DESCRIPTION

LIFTING DEVICE AND ATTITUDE ADJUSTING METHOD FOR CRANE LOAD

TECHNICAL FIELD

[0001] The present invention relates to a lifting device and an attitude adjusting method for a crane load.

BACKGROUND ART

[0002] There is a known lifting device that is provided with a plurality of slings for lifting a crane load and that holds the crane load at the horizontal position in a state in which the crane load is lifted (see JPH9-118492A). The lifting device disclosed in JPH9-118492A is provided with inclined-angle detection means, sling-length changing means, and horizontal control means. The inclined-angle detection means detects inclination of the crane load relative to the horizontal direction, the sling-length changing means changes lengths of the individual slings, and the horizontal control means controls the sling-length changing means such that the lengths of the slings are changed until the inclined-angle detection means detects the horizontal position of the crane load. In addition, JPH9-118492A discloses that it is possible to employ, as the sling-length changing means, a winch mechanism equipped with a driving device capable of winding up and sending out the slings.

[0003] Furthermore, JPH9-118492A discloses that a recovery operation is performed by driving devices 9xa and 9xb when an inclination in the X-axis direction is detected by an X-axis inclined angle detection sensor until an inclined angle detection sensor 12x returns to a horizontal state, and the

recovery operation is performed by driving devices 9ya and 9yb when an inclination in the Y-axis direction is detected by an Y-axis inclined angle detection sensor until an inclined angle detection sensor 12y returns to the horizontal state.

SUMMARY OF INVENTION

[0004] However, depending on a method of adjusting the attitude of the crane load, there is a risk in that a part of a plurality of slings is loosened. For example, in a configuration in which a beam is supported with four slings, there is a problem in that, if lengths L1 and L2 of two slings are each changed in the opposite directions at the same time by the same amount (see paragraph [0019] in JPH9-118492A), one of the slings is loosened, and the attitude of the crane load is decided by only three slings, and as a result, the load applied to the three slings is increased.

[0005] An object of the present invention is to provide a lifting device and an attitude adjusting method for a crane load capable of adjusting an attitude of a crane load without loosening slings such as wire ropes, etc. linking a lifting beam and a lifting equipment.

[0006] According to one aspect of the present invention, a lifting device includes: a lifting beam linkable to a crane load; at least four slings configured to link the lifting beam and a lifting equipment of a crane; attachment parts provided on the lifting beam, the at least four slings being respectively attached to the attachment parts; an inclined angle measuring device provided on at least one of the crane load and the lifting beam, the inclined angle measuring device being configured to measure an inclined angle relative to a horizontal plane; distance adjusting devices provided on at least (N-1) number of the

slings among the at least four slings when number of the slings is N, the distance adjusting devices being configured to adjust distances between the lifting equipment and the attachment parts attached to the slings; and a control device configured to adjust an attitude of the crane load by controlling the distance adjusting devices based on the inclined angle measured by the inclined angle measuring device. The inclined angle measuring device is configured to be capable of measuring the inclined angles about an X-axis and a Y-axis that are perpendicular to each other. The control device adjusts: an attitude of the crane load about the X-axis to the predetermined attitude, based on the inclined angle about the X-axis, by holding distances between the lifting equipment and all of the attachment parts provided on a first side of a first vertical plane as a boundary and by controlling a plurality of the distance adjusting devices in parallel such that distances between the lifting equipment and all of the attachment parts provided on a second side of the first vertical plane as the boundary are respectively reduced or increased, the first vertical plane being parallel to the X-axis, perpendicular to a horizontal plane, and including a center of gravity of the crane load; and an attitude of the crane load about the Y-axis to the predetermined attitude, based on the inclined angle about the Y-axis, by holding distances between the lifting equipment and all of the attachment parts provided on a first side of a second vertical plane as a boundary and by controlling the plurality of the distance adjusting devices in parallel such that distances between the lifting equipment and all of the attachment parts provided on a second side of the second vertical plane as the boundary are respectively reduced or increased, the second vertical plane being parallel to the Y-axis, perpendicular to the horizontal plane, and including the center of gravity of the crane load.

[0007] According to another aspect of the present invention, a method of adjusting an attitude of a crane load by a lifting device provided with: a lifting beam linkable to a crane load; at least four slings configured to link the lifting beam and a lifting equipment of a crane; attachment parts provided on the lifting beam, the at least four slings being respectively attached to the attachment parts; an inclined angle measuring device provided on at least one of the crane load and the lifting beam, the inclined angle measuring device being configured to measure an inclined angle relative to a horizontal plane; and distance adjusting devices provided on at least (N-1) number of the slings among the at least four slings when number of the slings is N, the distance adjusting devices being configured to adjust distances between the lifting equipment and the attachment parts attached to the slings. The attitude of the crane load being configured to be adjusted based on the inclined angle measured by the inclined angle measuring device, and The inclined angle measuring device being configured to be capable of measuring the inclined angles about an X-axis and a Y-axis that are perpendicular to each other. The method includes: a first attitude adjustment step of adjusting an attitude of the crane load about the X-axis to the predetermined attitude, based on the inclined angle about the X-axis, by holding distances between the lifting equipment and all of the attachment parts provided on a first side of a first vertical plane as a boundary and by operating a plurality of the distance adjusting devices in parallel such that distances between the lifting equipment and all of the attachment parts provided on a second side of the first vertical plane as the boundary are respectively reduced or increased, the first vertical plane being parallel to the X-axis, perpendicular to a horizontal plane, and including a center of gravity of the crane load; and a second attitude

adjustment step of adjusting an attitude of the crane load about the Y-axis to the predetermined attitude, based on the inclined angle about the Y-axis, by holding distances between the lifting equipment and all of the attachment parts provided on a first side of a second vertical plane as a boundary and by operating the plurality of the distance adjusting devices in parallel such that distances between the lifting equipment and all of the attachment parts provided on a second side of the second vertical plane as the boundary are respectively reduced or increased, the second vertical plane being parallel to the Y-axis, perpendicular to the horizontal plane, and including the center of gravity of the crane load.

BRIEF DESCRIPTION OF DRAWINGS

[0008] FIG. 1 is a simplified perspective view of a lifting device according to a first embodiment of the present invention.

FIG. 2A is a schematic plan view of the lifting device.

FIG. 2B is a schematic plan view showing position of the center of gravity of a crane load.

FIG. 3 is a flow chart describing an adjustment procedure of an attitude of a block (the crane load).

FIG. 4A is a diagram viewed from the IV direction in FIG. 1 and shows the crane load in a lifted state.

FIG. 4B is a diagram for explaining a first attitude adjustment step and shows a state in which the attitude of the crane load about the X-axis is adjusted to a predetermined attitude.

FIG. 5A is a diagram viewed from the V direction in FIG. 1 and shows the crane load in the lifted state.

FIG. 5B is a diagram for explaining a second attitude adjustment step and shows a state in which the attitude of the crane load about the Y-axis is adjusted to the predetermined attitude.

FIG. 6 is a simplified perspective view of the lifting device according to a second embodiment of the present invention.

FIG. 7 is a flow chart showing an example of the process content of an attitude adjustment control performed by a control device.

FIG. 8 is a flow chart showing an example of the content of a first attitude control executed by the control device.

FIG. 9 is a flow chart showing an example of the content of a second attitude control executed by the control device.

FIG. 10 is a simplified perspective view of the lifting device according to a third embodiment of the present invention.

FIG. 11 is a flow chart showing an example of the content of the first attitude control executed by the control device.

FIG. 12 is a flow chart showing an example of the content of the second attitude control executed by the control device.

FIG. 13 is a simplified perspective view of the lifting device according to a second modification of this embodiment.

FIG. 14A is a side view showing a state in which a hydraulic cylinder of a retracting device is extended.

FIG. 14B is a side view showing a state in which the hydraulic cylinder of the retracting device is contracted.

FIG. 15 is a schematic plan view of the lifting device according to a third modification of the present embodiment.

FIG. 16A is a diagram for explaining the attitude adjusting method for a

case in which the center of gravity of the crane load is closer to a lifting lug P11 than a lifting lug P31 and closer to the lifting lug P11 than a lifting lug P12.

FIG. 16B is a diagram for explaining the attitude adjusting method for a case in which the center of gravity of the crane load is closer to the lifting lug P31 than the lifting lug P11 and closer to the lifting lug P12 than the lifting lug P11.

DESCRIPTION OF EMBODIMENTS

[0009] A lifting device and an attitude adjusting method for a crane load according to embodiments of the present invention will be described with reference to the drawings.

[0010] <FIRST EMBODIMENT>

A lifting device 100 and an attitude adjusting method of a crane load 8 according to a first embodiment of the present invention will be described with reference to FIGs. 1 to 5.

[0011] FIG. 1 is a simplified perspective view of the lifting device 100. As shown in FIG. 1, the lifting device 100 is provided with: a lifting beam 101 that is linkable to the crane load 8; four slings 120 that link the lifting beam 101 and a lifting equipment 9 such as a lifting hook, etc. of a crane (not shown); lifting lugs (attachment parts) 140 that are provided on the lifting beam 101 and to which the four slings 120 are respectively attached; an inclined angle measuring device 103 that is provided on the lifting beam 101 and that measures an inclined angle relative to the horizontal plane; and chain blocks (distance adjusting devices) 130 provided on three slings 120 among the four slings 120.

[0012] FIG. 2A is a schematic plan view of the lifting device 100. As shown

in FIGs. 1 and 2A, the lifting beam 101 is formed to have an rectangular frame shape. The lifting beam 101 has a pair of main members 111 that are arranged in parallel with each other and three connecting members 112 that connect the pair of main members 111 together at both end portions and the center portion of the main members 111 in the length-wise direction. A section steel such as that having a cross-section of H-shape, I-shape, and so forth can be used for the main members 111 and the connecting members 112.

[0013] In the following, for the sake of convenience of description, the X-axis , the Y-axis, and the Z-axis of the lifting beam 101 are defined as shown in FIG. 1. The X-axis , the Y-axis, and the Z-axis are perpendicular to each other. In addition, the direction parallel to the X-axis is referred to as the X-axis direction, the direction parallel to the Y-axis is referred to as the Y-axis direction, and the direction parallel to the Z-axis is referred to as the Z-axis direction. The X-axis is the axis parallel to the width-wise direction of the lifting beam 101, in other words, the length-wise direction of the connecting members 112. The Y-axis is the axis parallel to the length-wise direction of the lifting beam 101, in other words, the length-wise direction of the main members 111. The Z-axis is the axis perpendicular to the XY-plane. In the lifting beam 101, the attitude in which the Z-axis is parallel to the vertical axis, in other words, the attitude in which the Z-axis is perpendicular to the horizontal plane is referred to a horizontal attitude.

[0014] As shown in FIG. 1, the four lifting lugs 140 to which each of the four slings 120 are respectively attached are provided on a top surface of the main members 111 of the lifting beam 101. Eight lifting lugs 150 to which each of eight slings 104 are respectively attached are provided on a lower surface of the

main members 111 of the lifting beam 101. The lifting lugs 140 and 150 are formed of, for example, a semicircular plate with a through hole and are fixed to the main members 111 by welding, etc.

[0015] The lifting lugs 140 are lifting attachment parts to be lifted by the crane, and the lifting lugs 150 are suspending attachment parts from which the crane load 8 is suspended. The lifting lugs 140 of the lifting beam 101 are linked to the lifting equipment 9 of the crane via the slings 120. The lifting lugs 150 of the lifting beam 101 are linked to lifting lugs 8a of the crane load 8 via the slings 104 such as wire ropes, etc. The lengths of the slings 104 and the positions of the lifting lugs 8a are set such that the attitude of the crane load 8 becomes the same as the attitude of the lifting beam 101. In this embodiment, all of the lengths of the eight slings 104 are the same, and arrangement intervals of the lifting lugs 8a are the same as arrangement intervals of the lifting lugs 150 of the lifting beam 101.

[0016] The lifting lugs 140 that are provided at four points of the lifting beam 101 are respectively arranged such that the distances from the center of gravity of the lifting beam 101 become the same distance. In this embodiment, assuming the direction parallel to the X-axis as the row direction and the direction parallel to the Y-axis as the column direction, the respective lifting lugs 140 are arranged in a matrix of 2 rows by 2 columns.

[0017] The slings 120 for linking the lifting equipment 9 of the crane and the lifting beam 101 will be described in detail. The lifting device 100 according to this embodiment has a first sling 121, a second sling 122, a third sling 123, and a fourth sling 124 as the four slings 120. In the following, the lifting lug 140 to which the first sling 121 is attached is referred to as a first lifting lug 141 (first attachment part), the lifting lug 140 to which the second

sling 122 is attached is referred to as a second lifting lug 142 (second attachment part), the lifting lug 140 to which the third sling 123 is attached is referred to as a third lifting lug 143 (third attachment part), and the lifting lug 140 to which the fourth sling 124 is attached is referred to as a fourth lifting lug 144 (fourth attachment part).

