Nov. 27, 1962 J. C. PATTERSON, SR 3,065,862

METHOD TO PREVENT A LOAD FROM SWINGING DURING HOISTING AND TURNING OF A CRANE

Filed April 14, 1960 4 Sheets-Sheet 1

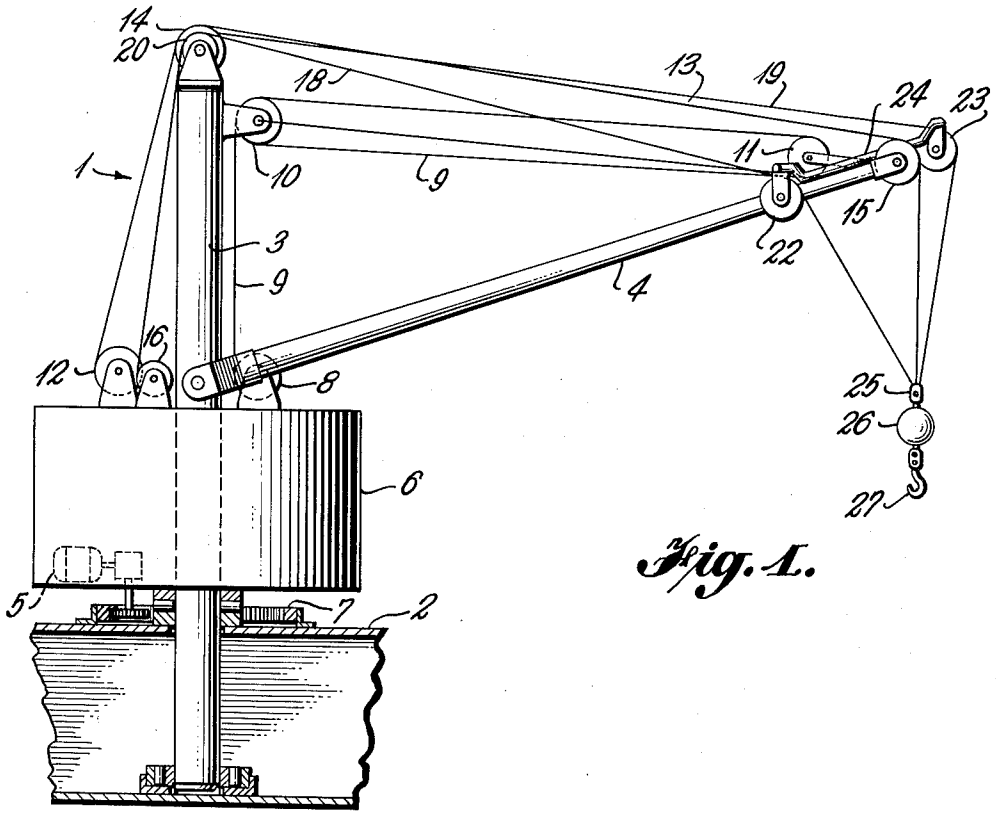
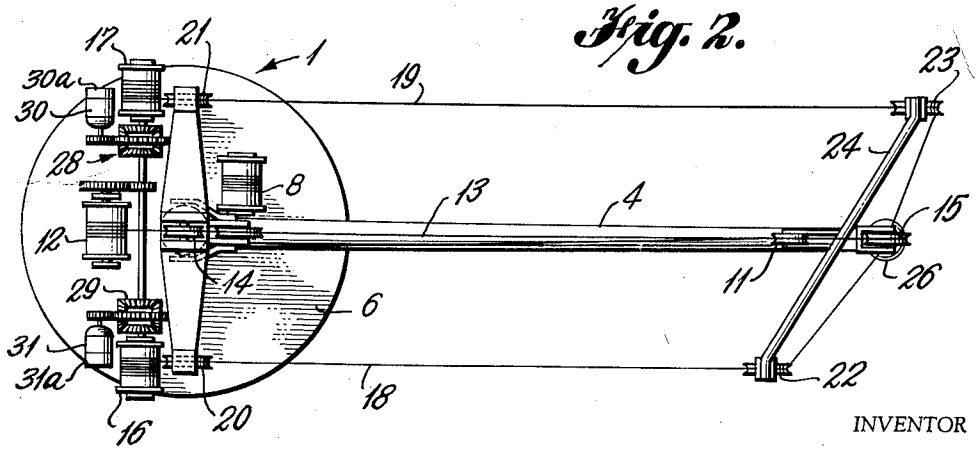


Fig. 1.

Fig. 2.



