Apparatus for avoiding collision when lowering container

An obstacle (15) in the vicinity of a line extending from a side face of the container is detected by a first infrared-beam sensor (11), and an obstacle located farther towards the outside than the line extending from the side face of the container is detected by a second infrared-beam sensor (12). Accordingly, when lowering the container, which is gripped by a load block (45), it is possible to prevent the lower end of the container from colliding with the obstacle (15), and in addition, it is possible to detect an obstacle substantially directly underneath, even when the load block (45) and so on is suspended at an angle by wires.

FIG. 1

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Description

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

[0001] The present invention relates to an apparatus for avoiding a collision when lowering a container.

2. DESCRIPTION OF RELATED ART

[0002] At dock container yards, transfer cranes are used for stacking containers. These transfer cranes include a gantry formed of horizontally disposed girders above the container yard, which are connected at both ends by pillar-like leg structures, and running mechanisms provided at the bottom of the leg structures. A trolley that moves in the longitudinal direction of the girders is provided on the girders, and a load block for hoisting a load such as a container is suspended from the trolley by wires.

[0003] When stacking containers with this transfer crane, the container is gripped by the load block and the trolley is moved horizontally to a point above a target position. Then, the wires are gradually unwound, while avoiding a collision between the suspended container and other containers stacked in the vicinity, to place the container in the target position.

[0004] In order to perform this container stacking operation automatically, a technology for lowering the suspended container from above the target position to the target position while avoiding a collision between the suspended container and the nearby stacked containers is necessary.

[0005] For example, Japanese Unexamined Patent Application Publication No. HEI-10-167663 discloses a technology in which stacking guides are attached to the load block gripping the container, sensors for detecting interference between the suspended container and stacks of other containers is provided on the stacking guides, and the suspended container is lowered to the target position while avoiding a collision.

[0006] However, stacking guides such as those disclosed in the above-cited publication increase the cost and require maintenance, and therefore, they are disadvantageous in terms of satisfying demands for cost reduction.

BRIEF SUMMARY OF THE INVENTION

[0007] An object of the present invention is to provide a crane and an apparatus for avoiding a collision when lowering a container in which it is possible to quickly place a container at a target position while avoiding a collision between the suspended container and other containers stacked nearby, without employing stacking guides.

[0008] In order to solve the problems described above, the present invention provides the following solutions.

[0009] The present invention provides a collision-avoidance apparatus for a crane, for use in a crane which carries out loading and unloading operations by gripping and moving a container with a load block suspended by wires and which prevents a collision when unwinding the wires, the apparatus comprising a first obstacle detection unit, provided in the load block, for detecting an obstacle in the vicinity of the region below a line extending from a side wall of the container; and a second obstacle detection unit, provided in the load block, for detecting an obstacle that is farther towards the outside than the extending line.

[0010] According to this configuration, an obstacle is detected in the vicinity of the region on the line extending from the side face of the container, in other words, close to a point below a straight line substantially parallel to the side face of the container, by the first obstacle detection unit. Therefore, when the container, which is gripped by the load block, for example, is lowered, it is possible to prevent the lower end of the container from colliding with the obstacle. Furthermore, because an obstacle located farther towards the outside than the line extending from the side face of the container is detected by the second obstacle detection unit, it is possible to detect an obstacle substantially directly underneath, even when the load block and so on is suspended at an angle by the wires, as shown in Fig. 13 for example. Accordingly, it is possible to prevent the block from colliding with the obstacle. In addition, it is possible to avoid obstacles more effectively by distributing the detection function among a plurality of sensors.

[0011] In the collision-avoidance apparatus for a crane described above, when the obstacle is detected by the first obstacle detection unit or the second obstacle detection unit, the load block may be moved horizontally until the obstacle is no longer detected by the first obstacle detection unit or the second obstacle detection unit.

[0012] According to this configuration, when an obstacle is detected by the first obstacle detection unit or the second obstacle detection unit, because the load block is moved horizontally until the obstacle is no longer detected by the first obstacle detection unit or the second obstacle detection unit, it is possible to quickly lower the container to the target position without causing a collision between, for example, the container or load block and the obstacle.