[0018] For example, the first sling 121 is formed of a single wire rope, an upper end portion of which is attached to the lifting equipment 9, and a lower end portion of which is attached to the lifting lug 140 via a shackle, etc.

[0019] The second sling 122 has the chain block 130, a wire rope 138 that links the chain block 130 and the lifting equipment 9, and a wire rope 139 that links the chain block 130 and the lifting lug 140.

[0020] The chain block 130 is a known chain block of a suspended type provided with a main body portion 130b with a built-in gear mechanism (not shown), an upper hook 130a that is attached to the main body portion 130b, a load chain 130d and a hand chain 130e that are attached to the gear mechanism, and a lower hook 130c that is attached to one end of the load chain 130d. In the main body portion 130b, a load sheave and a hand chain wheel constituting the gear mechanism are provided coaxially.

[0021] The chain block 130 is configured so as to be capable of feeding the load chain 130d into/out from the chain block 130 (wind up/wind down) by operating the hand chain 130e. As shown in the figure, in a state in which a predetermined tension is applied to the slings 120, the chain blocks 130 are respectively provided on lines connecting the lifting lugs 140 and the lifting equipment 9.

[0022] In this embodiment, because the chain block 130 capable of extending/contracting along a line connecting the second lifting lug 142 and

the lifting equipment 9 is provided on the second sling 122, it is possible to adjust the length of the second sling 122. As described above, the chain block 130 provided on the second sling 122 functions as a distance adjusting device that adjusts the distance between the second lifting lug 142 and the lifting equipment 9 by adjusting the length of the chain block 130 itself, in other words, the length of the load chain 130d fed out from the main body portion 130b.

[0023] It should be noted that, the third sling 123 and the fourth sling 124 have the same configuration as the second sling 122. In other words, the chain blocks 130 are respectively provided on the third sling 123 and the fourth sling 124, and the lengths of the third sling 123 and the fourth sling 124 are adjustable by the chain blocks 130. On the other hand, the chain block 130 is not provided on the first sling 121.

[0024] As described above, in this embodiment, when the number of the slings 120 is N (in this embodiment, N = 4), the chain blocks 130 are provided only on (N-1) number of the slings 120 among N number of the slings 120.

[0025] The inclined angle measuring device 103 is a sensor capable of measuring the inclined angles about the X-axis and the Y-axis that are perpendicular to each other, and has an X-axis-inclined-angle sensor 103x that measures the inclined angle α about the X-axis and a Y-axis-inclined-angle sensor 103y that measures the inclined angle β about the Y-axis. The X-axis-inclined-angle sensor 103x is attached to a side surface of the center portion of the main members 111 in the length-wise direction. The X-axis-inclined-angle sensor 103x has a display portion for displaying the measured inclined angle α about the X-axis. The Y-axis-inclined-angle sensor 103y is attached to a side surface of the center

portion of the connecting members 112 in the length-wise direction. The Y-axis-inclined-angle sensor 103y has a display portion for displaying the measured inclined angle β about the Y-axis.

[0026] Next, a method of constructing a predetermined structure in which, when the structure is constructed by assembling a plurality of blocks, the blocks are lifted as the crane load 8 and assembled to predetermined locations will be described. With the structure that is constructed by building the plurality of blocks in the vertical direction, the structure may be tilted with respect to the vertical axis if the blocks are built with low accuracy. Therefore, when the block is lifted as the crane load 8 and held at the predetermined location, the attitude of the block (the crane load 8) needs to be adjusted with a high accuracy such that the desired attitude is achieved for the block (the crane load 8).

[0027] In this embodiment, because the attitude of the crane load 8 is adjusted in accordance with the procedure, which will be described below, on the basis of the inclined angles α and β measured by the inclined angle measuring device 103, it is possible to adjust the attitude of the crane load 8 with high accuracy.

[0028] FIG. 3 is a flow chart for explaining an adjustment procedure of the attitude of the block (the crane load 8) will be described. As shown in FIG. 3, the adjusting method of the attitude of the crane load 8 according to this embodiment includes a preparation step S10, a crane load lifting step S20, an initial state checking step S30, a first attitude adjustment step S40, a second attitude adjustment step S50, and an installation step S60. As described below, an operator performs operations in the order of the preparation step S10, the crane load lifting step S20, the initial state checking step S30, the first

attitude adjustment step S40, the second attitude adjustment step S50, and the installation step S60.

[0029] (Preparation Step)

In the preparation step S10, the lifting lugs 140 of the lifting device 100 placed at a predetermined storage space are linked to the lifting equipment 9 of the crane by the slings 120. It should be noted that, before the operation of linking the slings 120 is performed, the length of each of the chain blocks 130 is adjusted such that the respective lengths of the four slings 120 (the length from an attachment point to the lifting lug 140 to the attachment point to the lifting equipment 9) become the same.

[0030] After the four slings 120 are attached, the crane is operated to lift the lifting beam 101 and the lifting beam 101 is moved above the crane load 8. Next, the lifting lugs 150 of the lifting beam 101 are linked to the lifting lugs 8a of the crane load 8 by the slings 104. After the eight slings 104 are attached, the preparation step S10 is finished.

[0031] (Crane Load Lifting Step)

In the crane load lifting step S20, the crane is operated to lift the crane load 8 via the lifting device 100. As shown in FIGs. 4A and 5A, once the crane load 8 is lifted up, the crane load 8 and the lifting beam 101 become an inclined state with respect to a horizontal plane HP such that the center of gravity G of the crane load 8 is positioned vertically below (directly below) the lifting equipment 9.

[0032] (Initial State Checking Step)

In the initial state checking step S30, the inclined angle of the lifting beam 101 is measured by the inclined angle measuring device 103. It should be noted that, in this embodiment, an inclined attitude of the crane load 8 is

the same as the inclined attitude of the lifting beam 101. Therefore, "measuring the inclined angle of the lifting beam 101" has the same meaning as "measuring the inclined angle of the crane load 8". In the initial state checking step S30, the inclined angle α of the lifted crane load 8 about the X-axis relative to the horizontal plane HP (see FIG. 4A) is measured by the X-axis-inclined-angle sensor 103x, and the inclined angle β of the lifted crane load 8 about the Y-axis from the horizontal plane HP (see FIG. 5A) is measured by the Y-axis-inclined-angle sensor 103y. The inclined angle α measured in the initial state checking step S30 is recorded as a value α0, and the inclined angle β measured in the initial state checking step S30 is recorded as a value β0.

[0033] (First Attitude Adjustment Step)

In the first attitude adjustment step S40, the attitudes of the crane load 8 and the lifting beam 101 about the X-axis are adjusted to a predetermined attitude by the chain blocks 130. In this embodiment, the predetermined attitude about the X-axis refers to the attitude at which the inclined angle α about the X-axis relative to the horizontal plane HP is substantially 0°.

[0034] The first attitude adjustment step S40 will be described in detail with reference to FIGs. 2B, 4A, and 4B. In the first attitude adjustment step S40, the length of a predetermined sling 120 is adjusted to adjust the attitude about the X-axis. The sling 120 to be subjected to the adjustment of the length by the chain block 130 in the first attitude adjustment step S40 is decided as described below.

[0035] As shown in FIGs. 2B and 4A, an imaginary plane that is parallel to the X-axis, perpendicular to the horizontal plane HP, and includes the center of gravity G of the crane load 8 is defined as a first vertical plane VP1. The

slings 120 attached to all of the lifting lugs 140 provided on the first side of the first vertical plane VP1 as the boundary are each recognized as "a non-adjustment object" the length of which is not to be adjusted. Here, a plurality of lifting lugs 140 provided on the first side of the first vertical plane VP1 as the boundary include the first lifting lug 141 to which the first sling 121, on which the chain block 130 is not provided, is attached. In addition, all of the slings 120 provided on the second side of the first vertical plane VP1 as the boundary are each recognized as "an adjustment object" the length of which is to be adjusted.

[0036] In the first attitude adjustment step S40, for the slings 120 (121 and 123) that have been recognized as the non-adjustment objects, the lengths are not adjusted, and the distances between the lifting lugs 140 and the lifting equipment 9 are held. On the other hand, in the first attitude adjustment step S40, for the slings 120 (122 and 124) that have been recognized as the adjustment object, the lengths are adjusted, and the distances between the lifting lugs 140 and the lifting equipment 9 are changed.

[0037] In the first attitude adjustment step S40, the operator concurrently operates the chain block 130 of the second sling 122 that has been recognized as the adjustment object (hereinafter, also referred to as a second chain block 132) and the chain block 130 of the fourth sling 124 that has been recognized as the adjustment object (hereinafter, also referred to as a fourth chain block 134).

[0038] In this embodiment, as shown in FIG. 4A, the attitude is such that the second lifting lug 142 is positioned at higher level than the first lifting lug 141, and the fourth lifting lug 144 is positioned at the higher level than the third lifting lug 143. Therefore, in this embodiment, the second chain block

132 and the fourth chain block 134 are operated in parallel such that the linear distance between the second lifting lug 142 and the lifting equipment 9 and the linear distance between the fourth lifting lug 144 and the lifting equipment 9 are respectively increased. It should be noted that, "the second chain block 132 and the fourth chain block 134 are respectively operated in parallel" includes not only a case in which both chain blocks are operated at exactly the same time, but also a case in which the both chain blocks are operated alternately.

[0039] At this time, it is preferable that the attitude of the crane load 8 about the X-axis be adjusted to the predetermined attitude by operating the second chain block 132 and the fourth chain block 134 in parallel such that the inclined angle β about the Y-axis (see FIG. 5A) is maintained within a predetermined inclined angle range ($\beta 0 - \Delta\beta \leq \beta \leq \beta 0 + \Delta\beta$). It should be noted that, the value $\beta 0 - \Delta\beta$ is the lower limit value of the inclined angle range, and the value $\beta 0 + \Delta\beta$ is the upper limit value of the inclined angle range. The upper limit value and the lower limit value are set such that the tension of at least a predetermined value is applied to all of the slings 120. By adjusting the inclined angle α by operating the chain blocks 130 such that the inclined angle β is not essentially changed from the initial state, it is possible to maintain a state in which the tension of at least the predetermined value is applied to each of the slings 120.

[0040] The operator operates the chain blocks 130 provided on the second sling 122 and the fourth sling 124 while checking the inclined angles α and β displayed on the display portions of the X-axis-inclined-angle sensor 103x and the Y-axis-inclined-angle sensor 103y, and thereby, the operator adjusts the attitudes of the crane load 8 and the lifting beam 101 about the X-axis until

the inclined angle α becomes a predetermined angle α1 (in this embodiment, α1 = 0°) as shown in FIG. 4B. As a result, the first attitude adjustment step S40 is finished.

[0041] In the first attitude adjustment step S40, the second chain block 132 and the fourth chain block 134 are operated such that the inclined angle β is not essentially changed from the initial state. Therefore, the amount of downward movement of the second lifting lug 142 in the Z-axis direction (alternatively, the amount of downward movement in the vertical direction) can be made substantially the same as the amount of downward movement of the fourth lifting lug 144 in the Z-axis direction (alternatively, the amount of downward movement in the vertical direction). As a result, in the first attitude adjustment step S40, the lifting beam 101 can be revolved about the X-axis until the inclined angle α about the X-axis becomes substantially 0°, and it is possible to prevent loosening of the sling 120 in this step.

[0042] It should be noted that, in the initial state, in a case in which the inclination direction about the X-axis is inverted, in other words, in a case in which the attitude is such that the second lifting lug 142 is positioned at the lower level than the first lifting lug 141 and the fourth lifting lug 144 is positioned at the lower level than the third lifting lug 143, the lengths of the second sling 122 and the fourth sling 124 are reduced concurrently. In other words, the second chain block 132 and the fourth chain block 134 are operated in parallel such that the linear distance between the second lifting lug 142 and the lifting equipment 9 and the linear distance between the fourth lifting lug 144 and the lifting equipment 9 are respectively reduced.

[0043] (Second Attitude Adjustment Step)

In the second attitude adjustment step S50, the attitudes of the crane

load 8 and the lifting beam 101 about the Y-axis are adjusted to the predetermined attitude by the chain blocks 130. In this embodiment, the predetermined attitude about the Y-axis refers to the attitude in which the inclined angle β about the Y-axis relative to the horizontal plane HP becomes substantially 0°.

[0044] The second attitude adjustment step S50 will be described in detail with reference to FIGs. 2B, 5A, and 5B. In the second attitude adjustment step S50, the length of the predetermined sling 120 is adjusted to adjust the attitude about the Y-axis. The sling 120 to be subjected to the adjustment of the length by the chain block 130 in the second attitude adjustment step S50 is decided as described below.

[0045] As shown in FIGs. 2B and 5A, an imaginary plane that is parallel to the Y-axis, perpendicular to the horizontal plane HP, and includes the center of gravity G of the crane load 8 is defined as a second vertical plane VP2. The slings 120 attached to all of the lifting lugs 140 provided on the first side of the second vertical plane VP2 as the boundary are each recognized as "the non-adjustment object" the length of which is not to be adjusted. Here, a plurality of lifting lugs 140 provided on the first side of the second vertical plane VP2 as the boundary include the first lifting lug 141 to which the first sling 121, on which the chain block 130 is not provided, is attached. In addition, all of the slings 120 provided on the second side of the second vertical plane VP2 as the boundary are each recognized as "the adjustment object" the length of which is to be adjusted.

