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BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a crane apparatus which is used, for example, as a transfer crane of port cargo handling equipment.

2. Description of the Related Art

A conventional transfer crane has a gate-shaped body frame, which can travel by a plurality of traveling wheels. On the top of the body frame, a trolley can move transversely. On the trolley, a rotationally drivable takeup drum is borne. A hoisting accessory is attached to the lower end of a plurality of load suspending wire ropes wound off from the takeup drum. Thus, as the trolley moves on the body frame, a suspended load held by the hoisting accessory can be traversed. When the takeup drum is rotationally driven at a predetermined stop position of the trolley to take up or pay out the plural wire ropes, the suspended load can be moved upwards or downwards.

With the above-described conventional crane apparatus, rails are provided on transverse girders placed on the body frame, and the trolley is supported on the rails. In consideration of the weight of the rails, the weight of the trolley, or the weight of the



suspended load imposed on the hoisting accessory, not only the transverse girders and the body frame, but also the entire crane apparatus must have great rigidity, inducing a large size and a heavy weight. When the trolley is moved laterally and stopped at a predetermined position, with the suspended load being held by the hoisting accessory, sway occurs in the hoisting accessory and the suspended load owing to an inertial force in the lateral direction. This sway does not settle quickly. To prevent sway of the hoisting accessory and the suspended load when the trolley stops, the trolley has to be moved at a slow speed. Since a long time is required for work, the work efficiency is low.

As a solution to the above-mentioned problem, a crane apparatus as shown, for example, in FIG. 4 is available. In this conventional crane apparatus, as shown in FIG. 4, left and right traverser drums 101 and 102 as a pair, and left and right hoisting accessory drums 103 and 104 as a pair are rotatably supported on the top of a gate-shaped body frame via clutches 105 and 106, respectively, and are rotationally drivable by left and right drive motors 107 and 108 as a pair. First right and left traverser wire ropes 109 and 110 as a pair have an end taken up by the traverser drums 102 and 101, and have the other end connected to a right connecting portion 114 on a

traverser 113 via right and left sheaves 111 and 112, respectively. Second right and left traverser wire ropes 115 and 116 as a pair have an end taken up by the traverser drums 102 and 101, and have the other end connected to a left connecting portion 119 on the traverser 113 via right and left sheaves 117 and 118, respectively. Furthermore, right and left hoisting accessory wire ropes 120 and 121 as a pair have an end taken up by the hoisting accessory drums 104 and 103, and have the other end passed over low-position rope pulleys 126 and 127 via right and left sheaves 122 and 123 and right and left sheaves 124 and 125 of the traverser 113, and then connected to connecting portions 128 and 129 of the traverser 113. From the rope pulleys 126 and 127, a hoisting accessory 130 capable of holding a container C is suspended. Hence, there is no need to provide rails and a trolley on the body frame. Since the weight on the body frame is reduced, the crane apparatus can be made compact and light-weight. Besides, the traverser 113, which supports the hoisting accessory 130, is supported by the wire ropes 109, 110, 115, 116 at the two separated connecting portions 114 and 119. Hence, sway of the hoisting accessory 130 and the suspended load C due to their inertial force is suppressed, and the work efficiency is increased.

In the conventional crane apparatus described

above, let the weight of the hoisting accessory 130 and the suspended load C be W . Then, the rope tension T of the hoisting accessory wire ropes 120 and 121 will be:

$$T = W/4$$

The rope tensions T_{1R} and T_{1L} of the first traverser wire ropes 109 and 110, and the rope tensions T_{2R} and T_{2L} of the second traverser wire ropes 115 and 116 will be given by:

$$T_{1R} = (W/2)\cos\theta_2/\sin(\theta_1 + \theta_2) - W/8$$

$$T_{1L} = (W/2)\cos\theta_1/\sin(\theta_1 + \theta_2) - W/8$$

$$T_{2R} = T_{1R}$$

$$T_{2L} = T_{1L}$$

where θ_1 is the angle of each of the wire ropes 109, 115 and 120, and θ_2 is the angle of each of the wire ropes 110, 116 and 121.

In other words, the rope tensions T_{1R} and T_{1L} of the first traverser wire ropes 109 and 110, and the rope tensions T_{2R} and T_{2L} of the second traverser wire ropes 115 and 116 vary with the angle θ_1 of each of the wire ropes 109, 115 and 120, and the angle θ_2 of each of the wire ropes 110, 116 and 121, namely, the traversing position of the hoisting accessory 130. Whereas the rope tension T of each of the hoisting accessory wire ropes 120 and 121 is constant ($W/4$) regardless of the traversing position of the hoisting accessory 130.

