503 and maximum load 504 are displayed on the screen.

[0031] The contents set during the operation range limit display mode are transferred in the form of numerical data from the display CPU to the main unit CPU. Assuming that the radius limit setting key is depressed under the conditions of the boom length ℓ_i and the boom angle θ_i, the limit radius numerical data obtained is $R_L = \ell_i \sin \ell_i$. The display unit CPU displays the hatched area on the right side of R_L. If the boom moves toward the outside of the set operation limit range, the main unit CPU detects it so that a warning is issued or the crane is automatically stopped. An operator can visually recognize the motion of the boom within the allowable operation range as shown at (E) with respect to the non-operation range. It is a significant advantage that an operator can forecast the next stage boom motion.

(4) Target Display Mode

[0032] Upon activation of a mode selection key on the touch panel 310B, the display unit CPU enters the target display mode which displays a screen image such as shown in Fig. 6. This target display mode is used when an operator cannot see a lifting load from the operator seat of the crane. Target index marks 605 and 606 indicated by solid lines in Fig. 6 are used for the setting of target points. The side of an innermost square of the target index mark corresponds to an actual length of 15 cm, that of the next square to an actual length of 30 cm, and that of the outermost square to an actual length of 60 cm. First, the crane is operated to move an actual lifting load to a target location which is set as a fist target upon activation of a key on the touch panel 310B. The first target is the origin of the coordinate system of the screen. A lifting load position 607 is displayed on the screen at the position apart from the origin by a certain distance. After setting the first target, an operator can recognize from the screen the positional relation of the lifting load with the target position without seeing the actual lifting load. It is common for a crane operation to slew the

crane and transfer a lifting load from the first point to the second point. In such a case, the target index mark 605 is set at the first point, and the target index mark 606 is set at the second point. The index marks 605 and 606 have independent coordinate systems so that the distance between the target index marks 605 and 606 is not related to an actual distance therebetween. The frames indicated by a dotted line are the effective display area of the coordinate systems of the first and second points, the side of the frame corresponding to an actual length of, e.g., 100 cm. The position of a lifting load within this effective area is represented by ⧾ mark. Even if the lifting load moves outside of this area, the ⧾ mark as at 607' is displayed while moving along the dotted line so that the direction of the lifting load can be recognized by an operator. While seeing the ⧾ mark on the screen relative to the target index mark, an operator can continue the transfer operation of the lifting load between the first and second points without actually seeing them.

[0033] The numerical values of the distances of the lifting load to the first and second points are displayed at the upper area of the screen at 603 and 604. For convenience purpose, the outrigger setting 609 and slewed boom position 608 are displayed at the lower left area of the screen. For reference purpose, there are also displayed a lifting load 612 and maximum load 611. Reference numeral 601 indicates the display mode, and 602 indicates the safety numerical value for the crane operation during this display mode.

[0034] The actual position of a lifting load is calculated as lifting load position data at the main unit CPU by using the data from various sensors and the data on the crane structure, and the lifting load position data are supplied to the display unit CPU. Upon activation of a touch key on the display unit to set a certain position as the origin of the target index mark 605, the display unit CPU uses the lifting load position data at that time as the origin of the index mark 605. The display unit CPU displays the lifting load position 607 on the screen relative to the target index mark in accordance with a difference between the current lifting load position data and the lifting load position data at the time of setting. If the lifting load moves outside of the outermost square of the index mark, the display unit CPU displays the ⧾ mark along the dotted line 613 to indicate the direction of the lifting load position. If the lifting load comes thereafter near the first or second point (i.e., comes within the outermost square of the index mark), then the position is again displayed.

[0035] An example of the display image shown in Fig. 6 provides two independent two-dimensional target index marks. It is also possible to display three or more index marks, or three-dimensional index marks.

(5) Limit Load - Slewing Angle Display Mode

[0036] The lifting load capacity of a crane depends on the posture of the crane structure such as a front, rear, right and left position, so that the boom slewing of the crane should be paid attention. When the display unit CPU enters the limit load - slewing angle display mode upon key activation on the touch panel 310B, the display image as shown in Fig. 7 appears on the screen. A crane is schematically shown at the center on the screen, with the outrigger setting being displayed at 706. A boom is schematically displayed at 705 for indicating the actual boom length and boom slewed position. A cross mark 704 at the distal end of the schematically displayed boom 705 indicates the current distal end of the boom. A solid line A or dotted line B indicates a safety load range area 703. The operation is judged as safe so long as the cross mark 704 is displayed within the area. The safety load range on the screen changes with the set outrigger conditions. It is convenient for a crane operator to use this mode when the crane is slewed.

[0037] For reference purpose, there are also displayed on the screen, a mode indication 701, safety numerical value 702, boom length numerical value 707, boom operation status 708, boom angle 709, actual load 710, lifting distance 711, operation radius 712, and maximum load 713.

(6) Performance Curve Display Mode

[0038] The typical parameter for a safety crane operation is a lifting load curve relative to the operation radius as shown in Fig. 2B. It is convenient for an operator to know the operation safety margin by visually recognizing the current operation status from this safety index curve. Upon activation of a mode switching key on the touch panel 310B, the display unit CPU enters the performance curve display mode and displays a display image on the screen as shown in Fig. 8. The performance curve is collectively determined from a combination of crane operation parameters such as the outrigger projection state, boom length, use or non-use of jib, slewing angle and the like. The main unit CPU uses such operation parameters, accesses the previously stored specific load data relative to the operation radius conforming with each crane specification, and sends the specific load data to the display unit CPU. The display unit CPU displays an operation status performance curve 803 such as shown at the rightside on the screen. A + mark at 804 is displayed at the coordinate position determined by the current operation radius and actual load. An operator can know the operation margin from the position of the + mark relative to the curve. The numerical value of a marginal operation radius is displayed at 806 near the + mark. This numerical value indication 806 moves as the + mark 804 moves so that the operator can easily recognize this value.

[0039] For reference purpose, during the performance curve display mode, there are displayed La current actual load 811, boom slewing status 808, outrigger setting 809, and boom operation status 810.

(7) Performance Display Mode

[0040] There is provided a total specific load table such as shown in Fig. 9A which is referred to for the crane safety operation. This table provides specific loads relative to operation radii conforming with each crane specification, when the outrigger setting status and boom length are given. While referring to the table, an operator can judge if, for example, the set outrigger and boom length are sufficient for the lifting load and operation radius of an operation to be carried out. Upon key activation on the touch panel 310B, the display unit CPU displays a display image as shown in Fig. 9B. This mode is referred to for an operation to be carried out so that in this mode the crane is essentially in a stop state. An operator first uses the ten keys 310A to enter the numeral value of a desired boom length in an area 902 where a cursor flashes. During this mode, the entered boom length is not set as an actual boom length value. Thereafter, the flashing cursor moves to an area 903 wherein the numerical value of a desired slewing angle is entered. The outrigger status and the like have already been set during the previous operation status display mode (Fig. 3). Upon input of these values, the display unit CPU receives from the main unit CPU (or the display unit CPU itself may have such data) maximum specific load data for the operation radius Rm for the given conditions, and displays them in a numerical value table 904. If the boom length and the like set for a desired operation are determined as improper upon reference to the displayed data, the table with these numerical values is reset, and a new boom length and the like are again entered.