[0046] In the second attitude adjustment step S50, for the slings 120 (121 and 122) that have been recognized as the non-adjustment objects, the lengths are not adjusted, and the distances between the lifting lugs 140 and the lifting

equipment 9 are held. On the other hand, in the second attitude adjustment step S50, for the slings 120 (123 and 124) that have been recognized as the adjustment object, the lengths are adjusted, and the distances between the lifting lugs 140 and the lifting equipment 9 are changed.

[0047] In the second attitude adjustment step S50, the operator concurrently operates the chain block 130 of the third sling 123 that has been recognized as the adjustment object (hereinafter, also referred to as a third chain block 133) and the chain block 130 of the fourth sling 124 that has been recognized as the adjustment object (the fourth chain block 134).

[0048] In this embodiment, as shown in FIG. 5A, the attitude is such that the third lifting lug 143 is positioned at the higher level than the first lifting lug 141, and the fourth lifting lug 144 is positioned at the higher level than the second lifting lug 142. Therefore, in this embodiment, the third chain block 133 and the fourth chain block 134 are operated in parallel such that the linear distance between the third lifting lug 143 and the lifting equipment 9 and the linear distance between the fourth lifting lug 144 and the lifting equipment 9 are respectively increased. It should be noted that, "the third chain block 133 and the fourth chain block 134 are respectively operated in parallel" includes not only a case in which both chain blocks are operated at exactly the same time, but also a case in which the both chain blocks are operated alternately.

[0049] At this time, it is preferable that the attitude of the crane load 8 about the Y-axis be adjusted to the predetermined attitude by operating the third chain block 133 and the fourth chain block 134 in parallel such that the inclined angle α about the X-axis (see FIG. 4A) is maintained within the predetermined inclined angle range ($\alpha 1 - \Delta\alpha \leq \alpha \leq \alpha 1 + \Delta\alpha$). It should be noted

that, the value $\alpha 1 - \Delta\alpha$ is the lower limit value of the inclined angle range, and the value $\alpha 1 + \Delta\alpha$ is the upper limit value of the inclined angle range. The upper limit value and the lower limit value are set such that the tension of at least a predetermined value is applied to all of the slings 120. By adjusting the inclined angle β by operating the chain blocks 130 such that the inclined angle α is not essentially changed from the state in which the angle α has been adjusted to the predetermined angle $\alpha 1$ (in this embodiment, $\alpha 1 = 0°$) in the first attitude adjustment step S40, it is possible to maintain a state in which the tension of at least the predetermined value is applied to each of the slings 120.

[0050] The operator operates the chain blocks 130 provided on the third sling 123 and the fourth sling 124 while checking the inclined angles α and β displayed on the display portions of the X-axis-inclined-angle sensor 103x and the Y-axis-inclined-angle sensor 103y, and thereby, the operator adjusts the attitudes of the crane load 8 and the lifting beam 101 about the Y-axis until the inclined angle β becomes the predetermined angle $\beta 1$ (in this embodiment, $\beta 1 = 0°$) as shown in FIG. 5B. As a result, the second attitude adjustment step S50 is finished, and the attitude of each of the crane load 8 and the lifting beam 101 becomes the horizontal attitude.

[0051] In the second attitude adjustment step S50, the third chain block 133 and the fourth chain block 134 are operated such that the inclined angle α is not essentially changed from the state after the first attitude adjustment step has been finished. Therefore, the amount of downward movement of the third lifting lug 143 in the Z-axis direction (alternatively, the amount of downward movement in the vertical direction) can be made substantially the same as the amount of downward movement of the fourth lifting lug 144 in the

Z-axis direction (alternatively, the amount of downward movement in the vertical direction). As a result, in the second attitude adjustment step S50, the lifting beam 101 can be revolved about the Y-axis until the inclined angle β about the Y-axis becomes substantially 0°, and it is possible to prevent loosening of the sling 120 in this step.

[0052] It should be noted that, in a state after the first attitude adjustment step has been finished, in a case in which the inclination direction about the Y-axis is inverted, in other words, in a case in which the attitude is such that the third lifting lug 143 is positioned at the lower level than the first lifting lug 141 and the fourth lifting lug 144 is positioned at the lower level than the second lifting lug 142, the lengths of the third sling 123 and the fourth sling 124 are reduced concurrently. In other words, the third chain block 133 and the fourth chain block 134 are operated in parallel such that the linear distance between the third lifting lug 143 and the lifting equipment 9 and the linear distance between the fourth lifting lug 144 and the lifting equipment 9 are respectively reduced.

[0053] (Installation Step)

In the installation step S60, the crane is operated to move the crane load 8 to a predetermined location and allows the crane load 8 to be installed to an installation object. Once the installation of the crane load 8 is finished, the slings 104 are detached from the lifting lugs 8a of the crane load 8, and the installation step S60 is finished.

[0054] According to the above-described embodiment, following operational advantages are afforded.

[0055] (1) The adjusting method of the attitude of the crane load 8 according to this embodiment includes the first attitude adjustment step S40

and the second attitude adjustment step S50. In the first attitude adjustment step S40, the attitude of the crane load 8 about the X-axis is adjusted to the predetermined attitude, on the basis of the inclined angle α about the X-axis, by holding the distances between the lifting equipment 9 and all of lifting lugs (141 and 143) provided on the first side of the first vertical plane VP1 as the boundary and by operating the plurality of chain blocks (132 and 134) in parallel such that the distances between the lifting equipment 9 and all of the lifting lugs (142 and 144) provided on the second side of the first vertical plane VP1 as the boundary are respectively reduced or increased. In the second attitude adjustment step S50, the attitude of the crane load 8 about the Y-axis is adjusted to the predetermined attitude, on the basis of the inclined angle β about the Y-axis, by holding the distances between the lifting equipment 9 and all of the lifting lugs (141 and 142) provided on the first side of the second vertical plane VP2 as the boundary and by operating the plurality of chain blocks (133 and 134) in parallel such that the distances between the lifting equipment 9 and all of the lifting lugs (143 and 144) provided on the second side of the second vertical plane VP2 as the boundary are respectively reduced or increased.

[0056] In the first attitude adjustment step S40, because the attitude about the X-axis is adjusted by operating the plurality of chain blocks (132 and 134) in parallel, it is possible to prevent loosening of the sling 120 as compared with a case in which three chain blocks (132, 133, and 134) are operated in parallel. In addition, in the second attitude adjustment step S50, because the attitude about the Y-axis is adjusted by operating the plurality of chain blocks (133 and 134) in parallel, it is possible to prevent loosening of the sling 120 as compared with a case in which three chain blocks (132, 133, and 134) are operated in

parallel. In other words, according to this embodiment, it is possible to adjust the attitude of the crane load 8 without loosening the sling 120 linking the lifting beam 101 and the lifting equipment 9.

[0057] (2) By performing two steps: the first attitude adjustment step S40 and the second attitude adjustment step S50, it is possible to adjust the attitudes of the crane load 8 and the lifting beam 101 to the target attitude. In other words, according to this embodiment, it is not required to perform a complex operation and an operation in a manner of trial-and-error, and it is possible to rapidly perform the attitude adjustment operation for the crane load 8 and the lifting beam 101.

[0058] (3) Because the attitude of the crane load 8 can be adjusted in accordance with the inclined angle measuring device 103 that is capable of measuring the inclined angle α about the X-axis and the inclined angle β about the Y-axis, it is possible to adjust the attitude of the crane load 8 with high accuracy as compared with a case in which the attitude of the crane load 8 is visually adjusted.

[0059] (4) In this embodiment, because the inclined angle measuring device 103 is provided on the lifting beam 101, it is also possible to adjust the attitude of the lifting beam 101 in a state in which the crane load 8 is not suspended. Therefore, it is possible to adjust the attitude of the lifting beam 101 to the horizontal attitude after the crane load 8 has been lowered but before next crane load 8 is lifted. Because the position of the center of gravity G of the crane load 8 differs depending on the type and shape of the crane load 8, by adjusting the attitude of the lifting beam 101 to the horizontal attitude (the initial attitude) in advance, it is possible to achieve an improvement in efficiencies of lifting operation of the crane load 8.

[0060] (5) The chain blocks 130 are provided on the slings 120 linking the lifting equipment 9 and the lifting beam 101. Here, the number of the slings 104 (in this embodiment, eight) linking the lifting beam 101 and the crane load 8 may be larger than the number of the slings 120 (in this embodiment, four) linking the lifting equipment 9 and the lifting beam 101. Therefore, as compared with the case in which the chain blocks 130 are provided on the slings 104 linking the lifting beam 101 and the crane load 8, the number of the chain blocks 130 can be reduced, and it is possible to improve efficiencies of the operation.

[0061] (6) In addition, in a case in which the chain blocks 130 are provided on the slings 104, the chain blocks 130 needs to be removed when the lifting beam 101 is placed in the storage space, and the chain blocks 130 needs to be attached to the lifting beam 101 again when the lifting beam 101 is to be used again. In contrast, in this embodiment, because the chain blocks 130 are provided on the slings 120 linking the lifting equipment 9 and the lifting beam 101, when the lifting beam 101 is stored, the chain blocks 130 needs not be removed from the lifting beam 101. Therefore, according to this embodiment, the operation of removing the chain blocks 130 can be omitted when the lifting beam 101 is stored, and the operation of attaching the chain blocks 130 can be omitted when the lifting beam 101 is used again, and therefore, it is possible to improve the operation efficiencies.

[0062] (7) In this embodiment, the chain blocks 130 are not provided on all of the slings 120 linking the lifting equipment 9 and the lifting beam 101, and when the number of the slings 120 is N (in this embodiment, N = 4), the chain blocks 130 are provided only on (N-1) number of slings (122, 123, and 124) among all of the slings 120. Therefore, it is possible to reduce weight and cost

of the lifting device 100 as compared with a case in which the chain blocks 130 are provided on all of the slings 120.

[0063] <Second Embodiment>

A lifting device 200 according to a second embodiment of the present invention will be described with reference to FIGs. 6 to 9. In the following, differences from the above-mentioned first embodiment will be mainly described, and in the figures, components that are the same as or correspond to the components described in the above-mentioned first embodiment are assigned the same reference numerals and description thereof will be omitted.

[0064] In the above-mentioned first embodiment, the explanation has been given to the example in which the attitudes of the crane load 8 and the lifting beam 101 are adjusted by the operator by manually operating the predetermined chain block 130 while visually checking the inclined angles α and β displayed on the display portions of the X-axis-inclined-angle sensor 103x and the Y-axis-inclined-angle sensor 103y. In contrast, in the second embodiment, the attitudes of the crane load 8 and the lifting beam 101 are automatically adjusted by a control device 260. The detail will be described below.

[0065] FIG. 6 is a simplified perspective view of the lifting device 200. As shown in FIG. 6, the lifting device 200 according to the second embodiment is provided with the lifting beam 101, four slings 220, an inclined angle measuring device 203 that is attached to the lifting beam 101, and the control device 260 that is attached to the lifting beam 101.

[0066] In the second embodiment, the inclined angle measuring device 203 is a sensor capable of measuring capable of measuring the inclined angles about the X-axis and the Y-axis that are perpendicular to each other, and has

an X-axis-inclined-angle sensor 203x that measures the inclined angle α about the X-axis and a Y-axis-inclined-angle sensor 203y that measures the inclined angle β about the Y-axis.

[0067] The X-axis-inclined-angle sensor 203x outputs information related to the inclined angle α about the X-axis, which is the measurement result, to the control device 260. The Y-axis-inclined-angle sensor 203y outputs information related to the inclined angle β about the Y-axis, which is the measurement result, to the control device 260.

[0068] Similarly to the above-mentioned first embodiment, the lifting device 200 is provided with four slings 220. A second sling 222, a third sling 223, and a fourth sling 224 are each provided with an electric chain block 230 having an electric motor 230m instead of the manually operated chain block 130 described in the above-mentioned first embodiment. It should be noted that, a first sling 221 is not provided with the electric chain block 230.

[0069] For the sake of convenience of description, the electric chain block 230 provided on the second sling 222 is referred to as a second electric chain block 232, the electric chain block 230 provided on the third sling 223 is referred to as a third electric chain block 233, and the electric chain block 230 provided on the fourth sling 224 is referred to as a fourth electric chain block 234. It should be noted that, the respective electric chain blocks 230 (232, 233, and 234) are the same chain blocks. Therefore, a representative description will be given on the electric chain block 230 provided on the second sling 222.

[0070] The electric chain block 230 functions as the distance adjusting device that adjusts the distance between the second lifting lug 142 and the lifting equipment 9 by adjusting the length of the load chain 130d fed out from

the main body portion 130b by using the electric motor 230m and deceleratingly rotating the load sheave mashed with the load chain 130d.

