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APPARATUS FOR DAMPING PENDULUM MOTIONS OF
THE LOAD SUSPENDED FROM A LIFTING MACHINE

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2 Sheets-Sheet 1

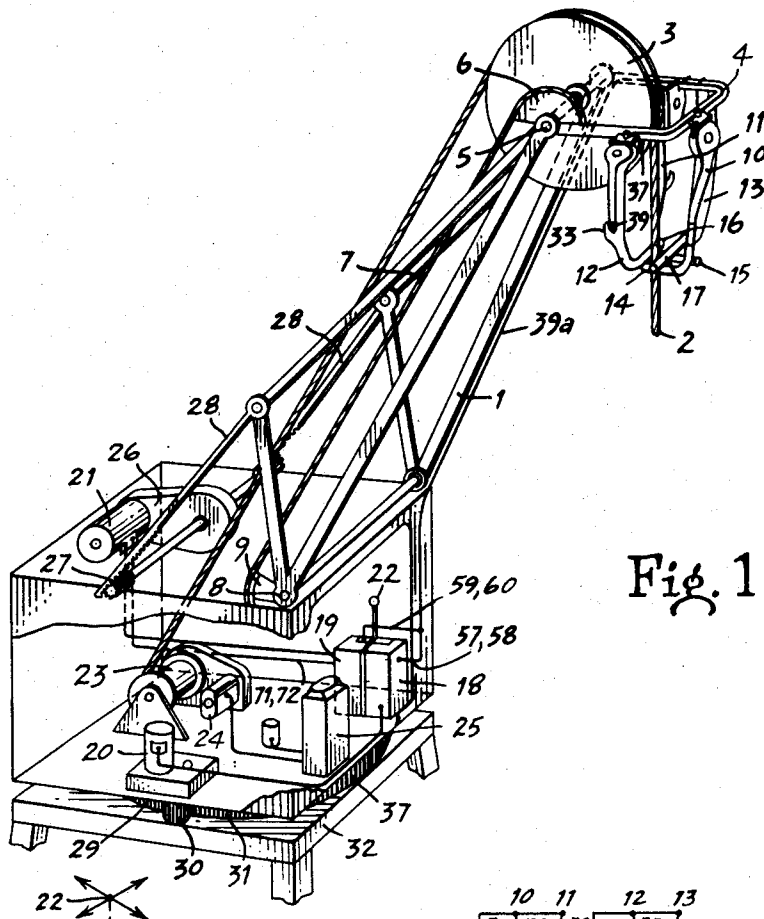


Fig. 1

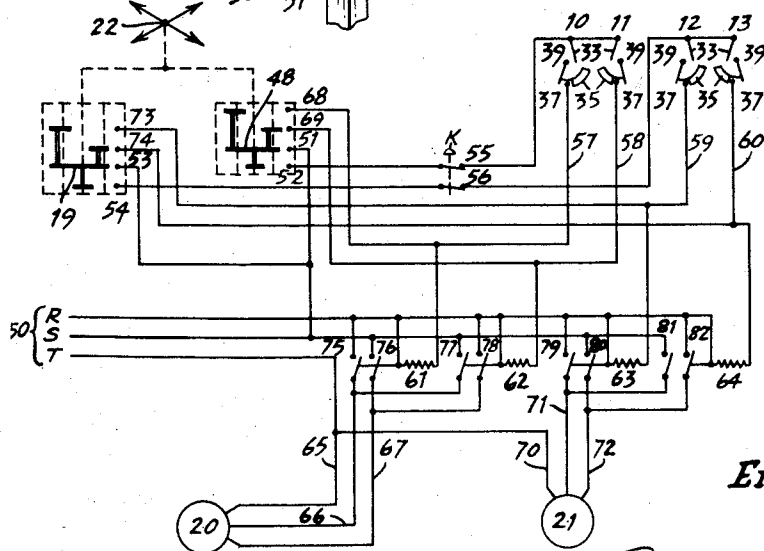


Fig. 5

INVENTOR
Erwin Gercke,

BY *Bailey, Stephens & Huetting*
 ATTORNEYS

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2 Sheets-Sheet 2

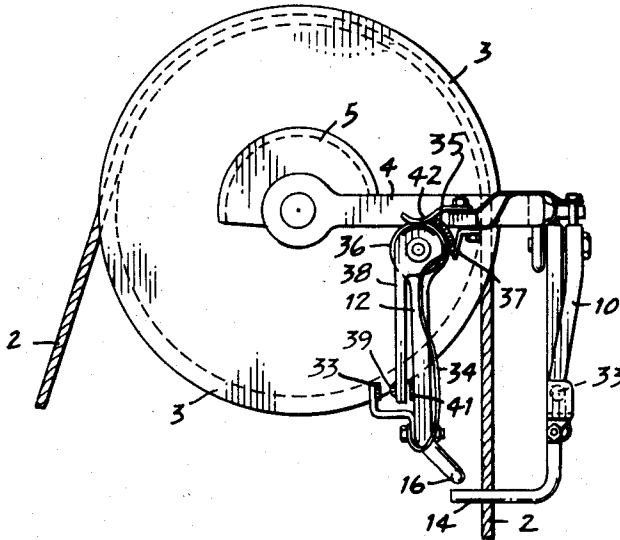


Fig. 2

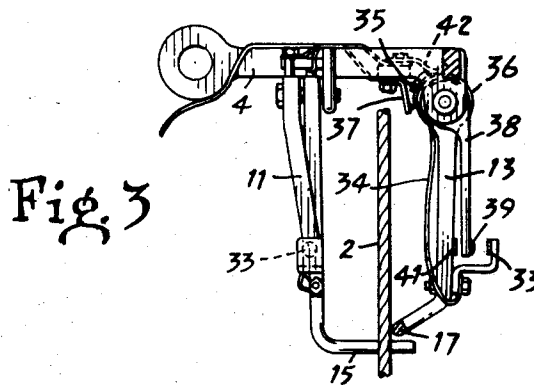


Fig. 3

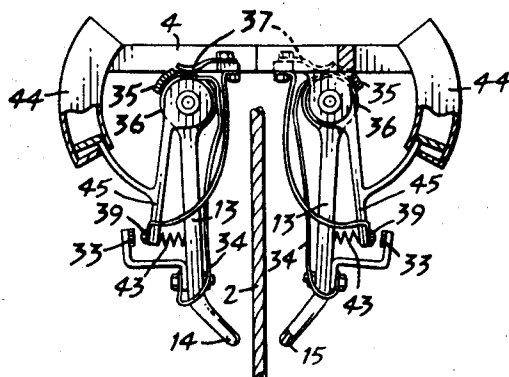


Fig. 4

INVENTOR
Erwin Gercke,

BY *Bailey, Stephens & Huetting*

ATTORNEYS

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APPARATUS FOR DAMPING PENDULUM MOTIONS OF THE LOAD SUSPENDED FROM A LIFTING MACHINE

Erwin Gercke, Nurnberg, Germany, assignor to Maschin-fabrik Augsburg-Nurnberg A.G., Nurnberg, Germany

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10 Claims. (Cl. 212—58)

This invention relates to an apparatus for damping pendulum motions of the load suspended from a crane or other hoisting apparatus or lifting machine.

In cranes or other lifting machines the load tends to get into a pendulum movement as it is slowed down from a horizontally extending motion (horizontal travel, slewing or jib motion). The oscillations of the load can be compensated by a corresponding control of the load-carrying means. However, this requires a prompt grasping of the situation, proper selection of the control means and sensitive rating of the control times. It will be appreciated that few operators are able to tackle this task.

It is an object of the present invention to provide means for automatically damping such movements, independently of any manual control.