[0013] In the collision-avoidance apparatus for a crane described above, the first obstacle detection unit preferably detects the obstacle in the vicinity of a region on the line extending from the side surface of the container while the
container is being gripped by the load block.

[0014] According to this configuration, because the first obstacle detection unit is used as a sensor for detecting interference between the lower end of the container and the obstacle, it is possible to quickly lower the container without excessively the obstacle to prevent a collision between the load block and the obstacle.

5 [0015] In the collision-avoidance apparatus for a crane described above, the second obstacle detection unit preferably detects an obstacle above the lower end of the container while the container is being gripped by the load block.

[0016] According to this configuration, after avoiding a collision between the lower end of the container and the obstacle using the first obstacle detection unit, it is possible, using the second obstacle detection unit, to carry out collision avoidance between the load block and the obstacle without excessively avoiding the obstacle.

10 [0017] In the collision-avoidance apparatus for a crane described above, as the first obstacle detection unit and the second obstacle detection unit, sensors that detect obstacles in respective detection regions by emitting electromagnetic waves in predetermined directions and detecting reflections of the electromagnetic waves may be used.

[0018] By employing sensors using electromagnetic waves as the first obstacle detection unit and the second obstacle detection unit, the cost of the apparatus can be reduced.

[0019] The collision-avoidance apparatus for a crane described above preferably further includes an inclinometer for detecting the inclination of the container, wherein, when the inclination angle detected by the inclinometer is at or above a predetermined angle, unwinding of the wires is stopped.

[0020] According to this configuration, by stopping the unwinding of the wires when the inclination of the container is at or above the predetermined angle, the lowering of the container or load block is stopped. Accordingly, it is possible to improve the safety when unwinding the wires.

[0021] The collision-avoidance apparatus for a crane described above may further include a third obstacle detection unit, provided at an edge of the load block, for detecting a collision between the load block and the container when the container is gripped by the load block.

[0022] According to this configuration, because the third obstacle detection unit for detecting a collision between the load block and the container when the container is gripped by the load block is provided, it is possible to quickly grip the container with the load block without the load block colliding with the container. The second obstacle detection unit described above may also be used as the third obstacle detection unit.

[0023] In the collision-avoidance apparatus for a crane described above, the load block may include an outer frame having gripping members for gripping the container; and the third obstacle detection unit may be disposed at an edge of the outer frame and may be a sensor that detects contact with the container by emitting electromagnetic waves downward and outward at an angle and receiving reflected waves of the electromagnetic waves.

[0024] According to this configuration, because the third obstacle detection unit is disposed at the edge of the outer frame of the gripping members for gripping the container, by emitting electromagnetic waves downward and outward at an angle from the edge of the outer frame and receiving the reflected waves of these electromagnetic waves, the third obstacle detection unit can determine whether the container is directly seated below the gripping members, that is, whether the container is positioned in a region where it can be reliably gripped by the gripping members. Therefore, it is possible to reliably grip the container while avoiding a collision between an obstacle and the load block.

[0025] The third obstacle detection unit may be disposed, for example, on the outer side of the lower face of the frame, or it may be attached to a side face of the frame.

[0026] For example, the third obstacle detection unit may be disposed at a position so that the electromagnetic waves are radiated 100 mm outside the container when the load block is positioned 2.5 m above the container.

[0027] With the collision-avoidance apparatus for a crane according to the present invention, an advantage is provided in that it is possible to quickly lower the container to a target position while avoiding a collision between an obstacle and the container and load block, without employing stacking guides.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0028] Fig. 1 is a diagram illustrating the configuration and construction of a transfer crane, which is a crane according to a first embodiment of the present invention.

Fig. 2 is an enlarged view of a load block section viewed from the front of the crane shown in Fig. 1.

Fig. 3 is a diagram for explaining a procedure for controlling the unwinding of wires, which is carried out by a collision-avoidance apparatus for a crane according to the first embodiment of the present invention.

Fig. 4 is a flowchart showing the procedure for controlling the unwinding of wires, which is carried out by the collision-avoidance apparatus for a crane according to the first embodiment of the present invention.

