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PATENT SPECIFICATION (11)

1 304 125

DRAWINGS ATTACHED

(19)

- (21) Application No. 41479/71 (22) Filed 6 Sept. 1971
(31) Convention Application No. 77584 (32) Filed 2 Oct. 1970 in
(33) United States of America (US)
(44) Complete Specification published 24 Jan. 1973
(51) International Classification B66C 13/06 19/00
(52) Index at acceptance B8B 2A1 2A2 2A6 2B2 2B5



(54) A VARIABLE CENTRES ROPE SUSPENSION SYSTEM FOR A GANTRY CRANE

(71) We, FRUEHAUF CORPORATION, a Corporation organized and existing under the laws of the State of Michigan, United States of America, of 2350 Blanding Avenue, Alameda, California, United States of America, do hereby declare the invention, for which we 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:—

The present invention relates to anti-sway devices for inhibiting and arresting sway of a suspended load and more particularly it relates to a variable centres rope suspension system for a gantry crane.

A problem associated with the handling of cargo by large cranes is sway of the load as the load is moved between its pickup point and its deposition point. Due to the length of the ropes supporting the load, and the distance and speed with which the load must be moved to obtain the maximum utilization of the crane, the load experiences pendulum motion due to the combined action of the horizontal acceleration and deceleration forces acting on the inertia of the load.

It is necessary accurately to position the suspended load for deposition, and to effect this it is very important to be able to stop the horizontal movement of the load and accurately to place and release the load in the shortest possible time in order to reduce the cycle time of the crane in effecting the transfer of each cargo container.

Many types of methods and devices have been considered for the arresting or inhibiting of sway or pendulum motion of suspended loads. One such device which considers the problems involved is disclosed in the specification of United States Patent No. 3,375,938. The important features of the anti-sway device disclosed in the said patent specification include the capability of the anti-sway device to inhibit and arrest sway in all directions of motion, both forward and backward with respect to the crane, and rotational sway about a vertical axis. Further, it is important that the device

operate automatically and require no power input and only minor operator attention. However, the device of the referenced patent relates to a relatively short lift suspension system having relatively short suspension cables.

The problem of inhibiting sway in a crane having to lift a load from a high gantry involves quite different considerations which require a different approach to the problem but which demand the same features of automatic operation and negligible power input and operator attention. When the load is suspended from long ropes the amplitude of sway is increased and the problem of arresting or inhibiting sway is likewise greatly increased. A large crane is a very expensive item both to acquire and to operate, and it therefore is very important to obtain the maximum efficiency and utilization of the crane. To do this, it is necessary to pick up and move the load as fast as possible from its pickup point to its point of deposition. However this necessarily involves large horizontal acceleration and deceleration rates which are the primary factors inducing sway in a load.

When moving cargo containers between dockside and a ship, the containers must be moved from the pickup point to a position over the deposition point, and whether the container will be deposited within the guides of a shipboard cell, or on a pile of containers, or on a truck bed, or railroad car, the container must be very accurately located with respect to the deposition point before it is set down. With the very large and expensive cranes now being constructed, with the gantry typically 75 to 80 feet above the dock area, a need exists for an anti-sway device for high lift cranes which can increase the handling capacity of the crane by decreasing the cycle time of moving a container between its pickup and deposition points. This can be most effectively achieved by reducing the sway of the load while it is being handled by the crane to minimize the time required to accurately position the load for setdown and release.

The present invention is a variable centres rope suspension system for an overhead travelling crane. It is designed to reduce the swaying motion of a suspended load and to reduce the time necessary for locating and setting the load at its deposition point.

According to the present invention there is provided a variable centres rope suspension system for an overhead travelling crane comprising a crane structure supporting a gantry having a pair of trolley rails mounted thereon, at least one trolley assembly mounted on the rails, a load engaging means suspended from the trolley assembly by reeving depending from sheaves mounted on the trolley assembly, means for moving the sheaves apart a selected distance to incline the reeving with respect to the load engaging means to inhibit sway of the load, and means for moving the trolley assembly along the gantry rails to transport a load between its pickup and deposition areas.