With this and further objects in view, according to the present invention the load rope is supervised by a sensing or detector device which operates switching members for releasing compensating movements (horizontal travel, slewing, or jib motor or the like) in dependence upon deviations of the rope from its vertical position. The detector device comprises in each of the longitudinal and transverse planes of the load or jib sheave a pair of sensing or feeling members arranged in such a way that the two sensing members of each pair are located on opposite sides of the rope. The feeling or sensing members may be mounted individually and freely exposed in a frame which depending on the type of crane (e.g. travelling crab or luffing crane) is either fixedly arranged on the part of the crane carrying the load or jib sheave or pivotally mounted on the jib coaxially with this sheave, being maintained in a horizontal position, independently of the position of the jib, by a parallel motion coupled therewith.

According to a further important feature of the invention a trailing member with a contact is mounted coaxially with each sensing member, said contact being able to cooperate in dependence upon a pendulum motion of the rope, with a further contact fixedly connected to the sensing member, in such a manner that by the closing of the contact an electric circuit for a starting device energizing a horizontal travel, slewing, or jib motor or the like in the direction of the engagement of the rope is activated. Each pair of contacts is connected in series with a contact segment which when moved out of its position of rest is slidably engaged by a sliding contact, said segment being mounted on a carrier which is fixedly connected with the respective sensing member belonging thereto.