Fig. 5 is a diagram for explaining the procedure for controlling the unwinding of wires, which is carried out by the collision-avoidance apparatus for a crane according to the first embodiment of the present invention.
Fig. 6 is a diagram for explaining the procedure for controlling the unwinding of wires, which is carried out by the collision-avoidance apparatus for a crane according to the first embodiment of the present invention.

Fig. 7 is a diagram for explaining the procedure for controlling the unwinding of wires, which is carried out by the collision-avoidance apparatus for a crane according to the first embodiment of the present invention.

Fig. 8 is a diagram for explaining the procedure for controlling the unwinding of wires, which is carried out by the collision-avoidance apparatus for a crane according to the first embodiment of the present invention.

Fig. 9 is a diagram for explaining the procedure for controlling the unwinding of wires, which is carried out by the collision-avoidance apparatus for a crane according to the first embodiment of the present invention.

Fig. 10 is a diagram for explaining the procedure for controlling the unwinding of wires, which is carried out by the collision-avoidance apparatus for a crane according to the first embodiment of the present invention.

Fig. 11 is a diagram schematically showing the configuration of a collision-avoidance apparatus for a crane according to a second embodiment of the present invention, showing an enlarged view of a load block section viewed from the side of the crane illustrated in Fig. 1.

Fig. 12 is a diagram showing an example of the detection positions detected by third infrared-beam sensors included in the collision-avoidance apparatus for a crane according to the second embodiment of the present invention.

Fig. 13 is a diagram showing an example of the technology used in the related art.

DETAILED DESCRIPTION OF THE INVENTION

[0029] In the following, a first embodiment and a second embodiment of an apparatus for avoiding a collision when lowering a container according to the present invention will be described in turn with reference to the drawings. In the description given here, a transfer crane will be used as an example of the crane.

First Embodiment

[0030] In Fig. 1, reference characters R1 represent a transfer crane (crane). This transfer crane R1 includes a gantry 2 formed of pillar-like leg structures 42a and 42b connected at both ends of girders 41, which are disposed horizontally.

[0031] A plurality of wheels 43 are provided at the lower ends of each of the leg structures 42a and 42b constituting the gantry 2. These wheels 43 enable the transfer crane R1 to move. Running motors (not shown in the drawing) are provided at the lower ends of each of the leg structures 42a and 42b. At least one of the wheels 43 provided at the lower ends of each of the leg structures 42a and 42b is driven with these running motors. In other words, the transfer crane R1 moves by rotationally driving the wheels 43 with the running motors. In addition, these wheels 43 are steerable.

[0032] A trolley 44, which is supported so as to be capable of moving along the longitudinal direction of the girders 41, is provided on the girders 41. A load block 45 for hoisting the load, such as a container, is suspended from this trolley 44 by wires 46.

[0033] A raising-and-lowering mechanism 47 for winding and unwinding (letting-out) the wires 46 is provided on the trolley 44. By rotating a drum (not shown in the drawing) around which the wires 46 are wound using a winch motor (not shown in the drawing), this raising-and-lowering mechanism 47 winds and unwinds the wires 46 on the drum to raise and lower the load block 45. Furthermore, a trolley device (not shown in the drawing) for making the trolley 44 run in the longitudinal direction of the girders 41, that is, in the horizontal direction, by means of a trolley motor (not shown in the drawing) is provided on the trolley 44.

[0034] A diesel-engined generator 10 is provided on the leg structure 42a constituting the gantry 2, at the lower end thereof, and is driven using fuel supplied from a fuel tank (not shown in the drawing) provided adjacent thereto. Also, the leg structure 42b at the opposite end is provided with a control panel 20. The control panel 20 includes a control device. By operating this control device to carry out collision avoidance when lowering a container (described later), the container can be lowered to a target position while avoiding a collision with an obstacle.

[0035] The control device has a configuration including, for example, a CPU (central processing unit), a HD (hard disk), a ROM (read only memory), and a RAM (random access memory). A sequence of processes for implementing the individual functions of the collision-avoidance control operation (described later) is stored in the HD or the like in the form of a program. By loading this program into the RAM or the like and executing information processing and computation, the CPU controls the unwinding of the wires and lateral motion control of the trolley, which are described later.