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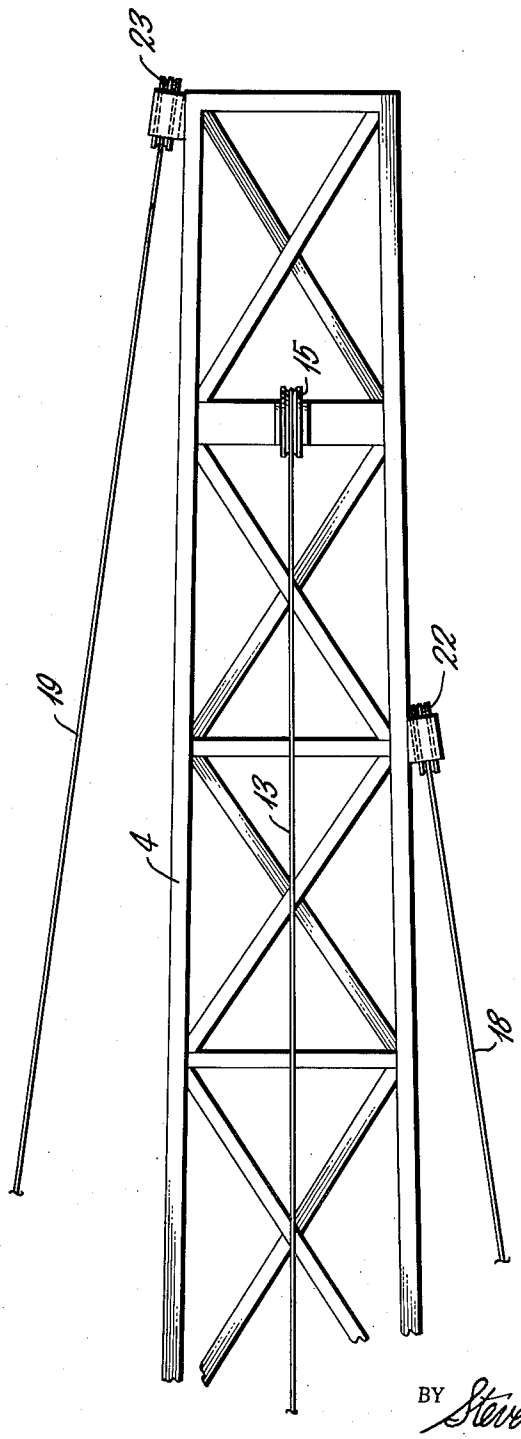


Fig. 3.

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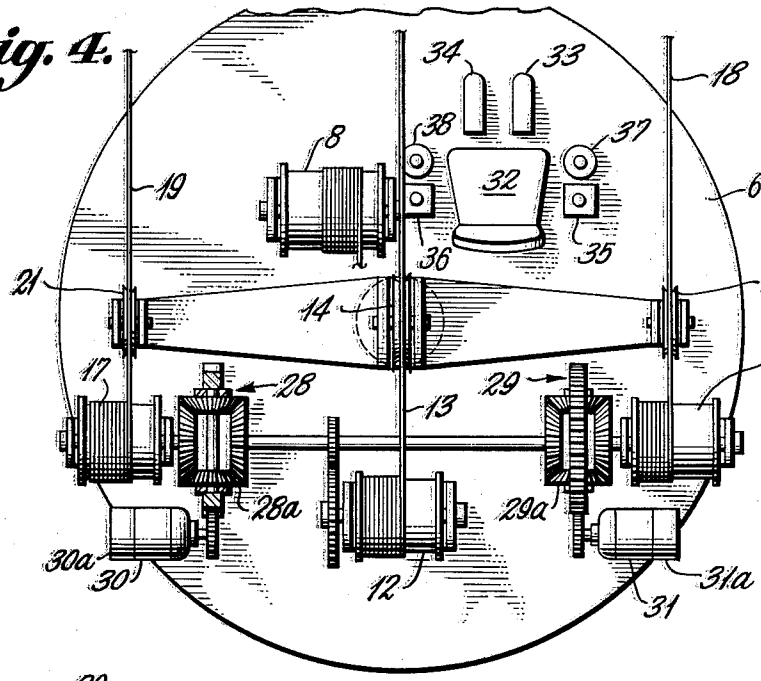
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METHOD TO PREVENT A LOAD FROM SWINGING DURING HOISTING AND TURNING OF A CRANE

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Fig. 4.