Under these situations, when the hoisting accessory 130 is traversed most rightward, the hoisting accessory 130 stops at a position at which rightward and leftward horizontal components of force from the hoisting accessory wire ropes 120 and 121 are balanced, as shown in FIG. 5, because the rope tension T of the hoisting accessory wire rope 120 and that of the hoisting accessory wire rope 121 are the same. Thus, the hoisting accessory 130 cannot be brought fully close to a crane leg 131 which supports the sheave 122, etc. As a result, the traversing range of the hoisting accessory 130 narrows. A full traversing function of the crane cannot be exhibited, and the work efficiency is low. If the position of the crane leg 131 is brought outward (rightward in FIG. 5), together with the sheave 122, to enlarge the traversing range of the hoisting accessory 130, the apparatus will be upsized.

SUMMARY OF THE INVENTION

The present invention has been accomplished to solve the above-described problems with the earlier technology. It is an object of this invention to provide a crane apparatus designed to increase the work efficiency by enlarging the traversing range of a hoisting accessory without upsizing the apparatus.

23 OCT 2002

A first aspect of the present invention, as a means of attaining the above object, is a crane apparatus comprising:

a body frame;

traverser drums and hoisting accessory drums rotatably mounted on the body frame and normally and reversely rotatable by a drive motor;

a traverser having right and left connecting portions as a pair, and right and left sheaves as a pair;

right and left rope pulleys as a pair positioned below the traverser;

first right and left traverser wire ropes as a pair having an end taken up by the traverser drums, and having the other end connected to the right connecting portion of the traverser;

second right and left traverser wire ropes as a pair having an end taken up by the traverser drums, and having the other end connected to the left connecting portion of the traverser;

first right and left hoisting accessory wire ropes as a pair having an end taken up by the hoisting accessory drums, and having the other end passed over the right rope pulley via the right sheave of the traverser and then connected to the traverser;

second right and left hoisting accessory wire ropes as a pair having an end taken up by the hoisting

accessory drums, and having the other end passed over the left rope pulley via the left sheave of the traverser and then connected to the traverser;

right and left traverser sheaves as a pair and right and left hoisting accessory sheaves as a pair for guiding the right-hand wire ropes to be parallel and the left-hand wire ropes to be parallel; and

a hoisting accessory capable of attaching and detaching a load thereto and therefrom, and suspended from the right and left rope pulleys.

Thus, the rope tension of each of the hoisting accessory wire ropes varies with the traversing position of the hoisting accessory as does the rope tension of each of the traverser wire ropes. When the hoisting accessory comes to a terminal area in a traversing direction, the position at which the rightward and leftward horizontal components of force are balanced is more outward than in the earlier technology. Thus, the traversing range of the hoisting accessory widens. As noted from this, the traversing range of the hoisting accessory can be enlarged, and the work efficiency can be increased, without the need to upsize the apparatus.

In the crane apparatus as the first aspect of the invention, the hoisting accessory drums may be drivably connected to the drive motor, and the traverser drums may be drivably connected to the

23 OCT 2002

hoisting accessory drums via clutches. Consequently, the hoisting accessory drums may be driven independently to permit only the hoisting and lowering of the hoisting accessory.

A second aspect of the invention is a crane apparatus comprising:

a body frame;

traverser drums and hoisting accessory drums rotatably mounted on the body frame and normally and reversely rotatable by a drive motor;

a traverser having right and left connecting portions as a pair, and right and left sheaves as a pair;

right and left rotating drums as a pair suspended from the traverser;

first right and left traverser wire ropes as a pair having an end taken up by the traverser drums, and having the other end connected to the right connecting portion of the traverser;

second right and left traverser wire ropes as a pair having an end taken up by the traverser drums, and having the other end connected to the left connecting portion of the traverser;

first right and left hoisting accessory wire ropes as a pair having an end taken up by the hoisting accessory drums, and having the other end passed over the right rotating drum via the right sheave of the

traverser;

second right and left hoisting accessory wire ropes as a pair having an end taken up by the hoisting accessory drums, and having the other end passed over the left rotating drum via the left sheave of the traverser;

right and left traverser sheaves as a pair and right and left hoisting accessory sheaves as a pair for guiding the right-hand wire ropes to be parallel and the left-hand wire ropes to be parallel; and

a hoisting accessory capable of attaching and detaching a load thereto and therefrom, and connected to right and left suspending wire ropes as a pair paid out from the right and left rotating drums.

