

PATENT SPECIFICATION

(11)

1 542 821

542 821

(21) Application No. 216/77 (22) Filed 5 Jan. 1977

(31) Convention Application No's

51/002796

(32) Filed 14 Jan. 1976

51/053267

12 May 1976 in

(33) Japan (JP)

(44) Complete Specification published 28 March 1979

51) INT. CL.² B66C 13/06

(52) Index at acceptance
B8B 2B5



(54) DEVICE FOR DAMPING THE SWINGING MOVEMENT OF A LOAD HUNG BY A CRANE

(71) We, HITACHI, LTD., a Japanese Body Corporate of 5-1, 1-chome, Marunouchi, Chiyoda-ku, Tokyo, Japan, do hereby declare the invention for which we 5 pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a device for 10 damping the swinging movement of a load or cargo, the device being adapted for use with a crane of the type in which the cargo is lifted by means of the crane through ropes and moved from one place to another to 15 load or unload the cargo.

One problem commonly encountered with respect to a crane of the type in which a load or cargo is lifted by means of a trolley through ropes and moved from one 20 place to another is that the cargo moves in pendulum motion when the trolley stops at the destination. If the cargo hung from ropes moves in pendulum motion, difficulty will naturally be experienced in lowering 25 the cargo and accurately putting the same down in a predetermined position. Thus this type of crane has the disadvantage of reduced efficiency with which a loading or unloading operation is performed. There 30 has hitherto been a demand for effective means for obviating this disadvantage.

In order to obviate this disadvantage, various proposals have hitherto been made to provide the crane with a device for 35 suppressing the pendulum motion of a cargo lifted and moved by the crane of the type described.

In one type of swinging movement stopping device generally known in the art, a 40 rope is obliquely trained between the trolley and the cargo hung thereby so that the rope may develop a horizontal component of tension which is effective to offer resistance to the pendulum motion of the cargo. However, some disadvantages are associated with

this type of device. For one thing, the angle of inclination imparted to the rope is restricted by the size of the trolley, and it is impossible to provide a horizontal component tension of high magnitude. Moreover, 50 as the rope repeatedly lengthens and contracts, the rope performs a spring action. Because of these defects, this known device has little effect in damping the pendulum motion of the cargo. 55

The prior art capable of increasing the effect of damping the pendulum motion of the cargo which is most closely related to the present invention is disclosed in U.S. Patent No. 3,746,182. The device of this 60 prior art comprises a pair of rope winding drums mounted on the trolley of the crane in a manner to be disposed symmetrically on left and right ends of the trolley, ropes paid out of the rope winding drums and 65 trained over the sheaves on a spreader in such a manner that the ropes run symmetrically at left and right sides, a balance beam mounted on the trolley for tilting motion so that one end of each of the ropes 70 to be wound is secured to each of the tilting ends of the balance beam in a manner to be symmetrical at left and right sides, and dash pots each mouned between one of the tilting 75 ends of the balance beam and the trolley.

In the swinging movement damping device constructed as aforesaid, when the spreader moves in swinging motion, the energy of the swinging motion manifests itself as the difference in rope tension between the ropes which are symmetrically 80 disposed at the left and right sides, thereby tilting the balance beam. The force for tilting the balance beam is transmitted to one of the dash pots and damped thereby. 85 As a result, the energy of the swinging motion is absorbed by the dash pot, and the swinging of the spreader is forcedly stopped.

In the prior art device constructed as aforementioned, the ropes to be wound are 90

each connected only at one end thereof to the balance beam. Thus the efficiency with which the energy of the swinging motion is transmitted to the dash pot is low. Because of this, the prior art device has a disadvantage in that it takes a long time for the swinging movement to come to a stop.

This invention has as its object the provision of an improved device for damping the swinging movement of a load or cargo which is hung by ropes from a trolley on a crane beam.