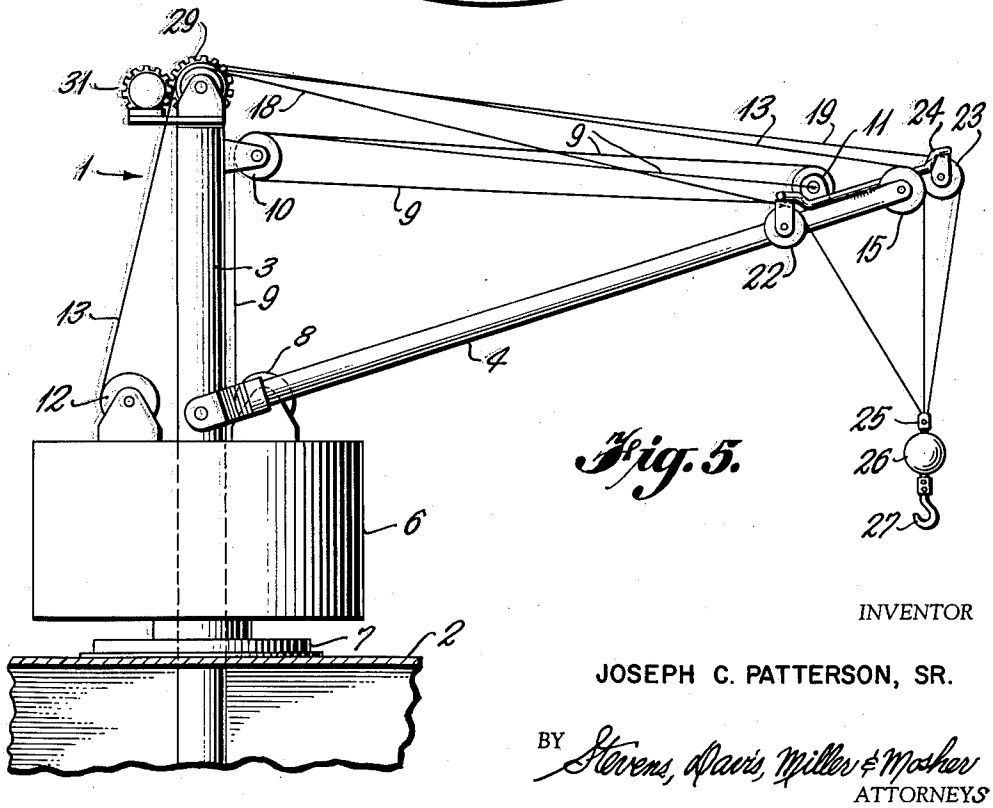


Fig. 5.

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METHOD TO PREVENT A LOAD FROM SWINGING DURING HOISTING AND TURNING OF A CRANE

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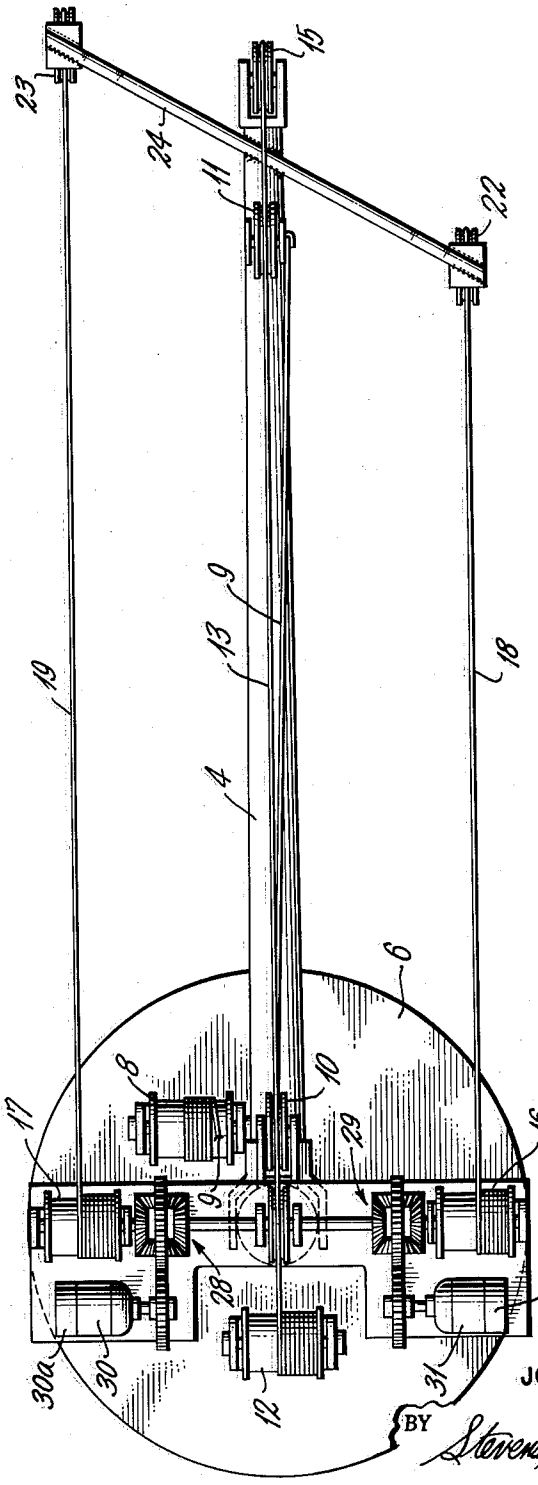


Fig. 6.