[0071] In the electric motor 230m, when a driving signal is input from the control device 260, a built-in break device (not shown) is set to a non-operating state, and a rotor (not shown) is rotated, thereby rotating the load sheave (not shown). As the load sheave (not shown) is rotated, the load chain 130d is fed out from the main body portion 130b, or the load chain 130d is fed into the main body portion 130b. In the electric motor 230m, when a stop signal is input from the control device 260, the rotation of the rotor (not shown) is stopped, and the break device (not shown) is set to an operating state, thereby locking the load sheave (not shown). As the load sheave (not shown) is locked, the length of the load chain 130d is maintained at a predetermined length.

[0072] The control device 260 is electrically connected to the inclined angle measuring device 203 and the electric motor 230m of the electric chain block 230. It should be noted that the present invention is not limited to the configuration in which the information is transferred through a wired communication between the control device 260 and each of the inclined angle measuring device 203 and the electric chain block 230, and the transfer of the information may be achieved through a wireless communication.

[0073] The control device 260 adjusts the attitudes of the crane load 8 and the lifting beam 101 by controlling the electric chain blocks 230 on the basis of the inclined angles α and β measured by the inclined angle measuring device 203.

[0074] The control device 260 is constituted of a microcomputer provided with a CPU (Central Processing Unit) as an operation circuit, a storing unit such as ROM (Read Only Memory), RAM (Random Access Memory), and so

forth, an input-output interface (I/O interface), and other peripheral circuits. The control device 260 may also be constituted of a plurality of microcomputers. In the storing unit of the control device 260, an attitude control program for controlling the attitude of the lifting device 200 is stored. In other words, the storing unit is a storage medium from which a program that realizes the function according to this embodiment can be read out.

[0075] It should be noted that, as the operation circuit, an MPU (Micro Processing Unit), a DSP (Digital Signal Processor), an ASIC (application specific integrated circuit), an FPGA (Field Programmable Gate Array), and so forth may be used instead of or together with the CPU.

[0076] FIG. 7 is a flow chart showing an example of the process content of an attitude adjustment control executed by the control device 260. The process shown in this flow chart is started when, for example, an attitude adjustment switch provided in the control device 260 is switched ON, and is executed repeatedly at a predetermined control cycle after an initial setting (not shown) is performed. With the attitude adjusting method for the crane load 8 and the lifting beam 101 according to the second embodiment, the preparation step S10 and the crane load lifting step S20 that have been described in the first embodiment are executed, and thereafter, a power of the control device 260 is turned ON, and thereby, the attitude adjustment switch of the control device 260 is switched ON. In other words, respective processes of the control device 260 are performed in a state in which the crane load 8 is lifted.

[0077] As shown in FIG. 7, in Step S201, the control device 260 acquires the information for the inclined angle α measured by the X-axis-inclined-angle sensor 203x (see FIG. 4A) and the inclined angle β measured by the

Y-axis-inclined-angle sensor 203y (see FIG. 5A), and the process proceeds to Step S210. It should be noted that, the inclined angle α acquired in this step is stored in the storing unit as an initial value α0 for the inclined angle α. Similarly, the inclined angle β acquired in this step is stored in the storing unit as an initial value β0 for the inclined angle β.

[0078] In this embodiment, as shown in FIGs. 4A and 5A, angle of 0° is set for the inclined angle α and the inclined angle β when the lifting beam 101 is at the horizontal attitude. In addition, as shown in FIG. 4A, when the second lifting lug 142 is positioned at the higher level than the first lifting lug 141, in other words, when the fourth lifting lug 144 is positioned at the higher level than the third lifting lug 143, a positive value is set for the inclined angle α. On the other hand, when the second lifting lug 142 is positioned at the lower level than the first lifting lug 141, in other words, when the fourth lifting lug 144 is positioned at the lower level than the third lifting lug 143, a negative value is set for the inclined angle α. As shown in FIG. 5A, when the third lifting lug 143 is positioned at the higher level than the first lifting lug 141, in other words, when the fourth lifting lug 144 is positioned at the higher level than the second lifting lug 142, a positive value is set for the inclined angle β. On the other hand, when the third lifting lug 143 is positioned at the lower level than the first lifting lug 141, in other words, when the fourth lifting lug 144 is positioned at the lower level than the second lifting lug 142, a negative value is set for the inclined angle β.

[0079] In Step S210, the control device 260 executes a first attitude control with which the attitudes of the crane load 8 and the lifting beam 101 about the X-axis are adjusted to the predetermined attitude by the electric chain blocks 230. Similarly to the above-mentioned first embodiment, the predetermined

attitude about the X-axis refers to the attitude at which the inclined angle α about the X-axis relative to the horizontal plane HP is substantially 0°.

[0080] In the first attitude control, similarly to the first attitude adjustment step S40 described in the first embodiment (see FIG. 3), the attitude about the X-axis is adjusted by adjusting the lengths of the second sling 222 and the fourth sling 224 that are the adjustment objects. When the first attitude control is finished, the process proceeds to Step S260.

[0081] In Step S260, the control device 260 executes a second attitude control with which the attitudes of the crane load 8 and the lifting beam 101 about the Y-axis are adjusted to the predetermined attitude by the electric chain blocks 230. Similarly to the above-mentioned first embodiment, the predetermined attitude about the Y-axis refers to the attitude at which the inclined angle β about the Y-axis relative to the horizontal plane HP is substantially 0°.

[0082] In the second attitude control, similarly to the second attitude adjustment step S50 described in the first embodiment (see FIG. 3), the attitude about the Y-axis is adjusted by adjusting the lengths of the third sling 223 and the fourth sling 224 that are the adjustment object. When the second attitude control is finished, the process shown in the flow chart in FIG. 7 is terminated.

[0083] FIG. 8 is a flow chart showing an example of the content of the first attitude control executed by the control device 260. As shown in FIG. 8, in Step S216, the control device 260 sets driving direction (rotation direction) of the electric motors 230m of the second and fourth electric chain blocks 232 and 234. The driving direction of the electric motor 230m includes the chain-feed-out direction that is the direction in which a load chain 103d is fed

out from a main body portion 103b and the chain-feed-in direction that is the direction in which the load chain 103d is fed into the main body portion 103b.

[0084] The control device 260 judges whether or not the second lifting lug 142 is positioned at the higher level than the first lifting lug 141 on the basis of the initial value $\alpha 0$ for the inclined angle about the X-axis acquired in Step S201. When the initial value $\alpha 0$ is a positive value and it is judged that the second lifting lug 142 is positioned at the higher level than the first lifting lug 141, the chain-feed-out direction is set as the driving direction of the electric motor 230m. On the other hand, when it is judged that the second lifting lug 142 is not positioned at the higher level than the first lifting lug 141, the chain-feed-in direction is set as the driving direction of the electric motor 230m. When the setting of the driving directions of the electric motors 230m is finished, the process proceeds to Step S221.

[0085] In Step S221, the control device 260 acquires the information for the inclined angle α measured by the X-axis-inclined-angle sensor 203x (see FIG. 4A) and the inclined angle β measured by the Y-axis-inclined-angle sensor 203y (see FIG. 5A), and the process proceeds to Step S224.

[0086] In Step S224, the control device 260 judges whether or not the absolute value $|\alpha|$ of the inclined angle about the X-axis is equal to or smaller than the threshold value αt. The threshold value αt is the threshold value for judging whether or not the attitude about the X-axis has become the predetermined attitude, and it is stored in the storing unit of the control device 260 in advance. In this embodiment, a value slightly larger than 0° is set as the threshold value αt.

[0087] When it is judged that the absolute value $|\alpha|$ of the inclined angle about the X-axis is equal to or smaller than the threshold value αt in Step

S224, the process proceeds to Step S247.

[0088] In Step S247, the control device 260 outputs the stop signal to the electric motors 230m of the second and fourth electric chain blocks 232 and 234, and the first attitude control is finished. Therefore, in a case in which the attitude about the X-axis is the predetermined attitude at the initial state when the crane load 8 is lifted, the stopped state of the second and fourth electric chain blocks 232 and 234 is maintained, and the process proceeds to the second attitude control.

[0089] When it is judged that the absolute value $|\alpha|$ of the inclined angle about the X-axis is larger than the threshold value αt in Step S224, the process proceeds to Step S227.

[0090] In Step S227, the control device 260 judges whether or not the inclined angle β about the Y-axis falls within the predetermined inclined angle range. More specifically, the control device 260 judges whether or not the inclined angle β falls within a range from $(\beta 0 - \Delta\beta)$ to $(\beta 0 + \Delta\beta)$, inclusive. When it is judged that the inclined angle β falls within the range from $(\beta 0 - \Delta\beta)$ to $(\beta 0 + \Delta\beta)$, inclusive, in Step S227, the process proceeds to Step S231. When it is judged that the inclined angle β does not fall within the range from $(\beta 0 - \Delta\beta)$ to $(\beta 0 + \Delta\beta)$, inclusive, in Step S227, the process proceeds to Step S234. It should be noted that, the value $\beta 0 - \Delta\beta$ is the lower limit value of the inclined angle range, and the value $\beta 0 + \Delta\beta$ is the upper limit value of the inclined angle range. For $\Delta\beta$ that determines the upper limit value and the lower limit value, a value is set in advance such that the tension of at least the predetermined value is applied to all of the slings 220.

[0091] In Step S231, the control device 260 outputs the driving signal corresponding to the driving direction set in Step S216 to the electric motor

230m of the second electric chain block 232 and the electric motor 230m of the fourth electric chain block 234, and the process returns to Step S221.

[0092] Next, an explanation will be given of a process (Steps S234 to S244) for stopping one of the second electric chain block 232 and the fourth electric chain block 234, and bringing back the inclined angle β to the predetermined inclined angle range, when the inclined angle β about the Y-axis falls out of the predetermined inclined angle range.

[0093] In Step S234, the control device 260 judges whether the driving direction set in Step S216 is the feed-in direction or the feed-out direction. When it is judged that the driving direction is set to the feed-in direction in Step S234, the process proceeds to Step S236. When it is judged that the driving direction is set to the feed-out direction in Step S234, the process proceeds to Step S238.

[0094] In Step S236, the control device 260 judges whether or not the inclined angle β about the Y-axis is larger than the value $\beta 0 + \Delta\beta$. In other words, the process of Step S236 is synonymous with the process judging that the inclined angle β from the horizontal plane HP about the Y-axis is increased from the initial state by at least a predetermined amount. When it is judged that the inclined angle β about the Y-axis is larger than the value $\beta 0 + \Delta\beta$ in Step S236, the process proceeds to Step S241. When it is judged that the inclined angle β about the Y-axis is not larger than the value $\beta 0 + \Delta\beta$ in Step S236, the process proceeds to Step S244. It should be noted that, in a case in which a negative judgment is made in Step S227 and a negative judgment is made in Step S236, it means that the inclined angle β about the Y-axis is smaller than the value $\beta 0 - \Delta\beta$.

[0095] In Step S238, the control device 260 judges whether or not the

inclined angle β about the Y-axis is smaller than the value β0 - Δβ. In other words, the process of Step S238 is synonymous with the process judging that the inclined angle β from the horizontal plane HP about the Y-axis is decreased from the initial state by at least a predetermined amount. When it is judged that the inclined angle β about the Y-axis is smaller than the value β0 - Δβ in Step S238, the process proceeds to Step S241. When it is judged that the inclined angle β about the Y-axis is not smaller than the value β0 - Δβ in Step S238, the process proceeds to Step S244. It should be noted that, in a case in which a negative judgment is made in Step S227 and a negative judgment is made in Step S238, it means that the inclined angle β about the Y-axis is larger than the value β0 + Δβ.

[0096] In Step S241, the control device 260 outputs the stop signal to the electric motor 230m of the fourth electric chain block 234. Furthermore, in Step S241, the control device 260 outputs the driving signal corresponding to the driving direction set in Step S216 to the electric motor 230m of the second electric chain block 232, and the process returns to Step S221.

[0097] In Step S244, the control device 260 outputs the stop signal to the electric motor 230m of the second electric chain block 232. Furthermore, in Step S244, the control device 260 outputs the driving signal corresponding to the driving direction set in Step S216 to the electric motor 230m of the fourth electric chain block 234, and the process returns to Step S221.

[0098] When it is judged that the absolute value |α| of the inclined angle about the X-axis is equal to or smaller than the threshold value αt in Step S224, the process proceeds to Step S247. In Step S247, the control device 260 outputs the stop signal to the electric motors 230m of the second and fourth electric chain blocks 232 and 234, and the first attitude control is

finished.

[0099] FIG. 9 is a flow chart showing an example of the content of the second attitude control executed by the control device 260. Because the content of the second attitude control is similar to the content of the first attitude control, a part of the description of the second attitude control will be omitted. The second attitude control differs from the first attitude control in that the slings 220 recognized as the adjustment object are the third sling 223 and the fourth sling 224 in the second attitude control, whereas the slings 220 recognized as the adjustment object are the second sling 222 and the fourth sling 224 in the first attitude control.