According to the invention, there is provided a device for use in damping the swinging movement of a load hung from a crane, the device comprising a trolley adapted to be mounted for travelling on a beam of the crane, a pivotal member connected intermediate opposite ends thereof to the trolley for pivotal movement about a pivot axis extending in a direction which will be generally horizontal and transversely of the longitudinal axis of the beam when the trolley is mounted for travel on the beam; a pair of sheave means spaced apart from one another and mounted on the pivotal member on opposite sides of said pivot axis, each of said sheave means including at least one sheave, whereby in use of the device ropes may be trained over the sheave means and depend therefrom with a load suspension member being connected to the lower ends of the ropes; and damping means disposed between the trolley and said pivotal member for damping the pivotal movement of the pivotal member about said axis.

The device constructed as aforementioned in accordance with the invention, preferably further comprises a pair of carriages mounted on said pivotal member with one carriage disposed on each side of said pivot axis, one of said pair of sheave means being mounted on one of said pair of carriages, and the other sheave means being mounted on the other carriage; and adjusting means for moving said pair of carriages toward and away from one another to adjust the distance between said pair of carriages.

The invention will be further described, by way of example, with reference to the accompanying drawings, wherein:

Fig. 1 is a fragmentary schematic view of the trolley portion of a container crane in which this invention is incorporated, showing the cargo in a stationary condition;

Fig. 2 is a view similar to Fig. 1 but showing the cargo moving in pendulum motion.

Fig. 3 is a graph showing the manner in which the pendulum movement of the cargo hung by the crane embodying the invention as shown in Fig. 1 and Fig. 2 is damped, in comparison with the damping of the pendulum movement of a cargo by

devices of the prior art;

Fig. 4 is a schematic view of a modification of the embodiment of the invention;

Fig. 5 is a schematic view of another modification of the embodiment of the invention;

Fig. 6 is a schematic view of still another embodiment;

Fig. 7 is a view of a portion of the device shown in Fig. 6 as seen in the direction of arrows VII-VII; and

Fig. 8 is a block diagram for effecting control of the variable restrictor.

In Fig. 1, there is shown a trolley 1 of a container crane which is adapted to be driven by drive means 5 mounted on the trolley 1 to travel along rails 3 located on an overhead girder of the container crane. The trolley 1 has attached thereto a bracket 7 which supports at its lower end a portion, through a pin 9, a beam 11 in its center, so that the beam 11 is pivotally movable about the pin 9. Oil dampers 13 and 15 are mounted between opposite ends of the beam 11 and opposite ends of the trolley 1 and function to suppress the pivotal movement of the beam 11.

The beam 11 has attached to its central portion a bracket 21 which has piston rods of piston-cylinder assemblies 17 and 19 connected to opposite end portions thereof through pins so that the piston-cylinder assemblies 17 and 19 extend parallel to the beam 11 and in opposite directions relative to the bracket 21. The cylinders of the piston-cylinder assemblies 17 and 19 are mounted on carriages 23 and 25 respectively on the beam 11. The carriages 23 and 25 are adapted to move on the beam 11 as the piston-cylinder assemblies 17 and 19 are actuated such that the pistons are withdrawn into or extend from the cylinders. A pair of sheave means 27 and 29 are mounted on the beam 11 on opposite ends of the pivot pin 9. The sheave means 27 and 29 are mounted on the beam by means of carriages 23 and 25 respectively. Each of the pairs of sheave means 27 and 29 includes two sheaves. The pairs of sheave means 27 and 29 can swing about the pin 9 as the beam 11 moves in pivotal motion about the pin 9.

A spreader 35, which is a suspension member of the container crane, can be brought into engagement with a container and has mounted on its upper surface sheaves 37 and 39 arranged such that they have a center distance S_2 . Ropes 31 and 33 for supporting the spreader 35 extend along the overhead girder of the container crane and pass through the trolley 1 in reaching the spreader 35. More specifically, the rope 33 is trained over one of the sheave means 29 and runs downwardly to be trained over the sheave 39 on the spreader

35; then it runs upwardly and is trained over the other of the sheave means 29. The rope 31 is trained over one of the sheave means 27 and runs downwardly to be trained over the sheave 37 on the spreader 35; then it runs upwardly and is trained over the other of the sheave means 27.

The sheave means 27 and 29 are arranged such that they have a center distance S_1 which is greater than the center distance S_2 of the sheaves 37 and 39 on the spreader 35. By this arrangement, the spreader 35 can be placed in a stationary position in a stable manner when the trolley 1 is stationary.