[0041] For reference sake, during this mode there are displayed on the screen a mode indication 901, boom operation status 907, outrigger setting 906, and slewing angle 905.

- Operation Sequence of Apparatus -

[0042] According to the structure of the apparatus of this invention, the main unit controller and display unit controller each have its own CPU which executes an operation sequence running on a different program. The main unit controller receives the operation parameters from sensors and the operation range setting data from the display unit controller, calculates the actual load, operation radius, limit load and the like for the automatic stop control of the crane mechanism, and sends the calculated data to the display unit. The display unit controller displays the display image for a selected mode in accordance with the data from the main unit controller, modifies the displayed image in accordance with an input from a setting key, and sends the input setting data to the main unit controller. The main unit and display unit controllers carry out sequences running independently, so the transfer of commands and data therebetween is executed upon an interrupt.

[0043] The operations sequences of the main and display unit controllers are shown in Figs. 10 and 11, respectively.

[0044] The contents of each process of the main unit operation sequence are as follows.

[0045] S101 (Display Reception Process): Data sent from the display unit is checked, and if the data is not processed, it is processed.

[0046] S102 (Display Transmission Process): Data sent to the display unit is checked, and if the data is not sent as yet, the data is set at the transmission section to start transmitting.

[0047] S103 (Actual Load Calculation Process): Constants necessary for the calculation of various actual loads are obtained from data representative of outrigger status, boom operation status, boom length and the like, and in accordance with the obtained constants, an actual load calculation is executed to obtain the actual load, radius, lifting distance and the like.

[0048] S104 (Limit Load Calculation Process); A limit load is obtained in accordance with the outrigger status, boom operation status, boom length data, slewing angle data, boom angle data, radius data and the like.

[0049] S105 (Timer Interrupt Process): An interrupt is executed at the predetermined interval to execute a predetermined process at the predetermined interval.

[0050] S106 (Display Reception Interrupt Process): When one byte data is received from the display unit, an interrupt occurs so that the received data is stored in a reception data storage area.

[0051] S107 (Display Transmission Interrupt Process): After completion of one byte data transmission activated at S102, an interrupt occurs to check the next data and transmit it.

[0052] S108 (Top Terminal Reception Process): An interrupt occurs when data is received from the top terminal so that the received data is stored in a reception data storage area.

[0053] S109 (Analog Data Interrupt Process): An interrupt occurs after analog data is converted into digital data so that the digital data is stored in a storage area.

[0054] The contents of each process of the display unit operation sequence are as follows.

[0055] S111 (Boom Operation Status, Outrigger Status, Setting Mode): The number designated upon a key input during the routine for setting a display image shown in Fig. 3 is displayed reversely. After all key inputs are set, the display shown in Fig. 4 is automatically entered.

[0056] S112 (ACS Mode): The display shown in Fig. 4 is set and numerical data sent from the main unit is set, i.e.,

the boom length data is set at 402, boom angle data at 407, radius data at 406, actual load at 410, limit load at 408, and lifting distance at 409. The bar graphs at 411 and 403 are set in accordance with the safety degree and the boom length data, respectively. The slewing bar at 405 is set in accordance with the slewing angle data. The automatic stop indication at 412 is given in accordance in response to an automatic stop.

[0057] The display image of the boom changes with the boom operation to recognize the boom operation status set at S111. The outrigger operation status set at S111 is also recognized.

[0058] S113 (Operation Range Limit Mode): In this routine, the display shown in Fig. 5 is set and outputted.

[0059] S114 (Target Mode): In this routine, the display shown in Fig. 6 is set and the target is shown in accordance with a key input.

[0060] S115 (Limit Load - Slewing Angle Mode): In this routine, the display shown in Fig. 7 is set.

[0061] S116 (Performance Display Mode): In this routine, the display shown in Fig. 8 is set.

[0062] S117 (Performance Table Display Mode): In this routine, the display shown in Fig. 9B is set.

[0063] S120 (Main Unit Transmission Interrupt Process): An interrupt occurs after one byte data is transmitted to the main unit. It is checked if there is any data to be transmitted to the main unit, and if there is a data, it is transmitted.

[0064] S121 (Main Unit Reception Interrupt Process): An interrupt occurs after data sent from the main unit is received so that a process for storing the received data in a reception area is executed.

[0065] S122 (Timer Interrupt): A timer interrupt occurs at a predetermined interval and a timer flag is set to execute the process corresponding to the set timer flag.

[0066] In this embodiment, the interrupt process is constructed in a three hierarchical structure including (1) hard interrupt process, (2) soft interrupt process 1 and (3) soft interrupt process 2. The reason for providing this three hierarchical structure is as follows. In order to shorten the interrupt inhibition time, an interruption is inhibited during only the hard interrupt process which is set equal to or shorter than 800 microseconds. If the interrupt process takes too much time, the next interrupt may be inhibited. In order to avoid such inhibition, the three hierarchical structure is effective to make the interrupt inhibition time as short as possible. The hard interrupt is limited to a minimum such as for a data fetch process, and the next process is executed by a soft interrupt using a soft interrupt flag.

Claims

1. A safety apparatus for installation on a crane, said apparatus having a main unit (A, A^{I}, A^{II}) and a display unit (B, B^{I}, B^{II}), wherein:

said main unit comprises a main unit CPU (200), a terminal (207) via which crane operation status parameter data detected by a sensor is inputted to said main unit CPU (200), a terminal via which command and data are transmitted/received between said main unit CPU (200) and said display unit (B, B^{I}, B^{II}), and a memory for storing a limit load data for each crane operation status conforming with a crane specification;
said display unit comprises a display unit CPU (211) which runs on its own program independently from said main unit CPU, a display (212), a bit map memory for storing graphics data defining a display image including a schematic diagram of a crane to be displayed on said display (212), key means (310B) for manually inputting key input data concerning the setting of a crane mechanism such as an outrigger and boom and a terminal via which commands and data are transmitted/received between said display unit CPU (211) and said main unit (A, A^{I}, A^{II}),
said main unit CPU (200) determines the warning condition for crane operation in accordance with the limit load data in the memory, the crane operation status parameter data and the key input data, and transmits a crane operation status data to said display unit CPU in accordance with a said display image in a display mode selected by operation of said display unit (B, B^{I}, B^{II}), and
said display unit CPU (212) modifies the display image from time to time in accordance with the crane operation status data received from said main unit CPU to display motion in the crane schematic diagram on the display as the crane operation status changes.

2. A crane safety apparatus according to claim 1, wherein said main unit CPU (200) issues a limit signal when a crane actual operation status reaches a limit which is checked in accordance with crane control information including said stored limit load data and/or set crane operation range limit data.