[0100] As shown in FIG. 9, in Step S266, the control device 260 sets the driving direction (the rotation direction) of the electric motors 230m of the third and fourth electric chain blocks 233 and 234.

[0101] The control device 260 judges whether or not the third lifting lug 143 is positioned at the higher level than the first lifting lug 141 on the basis of the initial value β0 for the inclined angle about the Y-axis acquired in Step S201. When the initial value β0 is a positive value and it is judged that the third lifting lug 143 is positioned at the higher level than the first lifting lug 141, the chain-feed-out direction is set as the driving direction of the electric motor 230m. On the other hand, when it is judged that the third lifting lug 143 is not positioned at the higher level than the first lifting lug 141, the chain-feed-in direction is set as the driving direction of the electric motor 230m. When the setting of the driving directions of the electric motors 230m is finished, the process proceeds to Step S271.

[0102] In Step S271, the control device 260 executes the information acquisition process similar to that in Step S221, and the process proceeds to

Step S274.

[0103] In Step S274, the control device 260 judges whether or not the absolute value $|\beta|$ of the inclined angle about the Y-axis is equal to or smaller than the threshold value βt. The threshold value βt is the threshold value for judging whether or not the attitude about the Y-axis has become the predetermined attitude, and it is stored in the storing unit of the control device 260 in advance. In this embodiment, a value slightly larger than 0° is set as the threshold value βt.

[0104] When it is judged that the absolute value $|\beta|$ of the inclined angle about the Y-axis is equal to or smaller than the threshold value βt in Step S274, the process proceeds to Step S297.

[0105] In Step S297, the control device 260 outputs the stop signal to the electric motors 230m of the third and fourth electric chain blocks 233 and 234, and the second attitude control is finished. Therefore, in a case in which the attitude about the Y-axis is the predetermined attitude at the time when the first attitude control is finished, the stopped state of the third and fourth electric chain blocks 233 and 234 is maintained, and the attitude adjustment control for the crane load 8 and the lifting beam 101 is finished.

[0106] When it is judged that the absolute value $|\beta|$ of the inclined angle about the Y-axis is greater than the threshold value βt in Step S274, the process proceeds to Step S277.

[0107] In Step S277, the control device 260 judges whether or not the inclined angle α about the X-axis falls within the predetermined inclined angle range. More specifically, the control device 260 judges whether or not the inclined angle α falls within a range from $(\alpha 1 - \Delta\alpha)$ to $(\alpha 1 + \Delta\alpha)$, inclusive. When it is judged that the inclined angle α falls within the range from $(\alpha 1 - \Delta\alpha)$

to ($\alpha 1 + \Delta\alpha$), inclusive, in Step S277, the process proceeds to Step S281. When it is judged that the inclined angle α does not fall within the range from ($\alpha 1 - \Delta\alpha$) to ($\alpha 1 + \Delta\alpha$), inclusive, in Step S277, the process proceeds to Step S284. It should be noted that, the value $\alpha 1 - \Delta\alpha$ is the lower limit value of the inclined angle range, and the value $\alpha 1 + \Delta\alpha$ is the upper limit value of the inclined angle range. The value $\alpha 1$ is the inclined angle α about the X-axis at the time acquired in Step S221 in FIG. 8, in other words, the value $\alpha 1$ is the inclined angle α at the time when the first attitude control is finished. For $\Delta\alpha$ that determines the upper limit value and the lower limit value, a value is set in advance such that the tension of at least the predetermined value is applied to all of the slings 220.

[0108] In Step S281, the control device 260 outputs the driving signal corresponding to the driving direction set in Step S266 to the electric motor 230m of the third electric chain block 233 and the electric motor 230m of the fourth electric chain block 234, and the process returns to Step S271.

[0109] Next, an explanation will be given of a process (Steps S284 to S294) for stopping one of the third electric chain block 233 and the fourth electric chain block 234, and bringing back the inclined angle α into the predetermined inclined angle range process, when the inclined angle α about the X-axis falls out of the predetermined inclined angle range.

[0110] In Step S284, the control device 260 judges whether the driving direction set in Step S266 is the feed-in direction or the feed-out direction. When it is judged that the driving direction is set to the feed-in direction in Step S284, the process proceeds to Step S286. When it is judged that the driving direction is set to the feed-out direction in Step S284, the process proceeds to Step S288.

[0111] In Step S286, the control device 260 judges whether or not the inclined angle α about the X-axis is larger than the value α1 + Δα. In other words, the process of Step S286 is synonymous with the process judging that the inclined angle α from the horizontal plane about the X-axis is increased from the time when the first attitude control is finished by at least a predetermined amount. When it is judged that the inclined angle α about the X-axis is larger than the value α1 + Δα in Step S286, the process proceeds to Step S291. When it is judged that the inclined angle α about the X-axis is not larger than the value α1 + Δα in Step S286, the process proceeds to Step S294. It should be noted that, in a case in which a negative judgment is made in Step S277 and a negative judgment is made in Step S286, it means that the inclined angle α about the X-axis is smaller than the value α1 - Δα.

[0112] In Step S288, the control device 260 judges whether or not the inclined angle α about the X-axis is smaller than the value α1 - Δα. In other words, the process of Step S288 is synonymous with the process judging that the inclined angle α from the horizontal plane HP about the X-axis is decreased from the time when the first attitude control is finished by at least a predetermined amount. When it is judged that the inclined angle α about the X-axis is smaller than the value α1 - Δα in Step S288, the process proceeds to Step S291. When it is judged that the inclined angle α about the X-axis is not smaller than the value α1 - Δα in Step S288, the process proceeds to Step S294. It should be noted that, in a case in which a negative judgment is made in Step S277 and a negative judgment is made in Step S288, it means that the inclined angle α about the X-axis is larger than the value α1 + Δα.

[0113] In Step S291, the control device 260 outputs the stop signal to the electric motor 230m of the fourth electric chain block 234. Furthermore, in

Step S291, the control device 260 outputs the driving signal corresponding to the driving direction set in Step S266 to the electric motor 230m of the third electric chain block 233, and the process returns to Step S271.

[0114] In Step S294, the control device 260 outputs the stop signal to the electric motor 230m of the third electric chain block 233. Furthermore, in Step S294, the control device 260 outputs the driving signal corresponding to the driving direction set in Step S266 to the electric motor 230m of the fourth electric chain block 234, and the process returns to Step S271.

[0115] When it is judged that the absolute value $|\beta|$ of the inclined angle about the Y-axis is equal to or smaller than the threshold value βt in Step S274, the process proceeds to Step S297. In Step S297, the control device 260 outputs the stop signal to the electric motors 230m of the third and fourth electric chain blocks 233 and 234, and the second attitude control is finished.

[0116] The content of the attitude control executed by the control device 260 according to this embodiment is summarized as below. When the attitude adjustment switch of the control device 260 is switched ON by the operator after the crane load 8 is lifted up, the attitude adjustment control is executed by the control device 260. In the attitude adjustment control, the first attitude control for adjusting the attitude about the X-axis is first performed, and then, the second attitude control for adjusting the attitude about the Y-axis is performed.

[0117] In the first attitude control, the control device 260 adjusts the attitudes of the crane load 8 and the lifting beam 101 about the X-axis to the predetermined attitude, on the basis of the inclined angle α about the X-axis, by holding the linear distances between the lifting equipment 9 and all of the lifting lugs 140 (141 and 143) provided on the first side of the first vertical

plane VP1 as the boundary and by controlling the plurality of the electric chain blocks 230 (232 and 234) in parallel such that the linear distances between the lifting equipment 9 and all of the lifting lugs 140 (142 and 144) provided on the second side of the first vertical plane VP1 as the boundary are respectively reduced or increased.

[0118] Here, the plurality of the lifting lugs 140 (141 and 143) provided on the first side of the first vertical plane VP1 as the boundary include the first lifting lug 141 to which the first sling 221, on which the electric chain block 230 is not provided, is attached.

[0119] Furthermore, in this embodiment, the control device 260 adjusts the attitudes of the crane load 8 and the lifting beam 101 about the X-axis by controlling the electric chain blocks 230 (232 and 234) in parallel such that the inclined angle β about the Y-axis is maintained within the predetermined inclined angle range (from ($\beta 0 - \Delta\beta$) to ($\beta 0 + \Delta\beta$), inclusive). As a result, it is possible to suitably prevent loosening of the sling 220 while the attitudes of the crane load 8 and the lifting beam 101 about the X-axis are being adjusted.

[0120] In the second attitude control, the control device 260 adjusts the attitudes of the crane load 8 and the lifting beam 101 about the Y-axis to the predetermined attitude, on the basis of the inclined angle β about the Y-axis, by holding the linear distances between the lifting equipment 9 and all of the lifting lugs 140 (141 and 142) provided on the first side of the second vertical plane VP2 as the boundary and by controlling the plurality of the electric chain blocks 230 (233 and 234) in parallel such that the linear distances between the lifting equipment 9 and all of the lifting lugs 140 (143 and 144) provided on the second side of the second vertical plane VP2 as the boundary are respectively reduced or increased.

[0121] Here, the plurality of the lifting lugs 140 (141 and 142) provided on the first side of the second vertical plane VP2 as the boundary include the first lifting lug 141 to which the first sling 221, on which the electric chain block 230 is not provided, is attached.

[0122] Furthermore, in this embodiment, the control device 260 adjusts the attitudes of the crane load 8 and the lifting beam 101 about the Y-axis by controlling the electric chain blocks 230 (233 and 234) in parallel such that the inclined angle α about the X-axis is maintained within the predetermined inclined angle range (from ($\alpha 1 - \Delta\alpha$) to ($\alpha 1 + \Delta\alpha$), inclusive). As a result, it is possible to suitably prevent loosening of the sling 220 while the attitudes of the crane load 8 and the lifting beam 101 about the Y-axis is being adjusted.

[0123] According to the second embodiment described above, similarly to the first embodiment, it is possible to adjust the attitude of the crane load 8 without loosening the slings 220 linking the lifting beam 101 and the lifting equipment 9. In addition, because the attitude of the crane load 8 is adjusted automatically, it is possible to achieve an improvement in efficiencies of the operation. It should be noted that, "the plurality of the electric chain blocks 230 are respectively controlled in parallel" includes not only a case in which both chain blocks are controlled at exactly the same time (Steps S231 and S281), but also a case in which one of the chain blocks is temporarily stopped or a case in which the both chain blocks are operated alternately (Steps S241, S244, S291, and S294).

[0124] <Third Embodiment>

A lifting device 300 according to a third embodiment of the present invention will be described with reference to FIGs. 10 to 12. In the following, differences from the above-mentioned second embodiment will be mainly

described, and in the figures, components that are the same as or correspond to the components described in the above-mentioned second embodiment are assigned the same reference numerals and description thereof will be omitted.

[0125] In the above-mentioned second embodiment, the explanation has been given to the example in which the electric chain block 230 is controlled such that the inclined angle β about the Y-axis is maintained within the predetermined inclined angle range in the first attitude control for adjusting the attitude about the X-axis, and the electric chain block 230 is controlled such that the inclined angle α about the X-axis is maintained within the predetermined inclined angle range in the second attitude control for adjusting the attitude about the Y-axis.

[0126] In contrast, in this third embodiment, the load applied to each of the slings 220 is detected, and based on the detection results, the electric chain blocks 230 are controlled such that the load applied to each of the slings 220 is maintained within a predetermined load range.

[0127] FIG. 10 is a simplified perspective view of the lifting device 300. As shown in FIG. 10, in the lifting device 300, a load cell 370 serving as a load detection device is provided on each of the four slings 220. The load cell 370 detects the load (the tension) applied to the sling 220 and outputs a detection signal to a control device 360.

[0128] Similarly to the control device 260 described in the above-mentioned second embodiment, the control device 360 is configured so as to be capable of executing the first attitude control in which the electric chain blocks 230 are controlled such that the inclined angle α becomes the predetermined angle and the second attitude control in which the electric chain blocks 230 are controlled such that the inclined angle β becomes the predetermined angle.

Furthermore, the control device 360 controls each of the electric chain blocks 230 on the basis of the load detected by the load cells 370.

[0129] The control device 360 adjusts the attitudes of the crane load 8 and the lifting beam 101 about the X-axis by controlling the electric chain block 230 such that the load applied to each of the four slings 220, which is detected by the load cell 370, is maintained within a predetermined load range. In addition, the control device 360 adjusts the attitudes of the crane load 8 and the lifting beam 101 about the Y-axis by controlling the electric chain block 230 such that the load applied to each of the four slings 220, which is detected by the load cell 370, is maintained within a predetermined load range.

[0130] The content of the attitude control based on the load (the tension) applied to the sling will be described below in detail. It should be noted that, for the sake of convenience of description, the load cell 370 that detects the load (the tension) applied to the first sling 221 is referred to as a first load cell 371, and the load cell 370 that detects the load (the tension) applied to the second sling 222 is referred to as a second load cell 372. In addition, the load cell 370 that detects the load (the tension) applied to the third sling 223 is referred to as a third load cell 373, and the load cell 370 that detects the load (the tension) applied to the fourth sling 224 is referred to as a fourth load cell 374.