In the mechanism constructed as aforementioned, let us assume that the trolley 1 travelling in the direction of an arrow A stops its movement as shown in Fig. 2. If this occurs, the spreader 35 and container 41 will keep moving in the direction of the arrow A and then they will begin swinging in pendulum motion due to inertia. When the spreader 35 and container 41 swing in the direction of the arrow A, the rope 31 will increase in tension while the rope 33 will decrease in tension, and the beam 11 will move counterclockwise in pivotal motion about the pin 9. Consequently the sheave means 27 and 29 will move about the pin 9.

The beam 11 moving counterclockwise in pivotal motion will cause the oil damper 13 to expand and the oil damper 15 to contract. When the oil damper 13 expands and the oil damper 15 contracts, the force which causes the beam 11 to move in pivotal motion is absorbed by the dampers 13 and 15. In this way, the energy of the pendulum movement of the spreader 35 and the container 41 is absorbed by the oil dampers 13 and 15, with the result that the pendulum movement thereof is damped quickly. During damping of this swinging movement the sheave means 27 and 29 pivot with the beam about the pin 9 in accordance with the pendulum movement of the spreader 35 and container 41. Because of this, the ropes 31 and 33 are not subjected to an unduly high tension. This keeps the ropes 31 and 33 from extending or contracting too greatly, so that the ropes 31, 33 do not perform a spring action. This is conducive to quick cessation of the pendulum motion.

After the swinging movement of the spreader 35 and container 41 in the direction of the arrow A has reached a maximum, they move in an opposite direction toward the stationary position shown in Fig. 1. During this process, the beam 11 moves clockwise in pivotal motion about the pin 9, and the force which causes the beam to pivot is absorbed by the oil dampers 13 and 15, thereby decreasing the energy of the

pendulum movement of the spreader 35 and container 41. This results in a great reduction in the amplitude of the pendulum movement of the spreader 35 and container 41 in a short period of time. Thus, after the trolley 1 has come to a halt, the pendulum movement of the spreader 35 and container 41 comes to an end in a short period of time.

In the mechanism for damping the pendulum movement as described above the energy of the swinging movement is quickly converted to the tension of the ropes 31 and 33 and transmitted to the oil dampers 13 and 15 through the beam 11, thereby speeding the cessation of the swinging movement and shortening the duration of time in which the swinging movement takes place.

Fig. 3 shows the results of experiments conducted on damping of the swinging motion. In the graph, the time elapsed is set forth along the horizontal axis and the horizontal displacement of the bottom of the container 41 relative to the trolley along the vertical axis. In the figure, curves X and Z represent the swinging movements of loads which took place when swinging movement damping devices of the prior art were used. These curves show that the devices of the prior art have little effect in damping the swinging movement of the loads and reduce the efficiency with which loading or unloading is performed by the container crane. The swinging movement of the load when the device according to the present invention is used with a container crane is such that it can be indicated by a curve Y which shows that the swinging movement can be damped effectively in a short period of time.

What is particularly noteworthy in regard to the present invention is that, when cargoes are moved through a narrow hatchway of a ship into its hold for loading or out of its hold for unloading, the spacing between the ropes 31 and 33 can be reduced if the carriages 23 and 25 are moved toward each other by withdrawing the piston rods of the piston-cylinder assemblies 17 and 19 into the respective cylinders. This enables loading or unloading to be performed safely without the ropes 31 and 33 coming into contact with the edge of the hatchway.

Also, if the piston-cylinder assemblies 17 and 19 are actuated to move the carriages 23 and 25 and adjust the ropes 31 and 33 such that the point of intersection of the extensions of the ropes 31 and 33 draws nearer to the center of gravity of the container, the moment tending to cause the container 41 to be displaced can be minimized. Thus it is possible to prevent the swinging of the container about its center

of gravity.

Moreover, if the piston-cylinder assemblies 17 and 19 are actuated to vary the positions of the carriages 23 and 25 in accordance with the weight of the container 41, it is possible to set at a suitable level the force exerted on the oil dampers 13 and 15. This makes it possible to use the dampers 13 and 15 effectively, and offers the advantage of performing a swinging movement stopping operation effectively in conformity with the weight of the particular container.