In its preferred form the invention provides a variable centres rope suspension system for an overhead travelling crane comprising a crane structure supporting a gantry having a pair of trolley rails mounted thereon, a pair of generally rectangular trolleys mounted thereon, a frame interconnecting the trolleys and having slidable connections therewith, means for moving the trolleys along the gantry engaged with the frame, a pair of carriage screws mounted on the frame and engaged with the trolleys for reciprocating the trolleys with respect to the frame, drive means on the frame for synchronous rotation of the carriage screws in either direction to move the trolleys toward or away from each other, a pair of sheaves disposed at each end of each of the trolleys proximate the rails of the gantry and near the adjacent edges of the trolleys, a pair of sheaves disposed on each of the trolleys generally midway between the end pairs of sheaves and near the removed edges of the trolleys, a lifting spreader headblock suspended by wire ropes reeved from the sheaves on the trolleys, a pair of sheaves mounted coaxially at each end of the spreader headblock and generally at the lifting centre thereof, a pair of sheaves mounted on the spreader headblock midway between the end pairs of sheaves, a wire rope reeved through each pair of sheaves disposed at each end of the trolley and through one of the sheaves disposed at the corresponding end of the spreader headblock, a wire rope reeved through each pair of sheaves disposed midway between the end pairs of sheaves on the trolley and through one of the sheaves disposed midway between the end pairs of sheaves on said spreader headblock, and wire rope drums mounted on said crane for driving the wire rope reeving the sheaves mounted on the

trolleys being movable apart during use of the system to incline the reeving with respect to the spreader headblock to inhibit sway of the load.

A further aspect of the invention provides a method of arresting sway of a load suspended from a gantry crane including suspending a lifting spreader by wire ropes reeved from movable sheaves mounted on at least one trolley disposed on said gantry, and moving the sheaves apart when lifting a load attached to said spreader to incline the lifting ropes with respect to the spreader to inhibit sway of the load.

The present invention will become further apparent from the following description given by way of example with reference to the accompanying drawings, in which:

Figure 1 is a side elevation of a typical gantry crane employing the present invention;

Figure 2 is a plan view of the trolley and frame arrangement used in the crane of Figure 1;

Figure 3 is an end elevation of the trolley and frame arrangement and a suspended load as viewed along the gantry rails of the crane;

Figure 4 is a plan view of the trolley and frame and lifting spreader showing the reeving arrangement;

Figure 5 is a side elevation showing the reeving arrangement with the trolleys spaced apart a selected distance;

Figure 6 is an end elevation showing the reeving with the trolleys moved together;

Figure 7 is a schematic of the reeving of the trolleys and lifting spreader; and

Figure 8 is a schematic of the reeving of the drive for the trolleys on the gantry.

Referring to the drawings, there is shown a crane structure (21) supporting a gantry (23), which has trolley rails (25) thereon and which extend along both the boom portion (27) as well as the fixed portion (29) of the gantry. The crane itself is also mounted on rails (31) whereby it can be moved along the dock (33). The supporting structure of the crane is so arranged that a trolley assembly (35) mounted on the gantry can move from one end of the gantry to the other and carry a suspended load (37) thereunder without the load physically interfering with the crane supporting structure.

The trolley assembly (35) is mounted on the gantry rails and is movable therealong. In the preferred embodiment, the trolley assembly comprises a pair of trolleys (39,41) having means for moving said trolleys apart a selected distance. A means is provided which interconnects the trolleys and includes a frame (43) having sliding connections with each of the trolleys.

The means for moving the trolleys apart includes at least one carriage screw (45)

driven by a motor (47) mounted on the frame. The carriage screw includes a right hand threaded portion engaging one of the trolleys and a left handed threaded portion engaging the other of the trolleys whereby as the carriage screw is rotated in one direction or the other the trolleys are reciprocated with respect to the frame and to each other.

In the preferred embodiment, the trolleys are generally rectangular and have wheels (49) mounted at the ends thereof which engage the gantry rails (25). This can be seen most clearly in Figures 2 to 4 of the drawings. The frame is shown in Figure 2 as having longitudinal side beams (51) and interconnecting cross braces (53). The frame is carried on the trolleys by means of sliding connections which include side (55), bottom (57), and, if necessary, top rollers (not shown) mounted on the trolleys within which the longitudinal side beams (51) of the frame reciprocate.