Other and further objects, features and advantages of the invention will be pointed out hereinafter and appear in the appended claims forming part of the application.

In the accompanying drawings several now preferred embodiments of the invention are shown by way of illustration and not by way of limitation.

Fig. 1 is a perspective view of an embodiment of the automatic control arrangement according to the invention, together with the crane gear controlled thereby;

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Fig. 2 is a detail of Fig. 1, showing two of four sensing levers;

Fig. 3 is a detail of Fig. 1, showing the two sensing levers which cannot be seen in Fig. 2;

Fig. 4 shows a modified form of the sensing levers in Figs. 2 and 3; and

Fig. 5 is an electric circuit diagram of the control arrangement.

Similar reference numerals denote similar parts in the different views.

Referring now to the drawings in greater detail, it will be seen that a frame 4 is mounted on the jib 1, Fig. 1, of a crane, coaxially to the jib sheave or pulley 3 over which the load rope 2 is passed. Secured on a sector-shaped portion 6 of the frame 4, which is concentrically pivoted on the shaft 5 of the pulley 3, is a pull rope 7 whose lower end is held on a sector 9 which is of the same diameter as the sector 6 and fixedly mounted on the stationary pivot 8 of the jib. It will be understood that the members 5 to 9 cooperate to form a parallel motion for the frame 4 which therefore irrespective of the inclination of the jib 1 always occupies the horizontal position shown in Fig. 1.

Suspended from the frame 4, in the longitudinal and transverse plane of the jib 1, or of the travelling crane or the like, are two pairs of sensing members such as levers 10, 11, and 12, 13, in such a way that the load rope 2 is disposed between the projections or fingers 14, 15, 16, 17 thereof, Figs. 2, 3, and 4. The sensing levers are connected through electrical lines with the control boxes 18, and 19 for the motors 20 and 21 which are operated by a mutual lever 22. Rope 2 is wound on drum 23 operated by motor 24 which is controlled by control box 25. Motor 21 operates, through gear 26, two pinions 27 which engage racks 28 which are pivoted on jib 1. Motor 20 operates through the gear 29 the pinion 30 engaging the toothed ring 31 which is fixed to the frame 32. The arrangement of the sensing levers and the contacts thereon is shown on a large scale in Fig. 2. Each sensing lever 10, 11, 12, and 13 carries an insulated contact 33 which may be connected with a contact segment 35 through a lead 34. This contact segment is arranged on a disc, a sector 36 or the like, which is mounted coaxially with the appertaining sensing lever 10, 11, 12, or 13, and fixedly connected thereto. A sliding contact 37 engages the circumference of the sector 36 and is able to establish connection with the contact segment if the sector 36 is turned out of its normal position. Together with each of the aforementioned sensing levers, there is mounted on the frame 4 a lagging member such as trailing lever 38 which is also fixedly, but non-conductively connected with a contact 39. The contacts 33, 35, 37, and 39 are connected in series in a circuit including a self-starter for the slewing motor 20, and luffing motor 21, or the trolley-motor and the travelling-motor of a travelling crane, the connections of these contacts being provided in different manner in accordance with the possible directions of rotation of these motors, as shown in Fig. 5. The contact 39 may be directly connected with the cable 39a leading to the switch mechanism or indirectly through a contact segment 40, Fig. 2.

The sensing levers have a stop 41 for the trailing levers so that the latter can somewhat move between the contact plate 33 and the stop. The trailing levers are maintained in any position by frictional forces or the like, which in the present instance are provided by springs 42 engaging the contact segments. Thus the levers move only when pushed or pulled by the proper sensing lever. The sensing levers are made of conducting material and are mounted on insulated bushings. They are mounted freely swingable so that they always gravitate to a vertical position.

Fig. 4 shows another arrangement of the trailing levers. The sensing levers are arranged and provided with contacts exactly as shown in Figs. 2 and 3. Each trailing lever 45 is connected to the sensing lever by a spring 43 which maintains contacts 33 and 39 closed. The trailing levers are also connected to the pistons of pneumatic damping casings 44 which are journaled in frame 4. When a sensing lever is moved outward by the rope, the spring 43 tends to move lever 45. However the damping casing slows its movement, so that it somewhat lags and the contacts 33 and 39 are opened.