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3,065,862

METHOD TO PREVENT A LOAD FROM SWINGING DURING HOISTING AND TURNING OF A CRANE

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Filed Apr. 14, 1960, Ser. No. 22,351
7 Claims. (Cl. 212—58)

This invention relates to devices of the type used in conjunction with rotating or slewing cranes for the purpose of preventing a load depending from the crane from pendulating or swinging back and forth beneath the end of the boom from which it is suspended. In view of their function of reducing or preventing pendulation, devices of this type may be called and will hereinafter be referred to as anti-pendulation devices.

Anti-pendulation devices of the type comprising the present invention may be used with any crane structure functioning to move a load in a horizontal direction. These devices are, however, particularly useful in ship cargo loading operations or in any load transporting operation involving a shipboard crane for the reason that in such cases the pendulation or swinging of the load as it is moved horizontally is aggravated by the variable listing of the vessel due to the load being transferred athwart ship. At the same time, probably less pendulation of this type can be tolerated in shipboard operations than in normal land crane operations because of the limited operating area and necessity for close and constant control of the load in order to enter or leave the hatch openings.

In any load moving operation in which a crane is utilized, however, if the load depending from the end of the boom is allowed to develop a considerable amount of pendulation the load moving operations are considerably delayed and become increasingly time consuming because the operator of the crane must either wait for the load to stop swinging before lowering it into the hatch or else must attempt to eliminate the pendulation by avoiding rapid starts, stops and acceleration of the load in transit.

The pendulum action of the load which the present invention is designed to reduce or eliminate may be said to be of two types. The first of these types is pendulum action which is created by the rotation or slewing of the crane, that is the movement of the crane in a azimuthal direction. The second type of pendulum action is that which results from rapid luffing, that is movement up and down, of the boom. In the case of pendulation due to slewing, it will be apparent that the swinging or pendulum movement of the load will be approximately in a plane normal to the plane in which the boom is located. On the other hand, in the case of pendulation due to luffing, the pendulum action of the load occurs in a plane which is coincident with the plane of the boom. If luffing and slewing are carried out simultaneously the pendulum action of the load is the resultant of the two component types of pendulum action resulting from both the slewing movement of the boom and the luffing movement.

Devices designed to reduce or eliminate load swing or pendulation have been recently designed and patented, among which are those disclosed in U.S. Patents 2,805,781 and 2,627,984 both to A. L. Senn. In the Senn patents, the devices used to damp the pendulation of the load consist broadly of a hoisting line (as ordinarily used in cranes for hoisting the load) and two sway stabilization lines. The latter two lines are led upward away from the load depending from the boom at an angle from the direction of the hoisting line and at an angle from each other.

In other words, the three lines attached to the load define a pyramid with the load at its apex. The load may be stabilized and pendulation in any direction prevented by increasing the tension on the appropriate stabilizer line at the appropriate time. This increase in tension is accomplished by braking the drum to which the appropriate stabilizing line is led so as to prevent it from being paid out in answer to the inertial pull of the load as the boom tends to travel away from the load.

The present invention is in some some respects similar to the anti-pendulation devices disclosed in the Senn patents in that two vang lines which correspond to the Senn stabilization lines are provided in addition to the conventional hoisting line. However, the present invention constitutes a significant advance over the prior art and a contribution to the store of knowledge in its art in that a more positive and finer control of the vang lines is provided through the novel control system which I have developed.

It is thus proposed, according to the present invention to provide an anti-pendulation device which permits reduction or elimination of pendulum action of a load suspended from the boom of a crane.

Another object of the device of this invention is to provide for the damping of the pendulation of a crane load both in a plane normal to the plane of the boom and in a plane coincident with the plane of the boom.

A further object of this invention is to provide an independently controlled drive to the drums upon which the anti-pendulation or sway prevention lines are reeled, thereby permitting these lines to be paid out or retrieved independently of the hoisting line.

A further object of this invention is to provide a reversible control of the wing drums carrying the anti-pendulation or vang lines in an anti-pendulation device whereby these lines may be paid out or retrived faster than the hoisting line is paid out when occasion demands.

Another object of this invention is to provide individual control of each wing drum carrying vang lines in the novel anti-pendulation device of this invention, whereby one vang line may be paid out while the other vang line is being reeled in.

It is a specific object of the present invention to provide an anti-pendulation device which is capable of reducing or eliminating pendulum action of a load resulting from the luffing of a boom as well as reducing or eliminating pendulum action resulting from slewing the crane.

A further object of the present invention is to provide an anti-pendulation device for use on shipboard cranes and capable of damping any motion of the load being moved by the crane arising from rolling, pitching or yawing of the vessel upon which the crane is mounted.

Another object of this invention is to provide two vang lines attached to a load hook, which vang lines may be lengthened or shortened semi-automatically by an operator at a remote location in such manner as to positively and closely control the horizontal movement of the load at all times.