A motor (47) is mounted on the middle cross-brace (61) of the frame and includes a pair of drive shafts (63) which rotate differential gear transmissions (65). The gear transmissions drive carriage screws (45) which engage the trolleys through a threaded flange (67) secured to the trolleys. The outside ends of the carriage screws are mounted in bearing blocks (69) mounted on the frame. The carriage screws on opposite sides of the differential housings have opposite threads whereby as the motor is turned in one direction or the other the trolleys will reciprocate and move toward or away from each other. Limit switches are provided whereby as the trolleys reach their furthest extension or closest approach, the motor is automatically shut down to prevent any damage to the reciprocating drive system.

The frame (43) and drive screws (45), or any other suitable drive means, could be fixed to one of the trolleys whereby that trolley is dominant and the other trolley acts as a movable outrigger with respect to the dominant one.

A lifting spreader (71) quick change headblock is suspended from the trolley (35) by reeving depending from sheaves mounted on the individual trolleys and engaging sheaves mounted on the headblock. The quick change headblock can be attached to different length lifting spreaders or to a lifting beam to permit different sizes of cargo containers to be handled as well as other types of loads. The sheaves can be mounted directly on the spreader if versatility in load handling is not required.

The reeving includes at least two sets of sheaves (73,75,77,79) spaced apart on each of the trolleys and at least two sheaves (81,83) mounted proximate each end of the headblock. In the preferred embodiment, the

two sets of sheaves on the trolleys are each located in the corners of the trolleys proximate the gantry rails and proximate the adjacent edges of the two trolleys. Reference is made to Figures 2 and 4 which show the particular trolley and lifting spreader headblock sheave arrangements wherein the first pair of sheaves (73) of the first or left hand trolley 39 is located closer to the rails (25) than the second set of corresponding sheaves (77) on the other or second trolley at the proximate or first ends of said trolleys.

A similar staggering of the sheaves is provided for the other or third and fourth sets of sheaves (75,79) at the other corresponding or second ends of the trolleys. The sets of sheaves (81,83) at the ends of the lifting spreader headblock are coaxially mounted at the longitudinal lift centre of the headblock. Other positioning of the sheaves on either the trolley or the headblock can also fulfil the requirements of the present invention.

One wire rope is reeved from each of the sets of sheaves on each of the trolleys through at least one corresponding sheave disposed at the end of the headblock proximate or corresponding to the set of sheaves the wire rope is reeved from. In the preferred embodiment, this is effected by a first wire rope (85) being reeved from a first wire rope drum (87) outward along the gantry and over a first trolley sheave (89) in the first set of sheaves (73) on the left trolley (39) and down to the lifting spreader headblock (71), through a first load sheave of the sheaves (91) coaxially mounted in the pair of sheaves (81) at the first end of the spreader headblock proximate the first set of trolley sheaves (73) the wire rope is reeved from, back up over the other or second trolley sheave (93) of the first set of sheaves (73) from which trolley the rope is reeved, the first trolley, and then outward until it is deadened (95) with an adjustable connection (97) at the end of the gantry. A second wire rope (99) is reeved outward along the gantry from the same or first wire rope drum (87) and over third trolley sheave (101), one of the sheaves on the other or second trolley (41) in the set of sheaves at the first end corresponding to the first end of the first trolley, down through the other load sheave or second coaxially mounted sheave (103) of the pair of sheaves (81) at the first end of the spreader headblock, corresponding to the first ends of the first and second trolleys, and proximate the set of trolley sheaves (77) from which the wire rope is reeved, and back up over a fourth trolley sheave (105) or the other sheave of the set of trolley sheaves (77) on the second trolley, and outboard to the end of the gantry where it is adjustably deadened (107).

The same wire rope reeving arrangement

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from a second wire rope drum (109) occurs at the other or second ends of the first and second trolleys for supporting the other or second end of the lifting spreader headblock.