Thus, the rope tension of each of the hoisting accessory wire ropes varies with the traversing position of the hoisting accessory as does the rope tension of each of the traverser wire ropes. When the hoisting accessory comes to a terminal area in a traversing direction, the position at which the rightward and leftward horizontal components of force are balanced is more outward than in the earlier technology. Thus, the traversing range of the hoisting accessory widens. As noted from this, the traversing range of the hoisting accessory can be enlarged, and the work efficiency can be increased, without the need to upsize the apparatus.

In the crane apparatus as the second aspect of the invention, the hoisting accessory drums may be drivably connected to the drive motor, and the traverser drums may be drivably connected to the hoisting accessory drums via clutches. Consequently, the hoisting accessory drums may be driven independently to permit only the hoisting and lowering of the hoisting accessory.

In the crane apparatus as the second aspect of the invention, moreover, the hoisting accessory wire ropes and the suspending wire ropes may be passed over the rotating drum in opposite directions. Consequently, smooth actions can be performed.

A third aspect of the invention is a crane apparatus comprising:

- a body frame;

- traverser drums and hoisting accessory drums rotatably mounted on the body frame and normally and reversely rotatable by a drive motor;

- a traverser having right and left connecting portions as a pair, and right and left sheaves as a pair;

- first right and left rope pulleys as a pair suspended from the traverser;

- second right and left rope pulleys as a pair positioned below the first right and left rope pulleys;

- first right and left traverser wire ropes as

a pair having an end taken up by the traverser drums, and having the other end connected to the right connecting portion of the traverser;

second right and left traverser wire ropes as a pair having an end taken up by the traverser drums, and having the other end connected to the left connecting portion of the traverser;

a first hoisting accessory wire rope having an end taken up by the hoisting accessory drum, and having the other end passed over the first and second right rope pulleys via the right sheave of the traverser and then connected to the traverser;

a second hoisting accessory wire rope having an end taken up by the hoisting accessory drum, and having the other end passed over the first and second left rope pulleys via the left sheave of the traverser and then connected to the traverser;

right and left traverser sheaves as a pair and right and left hoisting accessory sheaves as a pair for guiding the right-hand wire ropes to be parallel and the left-hand wire ropes to be parallel; and

a hoisting accessory capable of attaching and detaching a load thereto and therefrom, and suspended from the second right and left rope pulleys.

Thus, the rope tension of each of the hoisting accessory wire ropes decreases because of the first and second rope pulleys, to reduce the rightward and

leftward horizontal components of force imposed on the hoisting accessory by the hoisting accessory wire ropes. As a result, when the hoisting accessory comes to a terminal area in a traversing direction, the position at which the rightward and leftward horizontal components of force are balanced is more outward than in the earlier technology. Thus, the traversing range of the hoisting accessory widens. As noted from this, the traversing range of the hoisting accessory can be enlarged, and the work efficiency can be increased, without the need to upsize the apparatus.

In the crane apparatus as the third aspect of the invention, the hoisting accessory drums may be drivably connected to the drive motor, and the traverser drums may be drivably connected to the hoisting accessory drums via clutches. Consequently, the hoisting accessory drums may be driven independently to permit only the hoisting and lowering of the hoisting accessory.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will become more apparent from the following description taken in connection with the accompanying drawings, in which:

FIG. 1 is a schematic constitution drawing of

a crane apparatus according to a first embodiment of the present invention;

FIG. 2 is a schematic constitution drawing of a crane apparatus according to a second embodiment of the invention;

FIG. 3 is a schematic constitution drawing of a crane apparatus according to a third embodiment of the invention;

FIG. 4 is a schematic constitution drawing of a conventional crane apparatus; and

FIG. 5 is a schematic view of the conventional crane apparatus during a traversing action.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of the present invention will now be described in detail with reference to the accompanying drawings.

FIG. 1 schematically shows the constitution of a crane apparatus according to a first embodiment of the invention.