[0036] Next, the apparatus for avoiding a collision when lowering a container according to the present embodiment will be described. Fig. 2 is a diagram depicting the configuration of the apparatus for avoiding a collision when lowering a container according to the present embodiment, showing a front magnified view of the region around the load block 45 shown in Fig. 1.

[0037] The load block 45 of the transfer crane R1 according to this embodiment includes an outer frame 14 having flippers (gripping members) 13 for gripping the container C. This outer frame 14 is disposed, for example, parallel to the longitudinal direction of the load block 45 and is configured so as to securely grip the upper part of the container C (see
Fig. 11, for example). First infrared-beam sensors (first obstacle detection units) 11 and second infrared-beam sensors (second obstacle detection units) 12, for example, are provided at least the four corners of this outer frame 14.

At least four of the first infrared-beam sensors 11 are provided in the outer frame 14. By emitting light beams (electromagnetic waves) SB1 downwards along lines extending from the respective side faces of the container C and receiving the reflections of these beams SB1, the first infrared-beam sensors 11 detect an obstacle 15 at least up to the side faces of the container C. The detection regions of the second infrared-beam sensors 12 should be set above the lower end of the container C. As shown in Fig. 2, these first infrared-beam sensors 11 are preferably disposed at the inner side of the outer frame 14 (that is, at positions close to the container C). By doing so, when controlling the unwinding of the wires (described later), it is possible to restrict the region detected by the first infrared-beam sensors 11 to a region extremely close to the side faces of the container C. Accordingly, it is possible to quickly lower the container C without excessively avoiding obstacles.

At least four of the second infrared-beam sensors 12 are provided in the outer frame 14. By emitting light beams SB2 outwards at a predetermined angle with respect to the respective side walls of the container C and receiving reflected beams, the second infrared-beam sensors 12 detect obstacles farther towards the outside than the lines extending from the side faces of the container C. The detection regions of the second infrared-beam sensors 12 should be set above the lower end of the container C. In other words, as shown in Fig. 2, making the distance traveled by the beams SB2 emitted from the second infrared-beam sensors 12 shorter than the distance to the lower end of the container C is preferable for detecting an obstacle located above the lower end of the container C.

Next, as shown in Fig. 6, if the obstacle 15 is detected by the first infrared-beam sensors 11 during this unwinding step ("YES" at step SA4 in Fig. 4), the control device stops unwinding the wires 46 (step SA5 in Fig. 4) and gradually moves the trolley 44 laterally (step SA6 in Fig. 4). Thus, by gradually moving the trolley 44 laterally, as shown in Fig. 7, once the obstacle can no longer be detected by the first infrared-beam sensor 11 ("NO" at step SA7 in Fig. 4), the lateral movement of the trolley 44 is stopped (step SA8 in Fig. 4), and unwinding of the wires 46 recommences (the process goes back to step SA3 in Fig. 4). Performing control in this way allows the container C to be gradually lowered while avoiding the obstacle 15 detected by the first infrared-beam sensors 11.

Subsequently, once the container reaches a point between the obstacles stacked on both sides, obstacle detection is performed using the second infrared-beam sensors 12. Then, as shown in Fig. 8, if the obstacle 15 is detected by the second infrared-beam sensors 12 ("YES" at step SA4 in Fig. 4), in the same way as above, the control device stops unwinding the wires 46 (step SA5 in Fig. 4) and gradually moves the trolley 44 laterally (step SA6 in Fig. 4). Then, as shown in Fig. 9, when the obstacle 15 is no longer detected by the second infrared-beam sensor 12 ("NO" at step SA7 in Fig. 4), the lateral movement of the trolley 44 is stopped (step SA8 in Fig. 4), and unwinding of the wires 46 recommences (step SA3 in Fig. 4).