To prevent or arrest rocking of the load about the coaxially mounted headblock sheaves, the reeving for suspending the lifting spreader can also include at least one middle set of sheaves (111,113) mounted generally in the middle of each of the trolleys and two lead sheaves (115,117) mounted midway from the ends of the spreader headblock and turned 90° with respect to the sheaves on the trolleys. A third wire rope (119) is reeved from a third wire rope drum (121) over a fifth trolley sheave (123) located on the first trolley close to the outer edge (125) of the first trolley, down around a third load sheave (115) on the side of the spreader headblock corresponding to the first or left trolley, back up and over a sixth trolley sheave (127) mounted on the first trolley close to the inner edge (129) of the first trolley adjacent to the second trolley, and outward along the gantry and deadened at the end of the gantry with an adjustable connection (131). A fourth wire rope (133) is then reeved from the third drum (121) outboard over a seventh trolley sheave (135) mounted close to the inner edge (137) of the second trolley adjacent to the first trolley, down around a fourth load sheave (117) mounted on the spreader headblock on the edge (139) of the headblock corresponding or proximate to the second trolley, back up around an eight trolley sheave (141) mounted close to the outer edge (143) of said second trolley, and outboard to the end of the gantry where it is deadened with an adjustable connection (145).

In the preferred embodiment, three wire rope drums (87,109,121) are utilized for driving the reeving which suspends the spreader. However, two drums could be employed with the three ropes on each side of the centre of the spreader headblock being reeved over the same drum, and all wire ropes could be reeved from a single drum.

Means are provided for co-ordinated moving of the trolleys along the gantry in any selected spaced apart relation. In the preferred embodiment, this is effected by engaging the moving means with the means which interconnects the trolleys. In other words, the drive cables for the trolleys are secured to the frame (43) which interconnects them. This reeving and drive arrangement is shown in Figure 8 of the drawings in a schematic form. Two continuously reeved wire ropes (147,149) are wrapped around drive drums (151,153) and run out around pulleys (155,157) at the end of the gantry where they reverse direction and run

inward and are secured (159,161) to the trolley interconnecting frame (43). The other ends (163,165) of the wire are secured to the frame and go rearward around reversing sheaves (167,169) at the rear end of the gantry, up over a set of tensioner pulleys (171,173), and outward to the drive drums (151,153).

While the preferred embodiment of the invention shows a pair of trolleys interconnected by a frame, the trolley assembly can be considered as a single unit having movable portions. The important feature is that means are provided for spacing the sheaves, mounted on the trolley assembly, apart from each other any selected distance. Thus it is contemplated that simply a single trolley could be provided with movable sheaves mounted on the trolley, and this would effect the invention equally as well as the preferred embodiment. Alternatively a trolley could be provided with a movable outrigger which would carry the sheaves. In either form, the means for co-ordinated moving of the trolleys along the gantry would probably involve attaching the drive cables directly to the trolleys rather than to an interconnecting frame. The basic concept of the invention is the fact that sheaves supporting the lifting spreader can be moved apart on the gantry of the crane and then moved in the spaced apart relation along the gantry with synchronous movements.

In operation, the load is picked up under the crane from a stack of containers, or a railroad flat car or a truck bed or from within a cell on board a ship, or off a storage rack on the deck of a ship, and then lifted from the pickup point and moved to its deposition area. If the container is being moved from a shoreside position to on board a ship, it is picked up usually with the trolleys spread apart and moved in that condition at relatively high speed outboard on the gantry until it is over the deposition point. If this be on top of the ship, then the trolleys can be left in their spaced apart position and the load deposited on the ship. However, if the load must be dropped into the hold of the ship within a cell, the load is moved over its deposition point, and after it has stopped swaying, the trolleys are then moved together and the load concurrently lowered into the cell guides as shown in Figure 1 of the drawings where the trolleys are illustrated in the outboard position. This is also illustrated in Figure 4 of the preferred embodiment views. The reeving is then retrieved and pulled up out of the ship, and as it is moved inboard, the trolleys are moved apart and spaced, and the cycle is begun again when the trolleys reach the inboard position over the pickup point.

The moving apart of the trolleys during the lifting and movement of the load inclines

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the reeving which supports the lifting spreader whereby sway is inhibited or arrested by placing horizontal force components on the load through the inclined lifting ropes.