These and other objects and advantages of my invention will become apparent and be better understood from a consideration of the following detailed disclosure of the invention in conjunction with the accompanying drawings.

Broadly, my invention is comprised of the conventional load hoisting line which depends vertically from a sheave at the end of a boom and attaches to the end of the load hook, two vang lines which attach to each side of the load hook and extend at an angle to the hoisting line and to each other from the load hook, a main drum upon which the hoisting line is reeled, two wing drums upon which the vang lines are reeled, and a control mechanism for controlling the direction of rotation and speed of rotation

of the wing drums. In ordinary operation when there is no load on the hoisting hook, the wing drums are driven solely by the main hoisting drum through differential gearing interposed between each wing drum and the hoisting drum. During such operations, the spider gear of each of the wing drums is held stationary. However, for purposes of damping pendulation of the load at appropriate times, the spider gear of each of the differentials has connected thereto a motor drive which may be actuated semi-automatically by the operator to drive the appropriate wing drum at such speed as to decrease the length of the vang line in the appropriate direction. The vang lines are so arranged with respect to the hoisting line that they form an angle with the hoisting line lying in a plane which is normal to the plane of the boom as well as an angle lying in a plane which is coincident with the plane of the boom. This arrangement permits control of the load to prevent pendulation due to slewing of the crane as well as that due to topping or luffing of the boom.

The specific structural details of the present invention can be better understood by referring to the accompanying drawings in which:

FIGURE 1 is a view in elevation showing the general arrangement of the anti-pendulation device of the present invention as employed in connection with a shipboard crane.

FIGURE 2 is a plan view of the anti-pendulation device shown in FIGURE 1.

FIGURE 3 is a detail showing the rigging of the hoisting line and vang lines of the present invention at the end of a boom of slightly different type than that shown in FIGURES 1 and 2.

FIGURE 4 is an enlarged plan view showing the relative arrangement of the hoisting drum, wing drums, wing drum control motors, and operator controls.

FIGURE 5 is an elevation view of a level luffing crane with wing drums, in which the differential gearing, vang drums, and control motors are mounted on top of the king post.

FIGURE 6 is a plan view of the arrangement shown in FIGURE 5.

Referring now in detail to FIGURE 1, a shipboard crane employing the anti-pendulation device of the present invention is designated generally by the numeral **1**. The king post **3** of the crane projects vertically from the deck **2** of the ship. Slewing of the crane is accomplished by utilizing power provided by the slewing motor **5** which acts through a mechanical linkage and internal ring gear **7** to drive the king post and boom through the desired arc of rotation. The slewing motor and luffing motor (not shown) are contained within the structure **6** which serves also to support the drums upon which the various lines are reeled. Mounted atop the structure **6** is a luffing drum **8** upon which luffing line **9** is reeled. The luffing line **9** passes from the luffing drum **8** upward to luffing sheave **10** and then outward in the direction of the boom to the luffing sheave **11**. As will be apparent from a reference to FIGURE 1, the luffing line **9** has several wraps and terminates adjacent the king post at the sheave **10**. The luffing sheave **11** is connected by cables to the boom. Also mounted atop the structure **6** are two wing drums **16** and **17** and a hoisting drum **12**. From FIGURE 2 it will be apparent that the hoisting drum **12** is located centrally between the wing drums **16** and **17** and slightly to the rear thereof. Vang lines **18** and **19** are reeled upon wing drums **16** and **17** and are led from their respective wing drums to the top of the king post **3** where they pass over vang line sheaves **20** and **21** respectively. From these sheaves, the vang lines **18** and **19** are led outwardly toward the end of the boom **4**. A yard arm **24** is mounted near the end of the boom to project at an angle from either side thereof. The arrangement of the yard arm with respect to the boom is such that one end of the yard arm projects beyond the end of the boom and the other end of the arm is located

inwardly of the end of the boom. The purpose of this arrangement is quite important to this invention and will be explained in detail hereinafter.

At each end of the yard arm **24** are mounted two sheaves **22** and **23**. The vang lines **18** and **19** are led from the king post outwardly over sheaves **22** and **23**, respectively, and from the sheaves pass downwardly to the swivel of the hoisting hook where they are connected. A third line, the hoisting line **13**, is also connected to the swivel of the hoisting hook and passes upward therefrom to the sheave **15** mounted at the end of boom **4**. The hoisting line is reeved over sheave **15** and then led back to the king post **3** and over large sheave **14** mounted atop the king post. From the large sheave **14** the hoisting line then is led downwardly and is reeled upon the hoisting drum **12**. An overhauling weight **26** is shown located between the swivel **25** and the hoisting hook **27**.