In the embodiment shown and described hereinabove, two oil dampers are used as damping means. It is to be understood, however, that the invention is not limited to this type of damping means, and that means comprising piston-cylinders and a restrictor, means for electrically absorbing energy, means utilizing a frictional force, etc. can be used as damping means in the invention.

Although the beam 11 has been shown and described as being hung below the trolley 1, the beam 11 may be mounted above the trolley 1.

Fig. 4 shows a modification of the embodiment of the invention shown in Fig. 1 and Fig. 2, in which piston-cylinder assemblies and a restrictor are used as damping means in place of the oil dampers 13 and 15. In Fig. 4, the beam 11 pivotally supported by the trolley 1 is connected at its left end through a hydraulic piston-cylinder assembly 43 and at its right end through a hydraulic piston-cylinder assembly 45 to the trolley 1. An upper cylinder chamber 47 of the piston-cylinder assembly 43 communicates with a lower cylinder chamber 49 of the piston-cylinder assembly 45 through a conduit 51, while a lower cylinder chamber 53 of the piston-cylinder assembly 43 communicates with an upper cylinder chamber 55 of the piston-cylinder assembly 45 through a conduit 57. A series circuit comprising a normally closed electromagnetic valve 59 and a variable restrictor 61 connects the conduits 57 and 51 together.

In the aforementioned construction, it is only after the normally closed electromagnetic valve 59 is opened following the deceleration of the trolley 1 from its normal traveling speed to a predetermined lower speed that the fluid in the cylinder chambers 47, 49, 53 and 55 is brought to a condition in which it can flow. Thus the beam 11 can move in pivotal motion about the pin 9.

When the spreader 35 and container 41 move in swinging motion, the beam 11 moves in pivotal motion about the pin 9 in synchronism with the swinging motion of the spreader and container. This causes the fluid in the cylinder chambers 47, 49,

53 and 55 to flow, through the variable restrictor 61 and electromagnetic valve 59, from one chamber to another. Thus a suitable resistance which is determined by the amount of restriction of the variable restrictor 61 is offered to the flows of the fluid, with the result that the free pivotal movement of the beam 11 is suppressed by the force exerted by the suitable resistance. If the free pivotal movement of the beam 11 is suppressed in this way, the pendulum movement of the spreader 45 and container 41 will be damped and they will finally stop their pendulum movement.

One of the advantages offered by the swinging movement damping device provided with the energy damping mechanism shown in Fig. 4 is that it is possible to obtain suitable energy damping characteristics in conformity with different swinging conditions. Another advantage is that, by operating the electromagnetic valve 59, it is possible to allow the fluid to flow between the cylinder chambers 47, 49 and the cylinder chambers 53 and 55 depending upon the direction of swinging movement, on to block the flow. For example, by closing the electromagnetic valve 59, it is possible to render the piston-cylinder assemblies 43 and 45 inoperative, so that the beam 11 can be kept in a position in which it is prevented from moving in pivotal motion or the beam can be locked before the need arises to stop the swinging motion of the spreader 35 and container 41. The electromagnetic valve 59 is opened when the trolley 1 has been decelerated to a suitable speed after approaching the destination, thereby unlocking the beam 11 and bringing it to a position in which it can move in pivotal motion. By this arrangement, it is possible to minimize the amplitude of a first swinging movement and damp the swinging movement more quickly than otherwise. In an alternative arrangement only one damping piston need be provided with the variable restrictor damping flow between opposite sides of the piston through a conduit connecting opposite ends of the cylinder in which the piston is slidable.

Fig. 5 shows another modification of the embodiment in which different means is used for selectively rendering the beam 11 pivotable or non-pivotable. The construction shown in Fig. 5 is a mechanical locking mechanism in which one end of the beam 11 is immovably held in place by a stopper 63 which is bifurcated in cross-section at its end to hold the end of the beam 11 by its forked end. The stopper 63 is mounted on the trolley 1 for horizontal sliding motion through a return spring 63. An electromagnetic coil 67 for locking the sliding movement of the stopper 63 is mounted

between the trolley 1 and the stopper 63. By supplying a signal to the electromagnetic coil 67, it is possible to cause the stopper 63 to move rightwardly in sliding motion in Fig. 5 by the biasing force of the return spring 65, so that the stopper 63 is moved out of engagement with the beam 11.