[First Embodiment]

In the crane apparatus of the present embodiment, as shown in FIG. 1, a body frame (not shown) is shaped like a gate. On the top of the body frame, right and left traverser drums 11 and 12 as a pair, and right and left hoisting accessory drums 13 and 14

as a pair are rotatably supported via clutches 15 and 16, and are rotationally drivable by right and left drive motors 17 and 18 as a pair. First right and left traverser wire ropes 19 and 20 as a pair have an end taken up by the traverser drums 11 and 12, and have the other end connected to a right connecting portion 24 of a traverser 23 via right and left sheaves 21 and 22. Second right and left traverser wire ropes 25 and 26 as a pair have an end taken up by the traverser drums 11 and 12, and have the other end connected to a left connecting portion 29 of the traverser 23 via right and left sheaves 27 and 28.

First right and left hoisting accessory wire ropes 31 and 32 as a pair have an end taken up by the hoisting accessory drums 13 and 14, and have the other end passed over a lower-position rope pulley 37 via right and left sheaves 33 and 34 and right sheaves 35, 36 of the traverser 23 and then connected to a connecting portion 38 of the traverser 23. Second right and left hoisting accessory wire ropes 39 and 40 as a pair have an end taken up by the hoisting accessory drums 13 and 14, and have the other end passed over a lower-position rope pulley 45 via right and left sheaves 41 and 42 and left sheaves 43, 44 of the traverser 23 and then connected to a connecting portion 46 of the traverser 23. A hoisting accessory 47 capable of holding a container C is suspended from the

rope pulleys 37, 45. The right-hand wire ropes 19, 25, 31, 39 are parallel to each another, and the left-hand wire ropes 20, 26, 32, 40 are also parallel to each another.

The clutches 15, 16 are disengaged, and the hoisting accessory drums 13 and 14 are rotated in opposite directions by the drive motors 17 and 18. When the hoisting accessory wire ropes 31, 32, 39, 40 are taken up in this state, the container C held by the hoisting accessory 47 can be lifted via the rope pulleys 37, 45. By paying out the hoisting accessory wire ropes 31, 32, 39, 40, on the other hand, the container C held by the hoisting accessory 47 can be lowered via the rope pulleys 37, 45. Alternatively, the clutches 15, 16 are engaged, and the respective drums 11, 12, 13 and 14 are rotated in the same direction by the drive motors 17 and 18. When the hoisting accessory wire ropes 31, 39 and the traverser wire ropes 19, 25 are taken up in this state, and at the same time the hoisting accessory wire ropes 32, 40 and the traverser wire ropes 20, 26 are paid out, the container C held by the hoisting accessory 47 can be caused to traverse rightward along with the traverser 23. On the other hand, when the hoisting accessory wire ropes 31, 39 and the traverser wire ropes 19, 25 are paid out, and at the same time the hoisting accessory wire ropes 32, 40 and the traverser wire

ropes 20, 26 are taken up, the container C held by the hoisting accessory 47 can be caused to traverse leftward along with the traverser 23.

In the crane apparatus of the present embodiment, let the total weight of the hoisting accessory 47 and the container C be W . Then, the rope tensions T_{01R} , T_{01L} , T_{02R} and T_{02L} of the hoisting accessory wire ropes 31, 32, 39 and 40 vary with the traversing position of the hoisting accessory 47 (container C). That is,

$$T_{01R} + T_{01L} = W/4 \dots\dots\dots \text{Balance in vertical direction (1)}$$

$$T_{01R}\cos\theta_1 - T_{01L}\cos\theta_2 = 0 \dots\dots\dots \text{Balance in horizontal direction (2)}$$

The equation (2) can be transposed as follows:

$$T_{01L} = T_{01R}\cos\theta_1/\cos\theta_2 \dots (3)$$

Substituting the equation (3) in the equation (1), followed by transposition, gives:

$$T_{01R} + T_{01R}\cos\theta_1/\cos\theta_2 = W/4$$

$$T_{01R} = (W/4)\cos\theta_2/(\cos\theta_1 + \cos\theta_2) \dots (4)$$

Substitution of the equation (3) into the equation (4), followed by transposition, yields:

$$T_{01L} = (W/4)\cos\theta_1/(\cos\theta_1 + \cos\theta_2) \dots (5)$$

Also, $T_{02R} = T_{01R}$, and $T_{02L} = T_{01L}$

In the above equations, θ_1 is the angle of each of the wire ropes 19, 25, 31 and 39, while θ_2 is the angle of each of the wire ropes 20, 26, 32 and 40.