By reference to FIGURE 2, a better understanding of the relative arrangement of the wing drums control motors and hoisting drum may be obtained. The two wing drums carrying the vang lines **18** and **19** are represented by the numerals **16** and **17**, respectively. The hoisting drum carrying the hoisting line or whip **13** is represented by numeral **12**. It will be perceived that the two wing drums **16** and **17** are adapted to be driven through the differential gears **28** and **29** by the hoisting drum. The wing drums are also subjected to a driving force supplied by control motors **30** and **31** acting through the spider gears **28***a* and **29***a* of differentials **28** and **29**, respectively.

Referring to FIGURE 4, it will be observed that each of the vang line electric control motors is equipped with an electric brake **30***a* and **31***a*. FIGURE 4 also shows the general arrangement of the operator's controls. Thus, two foot pedal switches **33** and **34** are disposed in front of the operator's seat **32** and two hand controls **35** and **36** are disposed upon the operator's right and left, respectively. Push button controls **37** and **38** to the operator's right and left, respectively, are utilized to reverse the direction of the control motors **30** and **31** to permit vang lines **18** and **19** to be paid out.

Having identified the parts and elements of my novel anti-pendulation device, I will now proceed to a description of the operation of the invention.

As has been previously pointed out, when the crane is slewed or is luffed, the inertia of the load depending from the end of the boom tends to make it lag behind the movement of the boom. This lagging behind of the load causes the vang line extending from the load in the direction of movement to tighten and due to the angle of pull helps to accelerate the load. The vang lines are arranged with respect to the load so that they form an angle with the hoisting line both in the plane of the boom and in a plane normal to the plane of the boom. Thus, the inertial tendency of the load to remain outwardly of the end of the boom when the boom is moved upwardly and inwardly in a luffing movement is to some extent offset by the angle of pull of vang line **18** acting in the plane of the boom. On the other hand, the inertia of the load which resists slewing movement is partially counteracted by the pull of vang line **19** acting in a plane at right angles to the plane of the boom. Any swinging or pendulation movement of the load which is a resultant of the slewing and luffing movement of the boom will be counteracted by the resultant of the angular pulls exerted by both vang lines **18** and **19**. For light loads and empty hook control operation, the normal pull of the vang lines will usually be sufficient to provide damping of any pendulum action.

However, when a heavy load is carried upon the load hook **27**, and the boom is rapidly accelerated, additional forces must be made to act upon the load through the vang lines in order to adequately prevent pendulum action. For this purpose, the novel control system of the present invention is utilized.

Referring to FIGURES 2 and 4, it will be observed that wing drums **16** and **17** are disposed on either side of hoisting drum **12** and are driven from the hoisting drum through two differential gears **28** and **29**. The ratio of the differential gearing and the wing and hoisting drum sizes is such that in ordinary operations the hoisting drum pays out the same amount of hoisting line as there is vang line paid out by each of the two wing drums **16** and **17**. Thus, when a load is simply to be raised vertically from an at rest position on the deck, the hoisting drum reels in hoisting line at the same rate as the wing drums are reeling in vang lines **18** and **19**. In such cases there is, of course, no problem of any pendulation movement of the load.

However, when the load is caused to move in a horizontal direction there will always be a tendency, due to the inertia of the load, to commence pendulation movement. Each of the differentials **28** and **29** is provided with a spider gear **28***a* and **29***a*, respectively, which is held stationary by control motor brakes **30***a* and **31***a* during movements of the load when no damping or anti-pendulation action is required. However, when a swinging movement in the load is set up by rapid acceleration of the boom in a horizontal direction, the spider gears **28***a* and **29***a* are positively driven by control motors **30** and **31** to speed up or slow down the wing drums **16** and **17** as required to tighten or release the tension on the vang lines **18** and **19**.

The control motors **30** and **31** are controlled by the operator depressing foot pedals **33** and **34**, or by depressing push buttons **37** and **38**. Thus when the boom is slewed counterclockwise, the load tends to lag behind the boom, and tension is exerted on the left vang line **19**. In order to overcome the tendency of the load to lag behind the boom, thus setting up pendulum action, the operator depresses the left foot pedal **34** which energizes the left control motor **30** causing the drum **17** to reel in vang line **19** thus exerting a horizontal component of force upon the load which compensates for the inertial tendency of the load to lag behind the boom and to the right thereof. The inertial force of the load is less than the force required to elevate the load in a vertical direction and therefore motors **30** and **31** are torque motors which have sufficient torque to exert a horizontal pull upon the load through the vang lines sufficient to overcome the inertia of the load, but insufficient to elevate the load in a vertical direction. Of course, the torque requirements of the motor will vary according to the weight of the load to be moved. I have therefore provided for adjustable resistances in the motor circuits for the purpose of adjusting the motor torque to the required value for any particular load.