Thus the beam 11 is brought to a position in which it can move in pivotal motion.

By using the mechanical locking mechanism shown in Fig. 5, it is possible to selectively move the beam 11 between pivotal and non-pivotal positions or between unlocked and locked positions, even if the electromagnetic valve 59 shown in Fig. 4 is not used and even if the energy damping means comprises the oil dampers 13 and 15 shown in Fig. 1.

Experiments were conducted on the timing of switching the beam between locked and unlocked positions. The results show that excellent swinging movement stopping effect can be achieved if the beam 11 is unlocked or brought to a pivotable position at the time the trolley 1 is decelerated such that its speed is reduced below 50% of its original speed following the application of the brake.

Switching of the beam 11 between its locked and unlocked positions may be performed manually. However, the end can be attained automatically by using an electric circuit in which a trolley speed detector is connected through a signal transmitting means to either the electromagnetic valve 59 or the electromagnetic coil 67.

With reference to the energy damping mechanism shown in Fig. 4, the amount of restriction of the variable restrictor 61 may be varied as required depending on the weight of the container 41 or the height to which the container 41 is lifted. This enables suitable energy damping characteristics to be obtained in conformity with swinging conditions. This mechanism will be described with reference to Figs. 6, 7 and 8.

In Figs. 6 and 7, the overhead girder 67 on which the trolley 1 travels has mounted at its forward end sheaves 69 and 71 which guide the ropes 33 and 31 respectively at one end thereof and which are supported by beams 75 and 77 respectively adapted to move in horizontal pivotal motion about a pin 73. The beams 75 and 77 are in engagement at their free ends with load cells 79 and 81 respectively which are secured to the girder 67. By this arrangement, the weight of the container 41 transmitted through the ropes 31 and 33 causes the free ends of the beams 75 and 79 respectively to move in horizontal pivotal movement and to apply pressure to the load cells 79 and 81. In this way, the weight of the container

41 can be detected by the load cells 79 and 81.

Meanwhile the ropes 31 and 33 are wound at the other end on a hoisting drum 83 and secured thereto. The hoisting drum 83 is mounted on a rotary shaft which is coupled to a synchronizer 85 so as to detect the height of the container 41 as the hoisting drum 83 is rotated.

By this arrangement, it is possible to quickly and positively change the amount of restriction of the variable restrictor 61 to a suitable level even if there arises a change in the weight of the container 41 or the height to which the container 41 is lifted.

The operation of changing the amount of restriction of the variable restrictor 61 to a suitable level can be performed manually. However, by processing the aforementioned detected values by a system shown in a block diagram in Fig. 8, it is possible to automatically set the amount of restriction of the variable restrictor to a suitable level. Processing of the detected values by the system of Fig. 8 will be explained briefly. A value 87 detected by the synchronizer 85 and a value 89 detected by the load cells 79 and 81 are supplied to a circuit 91 which calculates a maximum amount of restriction. The output of the circuit 91 is supplied to a restriction controller 93 which produces a signal. Based on the signal produced by the controller 93, the amount of restriction of the variable restrictor 61 is set at a level which is commensurate with the detected values 87 and 89. The reference numeral 95 designates a feedback circuit which interconnects input and output sides of the restriction controller 93.

By the use of the mechanism described hereinabove, it is possible to automatically vary the amount of restriction of the variable restrictor 61 to an optimum level in conformity with a change in the weight of the container 41 or the height to which the container 41 is lifted, thereby enabling energy damping characteristics to be more positively and quickly obtained in accordance with the swinging movement of the container 41. This makes it possible to very quickly bring about cessation of the swinging movement of the container 41, in spite of the fact that there are changes in conditions under which the swinging movement of the container 41 takes place, e.g. the weight of the container 41 and the height to which the container is lifted.