The rope tensions T_{1R} , T_{1L} , T_{2R} and T_{2L} of the traverser wire ropes 19, 20, 25 and 26 also vary with the traversing position of the hoisting accessory 47 (container C). That is,

$$T_{1R}\sin\theta_1 + T_{1L}\sin\theta_2 + T_{01R}\sin\theta_1 + T_{01L}\sin\theta_2 = W/2$$

...Balance in vertical
direction (6)

Substituting the aforementioned equations (4) and (5) into the equation (6), followed by transposition, yields:

$$\begin{aligned} & T_{1R}\sin\theta_1 + T_{1L}\sin\theta_2 \\ &= (W/2) [1 - (1/2) \{ \sin(\theta_1 + \theta_2) (\cos\theta_1 + \cos\theta_2) \}] \\ & \dots (7) \end{aligned}$$

Furthermore,

$$T_{1R}\cos\theta_1 - T_{1L}\cos\theta_2 = 0 \dots \text{Balance in horizontal direction (8)}$$

Substitution of the equation (7) in the equation (8), followed by transposition, gives:

$$\begin{aligned} T_{1R} &= (W/2) \cos\theta_2 / \sin(\theta_1 + \theta_2) \\ &\quad - (W/4) \cos\theta_2 / (\cos\theta_1 + \cos\theta_2) \\ & \dots (9) \end{aligned}$$

$$\begin{aligned} T_{1L} &= (W/2) \cos\theta_1 / \sin(\theta_1 + \theta_2) \\ &\quad - (W/4) \cos\theta_1 / (\cos\theta_1 + \cos\theta_2) \\ & \dots (10) \end{aligned}$$

Also, $T_{2R} = T_{1R}$, and $T_{2L} = T_{1L}$

As described above, the rope tensions T_{01R} , T_{01L} , T_{02R} and T_{02L} of the hoisting accessory wire ropes 31,

32, 39 and 40 vary with the traversing position of the hoisting accessory 47 (container C) as do the rope tensions T_{1R} , T_{1L} , T_{2R} and T_{2L} of the traverser wire ropes 19, 20, 25 and 26. That is, when the hoisting accessory 47 is caused to traverse most rightward, the rope angle θ_1 increases, and the rope angle θ_2 decreases. Thus, the tensions of the right-hand wire ropes 19, 25, 31 and 39 increase, while the tensions of the left-hand wire ropes 20, 26, 32 and 40 decrease. As a result, the leftward horizontal component of force on the hoisting accessory 47 (container C) becomes smaller than in the earlier technology, and the position at which the rightward and leftward horizontal components of force are balanced comes more rightward than in the earlier technology. Hence, the hoisting accessory 47 (container C) can be brought fully close to the crane leg as compared with the earlier technology. The traversing range of the hoisting accessory 47 widens, and the work efficiency of the crane can be increased without the necessity of upsizing the apparatus.

[Second Embodiment]

FIG. 2 schematically shows the constitution of a crane apparatus according to a second embodiment of the invention. Members having the same functions as explained in the above-mentioned embodiment will be assigned the same reference numerals, and overlapping explanations will be omitted.

In the crane apparatus of the present embodiment, right and left rotating drums 53 and 54 as a pair are supported in a suspended manner from a traverser 23 by ropes 51 and 52, as shown in FIG. 2. First right and left hoisting accessory wire ropes 31 and 32 have the other end passed over the right rotating drum 53 via right sheaves 35, 36 of the traverser 23, and connected to the right rotating drum 53. Second right and left hoisting accessory wire ropes 39 and 40 have the other end passed over the left rotating drum 54 via left sheaves 43, 44 of the traverser 23, and connected to the left rotating drum 54. A hoisting accessory 47 capable of holding a container C is suspended from the lower end of right and left suspending wire ropes 55 and 56 as a pair paid out from the rotating drums 53 and 54. The takeup directions of the hoisting accessory wire ropes 31, 32, 39, 40 and the suspending wire ropes 55, 56 on the rotating drums 53, 54 are the same. Hence, when only hoisting accessory drums (not shown) are rotated for a takeup action, the hoisting accessory wire ropes 31, 32, 39, 40 are taken up to rotate the rotating drums 53, 54. These rotating drums 53 and 54 take up the suspending wire ropes 55 and 56, whereby the container C held by the hoisting accessory 47 can be hoisted. Alternatively, the hoisting accessory wire ropes 31, 32, 39, 40 are paid out to rotate the rotating drums

53, 54. The rotating drums 53, 54 pay out the suspending wire ropes 55, 56, whereby the container C held by the hoisting accessory 47 can be lowered. The traversing action of the hoisting accessory 47 is the same as in the preceding embodiment, so that its explanation is omitted.