As the boom nears the end of its slewing movement to the left and begins to decelerate, the momentum of the load will carry it to the left of the boom in a pendulum movement. At this time, the operator depresses the right foot pedal **33** which energizes control motor **31** and in turn rotates drum **16** to retrieve vang line **18**. The load is then decelerated by the horizontal force acting through vang line **18** and tending to pull the load in the opposite horizontal direction from the direction of movement of the boom.

Of course, in slewing the boom to the right, the operator will reverse the sequence of actuation of the foot pedals **33** and **34** to prevent the development of pendulum action in the load.

Although substantially the same procedure is followed in damping load swing developed by a rapid luffing of the boom, the operation of the anti-pendulation device in this situation will be briefly reviewed for further clarity. When the luffing motor (not shown) is actuated the luffing drum **8** is rotated to retrieve luffing line **9**. This, of course, exerts a pull upon the outer end of boom **4** causing it to pivot about the hinged end at the king post and to move up in a vertical arc. The angular acceleration of the end of the boom causes the load to tend to remain, by virtue of its inertia, in a position outwardly of the end of the boom. To overcome this tendency of the load to remain in its initial position, the operator depresses right foot pedal **33** which causes drum **16** to retrieve vang line **18** in the manner heretofore described. As vang line **18** is retrieved, it exerts a horizontal component of force in the plane of the boom which causes the load to move from its initial position through an arc of a circle identical in configuration to that described by the end of the boom and directly beneath the end of the boom. In other words, the operator, by properly tensioning vang line **18** by the use of his right foot pedal **33**, may maintain the load directly beneath the end of the boom at all times during acceleration of the boom in luffing. Near the end of the upper luffing movement as the boom is decelerated the tendency of the load will, of course, be to swing inwardly towards the king post. To overcome this tendency the operator has merely to depress the left-hand foot pedal **34** thereby tensioning vang lines **19** and preventing this inward swing of the load. When the boom is rapidly lowered the actions of the operator will, of course, be reversed in order to prevent pendulation.

Although the foot pedal switches of my invention may be of any suitable type, I prefer to use the momentary contact type which are opened by springs when the foot pressure is removed.

Each of the control motors **30** and **31** is equipped with an electric brake, **30***a* and **31***a*, respectively, which is released when the motor is energized and spring set when the motor is deenergized. The function of these electric brakes is twofold. First, they are desirable in order to prevent the vang lines from being pulled out due to any swinging which might occur when the control motors are de-energized thus avoiding the possibility of rendering the vang lines useless during empty hook operations or when light loads are moved. The second function of the electric brakes is to provide a fine control of vang line tension by immediately stopping the motors upon depression of the operator's foot pedals thus absorbing the rotating energy of the motor before excessive tension has been applied to the vang lines.

A further feature of my invention is the provision of each of the control motors **30** and **31** with a reversing circuit. Thus, in the event that the operator inadvertently energizes one of the control motors when it is unnecessary to do so and thus causes the hook and load to be pulled to one side he may correct his error by energizing the reversing circuit to the motor improperly used, thereby reversing its direction and paying out an amount of vang line substantially equivalent to that which was inadvertently retrieved. Normally, this type of error will not be possible when there is a load of any substantial weight on the hook because the torque of the motor is insufficient to affect the load other than to correct its tendency to sway or develop pendulum action. However, operator errors of the type mentioned may frequently affect the operator's attempt to move the empty hook and its overhauling weight from one location to another. In order to energize the reversing circuits to motors **30** and **31**, the operator has at his right and left, push button controls **37** and **38**, respectively. To reverse the direction of rotation of drum **16** so as to pay out vang line, the operator has merely to depress push button **37**. If he desires to pay out vang line **19**, push button **38** is depressed.

I have now described the operation of my anti-pendulation device as it is used in conjunction with one type of shipboard crane. In FIGURES 5 and 6 a slightly different application of my anti-pendulation device is depicted. These figures show the anti-pendulation apparatus of the present invention adapted for use with a level luffing crane having limited operating platform space.

On some types of cranes, particularly certain shipboard types, the size of the crane structure **6** is of necessity reduced so that there is limited space on the platform for

the operator's chair, the wing and hoist drums, and the control motors provided for driving the wing drums independently of the hoist drums. Where this limitation exists the arrangement shown in FIGURES 5 and 6 may be employed.

In this arrangement, the wing drums **16** and **17** and their respective control motors **30** and **31** are located atop the king post **3**. The wing drums **16** and **17** are then driven from sheave **14** through differentials **28** and **29** also located atop the king post **3**. The overhauling weight **26** ordinarily used to pull out the empty hook **27**, is of sufficient weight to drive the wing drums as well as pull out the lines during empty hook operations. As in the case of the operation of the anti-pendulation device already described, the differential gearing and wing drums are so proportioned in size that the wing drums pay out or retrieve the same amount of their respective vang lines as hoist line has been paid out or retrieved by the hoist drum **12**.