An operator's cab is suspended from the end of the frame interconnecting the trolleys. It contains controls for remotely controlling the movement of the trolleys along the gantry, and for moving the trolleys apart any selected distance within the range of operation, and for operating the crane to handle the container or any other load.

WHAT WE CLAIM IS:—

1. A variable centres rope suspension system for an overhead travelling crane comprising a crane structure supporting a gantry having a pair of trolley rails mounted thereon, at least one trolley assembly mounted on the rails, a load engaging means suspended from the trolley assembly by reeving depending from sheaves mounted on the trolley assembly, means for moving the sheaves apart a selected distance to incline the reeving with respect to the load engaging means to inhibit sway of the load, and means for moving the trolley assembly along the gantry rails to transport a load between its pickup and deposition areas.

2. A system according to claim 1, wherein the trolley assembly comprises a pair of trolleys mounted on the rails and carrying the sheaves, the trolleys being movable apart a selected distance to incline the reeving with respect to the load engaging means, and the trolleys being movable along the gantry in their selected spaced apart relation.

3. A system according to claim 2 wherein the means for moving the trolleys apart includes means interconnecting the trolleys.

4. A system according to claim 3 wherein the means interconnecting said trolleys includes a remotely controlled power drive for moving the trolleys apart any selected distance within its range of operation.

5. A system according to claim 3 or 4, wherein the means for moving of the trolleys along the gantry is engaged with the means interconnecting the trolleys.

6. A system according to claim 3, 4 or 5, wherein the means interconnecting the trolleys includes a frame having sliding connections with each of the trolleys.

7. A system according to claim 6 when appendant to claim 4, wherein the power drive includes at least one carriage screw driven by a motor on the frame, said carriage screw having a right hand threaded portion engaging one of the trolleys and a left hand threaded portion engaging the other of the trolleys for reciprocating the trolleys with respect to the frame.

8. A system according to any one of claims 2 to 7, wherein the reeving depending

from each of the trolleys for suspending the load engaging means includes at least two sets of sheaves spaced apart on each of the trolleys and a lifting spreader headblock having at least two sheaves proximate each end of the headblock and wire rope reeved from each of the sets of sheaves on each of the trolleys through at least one corresponding sheave disposed at the end of the headblock proximate the set of sheaves from which the wire rope is reeved.

9. A system according to claim 8, wherein the wire rope reeving being reeved through the sets of sheaves disposed at corresponding ends of the trolleys is driven by the same wire rope drum.

10. A system according to any one of claims 2 to 9, wherein the reeving depending from each of the trolleys for suspending the lifting spreader headblock includes at least one set of sheaves located substantially centrally on each of the trolleys and a lifting spreader headblock having at least a pair of sheaves disposed midway from the ends of the spreader headblock and wire rope reeved from each of the sets of sheaves on the trolleys through at least one of the sheaves disposed midway from the ends of the headblock.

11. A variable centres rope suspension system for an overhead travelling crane comprising a crane structure supporting a gantry having a pair of trolley rails mounted thereon, a pair of generally rectangular trolleys mounted thereon, a frame interconnecting the trolleys and having slidable connections therewith, means for moving the trolleys along the gantry engaged with the frame, a pair of carriage screws mounted on the frame and engaged with the trolleys for reciprocating the trolleys with respect to the frame, drive means on the frame for synchronous rotation of the carriage screws in either direction to move the trolleys toward or away from each other, a pair of sheaves disposed at each end of each of the trolleys proximate the rails of the gantry and near the adjacent edges of the trolleys, a pair of sheaves disposed on each of the trolleys generally midway between the end pairs of sheaves and near the removed edges of the trolleys, a lifting spreader headblock suspended by wire ropes reeved from the sheaves on the trolleys, a pair of sheaves mounted coaxially at each end of the spreader headblock and generally at the lifting centre thereof, a pair of sheaves mounted on the spreader headblock midway between the end pair of sheaves a wire rope reeved through each pair of sheaves disposed at each end of the trolley and through one of the sheaves disposed at the corresponding end of the spreader headblock, a wire rope reeved through each pair of sheaves disposed midway between the end pairs of sheaves on

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the reeving which supports the lifting spreader whereby sway is inhibited or arrested by placing horizontal force components on the load through the inclined lifting ropes.