As described above, with the collision-avoidance apparatus for a crane according to the first embodiment of the present invention, the obstacle 15 in the vicinity of the line extending from the side face of the container C, in other words, close to the point below the straight line substantially parallel to the side face of the container C, is detected with
the first infrared-beam sensors 11. Therefore, when lowering the container C, which is gripped by the load block 45, for example, the lower end of the container C can be prevented from colliding with the obstacle 15.

Furthermore, since the obstacle 15 is detected when located farther towards the outside than the line extending from the side surface of the container C using the second infrared-beam detectors 12, as shown in Fig. 13 for example, it is possible to detect the obstacle 15 substantially directly below, even when the load block 45 and so forth is suspended by the wires 46 at an angle. Accordingly, for example, it is possible to prevent the load block 45 from colliding with the obstacle 15.

Moreover, because the first infrared-beam sensors 11 are used to detect the obstacle 15 in the vicinity of the lines extending from the side surfaces of the container C when the container C is gripped by the load block 45, it is possible to restrict the detection regions of the first infrared-beam sensors 11 to the regions extremely close to the container C. By doing so, only an obstacle 15 close to the side walls of the container C is detected, and therefore, the angle detected by this inclinometer is at or above a predetermined angle.

With this configuration, since unwinding of the wires 46 is stopped when the inclination of the container C is at or above the predetermined angle, it is possible to improve safety when unwinding the wires 46.

Second Embodiment

Next, a collision-avoidance apparatus for a crane according to a second embodiment of the present invention will be described with reference to Fig. 11. In the description in this embodiment too, the transfer crane shown in Fig. 1 is used as an example of a crane.

Fig. 11 is a side view of the load block 45, that is, a view taken from a direction perpendicular to the front direction (in the direction of arrow A) in Fig. 1.

As shown in Fig. 11, the collision-avoidance apparatus for a crane according to this embodiment includes third infrared-beam sensors (third obstacle detection units) 16 for detecting a collision between the load block 45 and the container C when the container C is gripped by the load block 45.

As shown in Fig. 12, the third infrared-beam sensors 16 are positioned so that, when the load block 45 is lowered to a point 2.5 m above the container C, the infrared beams are radiated to points 100 mm from the container. Fig. 12 shows the container C as viewed from above the load block 45.

Next, a method used in the above-configured transfer crane is for controlling the transfer of the container C, which is located at a predetermined position, when it is gripped by the load block 45 and hoisted will be described with reference to Fig. 11.

First, after moving the trolley 44 laterally to a point above the container C located at the predetermined position, the load block 45 is gradually lowered by unwinding the wires 46. At this time, while performing collision-avoidance control for the crane, as described above, the load block 45 is lowered so that the load block 45 does not collide with any surrounding obstacles (see Fig. 4).

Subsequently, when the load block 45 reaches the vicinity of the container C, it is determined, using the third infrared-beam sensors 16 described above, whether or not an obstacle, or in other words, here the container C to be gripped, is detected. If, as a result, the container C is detected by the third infrared-beam sensors 16, the trolley 44 is moved laterally until the container C is no longer detected. Accordingly, the load block 45 is moved in parallel, as well as downwards, while avoiding a collision with the container C. Then, when the load block 45 reaches a position where it contacts the upper surface of the container C, the control device stops unwinding the wires 46, and thereafter, the container C is moved laterally until the container C is no longer detected. Accordingly, for example, it is possible to prevent the load block 45 from colliding with the obstacle 15.

As described above, with the collision-avoidance apparatus for a crane according to the second embodiment, the third infrared-beam sensors 16 are provided for detecting a collision between the load block 45 and the container C when the container C is gripped by the load block 45. Therefore, it is possible to quickly grip the container C with the
load block 45 without the load block 45 colliding with the container C.

In particular, by disposing the third infrared-beam sensors 16 at the edges of the outer frame 14, which is provided with the gripping members 13 for gripping the container C, and by emitting infrared light from the third infrared-beam sensors 16 at a downward and outward angle from the edges of the outer frame 14 and receiving the reflected beams of this infrared light, it is possible to determine whether the container is seated directly below the gripping members 13, that is, whether the container C is positioned in a region where it can be reliably gripped by the gripping members 13. Accordingly, it is possible to reliably grip the container C while avoiding a collision between the container C and the load block 45.