Fig. 5 shows the connection of the single contacts with each other and with the motor circuits. For controlling the three-phased slewing motor 20, the control current leads from phase S of the power supply line 50 over contacts 51 and 52 in the control box 18, and the contact 55 of the button K to the contacts of the feelers 10 and 11. From the pertinent counter contacts 39, which are open in rest position, the current leads over the contact segments 35 the sliding contacts 37 and the lines 57, 58 to the relay windings 61, 62. If the line 57 leads current because of closing the pertinent contacts 33, 39 and 35, 37, the relay winding 61 is actuated and closes the contacts 75 and 76. Contact 75 connects the supply line 66 of the three-phase motor 20 with the phase R, and contact 76 connects the supply line 67 of the three-phase motor 20 with phase S. Supply line 65 is always connected with phase T of the power supply. The motor runs now in right hand direction until one of the contact connections 33, 39 or 35, 37 is broken, thus disconnecting relay winding 61 from the power supply which causes contacts 75 and 76 to open, so that the three-phase motor stops. If line 58 receives current because of closing of the pertinent contacts 33, 39 and 35, 37, the relay winding 62 actuates and so closes the contacts 77 and 78. Contact 77 connects the supply line 66 of the three-phase motor 20 with phase S and contact 78 connects the supply line 67 of the three-phase motor 20 with phase R. Supply line 65 is always connected with phase T of the power supply. The motor now turns to the left until one of the contact connections 33, 39 or 35, 37 is broken which causes a disconnecting of the relay winding 62, thus the contacts 77, 78 open and the three-phase motor 20 stops.

During voluntary turning of the crane by operating the rotary control roller 18, the relay windings are controlled directly over the contacts 68 and 69. The contacts 51 and 52 are therefore disconnected.

The controlling of the hoisting motor 21 is arranged in the same way as above disclosed for the slewing motor 20. The control current leads from phase S of the power supply 50 over the contacts 53 and 54 of the hoisting control box 19 and the contact 56 of the button K to the contacts 33 of the feelers 12 and 13. From the pertinent counter contacts 39 which are in open position, the current leads over the contact segments 35 the sliding contacts 37 and the lines 59, 60 to the relay windings 63 and 64. If the line 59 is supplied with current because of closing of the pertinent contacts 33, 39 and 35, 37, the relay winding 63 is actuated and closes the contacts 79 and 80. Contact 79 connects the supply line 71 of the hoisting motor 21 with phase R and contact 80 connects the supply line 72 of the hoisting motor 21 with phase S. Supply line 70 is always connected with phase T of the power supply. The hoisting motor turns in right hand direction until one of the contact connections 33, 39 or 35, 37 is broken. Thus the relay winding 63 is disconnected, the contacts 79 and 80 open and the hoisting motor 21 stops.

If now line 60 receives current because of closing of the pertinent contacts 33, 39 and 35, 37, the relay winding 64 is actuated and so closes the contacts 81 and 82. Contact 81 connects the supply line 71 of the hoisting motor 21 with phase S and contact 82 connects the supply line 72 of the hoisting motor 21 with phase R. Supply line 70 is always connected with phase T of the

power supply. The hoisting motor turns in left direction until one of the contact connections 33, 39 or 35, 37 is broken. Thus the relay winding 64 is disconnected. The contacts 81 and 82 open and the hoisting motor 21 stops.

During the voluntary hoisting or lowering of the crane by operating the hoisting control box 19, the relay windings 63 and 64 are controlled directly over the contacts 73 and 74. The contacts 53 and 54 therefore remain disconnected.