3. A crane safety apparatus according to claim 2, wherein
said main unit CPU (200) transmits said limit signal including a limit cause when a crane actual operation status reaches a limit which is checked in accordance with said received crane operation status parameter, and
said display unit CPU (212) displays an indication representative of the contents of said limit cause included

in said received limit signal.

Patentansprüche

1. Sicherheitsvorrichtung zur Anordnung an einem Kran, mit einer Haupteinheit (A, A', A") und einer Anzeigeeinheit (B, B', B"), wobei:

   die Haupteinheit eine CPU (200) für die Haupteinheit, einen Terminal (207), über den von einem Sensor erfaßte Kran-Betriebszustands-Parameterdaten in die CPU (200) der Haupteinheit eingegeben werden, einen Terminal, über den Anweisungen und Daten zwischen der CPU (200) der Haupteinheit und der Anzeigeeinheit (B, B', B") gesendet/empfangen werden, und einen Speicher zum Speichern von Grenzbelastungsdaten für jeden Kran-Betriebszustand, der mit einer speziellen Kranspezifikation übereinstimmt, aufweist;
   die Anzeigeeinheit eine CPU (211) für die Anzeigeeinheit, die mit ihrem eigenen Programm unabhängig von der CPU der Haupteinheit läuft, eine Anzeige (212), einen Bitmap-Speicher zum Speichern von graphischen Daten, die eine Bildanzeige einschließlich eines auf der Anzeige (212) anzuzeigenden schematischen Krandiagramms definieren, eine Tasteneinrichtung (310B) zum manuellen Eingeben von Tasten-Eingabedaten bezüglich der Einstellung eines Kranmechanismus, wie einer Ausfahrstütze und eines Auslegers, und einen Terminal, über den Anweisungen und Daten zwischen der CPU (211) der Anzeigeeinheit und der Haupteinheit (A, A', A") gesendet/empfangen werden, aufweist, und
   die CPU (200) der Haupteinheit die Warnbedingung für den Kranbetrieb gemäß den Grenzbelastungsdaten im Speicher, den Kran-Betriebszustands-Parameterdaten und den Tasteneingabedaten bestimmt und Kran-Betriebszustands-Daten an die CPU der Anzeigeeinheit gemäß der Bildanzeige in einem durch Betreiben der Anzeigeeinheit (B, B', B") gewählten Anzeigemodus sendet, und
   die CPU (211) der Anzeigeeinheit die Bildanzeige von Zeit zu Zeit gemäß den von der CPU der Haupteinheit empfangenen Kran-Betriebszustands-Daten modifiziert, um Bewegung in dem schematischen Krandiagramm auf der Anzeige anzuzeigen, wenn sich der Kran-Betriebszustand ändert.

2. Kran-Sicherheitsvorrichtung nach Anspruch 1, wobei die CPU (200) der Haupteinheit ein Grenzsignal abgibt, wenn ein tatsächlicher Betriebszustand des Krans eine Grenze erreicht, die gemäß Kran-Steuerinformationen überprüft wird, die die gespeicherten Grenzlastdaten und/oder festgesetzte Kran-Betriebsbereichs-Grenzdaten einschließen.

3. Kran-Sicherheitsvorrichtung nach Anspruch 2, wobei
   die CPU (200) der Haupteinheit das Grenzsignal mit einem Begrenzungsgrund sendet, wenn ein tatsächlicher Kran-Betriebszustand eine Grenze erreicht, die gemäß dem empfangenen Kran-Betriebszustands-Parameter überprüft wird, und
   die CPU (211) der Anzeigeeinheit eine Anzeige darstellt, die für die Inhalte des im empfangenen Grenzsignal enthaltenen Begrenzungsgrunds repräsentativ ist.

Revendications

1. Dispositif de sécurité pour grue comprenant une unité principale (A, A', A") et une unité d'affichage (B, B', B"), dans lequel :

   ladite unité principale comprend une CPU d'unité principale (200), une borne (207), par l'intermédiaire de laquelle un paramètre d'état de fonctionnement de la grue est entré dans ladite CPU d'unité principale (200), une borne, par l'intermédiaire de laquelle des commandes et des données sont transmises/reçues entre ladite CPU d'unité principale (200) et ladite unité d'affichage (B, B', B"), et une mémoire pour stocker des données de charge limite pour chaque état de fonctionnement de la grue se conformant à une spécification de grue ;
   ladite unité d'affichage comprend une CPU d'unité d'affichage (211), un dispositif d'affichage (212), une mémoire d'image en mode points pour stocker des données graphiques définissant une image d'affichage comportant un diagramme schématique d'une grue à afficher sur ledit dispositif d'affichage (212), un moyen à touches (310B) pour entrer manuellement des données d'entrée par touche concernant le paramétrage d'un mécanisme de grue tel qu'un empattement et une flèche, et une borne, par l'intermédiaire de laquelle des commandes et des données sont transmises/reçues entre ladite CPU d'unité d'affichage (212) et ladite unité principale (A, A', A"), et

ladite CPU d'unité principale (200) détermine les conditions d'alerte pour le fonctionnement de la grue en conformité avec les données de charge limite contenues dans la mémoire, les données de paramètres d'état de fonctionnement de la grue et les données d'entrée par touches, et transmet des données d'état de fonctionnement de la grue vers ladite CPU d'unité d'affichage en conformité avec ladite image d'affichage dans un mode d'affichage sélectionné par ladite unité d'affichage (B, B', B"), et
ladite CPU d'unité d'affichage (212) modifie l'image de temps en temps selon les données d'état de fonctionnement de la grue reçues de ladite CPU d'unité principale pour afficher un mouvement dans le digramme schématique de grue représenté sur l'affichage lorsque l'état de fonctionnement de la grue change.

2. Dispositif de sécurité pour grue selon la revendication 1, dans lequel ladite CPU d'unité principale (200) délivre un signal de limite quand un état réel de fonctionnement de la grue atteint une limite qui est vérifiée selon des informations de commande de la grue incluant lesdites données stockées de charge limite et/ou les données paramétrées de limite de plage de fonctionnement de la grue.

3. Dispositif de sécurité pour grue selon la revendication 2, dans lequel :

ladite CPU d'unité principale (200) transmet ledit signal de limite, incluant une cause de limite, quand un état réel de fonctionnement de la grue atteint une limite qui est vérifiée selon ledit paramètre reçu d'état de fonctionnement de la grue, et
ladite CPU d'unité d'affichage (212) affiche une indication représentative du contenu de ladite cause de limite incluse dans ledit signal de limite reçu.