[0131] The control device 360 judges whether or not the load applied to each of the slings 220 falls within a predetermined load range in the first attitude control and the second attitude control. When it is judged that the load applied to each of the slings 220 falls within a predetermined load range in the first attitude control, the control device 360 operates the second electric chain block 232 and the fourth electric chain block 234 concurrently to adjust

the inclined angle α about the X-axis. When it is judged that the load applied to each of the slings 220 falls within a predetermined load range in the second attitude control, the control device 360 operates the third electric chain block 233 and the fourth electric chain block 234 concurrently to adjust the inclined angle β about the Y-axis.

[0132] When it is judged that the load applied to each of the slings 220 does not fall within a predetermined load range in the first attitude control, one of the second electric chain block 232 and the fourth electric chain block 234 is stopped. Similarly, when it is judged that the load applied to each of the slings 220 does not fall within a predetermined load range in the second attitude control, one of the third electric chain block 233 and the fourth electric chain block 234 is stopped.

[0133] In the first attitude control, the control device 360 judges whether or not the condition for stopping the second electric chain block 232 has been established. In the first attitude control, the control device 360 judges that the condition for stopping the second electric chain block 232 has been established if any of the following conditions (Ai) to (Aviii) is satisfied:

[0134] (Ai) the second and fourth electric chain blocks 232 and 234 are driven in the feed-out direction, and a load T2 detected by the second load cell 372 is smaller than the lower limit value TL;

(Aii) the second and fourth electric chain blocks 232 and 234 are driven in the feed-out direction, and a load T4 detected by the fourth load cell 374 is equal to or larger than the upper limit value TH;

(Aiii) the second and fourth electric chain blocks 232 and 234 are driven in the feed-out direction, and a load T3 detected by the third load cell 373 is smaller than the lower limit value TL;

(Aiv) the second and fourth electric chain blocks 232 and 234 are driven in the feed-out direction, and a load T1 detected by the first load cell 371 is equal to or larger than the upper limit value TH;

[0135] (Av) the second and fourth electric chain blocks 232 and 234 are driven in the feed-in direction, and the load T2 detected by the second load cell 372 is equal to or larger than the upper limit value TH;

(Avi) the second and fourth electric chain blocks 232 and 234 are driven in the feed-in direction, and the load T4 detected by the fourth load cell 374 is smaller than the lower limit value TL;

(Avii) the second and fourth electric chain blocks 232 and 234 are driven in the feed-in direction, and the load T3 detected by the third load cell 373 is equal to or larger than the upper limit value TH; and

(Aviii) the second and fourth electric chain blocks 232 and 234 are driven in the feed-in direction, and the load T1 detected by the first load cell 371 is smaller than the lower limit value TL.

[0136] In the first attitude control, the control device 360 judges whether or not the condition for stopping the fourth electric chain block 234 has been established. In the first attitude control, the control device 360 judges that the condition for stopping the fourth electric chain block 234 has been established if any of the following conditions (Bi) to (Bviii) is satisfied:

[0137] (Bi) the second and fourth electric chain blocks 232 and 234 are driven in the feed-out direction, and the load T2 detected by the second load cell 372 is equal to or larger than the upper limit value TH;

(Bii) the second and fourth electric chain blocks 232 and 234 are driven in the feed-out direction, and the load T4 detected by the fourth load cell 374 is smaller than the lower limit value TL;

(Biii) the second and fourth electric chain blocks 232 and 234 are driven in the feed-out direction, and the load T3 detected by the third load cell 373 is equal to or larger than the upper limit value TH;

(Biv) the second and fourth electric chain blocks 232 and 234 are driven in the feed-out direction, and the load T1 detected by the first load cell 371 is smaller than the lower limit value TL;

[0138] (Bv) the second and fourth electric chain blocks 232 and 234 are driven in the feed-in direction, and the load T2 detected by the second load cell 372 is smaller than the lower limit value TL;

(Bvi) the second and fourth electric chain blocks 232 and 234 are driven in the feed-in direction, and the load T4 detected by the fourth load cell 374 is equal to or larger than the upper limit value TH;

(Bvii) the second and fourth electric chain blocks 232 and 234 are driven in the feed-in direction, and the load T3 detected by the third load cell 373 is smaller than the lower limit value TL; and

(Bviii) the second and fourth electric chain blocks 232 and 234 are driven in the feed-in direction, and the load T1 detected by the first load cell 371 is equal to or larger than the upper limit value TH.

[0139] In the second attitude control, the control device 360 judges whether or not the condition for stopping the third electric chain block 233 has been established. In the second attitude control, the control device 360 judges that the condition for stopping the third electric chain block 233 has been established if any of the following conditions (Ci) to (Cviii) is satisfied:

[0140] (Ci) the third and fourth electric chain blocks 233 and 234 are driven in the feed-out direction, and the load T3 detected by the third load cell 373 is smaller than the lower limit value TL;

(Cii) the third and fourth electric chain blocks 233 and 234 are driven in the feed-out direction, and the load T4 detected by the fourth load cell 374 is equal to or larger than the upper limit value TH;

(Ciii) the third and fourth electric chain blocks 233 and 234 are driven in the feed-out direction, and the load T2 detected by the second load cell 372 is smaller than the lower limit value TL;

(Civ) the third and fourth electric chain blocks 233 and 234 are driven in the feed-out direction, and the load T1 detected by the first load cell 371 is equal to or larger than the upper limit value TH;

[0141] (Cv) the third and fourth electric chain blocks 233 and 234 are driven in the feed-in direction, and the load T3 detected by the third load cell 373 is equal to or larger than the upper limit value TH;

(Cvi) the third and fourth electric chain blocks 233 and 234 are driven in the feed-in direction, and the load T4 detected by the fourth load cell 374 is smaller than the lower limit value TL;

(Cvii) the third and fourth electric chain blocks 233 and 234 are driven in the feed-in direction, and the load T2 detected by the second load cell 372 is equal to or larger than the upper limit value TH; and

(Cviii) the third and fourth electric chain blocks 233 and 234 are driven in the feed-in direction, and the load T1 detected by the first load cell 371 is smaller than the lower limit value TL.

[0142] In the second attitude control, the control device 360 judges whether or not the condition for stopping the fourth electric chain block 234 has been established. In the second attitude control, the control device 360 judges that the condition for stopping the fourth electric chain block 234 has been established if any of the following conditions (Di) to (Dviii) is satisfied:

[0143] (Di) the third and fourth electric chain blocks 233 and 234 are driven in the feed-out direction, and the load T3 detected by the third load cell 373 is equal to or larger than the upper limit value TH;

(Dii) the third and fourth electric chain blocks 233 and 234 are driven in the feed-out direction, and the load T4 detected by the fourth load cell 374 is smaller than the lower limit value TL;

(Diii) the third and fourth electric chain blocks 233 and 234 are driven in the feed-out direction, and the load T2 detected by the second load cell 372 is equal to or larger than the upper limit value TH;

(Div) the third and fourth electric chain blocks 233 and 234 are driven in the feed-out direction, and the load T1 detected by the first load cell 371 is smaller than the lower limit value TL;

[0144] (Dv) the third and fourth electric chain blocks 233 and 234 are driven in the feed-in direction, and the load T3 detected by the third load cell 373 is smaller than the lower limit value TL;

(Dvi) the third and fourth electric chain blocks 233 and 234 are driven in the feed-in direction, and the load T4 detected by the fourth load cell 374 is equal to or larger than the upper limit value TH;

(Dvii) the third and fourth electric chain blocks 233 and 234 are driven in the feed-in direction, and the load T2 detected by the second load cell 372 is smaller than the lower limit value TL; and

(Dviii) the third and fourth electric chain blocks 233 and 234 are driven in the feed-in direction, and the load T1 detected by the first load cell 371 is equal to or larger than the upper limit value TH.

[0145] FIG. 11 is a diagram similar to FIG. 8, and is a flow chart showing an example of the content of the first attitude control executed by the control

device 360 of the lifting device 300 according to the third embodiment. As shown in FIG. 11, in this embodiment, instead of the process of Step S221 in the flow chart shown in FIG. 8, the process of Step S321 is executed, and instead of the process of Step S227, the process of Step S327 is executed. In addition, as shown in FIG. 11, in this embodiment, instead of the processes of Steps S234, S236, and S238 in the flow chart shown in FIG. 8, the process of Step S337 is executed, and instead of the processes of Steps S241 and S244, the processes of Steps S341 and S344 are executed. The processes that are the same as the processes shown in FIG. 8 are assigned the same reference numerals, and parts different from the processes shown in FIG. 8 will be mainly described.

[0146] In Step S321, the control device 360 acquires the information for the inclined angles α and β and acquires the information for the loads (the tension) T1 to T4 detected by the respective load cells 370, and the process proceeds to Step S224.

[0147] When it is judged that the absolute value |α| of the inclined angle α about the X-axis is larger than the threshold value αt in Step S224, the process proceeds to Step S327. In Step S327, the control device 360 judges whether or not each of the load T1 detected by the first load cell 371, the load T2 detected by the second load cell 372, the load T3 detected by the third load cell 373, and the load T4 detected by the fourth load cell 374 falls within a predetermined load range.

[0148] The lower limit value TL of a predetermined load range has a value greater than zero, and it is stored in the storing unit of the control device 360 in advance. The upper limit value TH of a predetermined load range is set in consideration of the strength of the slings 220.

[0149] When it is judged that each of the loads T1 to T4 acquired in Step S321 falls within a predetermined load range (a range between equal to or larger than TL and less than TH) in Step S327, the process proceeds to Step S231. When it is judged that any of the loads T1 to T4 does not fall within a predetermined load range (the range between equal to or larger than TL and less than TH) in Step S327, the process proceeds to Step S337.

[0150] In Step S337, the control device 360 judges whether or not the stop condition for the second electric chain block 232 has been established. When it is judged that the stop condition for the second electric chain block 232 has been established in Step S337, the process proceeds to Step S341. When it is judged that the stop condition for the second electric chain block 232 has not been established in Step S337, the process proceeds to Step S344. It should be noted that, in a case in which a negative judgment is made in Step S337, it means that the stop condition for the fourth electric chain block 234 has been established.

[0151] In Step S341, the control device 360 outputs the stop signal to the electric motor 230m of the second electric chain block 232. Furthermore, in Step S341, the control device 360 outputs the driving signal corresponding to the driving direction set in Step S216 to the electric motor 230m of the fourth electric chain block 234, and the process returns to Step S321.

[0152] In Step S344, the control device 360 outputs the stop signal to the electric motor 230m of the fourth electric chain block 234. Furthermore, in Step S344, the control device 360 outputs the driving signal corresponding to the driving direction set in Step S216 to the electric motor 230m of the second electric chain block 232, and the process returns to Step S321.

[0153] FIG. 12 is a diagram similar to FIG. 9, and is a flow chart showing an

example of the content of the second attitude control executed by the control device 360 of the lifting device 300 according to the third embodiment. Because the content of the second attitude control is similar to the content of the first attitude control, a part of the description of the second attitude control will be omitted. The second attitude control differs from the first attitude control in that the slings 220 recognized as the adjustment objects are the third sling 223 and the fourth sling 224 in the second attitude control, whereas the slings 220 recognized as the adjustment objects are the second sling 222 and the fourth sling 224 in the first attitude control.

[0154] As shown in FIG. 12, in this embodiment, instead of the process of Step S271 in the flow chart shown in FIG. 9, the process of Step S371 is executed, and instead of the process of Step S277, the process of Step S377 is executed. In addition, as shown in FIG. 12, in this embodiment, instead of the processes of Steps S284, S286, and S288 in the flow chart shown in FIG. 9, the process of Step S387 is executed, and instead of the processes of Steps S291 and S294, the processes of Steps S391 and S394 are executed. The processes that are the same as the processes shown in FIG. 9 are assigned the same reference numerals, and parts different from the processes shown in FIG. 9 will be mainly described.

[0155] In Step S371, the control device 360 executes the information acquisition process similar to that in Step S321, and the process proceeds to Step S274.

[0156] In Step S377, the control device 360 executes a load judgment process similar to that in Step S327. When it is judged that each of the loads T1 to T4 acquired in Step S371 falls within a predetermined load range (the range between equal to or larger than TL and less than TH) in Step S377, the

process proceeds to Step S281. When it is judged that any of the loads T1 to T4 does not fall within a predetermined load range (the range between equal to or larger than TL and less than TH) in Step S377, the process proceeds to Step S387.

[0157] In Step S387, the control device 360 judges whether or not the stop condition for the third electric chain block 233 has been established. When it is judged that the stop condition for the third electric chain block 233 has been established in Step S387, the process proceeds to Step S391. When it is judged that the stop condition for the third electric chain block 233 has not been established in Step S387, the process proceeds to Step S394. It should be noted that, in a case in which a negative judgment is made in Step S387, it means that the stop condition for the fourth electric chain block 234 has been established.