The apparatus operates as follows: As soon as the load suspended from the load rope 2 begins to swing the respective sensing lever 10, 11, 12, or 13 located in the direction of the pendulum motion of the rope is seized by the rope through the fingers 14, 15, 16, and 17 and taken along. Hereupon, the sensing lever after traversing the length of path separating it from the trailing lever 38, or by means of the spring 43, takes the trailing lever 38 with it. If the contacts 33 and 39 possibly had been closed beforehand, they will now be opened before the respective trailing lever 38 is taken along by the sensing lever. Only when in the course of the swinging back motion of the load the respective sensing lever 10, 11, 12, or 13 is also moved back from its extreme position, is the connection between the contacts 33 and 39 established again, since the trailing lever in this case owing to the braking or retarding forces exerted upon it by the hereinbefore described means at first remains in its end position. The sets of contacts 35, 37, and 40 take up a closed position during the reversal of the motion of the swinging rope 2 and the self-starter is energized also for operation of the motor 20 or 21 compensating the pendulum motion. It may be assumed, for instance, that the load swings to the left. In this case the set of contacts of the sensing lever 11 is activated during the reversal of the swinging rope 2 and the leads 65, 66, and 67 of the slewing motor 20 are energized from the network through the phases R, S, T and the contacts 77 and 78 or (T) directly. The slewing motor 20 when starting causes slewing of the crane in an anticlockwise direction and thus a compensation of the rope 2 swinging to the left, and of the load carried by it. As the rope 2 swings to the right, the set of contacts of the sensing lever 10 will activate relay 61 and thus cause closing of the contacts 75 and 76. Hence, the leads 66 and 67 of the slewing motor 20 are connected to the phases SR in a reverse manner compared to the previous mode of connection. The slewing gear is then driven by the motor 20 in a clockwise direction. In an analogous way the jib motor 21 is actuated as the set of contacts of the sensing levers 12 or 13 is activated. As soon as the rope again takes up its vertical position, the contact segment 35 will be removed from the sliding contact 37 interrupting the circuit. The motor which had been in operation up to this moment is thus disconnected again. However, it will be started in an opposite direction of rotation as the rope swings out in an opposite direction. In this manner, the rope 2 and the load are exposed to successive damping impulses, whereby the swinging of the load is quieted in a short time.

The apparatus shown in Fig. 4 operates as follows: The spring 43 connecting the detector or sensing lever 10, 11, 12, or 13 with the trailing lever 45, is capable of overcoming the damping force counteracting the trailing lever 45, for connecting the contacts 33 and 39, as the carrying rope 2 is slowing down towards the end of its oscillating movement. Thus the compensating follow-motion caused by the corresponding driving motor is activated already before the load has reached the point of reversal of its swinging movement.

In order to prevent the compensating device from reacting in case of an intended or non-intended deflection of the rope 2 by forces acting upon it from the outside, e.g. by lateral pull by hand or by wind pressure, the contacts 55 and 56 which are normally closed can be opened manually by the button K during periods where

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a deflection of the rope not caused by pendulum motions of the load is to be expected, so as to deactivate the arrangement for automatic compensation of pendulum motions.

While the invention has been described in detail with respect to certain now preferred examples and embodiments of the invention it will be understood by those skilled in the art after understanding the invention that various changes and modifications may be made without departing from the spirit and scope of the invention and it is intended, therefore, to cover all such changes and modifications in the appended claims.

I claim:

1. A control device for a crane having a sheave support, a motor for moving said support, and a hoisting cable suspended from a sheave carried by said support comprising an electrical circuit connected to said motor for operating the motor, first switch means in said circuit closable by swinging of the cable in a first direction and openable by the swinging of the cable in a reverse direction, and second switch means in said circuit actuable by the swinging of the cable in the reverse direction to complete said circuit and energize said motor for moving said support in the first direction.

2. A control device for a crane having a sheave support, a motor for moving said support, and a hoisting cable suspended from a sheave carried by said support, comprising a sensing lever mounted adjacent said sheave and movable by the swinging of the cable in a first direction, a first switch closable by movement of the sensing lever in the first direction, a trailing lever mounted adjacent said sensing lever and movable by said sensing lever in said first direction, a second switch connected to said trailing lever and closable by said sensing lever during its path in returning to its original position upon the cable swinging in a reverse direction, and means for energizing said motor upon closing of both the first and second switches for moving the support in the first di-

rection while the cable is swinging out of contact with said sensing lever.

3. A control device as in claim 2, said sensing lever being freely suspended and returnable to its original position by gravity to close said second switch.

4. A control device as in claim 3, a frame joined to said support, and said sensing lever and trailing lever being coaxial and pivotally mounted on said frame.

5. A control device as in claim 4, said first switch comprising a segment joined to said sensing lever and a contact slidable on said segment.

6. A control device as in claim 5, further comprising retarding means for holding said trailing lever from free swinging movement.

7. A control device as in claim 6, said retarding means comprising a leaf spring joined to said frame and bearing on said trailing lever.

8. A control device as in claim 6, said retarding means comprising a dashpot secured between said frame and said trailing lever.

9. A control device as in claim 8, further comprising a spring connected between said sensing lever and said closing lever for closing said second switch as said sensing lever returns toward its original position.

10. A control device as in claim 2, a sensing lever with its trailing lever comprising a detector unit, and four detector units centered around said cable for controlling said motor in response to four directional movements of said cable.

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