FIG. 1

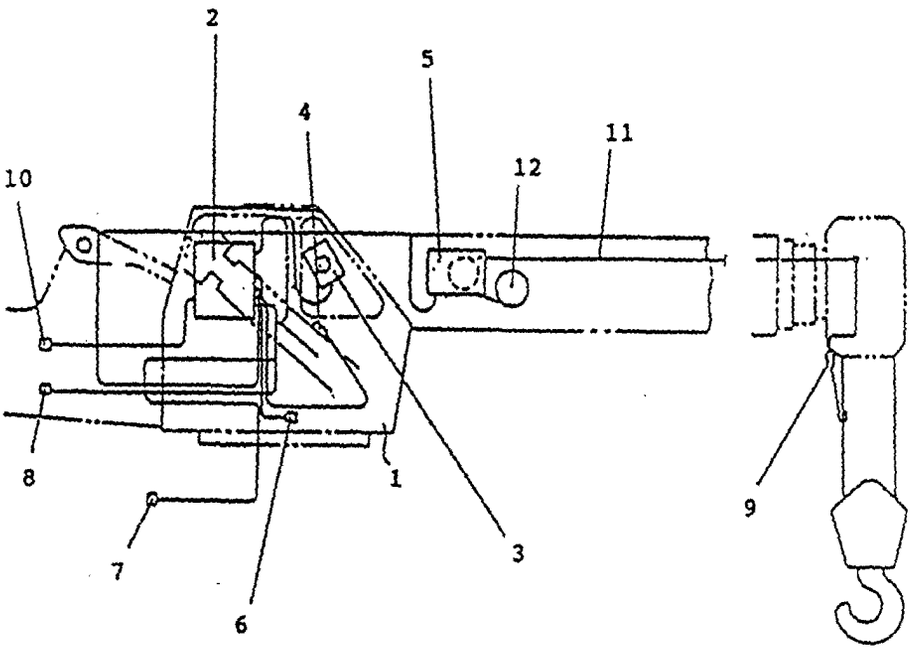


FIG. 2A

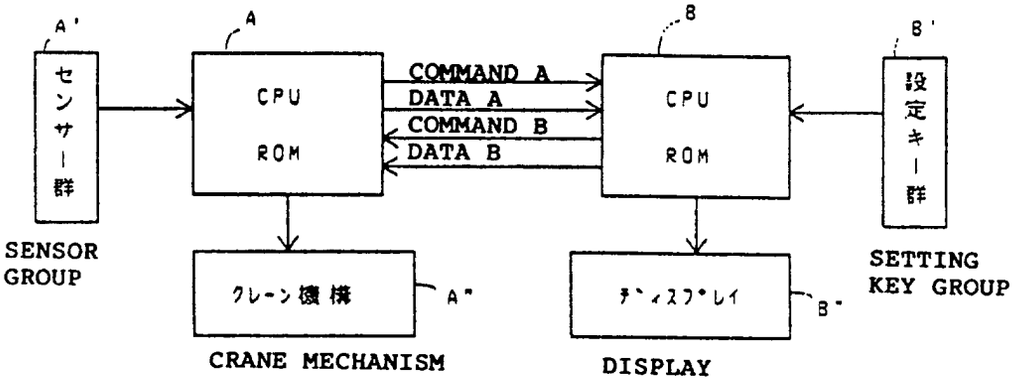

A'
A
B
B'
センサー群
CPU
ROM
COMMAND A
DATA A
COMMAND B
DATA B
CPU
ROM
設定キー群
SENSOR GROUP
SETTING KEY GROUP
クレーン機構
A"
ディスプレイ
B"
CRANE MECHANISM
DISPLAY

FIG. 2B

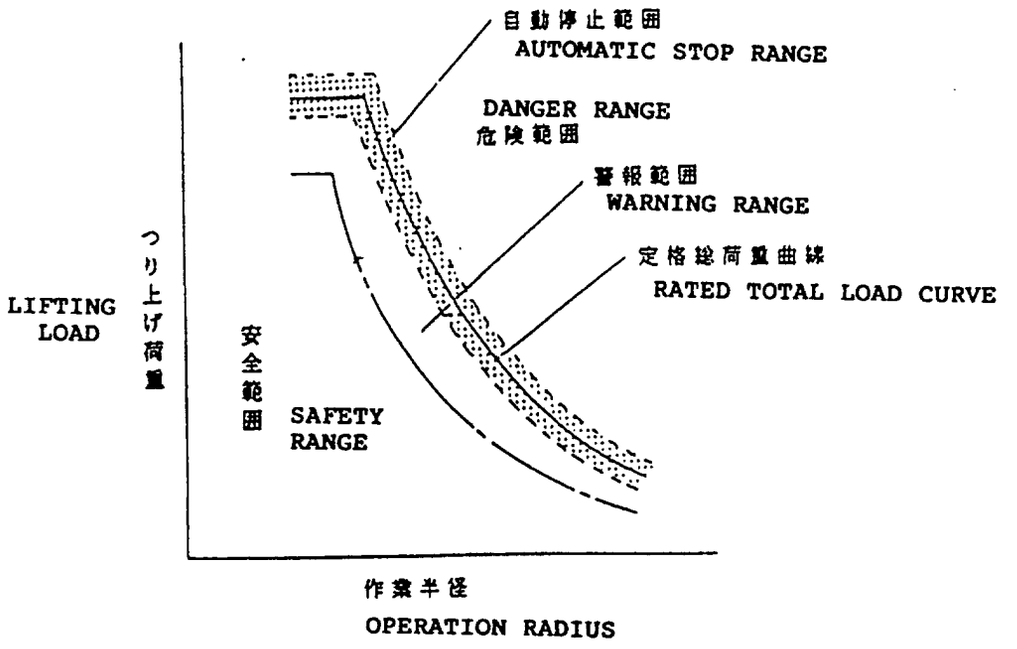

自動停止範囲
AUTOMATIC STOP RANGE
DANGER RANGE
危険範囲
警報範囲
WARNING RANGE
定格総荷重曲線
RATED TOTAL LOAD CURVE
LIFTING LOAD
つり上げ荷重
安全範囲
SAFETY RANGE
作業半径
OPERATION RADIUS