[0158] In Step S391, the control device 360 outputs the stop signal to the electric motor 230m of the third electric chain block 233. Furthermore, in Step S391, the control device 360 outputs the driving signal corresponding to the driving direction set in Step S266 to the electric motor 230m of the fourth electric chain block 234, and the process returns to Step S371.

[0159] In Step S394, the control device 360 outputs the stop signal to the electric motor 230m of the fourth electric chain block 234. Furthermore, in Step S394, the control device 360 outputs the driving signal corresponding to the driving direction set in Step S266 to the electric motor 230m of the third electric chain block 233, and the process returns to Step S371.

[0160] According to the third embodiment described above, the operational advantages similar to those of the second embodiment are afforded. It should be noted that, in this third embodiment, because the load (the tension) applied

to each of the slings 220 is detected directly and the electric chain blocks 230 are controlled on the basis of the detected results, it is possible to further effectively prevent the slings 220 from being distorted during the attitude control.

[0161] Following modifications are also within the scope of the present invention, and it is also possible to combine the configurations shown in the modifications with the configurations described in the above-mentioned embodiments, to combine the configurations described in the different embodiments described above with each other, and to combine the configurations described in the different modifications described below with each other.

[0162] <First Modification>

Although the example in which the chain blocks 130 are respectively provided on the slings 120 has been described in the first embodiment, the present invention is not limited thereto. Instead of the chain block 130, a hydraulic cylinder , an electric cylinder, a hoisting winch, and so forth may be provided as the distance adjusting device. Although the examples in which the electric chain blocks 230 are respectively provided on the slings 220 have been described in the second embodiment and the third embodiment, the present invention is not limited thereto. Instead of the electric chain block 230, the hydraulic cylinder, the electric cylinder, the hoisting winch, and so forth may be provided as the distance adjusting device.

[0163] <Second Modification>

Although the configurations in which the chain blocks (130, 230) extend/contract along the lines connecting the lifting equipment 9 and the lifting lugs 140 have been described in the above-mentioned embodiments, the

present invention is not limited thereto. As the distance adjusting devices provided on the slings (120, 220), various devices capable of adjusting the distances between the lifting lugs 140 and the lifting equipment 9 may be applied. For example, retracting devices 430 shown in FIGs. 13, 14A, and 14B may be provided on a lifting device 400 as the distance adjusting devices.

[0164] The lifting device 400 according to this modification is provided with the retracting devices (the distance adjusting devices) 430 a first end of which is attached to the lifting beam 101 and a second end of which is attached to each of slings 420. The retracting device 430 adjusts the distance between the lifting lug 140 and the lifting equipment 9 by pulling an attached portion 425 to the sling 420 and bending the slings 420. The retracting device 430 is provided on each of a second sling 422, a third sling 423, and a fourth sling 424, and it is not provided on a first sling 421.

[0165] In the lifting device 400 according to this modification, the lifting lugs 140 and the lifting equipment 9 are linked by the slings 420 formed of wire ropes, etc. In addition, the connecting members 112 at the center of the lifting beam 101 is provided with a bracket 412a to which the first ends of the retracting devices 430 are attached.

[0166] The bracket 412a is set at the center of the lifting beam 101. The attached portion of the retracting device 430 of the fourth sling 124 is provided on a line connecting the first lifting lug 141 and the fourth lifting lug 144 (on the diagonal line). In addition, the attached portion of the retracting device 430 of the second sling 122 is provided on a line connecting the second lifting lug 142 and the third lifting lug 143 (on the diagonal line). Furthermore, the attached portion of the retracting device 430 of the third sling 123 is provided on a line connecting the second lifting lug 142 and the third lifting lug 143 (on

the diagonal line). It should be noted that, the position of the bracket 412a is not limited to the center of the lifting beam 101, and it may be set at any position on the lifting beam 101.

[0167] The retracting device 430 is provided with: an extending/contracting part such as the chain block, the hydraulic cylinder, the electric cylinder, and so forth; an attachment member with which one end of the extending/contracting part is attached to the sling 420; and the attachment member with which the other end of the extending/contracting part is attached to the bracket 412a.

[0168] A case in which the extending/contracting part of the retracting device 430 is a hydraulic cylinder 430S is described with reference to FIG. 14A. It should be noted that, in FIG. 14A, only the retracting device 430 provided on the third sling 423 is shown, and illustration of the retracting devices 430 provided on the second sling 422 and the fourth sling 424 are omitted.

[0169] As shown in FIG. 14A, the hydraulic cylinder 430S has a cylindrical cylinder tube 430t, a piston rod 430r that is inserted into the cylinder tube 430t, and a piston (not shown) that is provided on a base end portion of the piston rod 430r and that divides an interior of the cylinder tube 430t into a bottom-side chamber and a rod side chamber.

[0170] A wire rope 438 is connected to the base end portion of the cylinder tube 430t, and the wire rope 438 is attached to the sling 420 via the attached portion 425 such as a mounting metal part, etc. A wire rope 439 is connected to a tip end portion of the piston rod 430r, and the wire rope 439 is attached to the bracket 412a via a shackle, etc.

[0171] According to such a modification, it is possible to contract the hydraulic cylinder 430S as shown in FIG. 14B by supplying working fluid to

the rod side chamber of the hydraulic cylinder 430S in an extended state shown in FIG. 14A to increase the pressure in the rod side chamber and by allowing the bottom-side chamber to communicate with a tank. As the hydraulic cylinder 430S is contracted, the attached portion 425 to the sling 420 moves so as to approach the bracket. As a result, as compared with a state before the hydraulic cylinder 430S is contracted, the distance between the lifting lug 140 and the lifting equipment 9 is reduced.

[0172] In addition, it is possible to extend the hydraulic cylinder 430S as shown in FIG. 14A by supplying the working fluid to the bottom-side chamber of the hydraulic cylinder 430S in the contracted state shown in FIG. 14B to increase the pressure in the bottom-side chamber and by allowing the rod side chamber to communicate with the tank. As the hydraulic cylinder 430S is extended, the attached portion 425 to the sling 420 moves so as to separate away from the bracket 412a. As a result, as compared with a state before the hydraulic cylinder 430S is extended, the distance between the lifting lug 140 and the lifting equipment 9 is increased.

[0173] According to such a modification, it is possible to adjust the attitudes of the crane load 8 and the lifting beam 101 by the procedure similar to that in the above-mentioned first embodiment. In addition, by employing the configuration in which the control device controls a control valve that controls an extension/contraction operation of the hydraulic cylinder 430S, similarly to the above-mentioned second embodiment and the third embodiment, it is possible to adjust the attitudes of the crane load 8 and the lifting beam 101 automatically.

[0174] In this modification, because the distance between the lifting equipment 9 and the lifting lug 140 is adjusted by the retracting device 430,

there is no need to change the length of the sling 120 itself. Therefore, by extending the respective retracting devices 430 to the extended state, it is possible to allow the distance between each of the lifting lugs 140 and the lifting equipment 9 to return to the initial state with ease. Therefore, it is possible to bring the attitude of the lifting beam 101 to the horizontal attitude in the initial state with ease after the crane load 8 has been lowered but before next the crane load 8 is lifted.

[0175] In addition, in this modification, because only a component force pulling the sling 120 is required for the retracting devices 430, compared with the second embodiment and the third embodiment, it is possible to employ a device with a smaller load capacity, and it is possible to achieve reduction in weight and cost of the lifting device 400.

[0176] <Third Modification>

Although the example in which four slings (120, 220) are provided has been described in the above-mentioned embodiment, the present invention is not limited thereto. It suffices to include four or more slings (120, 220). For example, the present invention may be applied to a lifting device 500 provided with six slings 520 as shown in FIG. 15. As illustrated, in this modification, distance adjusting devices 530 are respectively provided on five slings 520 among the six slings 520. Six lifting lugs 140 are arranged in a matrix of 3 rows by 2 columns.

[0177] Also in this modification, it is possible to adjust the attitudes of the crane load 8 and a lifting beam 501 by the procedure similar to those in the above-mentioned embodiments. An example of the attitude adjusting method in this modification will be described with reference to FIG. 16A. It should be noted that, for the sake of convenience of description, the lifting lug 140

positioned in the first row/first column is referred to as a lifting lug P11, the lifting lug 140 positioned in the first row/second column is referred to as a lifting lug P12, and the lifting lug 140 positioned in the second row/first column is referred to as a lifting lug P21. In addition, the lifting lug 140 positioned in the second row/second column is referred to as a lifting lug P22, the lifting lug 140 positioned in the third row/first column is referred to as a lifting lug P31, and the lifting lug 140 positioned in the third row/second column is referred to as a lifting lug P32.

[0178] As shown in FIG. 16A, a description will be given of the attitude adjusting method for a case in which the center of gravity G of the crane load is closer to the lifting lug P11 than the lifting lug P31 and closer to the lifting lug P11 than the lifting lug P12.

[0179] In the first attitude adjustment step S40, it is possible to adjust the attitudes of the crane load 8 and the lifting beam 501 about the X-axis to the predetermined attitude by holding the distances between the lifting equipment 9 and all of the lifting lugs P11 and P12 provided on the first side of the first vertical plane VP1 as the boundary and by controlling a plurality of corresponding distance adjusting devices 530 in parallel such that the distances between the lifting equipment 9 and all of the lifting lugs P21, P22, P31, and P32 provided on the second side of the first vertical plane VP1 as the boundary are respectively increased. Here, the plurality of the lifting lugs P11 and P12 provided on the first side of the first vertical plane VP1 as the boundary include the lifting lug P11 to which the sling 520, on which the distance adjusting device 530 is not provided, is attached. In other words, in the first attitude adjustment step S40, on the side of the first vertical plane VP1 as the boundary including the lifting lug P11 attached to the sling 520, on

which the distance adjusting device 530 is not provided, all of the distance adjusting devices 530 are not operated, and all of the distance adjusting devices 530 are operated on the other side.

[0180] In the second attitude adjustment step S50, it is possible to adjust the attitudes of the crane load 8 and the lifting beam 501 about the Y-axis to the predetermined attitude by holding the distances between the lifting equipment 9 and all of the lifting lugs P11, P21, and P31 provided on the first side of the second vertical plane VP2 as the boundary and by controlling the plurality of corresponding distance adjusting devices 530 in parallel such that the distances between the lifting equipment 9 and all of the lifting lugs P12, P22, and P32 provided on the second side of the second vertical plane VP2 as the boundary are respectively increased. Here, the plurality of the lifting lugs P11, P21, and P31 provided on the first side of the second vertical plane VP2 as the boundary include the lifting lug P11 to which the sling 520, on which the distance adjusting device 530 is not provided, is attached. In other words, in the second attitude adjustment step S50, on the side of the second vertical plane VP2 as the boundary including the lifting lug P11 attached to the sling 520, on which the distance adjusting device 530 is not provided, all of the distance adjusting devices 530 are not operated, and all of the distance adjusting devices 530 are operated on the other side.

[0181] As described above, it is possible to adjust the attitude of the crane load 8 about the X-axis to the predetermined attitude, on the basis of the inclined angle α about the X-axis, by operating or controlling the plurality of the distance adjusting devices 530 in parallel such that the distances between the lifting equipment 9 and all of other lifting lugs P21, P22, P31, and P32, among the plurality of the lifting lugs 140, than the attachment part group

(P11 and P12) in the row (the first row) including the lifting lug P11 attached to the sling 520 on which the distance adjusting device 530 is not provided are respectively increased. In addition, it is possible to adjust the attitude of the crane load 8 about the Y-axis to the predetermined attitude, on the basis of the inclined angle β about the Y-axis, by operating or controlling the plurality of the distance adjusting devices 530 in parallel such that the distances between the lifting equipment 9 and all of other lifting lugs P12, P22, and P32, among the plurality of the lifting lugs 140, than the attachment part group (P11, P21, and P31) in the column (the first column) including the lifting lug P11 attached to the sling 520 on which the distance adjusting device 530 is not provided are respectively increased.

[0182] As shown in FIG. 16B, a description will be given of the attitude adjusting method for a case in which the center of gravity G of the crane load 8 is closer to the lifting lug P31 than the lifting lug P11 and closer to the lifting lug P12 than the lifting lug P11.

[0183] In the first attitude adjustment step S40, it is possible to adjust the attitudes of the crane load 8 and the lifting beam 501 about the X-axis to the predetermined attitude by holding the distances between the lifting equipment 9 and all of the lifting lugs P11, P12, P21, and P22 provided on the first side of the first vertical plane VP1 as the boundary and by controlling the plurality of corresponding distance adjusting devices 530 in parallel such that the distances between the lifting equipment 9 and all of the lifting lugs P31 and P32 provided on the second side of the first vertical plane VP1 as the boundary are respectively reduced. Here, the plurality of the lifting lugs P11, P12, P21, and P22 provided on the first side of the first vertical plane VP1 as the boundary include the lifting lug P11 to which the sling 520, on which the

distance adjusting device 530 is not provided, is attached. In other words, in the first attitude adjustment step S40, on the side of the first vertical plane VP1 as the boundary including the lifting lug P11 attached to the sling 520, on which the distance adjusting device 530 is not provided, all of the distance adjusting devices 530 are not operated, and all of the distance adjusting devices 530 are operated on the other side.