In the crane apparatus of the present embodiment, too, let the total weight of the hoisting accessory 47 and the container C be W_L , the weight of the traverser 23 be W_T , and the weights of the rotating drums 53 and 54 be W_{D1} and W_{D2} . Then, the rope tensions T_{01R} , T_{01L} , T_{02R} and T_{02L} of the hoisting accessory wire ropes 31, 32, 39 and 40 vary with the traversing position of the hoisting accessory 47 (container C). That is,

$$T_{01R} + T_{01L} = W_L/2 \dots\dots\dots \text{Balance in vertical direction} \quad (11)$$

$$T_{01R}\cos\theta_1 - T_{01L}\cos\theta_2 = 0 \dots\dots\dots \text{Balance in horizontal direction} \quad (12)$$

The equation (12) can be transposed as follows:

$$T_{01L} = T_{01R}\cos\theta_1/\cos\theta_2 \dots\dots\dots (13)$$

Substituting the equation (13) in the equation (11), followed by transposition, gives:

$$T_{01R} = (W_L/2)\cos\theta_2/(\cos\theta_1 + \cos\theta_2) \dots\dots\dots (14)$$

Substitution of the equation (13) into the equation (14), followed by transposition, yields:

$$T_{01L} = (W_L/2)\cos\theta_1/(\cos\theta_1 + \cos\theta_2) \dots\dots\dots (15)$$

Also, $T_{02R} = T_{01R}$, and $T_{02L} = T_{01L}$

The rope tensions T_{1R} , T_{1L} , T_{2R} and T_{2L} of the traverser wire ropes 19, 20, 25 and 26 also vary with the traversing position of the hoisting accessory 47 (container C). That is,

$$\begin{aligned} T_{1R}\sin\theta_1 + T_{1L}\sin\theta_2 &= (W_T + W_{D1} + W_{D2})/2 \\ &+ (W_L/2 - T_{01R}\sin\theta_1 - T_{01L}\sin\theta_2) \\ &\dots \text{Balance in vertical} \\ &\text{direction (16)} \end{aligned}$$

Furthermore,

$$\begin{aligned} T_{1R}\cos\theta_1 - T_{1L}\cos\theta_2 &= 0 \dots \text{Balance in horizontal} \\ &\text{direction (17)} \end{aligned}$$

$$T_{1L} = T_{1R}\cos\theta_1/\cos\theta_2 \dots (18)$$

Based on the equations (16) and (18), the same calculations as in the aforementioned embodiment are made, giving:

$$\begin{aligned} T_{1R} &= \{ (W_L + W_T + W_{D1} + W_{D2})/2 \} \cos\theta_2 / \sin(\theta_1 + \theta_2) \\ &- (W_L/2) \cos\theta_2 / (\cos\theta_1 + \cos\theta_2) \\ &\dots (19) \end{aligned}$$

$$\begin{aligned} T_{1L} &= \{ (W_L + W_T + W_{D1} + W_{D2})/2 \} \cos\theta_1 / \sin(\theta_1 + \theta_2) \\ &- (W_L/2) \cos\theta_1 / (\cos\theta_1 + \cos\theta_2) \\ &\dots (20) \end{aligned}$$

Also, $T_{2R} = T_{1R}$, and $T_{2L} = T_{1L}$

As described above, the rope tensions T_{01R} , T_{01L} , T_{02R} and T_{02L} of the hoisting accessory wire ropes 31, 32, 39 and 40 vary with the traversing position of the hoisting accessory 47 (container C) as do the rope

tensions T_{1R} , T_{1L} , T_{2R} and T_{2L} of the traverser wire ropes 19, 20, 25 and 26. That is, when the hoisting accessory 47 is caused to traverse most rightward, the rope angle θ_1 increases, and the rope angle θ_2 decreases. Thus, the tensions of the right-hand wire ropes 19, 25, 31 and 39 increase, while the tensions of the left-hand wire ropes 20, 26, 32 and 40 decrease. As a result, the leftward horizontal component of force on the hoisting accessory 47 (container C) becomes smaller than in the earlier technology, and the position at which the rightward and leftward horizontal components of force are balanced comes more rightward than in the earlier technology. Hence, the hoisting accessory 47 (container C) can be brought fully close to the crane leg as compared with the earlier technology. The traversing range of the hoisting accessory 47 widens, and the work efficiency of the crane can be increased without the necessity of upsizing the apparatus.