FIG. 2C

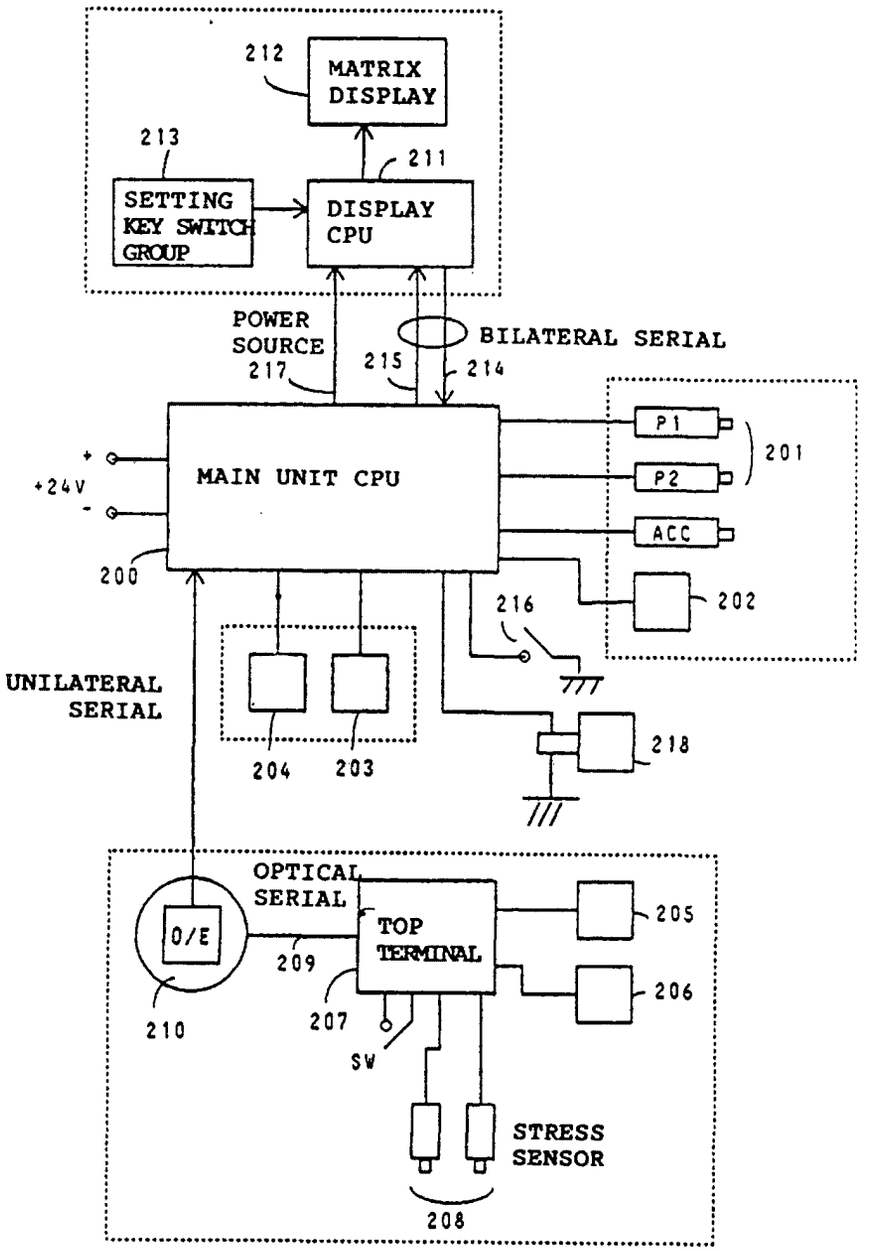

212
MATRIX DISPLAY
213
211
SETTING KEY SWITCH GROUP
DISPLAY CPU
POWER SOURCE
217
215
214
BILATERAL SERIAL
+
+24V
-
MAIN UNIT CPU
200
P1
P2
ACC
201
202
216
UNILATERAL SERIAL
204
203
218
OPTICAL SERIAL
O/E
210
209
TOP TERMINAL
205
206
207
SW
STRESS SENSOR
208

FIG. 3

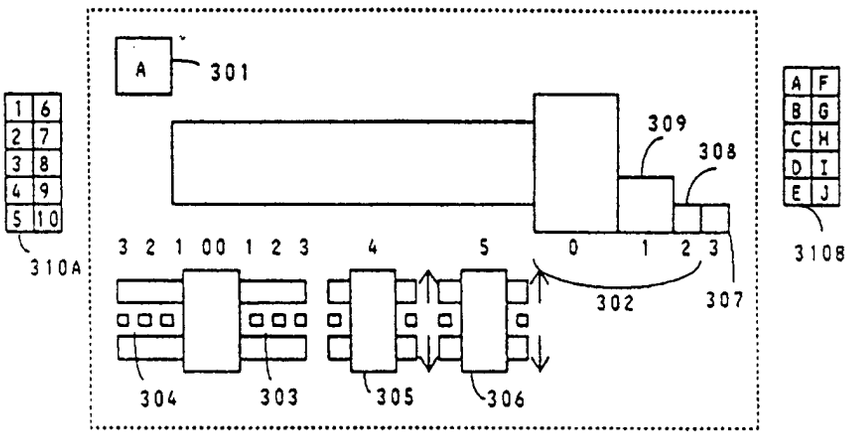

A
301
309
308
1 6
2 7
3 8
4 9
5 10
310A
A F
B G
C H
D I
E J
3108
3 2 1 00 1 2 3
4
5
0 1 2 3
302
307
304
303
305
306

FIG. 4A

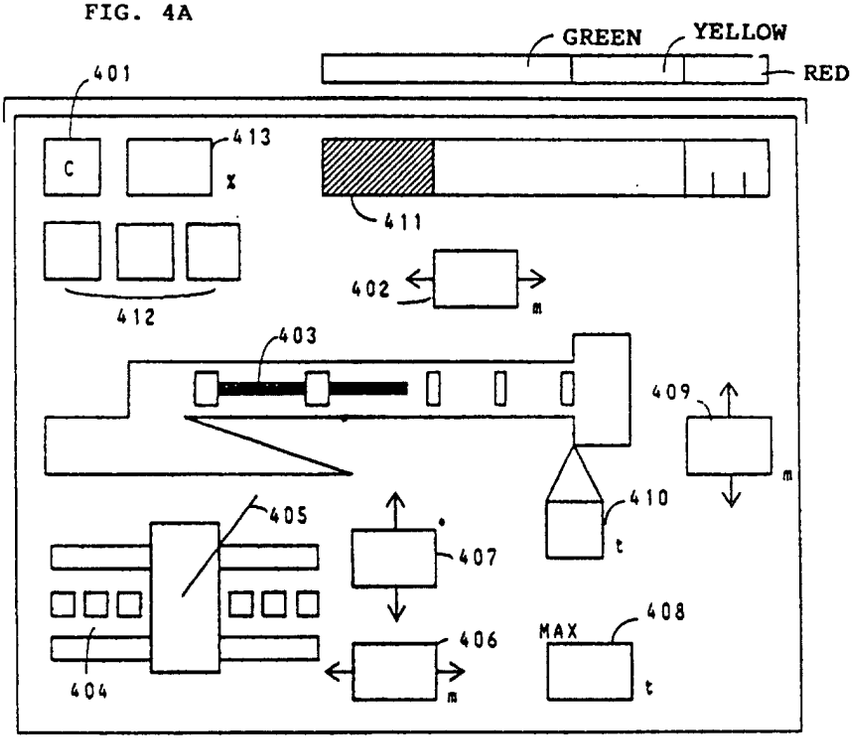
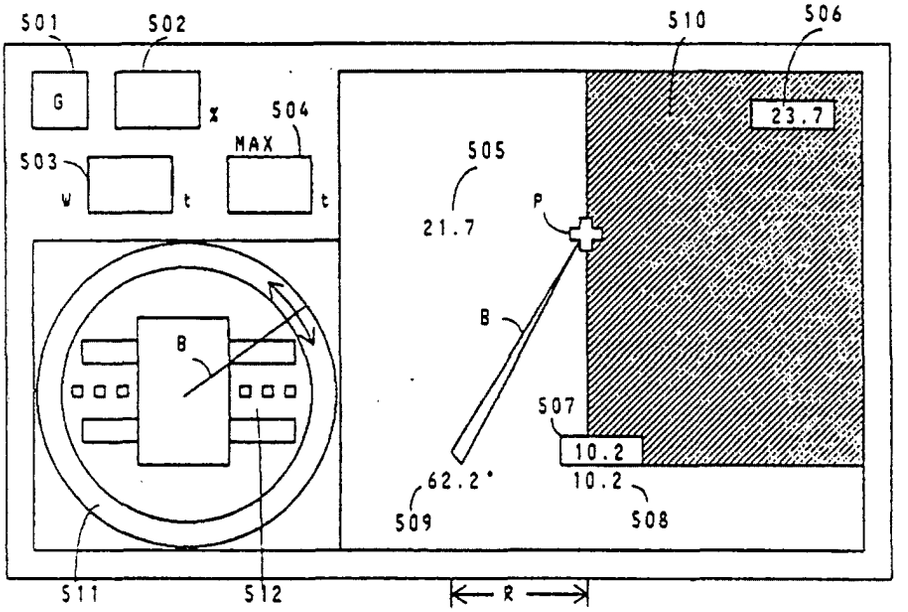
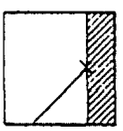
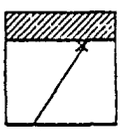