Although preferred embodiments of the present invention have been described above with reference to the drawings, the actual configuration is not particularly limited to these embodiments. Various modifications are possible so long as they do not depart from the spirit of the invention.

For example, the first infrared-beam sensors 11 and the second infrared-beam sensors 12 may be positioned, as one example, at the edges of the outer frame 14. The term edges, as used here, includes the lower surface, side surfaces and so on of the outer frame 14.

Also, the first infrared-beam sensors 11 and the second infrared-beam sensors 12 are, as one example, sensors for detecting obstacles; they may also be sensors having the same function as this type of sensor.

Furthermore, the third infrared-beam sensors 16 may be disposed, for example, on the outer sides of the lower surface of the outer frame 14, or they may be attached to the side faces of the outer frame 14. It is also possible to use the second infrared-beam sensors 12 described above as the third infrared-beam sensors 16.

Moreover, in the embodiments described above, a transfer crane that can move by means of the wheels 43 is described as an example of a crane; however, it is also possible to use a transfer crane that moves, for example, on rails.

Claims

1. A collision-avoidance apparatus for a crane, for use in a crane which carries out loading and unloading operations by gripping and moving a container with a load block suspended by wires and which prevents a collision when unwinding the wires, the apparatus comprising:

   a first obstacle detection unit, provided in the load block, for detecting an obstacle in the vicinity of the region below a line extending from a side wall of the container; and

   a second obstacle detection unit, provided in the load block, for detecting an obstacle that is farther towards the outside than the extending line.

2. A collision-avoidance apparatus for a crane according to Claim 1, wherein when the obstacle is detected by the first obstacle detection unit or the second obstacle detection unit, the load block is moved horizontally until the obstacle is no longer detected by the first obstacle detection unit or the second obstacle detection unit.

3. A collision-avoidance apparatus for a crane according to Claim 2, wherein the first obstacle detection unit detects the obstacle in the vicinity of a region on the line extending from the side surface of the container while the container is being gripped by the load block.

4. A collision-avoidance apparatus for a crane according to Claim 2 or Claim 3, wherein the second obstacle detection unit detects the obstacle above the lower end of the container while the container is being gripped by the load block.

5. A collision-avoidance apparatus for a crane according to one of Claims 1 to 4, wherein the first obstacle detection unit and the second obstacle detection unit are sensors that detect obstacles in respective detection regions by emitting electromagnetic waves in predetermined directions and detecting reflections of the electromagnetic waves.

6. A collision-avoidance apparatus for a crane according to one of Claims 1 to 5, further comprising:

   an inclinometer for detecting the inclination of the container, wherein, when the inclination angle detected by the inclinometer is at or above a predetermined angle, unwinding of the wires is stopped.

7. A collision-avoidance apparatus for a crane according to one of Claims 1 to 6, further comprising:

   a third obstacle detection unit, provided at an edge of the load block, for detecting a collision between the load
block and the container when the container is gripped by the load block.

8. A collision-avoidance apparatus for a crane according to Claim 7, wherein:

the load block includes an outer frame having gripping members for gripping the container; and
the third obstacle detection unit is disposed at an edge of the outer frame and is a sensor that detects contact
with the container by emitting electromagnetic waves downward and outward at an angle and receiving reflected
waves of the electromagnetic waves.
FIG. 3

TARGET POSITION
FIG. 4

START

MOVE TROLLEY LATERALLY

STOP TROLLEY

UNWIND WIRES

OBSTACLE DETECTED?

YES → STOP UNWINDING WIRES

NO → UNWIND WIRES

REACHED TARGET POSITION?

YES → STOP UNWINDING WIRES

NO → MOVE TROLLEY LATERALLY

OBSTACLE DETECTED?

YES → STOP UNWINDING WIRES

NO → MOVE TROLLEY LATERALLY

END

STOP LATERAL MOVEMENT OF TROLLEY
FIG. 13
## DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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The present search report has been drawn up for all claims

**The Hague** 31 May 2006

**Examiner:** Verheul, O
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