[0184] In the second attitude adjustment step S50, it is possible to adjust the attitudes of the crane load 8 and the lifting beam 501 about the Y-axis to the predetermined attitude by holding the distances between the lifting equipment 9 and all of the lifting lugs P11, P21, and P31 provided on the first side of the second vertical plane VP2 as the boundary and by controlling the plurality of corresponding distance adjusting devices 530 in parallel such that the distances between the lifting equipment 9 and all of the lifting lugs P12, P22, and P32 provided on the second side of the second vertical plane VP2 as the boundary are respectively reduced. Here, the plurality of the lifting lugs P11, P21, and P31 provided on the first side of the second vertical plane VP2 as the boundary include the lifting lug P11 to which the sling 520, on which the distance adjusting device 530 is not provided, is attached. In other words, in the second attitude adjustment step S50, on the side of the second vertical plane VP2 as the boundary including the lifting lug P11 attached to the sling 520, on which the distance adjusting device 530 is not provided, all of the distance adjusting devices 530 are not operated, and all of the distance adjusting devices 530 are operated on the other side.

[0185] It should be noted that, instead of operating or controlling, in parallel, only the distance adjusting devices 530 provided on the slings 520 attached to the lifting lugs P31 and P32, it may be possible to adjust the

attitude about the X-axis by operating or controlling, in parallel, the distance adjusting devices 530 provided on the slings 520 attached to the lifting lugs P21, P22, P31, and P32.

[0186] In other words, it is also possible to adjust the attitude of the crane load 8 about the X-axis to the predetermined attitude, on the basis of the inclined angle α about the X-axis, by operating or controlling the plurality of the distance adjusting devices 530 in parallel such that the distances between the lifting equipment 9 and all of other lifting lugs P21, P22, P31, and P32, among the plurality of the lifting lugs 140, than the attachment part group (P11 and P12) in the row (the first row) including the lifting lug P11 attached to the sling 520 on which the distance adjusting device 530 is not provided are respectively reduced. Furthermore, it is possible to adjust the attitude of the crane load 8 about the Y-axis to the predetermined attitude, on the basis of the inclined angle β about the Y-axis, by operating or controlling the plurality of the distance adjusting devices 530 in parallel such that the distances between the lifting equipment 9 and all of other lifting lugs P12, P22, and P32, among the plurality of the lifting lugs 140, than the attachment part group (P11, P21, and P31) in the column (the first column) including the lifting lug P11 attached to the sling 520 on which the distance adjusting device 530 is not provided are respectively reduced.

[0187] <Fourth Modification>

Although the examples in which the distance adjusting devices (the chain blocks (130, 230)) are respectively provided on only (N-1) number of the slings (120, 220) among all of the slings (120, 220) when the number of the slings (120, 220) is N (N is an integer of at least four) have been described in the above-mentioned embodiments, the present invention is not limited thereto.

The present invention may also be applied to the lifting device in which the distance adjusting devices are provided on at least (N-1) number of the slings (120, 220) among all of the slings (120, 220). For example, the number of the distance adjusting devices provided may be the same as the number of the slings (120, 220). In other words, the distance adjusting device may be provided on each of all of the slings (120, 220).

[0188] <Fifth Modification>

Although the examples in which the inclined angle measuring device (103, 203) is provided on the lifting beam 101 have been described in the above-mentioned embodiments, the present invention is not limited thereto. It suffices to provide the inclined angle measuring device (103, 203) on either of the crane load 8 or the lifting beam 101. In other words, the inclined angle measuring device (103, 203) may be provided only on the crane load 8, or it may be provided on both of the crane load 8 and the lifting beam 101.

[0189] <Sixth Modification>

In the first embodiment, a description has been given of the example in which, in the first attitude adjustment step S40, the attitude of the crane load 8 about the X-axis is adjusted by operating the second chain block 132 and the fourth chain block 134 in parallel such that the inclined angle β about the Y-axis measured by the Y-axis-inclined-angle sensor 103y is maintained within the predetermined inclined angle range ($\beta 0 - \Delta\beta \leq \beta \leq \beta 0 + \Delta\beta$); however, the present invention is not limited thereto. The operator may operate the second chain block 132 and the fourth chain block 134 in parallel until the inclined angle α about the X-axis becomes the predetermined angle while checking that the tension of at least the predetermined value is applied to each of the slings 120 by grabbing the sling 120, for example.

[0190] Similarly, in the first embodiment, a description has been given of the example in which, in the second attitude adjustment step S50, the attitude of the crane load 8 about the Y-axis is adjusted by operating the third chain block 133 and the fourth chain block 134 in parallel such that the inclined angle α about the X-axis measured by the X-axis-inclined-angle sensor 103x is maintained within the predetermined inclined angle range ($\alpha 1 - \Delta\alpha \leq \alpha \leq \alpha 1 + \Delta\alpha$); however, the present invention is not limited thereto. The operator may operate the third chain block 133 and the fourth chain block 134 in parallel until the inclined angle β about the Y-axis becomes the predetermined angle while checking that the tension of at least the predetermined value is applied to each of the slings 120 by grabbing the sling 120, for example.

[0191] <Seventh Modification>

In the second embodiment, in the first attitude control (the attitude control about the X-axis), the process is executed so as to stop one of the second electric chain block 232 and the fourth electric chain block 234 when the inclined angle β about the Y-axis falls out of the predetermined inclined angle range; however, the present invention is not limited thereto. The control may be executed such that the operation speed of one of the second electric chain block 232 and the fourth electric chain block 234 is reduced relative to the operation speed of the other. Similarly, in the second attitude control (the attitude control about the Y-axis), the process is executed so as to stop one of the third electric chain block 233 and the fourth electric chain block 234 when the inclined angle α about the X-axis falls out of the predetermined inclined angle range; however, the present invention is not limited thereto. The control may executed such that the operation speed of one of the third electric chain block 233 and the fourth electric chain block 234

is reduced relative to the operation speed of the other. It should be noted that, also in the third embodiment, it may be possible to execute the process that slows the operation speed of one of two electric chain blocks 230 instead of the processes (S337 to S344, S387 to S394) that stop one of two electric chain blocks 230.

[0192] <Eighth Modification>

Although the examples in which the wire rope is used as the sling (120, 220) have been described in the above-mentioned embodiments, a chain sling, an webbing sling, a round sling, and so forth may be used instead of the wire rope.

[0193] Embodiments of this invention were described above, but the above embodiments are merely examples of applications of this invention, and the technical scope of this invention is not limited to the specific constitutions of the above embodiments.

CLAIMS

1. A lifting device comprising:

a lifting beam linkable to a crane load;

at least four slings configured to link the lifting beam and a lifting equipment of a crane;

attachment parts provided on the lifting beam, the at least four slings being respectively attached to the attachment parts;

an inclined angle measuring device provided on at least one of the crane load and the lifting beam, the inclined angle measuring device being configured to measure an inclined angle relative to a horizontal plane;

distance adjusting devices provided on at least (N-1) number of the slings among the at least four slings when number of the slings is N, the distance adjusting devices being configured to adjust distances between the lifting equipment and the attachment parts attached to the slings; and

a control device configured to adjust an attitude of the crane load by controlling the distance adjusting devices based on the inclined angle measured by the inclined angle measuring device, wherein

the inclined angle measuring device is configured to be capable of measuring the inclined angles about an X-axis and a Y-axis that are perpendicular to each other, and

the control device adjusts:

an attitude of the crane load about the X-axis to the predetermined attitude, based on the inclined angle about the X-axis, by holding distances between the lifting equipment and all of the attachment parts provided on a first side of a first vertical plane as a boundary and by controlling a plurality of

the distance adjusting devices in parallel such that distances between the lifting equipment and all of the attachment parts provided on a second side of the first vertical plane as the boundary are respectively reduced or increased, the first vertical plane being parallel to the X-axis, perpendicular to a horizontal plane, and including a center of gravity of the crane load; and

an attitude of the crane load about the Y-axis to the predetermined attitude, based on the inclined angle about the Y-axis, by holding distances between the lifting equipment and all of the attachment parts provided on a first side of a second vertical plane as a boundary and by controlling the plurality of the distance adjusting devices in parallel such that distances between the lifting equipment and all of the attachment parts provided on a second side of the second vertical plane as the boundary are respectively reduced or increased, the second vertical plane being parallel to the Y-axis, perpendicular to the horizontal plane, and including the center of gravity of the crane load.

2. The lifting device according to claim 1, wherein

the distance adjusting devices are provided only on (N-1) number of the sling among the at least four slings,

a plurality of the attachment parts provided on the first side of the first vertical plane as the boundary include the attachment part attached to the sling that is not provided with the distance adjusting device, and

a plurality of the attachment parts provided on the first side of the second vertical plane as the boundary include the attachment part attached to the sling that is not provided with the distance adjusting device.

3. The lifting device according to claim 1 or 2, wherein

the control device adjusts:

the attitude of the crane load about the X-axis by controlling the distance adjusting devices such that the inclined angle about the Y-axis is maintained within the predetermined inclined angle range; and

the attitude of the crane load about the Y-axis by controlling the distance adjusting devices such that the inclined angle about the X-axis is maintained within the predetermined inclined angle range.

4. The lifting device according to claim 1 or 2, further comprising

a load detection device configured to detect load applied to each of the at least four slings, wherein

the control device adjusts:

an attitude of the crane load about the X-axis by controlling the distance adjusting devices such that the load applied to each of the at least four slings is maintained within a predetermined load range, the load being detected by the load detection devices; and

an attitude of the crane load about the Y-axis by controlling the distance adjusting devices such that the load applied to each of the at least four slings is maintained within a predetermined load range, the load being detected by the load detection devices.

5. The lifting device according to any one of claims 1 to 4, wherein a first end of the distance adjusting device is attached to the lifting beam and a second end of the distance adjusting device is attached to the sling, the distance adjusting device being configured to adjust a distance between the attachment

part and the lifting equipment by pulling an attached portion to the sling and bending the sling.

6. A method of adjusting an attitude of a crane load by a lifting device provided with: a lifting beam linkable to a crane load; at least four slings configured to link the lifting beam and a lifting equipment of a crane; attachment parts provided on the lifting beam, the at least four slings being respectively attached to the attachment parts; an inclined angle measuring device provided on at least one of the crane load and the lifting beam, the inclined angle measuring device being configured to measure an inclined angle relative to a horizontal plane; and distance adjusting devices provided on at least (N-1) number of the slings among the at least four slings when number of the slings is N, the distance adjusting devices being configured to adjust distances between the lifting equipment and the attachment parts attached to the slings,

the attitude of the crane load being configured to be adjusted based on the inclined angle measured by the inclined angle measuring device, and

the inclined angle measuring device being configured to be capable of measuring the inclined angles about an X-axis and a Y-axis that are perpendicular to each other,

the method comprising:

a first attitude adjustment step of adjusting an attitude of the crane load about the X-axis to the predetermined attitude, based on the inclined angle about the X-axis, by holding distances between the lifting equipment and all of the attachment parts provided on a first side of a first vertical plane as a boundary and by operating a plurality of the distance adjusting devices in

parallel such that distances between the lifting equipment and all of the attachment parts provided on a second side of the first vertical plane as the boundary are respectively reduced or increased, the first vertical plane being parallel to the X-axis, perpendicular to a horizontal plane, and including a center of gravity of the crane load; and

a second attitude adjustment step of adjusting an attitude of the crane load about the Y-axis to the predetermined attitude, based on the inclined angle about the Y-axis, by holding distances between the lifting equipment and all of the attachment parts provided on a first side of a second vertical plane as a boundary and by operating the plurality of the distance adjusting devices in parallel such that distances between the lifting equipment and all of the attachment parts provided on a second side of the second vertical plane as the boundary are respectively reduced or increased, the second vertical plane being parallel to the Y-axis, perpendicular to the horizontal plane, and including the center of gravity of the crane load.

7. The attitude adjusting method for the crane load according to claim 6, wherein

the distance adjusting devices are provided only on (N-1) number of the sling among the at least four slings,

a plurality of the attachment parts provided on the first side of the first vertical plane as the boundary include the attachment part attached to the sling that is not provided with the distance adjusting device, and

a plurality of the attachment parts provided on the first side of the second vertical plane as the boundary include the attachment part attached to the sling that is not provided with the distance adjusting device.

8. The attitude adjusting method for the crane load according to claim 6 or 7, wherein

in the first attitude adjustment step, the attitude of the crane load about the X-axis is adjusted by the distance adjusting devices such that the inclined angle about the Y-axis is maintained within the predetermined inclined angle range, and

in the second attitude adjustment step, the attitude of the crane load about the Y-axis is adjusted by the distance adjusting devices such that the inclined angle about the X-axis is maintained within the predetermined inclined angle range.