GREEN
YELLOW
RED
401
C
413
x
411
412
402
m
403
409
m
410
t
405
407
404
406
m
MAX
408
t

FIG. 5

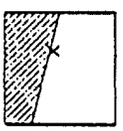



(A)

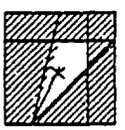
RADIUS LIMIT
半径制限


(D)

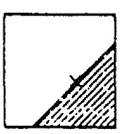
LIFTING DISTANCE LIMIT
揚程制限


(B)

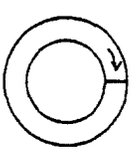
UPPER LIMIT OF BOOM ANGLE
上限角制限


(E)

OPERATION LIMIT RANGE
作業制限範囲


(C)

LOWER LIMIT OF BOOM ANGLE
下限角制限


(F)

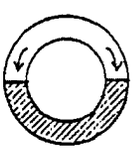

(G)

FIG. 6

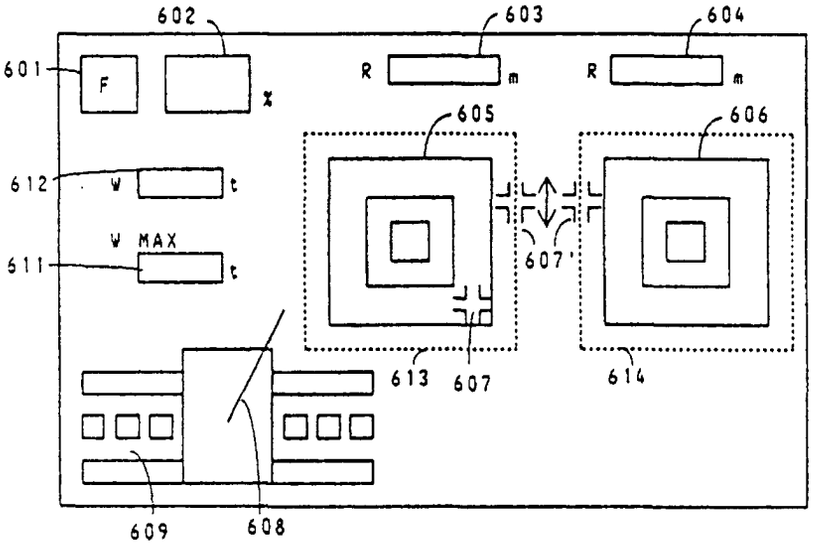

602
603
604
601
F
R
m
R
m
x
605
606
612
W
t
W MAX
611
t
607'
613
607
614
609
608

FIG. 7

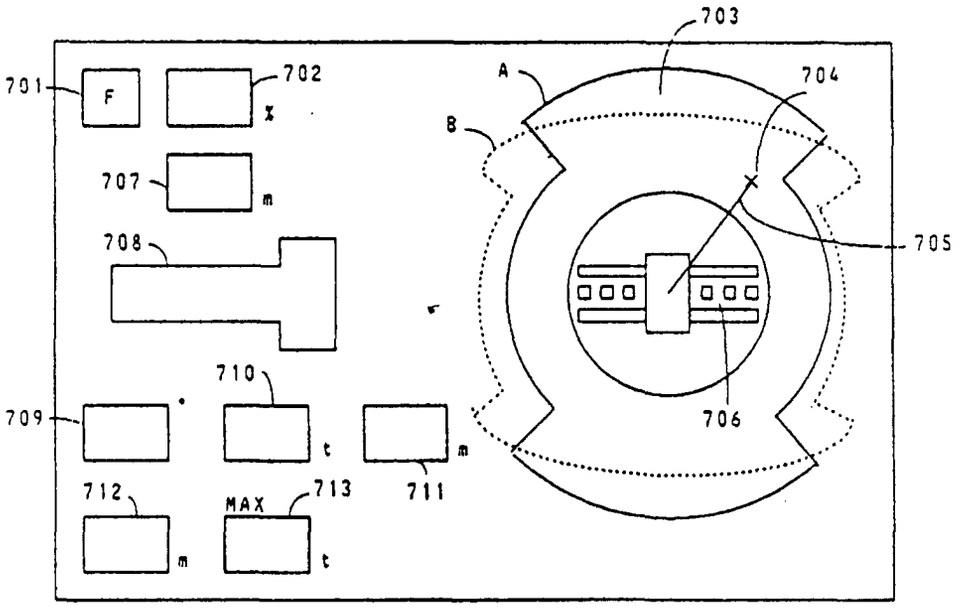

703
701
F
702
x
A
704
B
707
m
708
705
710
709
t
m
706
712
MAX
713
711
m
t

FIG. 8

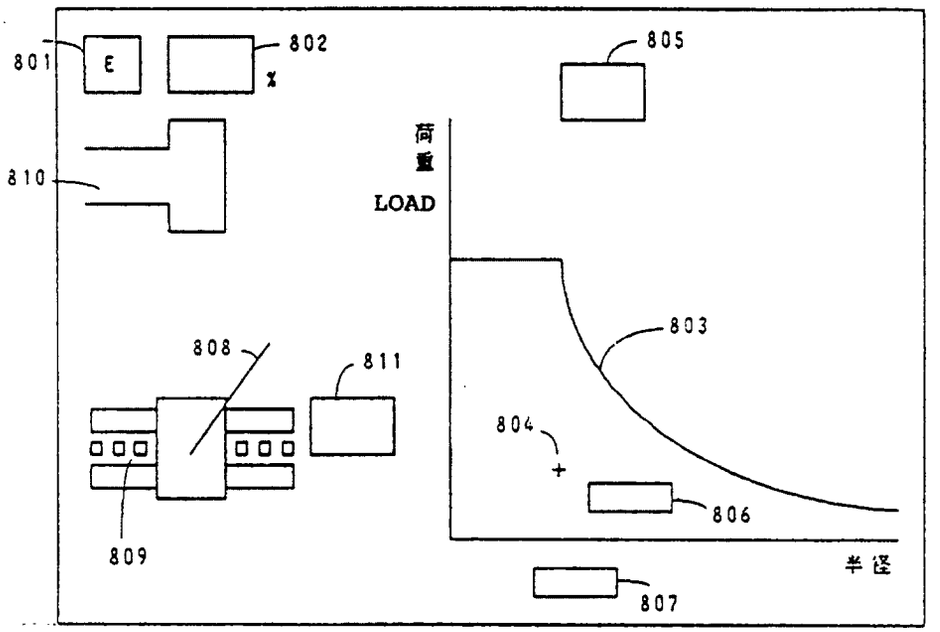

801
E
802
X
805
荷重
LOAD
810
803
808
811
804
+
806
809
半径
807

FIG. 9B

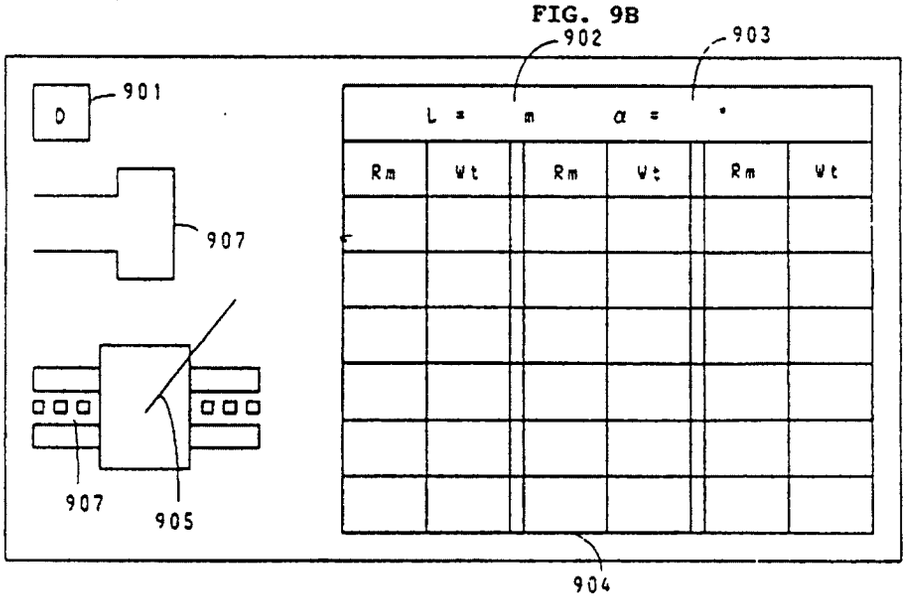
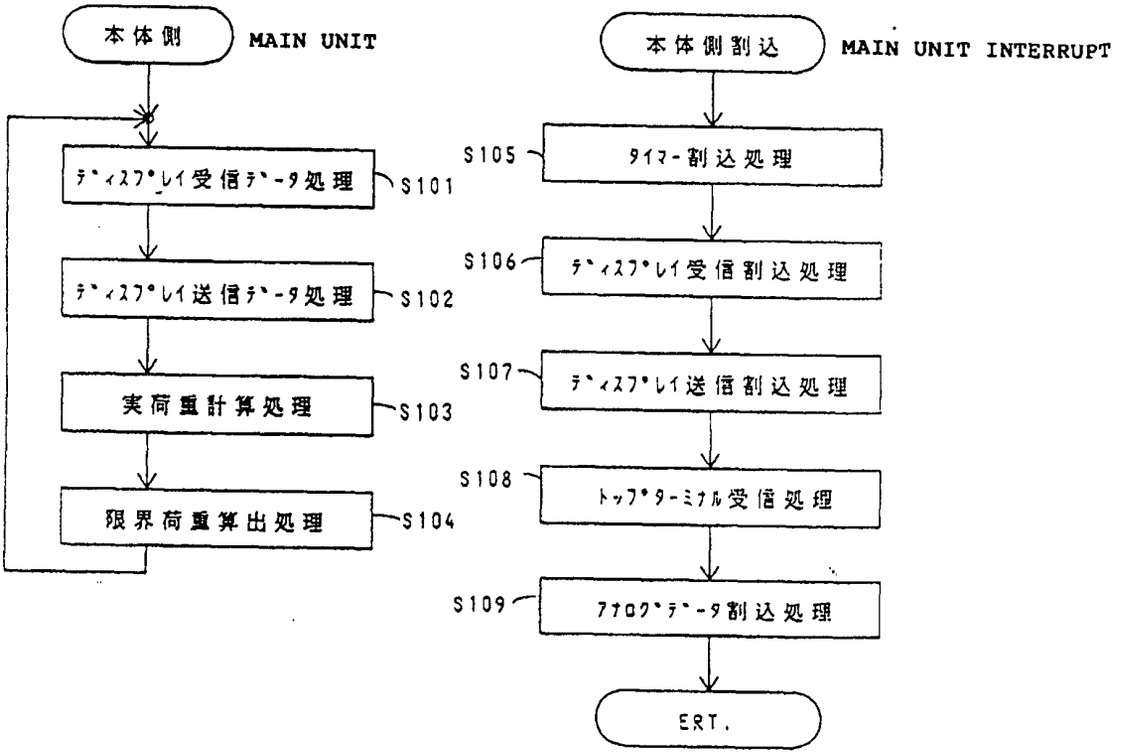