Although I have illustrated and described only two preferred embodiments of my novel anti-pendulation device, that is, two arrangements in which the wing drums and associated driving mechanisms are located on the control platform in the one case and atop the king post in the other, variations in the structure and principles of my device will be readliy apparent to those skilled in the art and are considered to be within the scope of this invention except as excluded from the language of the claims. For example, any type of reversible variable electric or hydraulic torque motors may be utilized to drive the wing drums independently of the hoist drum, and other arrangements for instantly braking these motors may be used so long as close and instantaneous control of the wing drums in both directions of rotation is achieved.

What is claimed is:

1. An anti-pendulation device for damping pendulation of a load suspended from a boom, comprising two wing drums, a hoist drum disposed between said wing drums, driving means connecting said hoist drum with each of said wing drums, said driving means including differential gearing adjacent each of said wing drums whereby said wing drums may be driven at a desired angular speed by said hoist drum, said differential gearing including a spider gear, a motor drivingly connected to the spider gear of each of said differentials whereby each of said wing drums may be driven independently of said hoist drum, a first cable extending from said hoist drum to the end of said boom and thence to said load, a pair of sheaves, each disposed on the opposite side of said boom from the other and spaced apart therefrom, one of said sheaves being disposed beyond the end of said boom and the other of said sheaves being disposed inwardly of the end of said boom, a second cable extending from one of said wing drums over one of said sheaves to the load carried by said crane and a third cable extending from the other of said wing drums over the other of said sheaves to said load.

2. A device for damping the pendulum action of a load being horizontally moved by a crane, said device comprising a hoisting line, two load stabilizing vang lines, means for paying out and retrieving equal lengths of each of said vang lines and said hoisting line, and means for paying out and retrieving a desired amount of either vang line independently of each other and of said hoisting line.

3. A device as claimed in claim 2 wherein said means for paying out and retrieving an equal length of each of said vang lines and said hoisting line comprises a pair of wing drums, a hoisting drum located between said wing drums, and transmission means connecting each of said wing drums with said hoisting drum whereby said wing drums may be driven from said hoisting drum at the same circumferential velocity as said hoisting drum.

4. A device as claimed in claim 3 wherein said means for paying out and retrieving a desired amount of either vang line comprises a pair of reversible control motors, one of which is drivingly connected to one of said wing drums and the other of which is drivingly connected to the other of said wing drums whereby each of said wing drums may be rotated forward or backward independently of each other and of said hoisting drum.

5. A device as claimed in claim 4 wherein said pair of reversible control motors each have an electric brake attached thereto for braking said motors when the power thereto is stopped.

6. An anti-pendulation device for use in conjunction with a crane of the type having a boom pivotally attached at one end to a king post, and a load depending from the other end, said device comprising a hook supporting said load, a plurality of lines each connected at one of its ends to said hook and diverging upwardly therefrom at an acute angle to the others of said lines, a pair of wing drums laterally spaced from each other, a hoist drum disposed between said wing drums, two of said lines being connected at their other ends to said hoist drum, a pair of sheaves located on opposite sides of said boom from each other and laterally spaced from said boom and from each other, one sheave of said pair of sheaves being located more distantly from the attached end of said boom than is the free end of said boom and carrying one of said lines which are connected to said wing drums, the other sheave of said pair of sheaves being located nearer the attached end of said boom than is the free end of said boom and carrying the other of said lines which are connected to said wing drums, transmission means connecting said wing drums with said hoist drum, said transmission means including a differential gearing unit interposed between said hoist drum and each of said wing drums, said differential gearing unit including a spider gear, a reversible torque motor connected to the spider gear of each of said differentials for driving said wing drums in either direction of rotation independently of said hoist drum and of each other, variable resistances in said motor electric circuits for varying the torque of said motors, and an electric brake connected to each of said motors for instantly stopping said motors when power to the motor is cut off.

7. An anti-pendulation device for use on cranes having a king post and a boom pivotally connected to said king post, said anti-pendulation device comprising a pair of wing drums mounted atop said king post, a first sheave disposed between said wing drums atop said boom king post, a hoist drum disposed vertically below said sheave, a second sheave carried by said boom at its end, a pair of sheaves located on opposite sides of said boom from each other and one of which is located beyond the end of said boom and the other of which is located inwardly from the end of said boom, vang lines extending from each of said wing drums over said pair of sheaves to the load being moved by said crane, a hoist line extending from said hoist drum over said first and second sheaves to said load, transmission means connecting said wing drums and said second sheave whereby the wing drums may be driven in rotation by said sheave, said transmission means including a differential located between each of said wing drums and said hoist drum, said differential gearing including a spider gear, a reversible variable torque motor connected to the spider gear of each of said differentials whereby said wing drums may be rotatably driven in either direction independently of each other and independently of said second sheave, and an electric brake on each of said torque motors whereby each of said motors may be instantly stopped when the power to said motors is cut off by the operation of said device.

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