WHAT WE CLAIM IS:

1. A device for use in damping the swinging movement of a load hung from a crane, the device comprising a trolley adapted to be mounted for travelling on a beam of the crane, a pivotal member con-

between the trolley 1 and the stopper 63. By supplying a signal to the electromagnetic coil 67, it is possible to cause the stopper 63 to move rightwardly in sliding motion in Fig. 5 by the biasing force of the return spring 65, so that the stopper 63 is moved out of engagement with the beam 11.

Thus the beam 11 is brought to a position in which it can move in pivotal motion.

By using the mechanical locking mechanism shown in Fig. 5, it is possible to selectively move the beam 11 between pivotal and non-pivotal positions or between unlocked and locked positions, even if the electromagnetic valve 59 shown in Fig. 4 is not used and even if the energy damping means comprises the oil dampers 13 and 15 shown in Fig. 1.

Experiments were conducted on the timing of switching the beam between locked and unlocked positions. The results show that excellent swinging movement stopping effect can be achieved if the beam 11 is unlocked or brought to a pivotable position at the time the trolley 1 is decelerated such that its speed is reduced below 50% of its original speed following the application of the brake.

Switching of the beam 11 between its locked and unlocked positions may be performed manually. However, the end can be attained automatically by using an electric circuit in which a trolley speed detector is connected through a signal transmitting means to either the electromagnetic valve 59 or the electromagnetic coil 67.

With reference to the energy damping mechanism shown in Fig. 4, the amount of restriction of the variable restrictor 61 may be varied as required depending on the weight of the container 41 or the height to which the container 41 is lifted. This enables suitable energy damping characteristics to be obtained in conformity with swinging conditions. This mechanism will be described with reference to Figs. 6, 7 and 8.

In Figs. 6 and 7, the overhead girder 67 on which the trolley 1 travels has mounted at its forward end sheaves 69 and 71 which guide the ropes 33 and 31 respectively at one end thereof and which are supported by beams 75 and 77 respectively adapted to move in horizontal pivotal motion about a pin 73. The beams 75 and 77 are in engagement at their free ends with load cells 79 and 81 respectively which are secured to the girder 67. By this arrangement, the weight of the container 41 transmitted through the ropes 31 and 33 causes the free ends of the beams 75 and 79 respectively to move in horizontal pivotal movement and to apply pressure to the load cells 79 and 81. In this way, the weight of the container

41 can be detected by the load cells 79 and 81.

Meanwhile the ropes 31 and 33 are wound at the other end on a hoisting drum 83 and secured thereto. The hoisting drum 83 is mounted on a rotary shaft which is coupled to a synchronizer 85 so as to detect the height of the container 41 as the hoisting drum 83 is rotated.

By this arrangement, it is possible to quickly and positively change the amount of restriction of the variable restrictor 61 to a suitable level even if there arises a change in the weight of the container 41 or the height to which the container 41 is lifted.

The operation of changing the amount of restriction of the variable restrictor 61 to a suitable level can be performed manually. However, by processing the aforementioned detected values by a system shown in a block diagram in Fig. 8, it is possible to automatically set the amount of restriction of the variable restrictor to a suitable level. Processing of the detected values by the system of Fig. 8 will be explained briefly. A value 87 detected by the synchronizer 85 and a value 89 detected by the load cells 79 and 81 are supplied to a circuit 91 which calculates a maximum amount of restriction. The output of the circuit 91 is supplied to a restriction controller 93 which produces a signal. Based on the signal produced by the controller 93, the amount of restriction of the variable restrictor 61 is set at a level which is commensurate with the detected values 87 and 89. The reference numeral 95 designates a feedback circuit which interconnects input and output sides of the restriction controller 93.

By the use of the mechanism described hereinabove, it is possible to automatically vary the amount of restriction of the variable restrictor 61 to an optimum level in conformity with a change in the weight of the container 41 or the height to which the container 41 is lifted, thereby enabling energy damping characteristics to be more positively and quickly obtained in accordance with the swinging movement of the container 41. This makes it possible to very quickly bring about cessation of the swinging movement of the container 41, in spite of the fact that there are changes in conditions under which the swinging movement of the container 41 takes place, e.g. the weight of the container 41 and the height to which the container is lifted.