In the present embodiment, the right and left suspending wire ropes 55 and 56 as a pair paid out from the rotating drums 53 and 54 may be passed over the lower-position right and left rope pulleys as a pair and then connected to the traverser 23, and the hoisting accessory 47 may be suspended from the rope pulleys, as in the preceding embodiment. In this case, the total weight of W_L of the hoisting accessory 47 and the container C can be shared between the hoisting

accessory wire ropes 31, 32, 39, 40 and the traverser wire ropes 19, 20, 25, 26.

[Third Embodiment]

FIG. 3 schematically shows the constitution of a crane apparatus according to a third embodiment of the invention. Members having the same functions as explained in the aforementioned embodiment will be assigned the same reference numerals, and overlapping explanations will be omitted.

In the crane apparatus of the present embodiment, first right and left rope pulleys 63 and 64 as a pair are supported in a suspended manner from a traverser 23 by ropes 61 and 62, as shown in FIG. 3. A first hoisting accessory wire rope 31 has the other end passed round the first right rope pulley 63 via a right sheave 35 of the traverser 23, further passed over a second right rope pulley 37, and then connected to a right connecting portion 38 of the traverser 23. A second hoisting accessory wire rope 40 has the other end passed round the first left rope pulley 64 via a left sheave 44 of the traverser 23, further passed over a second left rope pulley 45, and then connected to a left connecting portion 46 of the traverser 23. A hoisting accessory 47 capable of holding a container C is suspended from the second rope pulleys 37 and 45. Hence, when only hoisting accessory drums (not shown) are rotated for a takeup action, the

hoisting accessory wire ropes 31, 40 are taken up, whereby the container C held by the hoisting accessory 47 can be hoisted via the first rope pulleys 63, 64 and the second rope pulleys 37, 45. Alternatively, the hoisting accessory wire ropes 31, 40 are paid out, whereby the container C held by the hoisting accessory 47 can be lowered via the first rope pulleys 63, 64 and the second rope pulleys 37, 45. The traversing action of the hoisting accessory 47 is the same as in the aforementioned embodiment, so that its explanation is omitted.

In the crane apparatus of the present embodiment, the hoisting accessory wire ropes 31, 40 are connected to the traverser 23 via the first rope pulleys 63, 64 and the second rope pulleys 37, 45. Thus, rightward and leftward horizontal components of force, which the hoisting accessory wire ropes 31, 40 impose on the hoisting accessory 47, can be decreased. That is,

$$T = W/8$$

$$T_{1R} = (W/2)\cos\theta_2/\sin(\theta_1 + \theta_2) - W/16$$

$$T_{1L} = (W/2)\cos\theta_1/\sin(\theta_1 + \theta_2) - W/16$$

Also, $T_{2R} = T_{1R}$, and $T_{2L} = T_{1L}$

As described above, since the rope tensions T of the hoisting accessory wire ropes 31, 40 are decreased, the rightward and leftward horizontal components of force on the hoisting accessory 47

(container C) are decreased. Whereas the rope tensions T_{1R} , T_{1L} , T_{2R} and T_{2L} of traverser wire ropes 19, 20, 25 and 26 are increased, whereby the rightward and leftward horizontal components of force on the hoisting accessory 47 (container C) are increased. Thus, the position at which the rightward and leftward horizontal components of force are balanced comes more outward than in the earlier technology. Hence, the hoisting accessory 47 (container C) can be brought fully close to the crane leg as compared with the earlier technology. The traversing range of the hoisting accessory 47 widens, and the work efficiency of the crane can be increased without the necessity of upsizing the apparatus.

In the foregoing respective embodiments, the connecting portions 24, 29 and the sheaves 35, 36, 43, 44 of the traverser 23, the rope pulleys 37, 45, 63, 64, the first and second traverser wire ropes 19, 20, 25, 26, the first and second hoisting accessory wire ropes 31, 32, 39, 40, the traverser sheaves 21, 22, 27, 28, the hoisting accessory sheaves 33, 34, 41, 42, the rotating drums 53, 54, and the suspending wire ropes 55, 56 have been constituted as a pair composed of right and left members. However, they may be provided as a plurality of pairs.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such

23 OCT 2002

variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

23 OCT 2002

What is claimed is:

1. A crane apparatus comprising:

a body frame;

traverser drums and hoisting accessory drums rotatably mounted on the body frame and normally and reversely rotatable by a drive motor;

a traverser having right and left connecting portions as a pair, and right and left sheaves as a pair;

right and left rope pulleys as a pair positioned below the traverser;

first right and left traverser wire ropes as a pair having an end taken up by the traverser drums, and having the other end connected to the right connecting portion of the traverser;

second right and left traverser wire ropes as a pair having an end taken up by the traverser drums, and having the other end connected to the left connecting portion of the traverser;

first right and left hoisting accessory wire ropes as a pair having an end taken up by the hoisting accessory drums, and having the other end passed over the right rope pulley via the right sheave of the traverser and then connected to the traverser;

second right and left hoisting accessory wire ropes as a pair having an end taken up by the hoisting

accessory drums, and having the other end passed over the left rope pulley via the left sheave of the traverser and then connected to the traverser;

right and left traverser sheaves as a pair and right and left hoisting accessory sheaves as a pair for guiding the right-hand wire ropes to be parallel and the left-hand wire ropes to be parallel; and

a hoisting accessory capable of attaching and detaching a load thereto and therefrom, and suspended from the right and left rope pulleys.

2. The crane apparatus of claim 1, wherein the hoisting accessory drums are drivably connected to the drive motor, and the traverser drums are drivably connected to the hoisting accessory drums via clutches.

3. A crane apparatus comprising:

a body frame;

traverser drums and hoisting accessory drums rotatably mounted on the body frame and normally and reversely rotatable by a drive motor;

a traverser having right and left connecting portions as a pair, and right and left sheaves as a pair;

right and left rotating drums as a pair suspended from the traverser;

23 OCT 2002

first right and left traverser wire ropes as a pair having an end taken up by the traverser drums, and having the other end connected to the right connecting portion of the traverser;

second right and left traverser wire ropes as a pair having an end taken up by the traverser drums, and having the other end connected to the left connecting portion of the traverser;

first right and left hoisting accessory wire ropes as a pair having an end taken up by the hoisting accessory drums, and having the other end passed over the right rotating drum via the right sheave of the traverser;

second right and left hoisting accessory wire ropes as a pair having an end taken up by the hoisting accessory drums, and having the other end passed over the left rotating drum via the left sheave of the traverser;

right and left traverser sheaves as a pair and right and left hoisting accessory sheaves as a pair for guiding the right-hand wire ropes to be parallel and the left-hand wire ropes to be parallel; and

a hoisting accessory capable of attaching and detaching a load thereto and therefrom, and connected to right and left suspending wire ropes as a pair paid out from the right and left rotating drums.

4. The crane apparatus of claim 3, wherein the hoisting accessory drums are drivably connected to the drive motor, and the traverser drums are drivably connected to the hoisting accessory drums via clutches.

5. The crane apparatus of claim 3, wherein the hoisting accessory wire ropes and the suspending wire rope are passed over the rotating drum in opposite directions.

6. A crane apparatus comprising:

a body frame;

traverser drums and hoisting accessory drums rotatably mounted on the body frame and normally and reversely rotatable by a drive motor;

a traverser having right and left connecting portions as a pair, and right and left sheaves as a pair;

first right and left rope pulleys as a pair suspended from the traverser;

second right and left rope pulleys as a pair positioned below the first right and left rope pulleys;

first right and left traverser wire ropes as a pair having an end taken up by the traverser drums, and having the other end connected to the right connecting portion of the traverser;

second right and left traverser wire ropes as a pair having an end taken up by the traverser drums, and having the other end connected to the left connecting portion of the traverser;

a first hoisting accessory wire rope having an end taken up by the hoisting accessory drum, and having the other end passed over the first and second right rope pulleys via the right sheave of the traverser and then connected to the traverser;

a second hoisting accessory wire rope having an end taken up by the hoisting accessory drum, and having the other end passed over the first and second left rope pulleys via the left sheave of the traverser and then connected to the traverser;

right and left traverser sheaves as a pair and right and left hoisting accessory sheaves as a pair for guiding the right-hand wire ropes to be parallel and the left-hand wire ropes to be parallel; and

a hoisting accessory capable of attaching and detaching a load thereto and therefrom, and suspended from the second right and left rope pulleys.

7. The crane apparatus of claim 6, wherein the hoisting accessory drums are drivably connected to the drive motor, and the traverser drums are drivably connected to the hoisting accessory drums via clutches.