902
903
901
D
L = m α = °
Rm
Wt
Rm
Wt
Rm
Wt
907
907
905
904

FIG. 10



S101 : PROCESSING OF DISPLAY RECEPTION DATA

S102 : PROCESSING OF DISPLAY TRANSMISSION DATA

S103 : CALCULATION OF ACTUAL LOAD

S104 : CALCULATION OF LIMIT LOAD

S105 : PROCESSING OF TIMER INTERRUPT

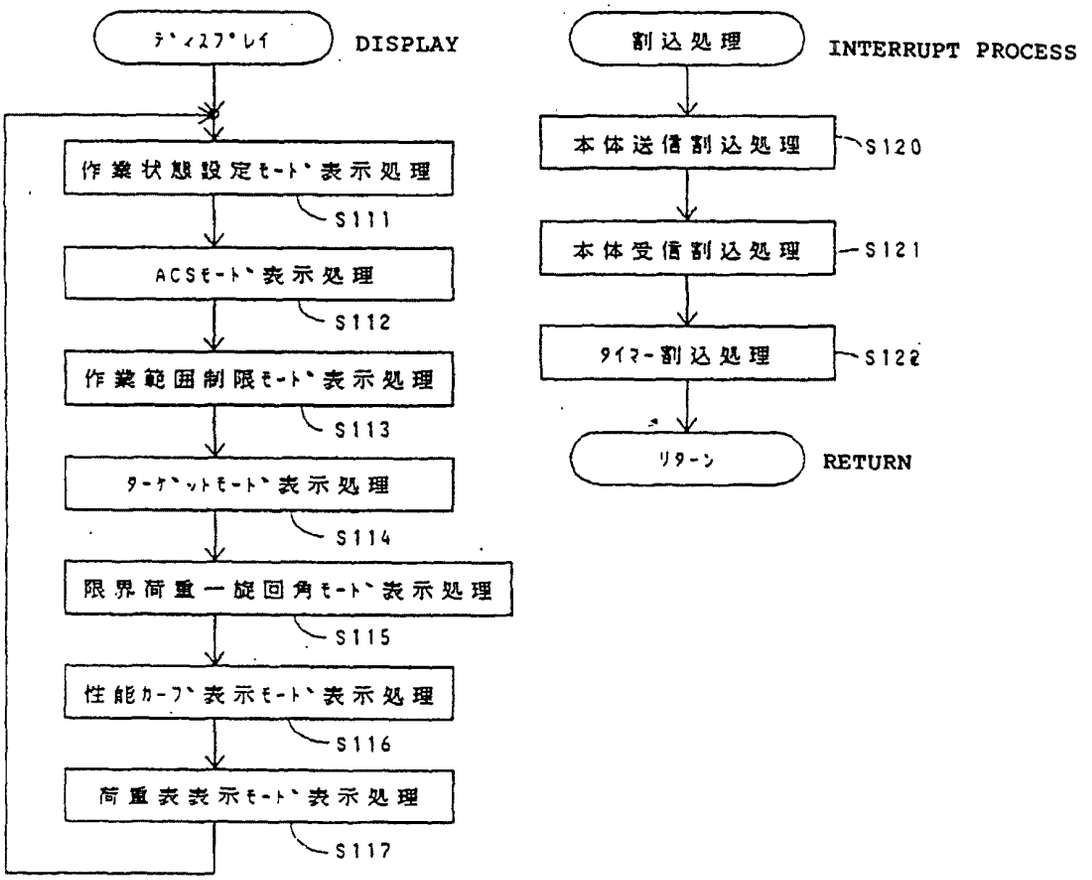
S106 : PROCESSING OF DISPLAY RECEPTION INTERRUPT

S107 : PROCESSING OF DISPLAY TRANSMISSION INTERRUPT

S108 : PROCESSING OF TOP TERMINAL RECEPTION

S109 : PROCESSING OF ANALOG DATA INTERRUPT

FIG. 11



S111 : PROCESSING OF OPERATION STATUS SETTING MODE DISPLAY

S112 : PROCESSING OF ACS MODE DISPLAY

S113 : PROCESSING OF OPERATION RANGE LIMIT MODE

S114 : PROCESSING OF TARGET MODE DISPLAY

S115 : PROCESSING OF LIMIT LOAD - SLEWING ANGLE MODE DISPLAY

S116 : PROCESSING OF PERFORMANCE CURVE DISPLAY MODE DISPLAY

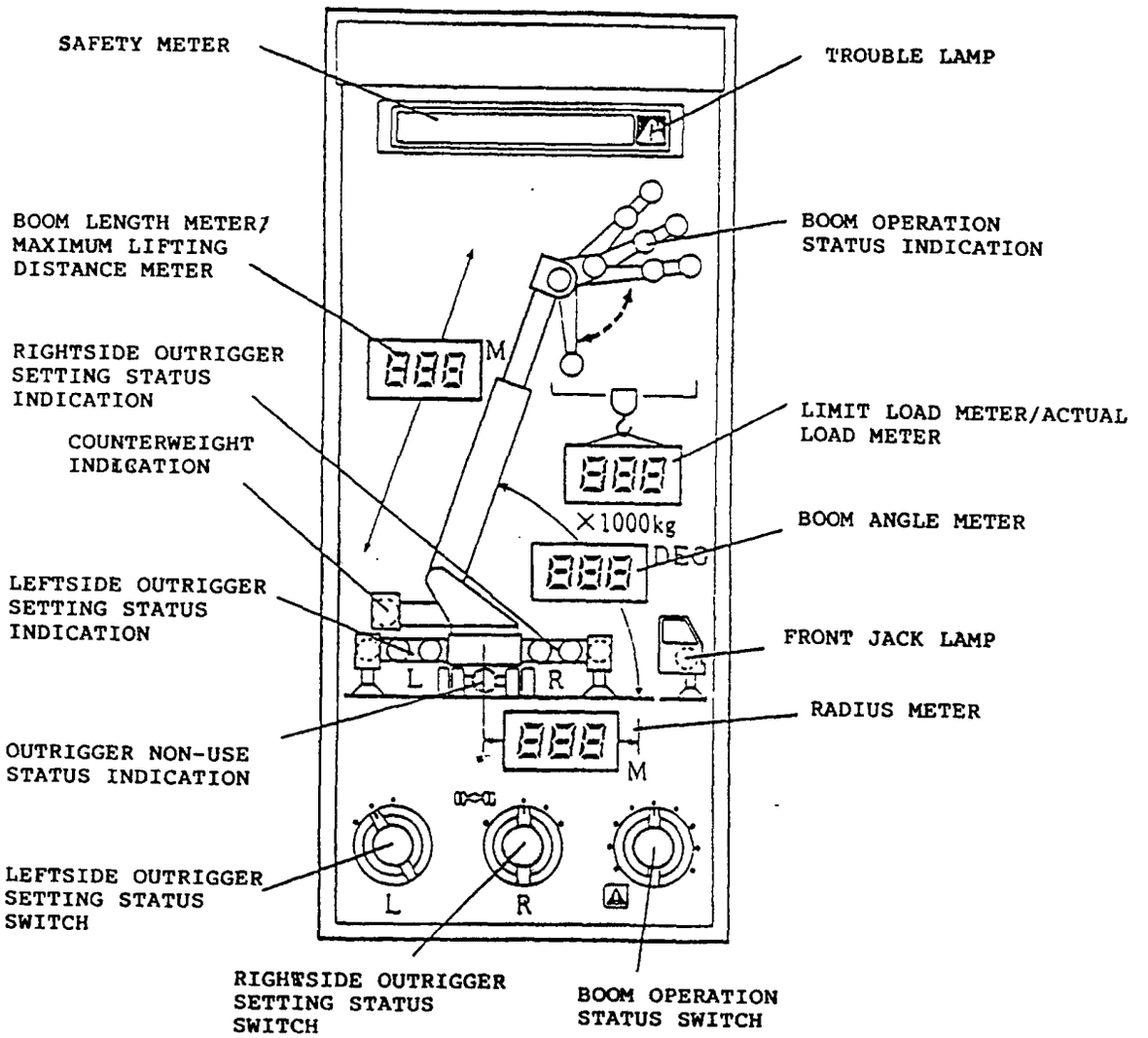
S117 : PROCESSING OF LOAD TABLE DISPLAY MODE DISPLAY

S120 : PROCESSING OF MAIN UNIT TRASMISSION INTERRUPT

S121 : PROCESSING OF MAIN UNIT RECEPTION INTERRUPT

S122 : PROCESSING OF TIMER INTERRUPT

FIG. 12



（従来技術）

PRIOR ART