WHAT WE CLAIM IS:

1. A device for use in damping the swinging movement of a load hung from a crane, the device comprising a trolley adapted to be mounted for travelling on a beam of the crane, a pivotal member con-



nected intermediate opposite ends thereof to the trolley for pivotal movement about a pivot axis extending in a direction which will be generally horizontal and transversely of the longitudinal axis of the beam when the trolley is mounted for travel on the beam; a pair of sheave means spaced apart from one another and mounted on the pivotal member on opposite sides of said pivot axis, each of said sheave means including at least one sheave, whereby in use of the device ropes may be trained over the sheave means and depend therefrom with a load suspension member being connected to the lower ends of the ropes; and damping means disposed between the trolley and said pivotal member for damping the pivotal movement of the pivotal member about said axis.

2. A device as claimed in claim 1, further comprising a pair of carriages mounted on said pivotal member with one carriage disposed on each side of said pivot axis, one of said pair of sheave means being mounted on one of said pair of carriages, and the other sheave means being mounted on the other carriage; and adjusting means for moving said pair of carriages toward and away from one another to adjust the distance between said pair of carriages.

3. A device as claimed in claim 1 or 2, wherein the distance between the center of the two sheave means is greater than the horizontal distance between the connecting points of the ropes to the load suspension member.

4. A device as claimed in Claim 1, 2 or 3, wherein said damping means comprises a means for adjusting the damping rate of the pivotal movement of said pivotal member.

5. A device as claimed in Claim 1, wherein said damping means comprises at least one cylinder, a piston slidable in said cylinder to divide a space in said cylinder into two chambers, conduit means for communicating said two chambers with each other, and a restriction means mounted in said conduit means for restricting the flow of a fluid, said cylinder being connected to one of said trolley and said pivotal member, and said piston being connected to the other of said pivotal member and said trolley.

6. A device as claimed in Claim 5, wherein said restriction means is a variable restrictor.

7. A device as claimed in Claim 5 or 6, further comprising locking means for locking the pivotal movement of said pivotal member, said locking means comprising a

valve means connected in series with said restriction means in said conduit means.

8. A device as claimed in Claim 7, wherein said valve means comprises an electromagnetic valve.

9. A device as claimed in Claim 7, wherein said valve means comprises a normally closed valve, said normally closed valve being operative in response to the speed of travel of the trolley thereby to be shifted to its open position.

10. A device as claimed in Claim 1, further comprising locking means interposed between said trolley and said pivotal member for locking the pivotal movement of said pivotal member.

11. A device as claimed in Claim 10, wherein said locking means comprises means for holding one end of said pivotal member.

12. A device as claimed in Claim 11, wherein said holding means comprises a stopper slidably mounted on said trolley, said stopper having an end portion disposed adjacent said pivotal member and complementary in shape with said one end of the pivotal member.

13. A device as claimed in Claim 12, wherein said holding means further comprises a spring urging said stopper in one direction, and a locking member for locking the stopper to prevent the same from moving in said one direction due to the biasing force of said spring.

14. A device as claimed in Claim 13, wherein said locking member is an electromagnetic coil.

15. A device as claimed in Claim 13, wherein said locking member is operative in response to the speed of travel of said trolley to unlock the stopper for releasing the engagement of the stopper with said pivotal member.

16. A device as claimed in Claim 1, further comprising a pair of sheaves mounted on said suspension member for the training thereover of said ropes.

17. A device as claimed in any preceding Claim, with the trolley mounted on the beam of a crane with the ropes suspending the load suspension member from the sheave means.

18. A device according to claim 17, comprising load measuring means located adjacent one end of each of said ropes, means for winding the other end of each of said ropes thereon, and means coupled to said rope winding means for detecting the lengths of portions of said ropes depending from said trolley.



* C L M S *

19. A device as claimed in claim 18, further comprising a control means for controlling the amount of damping to be effected by said damping means to damp the pivotal movement of the pivotal member on the basis of the values detected by said load measuring means and said detecting means.

20. A device for damping the swinging movement of a load hung by a crane, sub-

stantially as hereinbefore described with 10 reference to and as shown by the accompanying drawings.

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Printed for Her Majesty's Stationery Office by The Tweeddale Press Ltd., Berwick-upon-Tweed, 1979.
Published at the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.



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