An operator's cab is suspended from the end of the frame interconnecting the trolleys. It contains controls for remotely controlling the movement of the trolleys along the gantry, and for moving the trolleys apart any selected distance within the range of operation, and for operating the crane to handle the container or any other load.

WHAT WE CLAIM IS:—

1. A variable centres rope suspension system for an overhead travelling crane comprising a crane structure supporting a gantry having a pair of trolley rails mounted thereon, at least one trolley assembly mounted on the rails, a load engaging means suspended from the trolley assembly by reeving depending from sheaves mounted on the trolley assembly, means for moving the sheaves apart a selected distance to incline the reeving with respect to the load engaging means to inhibit sway of the load, and means for moving the trolley assembly along the gantry rails to transport a load between its pickup and deposition areas.

2. A system according to claim 1, wherein the trolley assembly comprises a pair of trolleys mounted on the rails and carrying the sheaves, the trolleys being movable apart a selected distance to incline the reeving with respect to the load engaging means, and the trolleys being movable along the gantry in their selected spaced apart relation.

3. A system according to claim 2 wherein the means for moving the trolleys apart includes means interconnecting the trolleys.

4. A system according to claim 3 wherein the means interconnecting said trolleys includes a remotely controlled power drive for moving the trolleys apart any selected distance within its range of operation.

5. A system according to claim 3 or 4, wherein the means for moving of the trolleys along the gantry is engaged with the means interconnecting the trolleys.

6. A system according to claim 3, 4 or 5, wherein the means interconnecting the trolleys includes a frame having sliding connections with each of the trolleys.

7. A system according to claim 6 when appendant to claim 4, wherein the power drive includes at least one carriage screw driven by a motor on the frame, said carriage screw having a right hand threaded portion engaging one of the trolleys and a left hand threaded portion engaging the other of the trolleys for reciprocating the trolleys with respect to the frame.

8. A system according to any one of claims 2 to 7, wherein the reeving depending

from each of the trolleys for suspending the load engaging means includes at least two sets of sheaves spaced apart on each of the trolleys and a lifting spreader headblock having at least two sheaves proximate each end of the headblock and wire rope reeved from each of the sets of sheaves on each of the trolleys through at least one corresponding sheave disposed at the end of the headblock proximate the set of sheaves from which the wire rope is reeved.

9. A system according to claim 8, wherein the wire rope reeving being reeved through the sets of sheaves disposed at corresponding ends of the trolleys is driven by the same wire rope drum.

10. A system according to any one of claims 2 to 9, wherein the reeving depending from each of the trolleys for suspending the lifting spreader headblock includes at least one set of sheaves located substantially centrally on each of the trolleys and a lifting spreader headblock having at least a pair of sheaves disposed midway from the ends of the spreader headblock and wire rope reeved from each of the sets of sheaves on the trolleys through at least one of the sheaves disposed midway from the ends of the headblock.

11. A variable centres rope suspension system for an overhead travelling crane comprising a crane structure supporting a gantry having a pair of trolley rails mounted thereon, a pair of generally rectangular trolleys mounted thereon, a frame interconnecting the trolleys and having slidable connections therewith, means for moving the trolleys along the gantry engaged with the frame, a pair of carriage screws mounted on the frame and engaged with the trolleys for reciprocating the trolleys with respect to the frame, drive means on the frame for synchronous rotation of the carriage screws in either direction to move the trolleys toward or away from each other, a pair of sheaves disposed at each end of each of the trolleys proximate the rails of the gantry and near the adjacent edges of the trolleys, a pair of sheaves disposed on each of the trolleys generally midway between the end pairs of sheaves and near the removed edges of the trolleys, a lifting spreader headblock suspended by wire ropes reeved from the sheaves on the trolleys, a pair of sheaves mounted coaxially at each end of the spreader headblock and generally at the lifting centre thereof, a pair of sheaves mounted on the spreader headblock midway between the end pair of sheaves a wire rope reeved through each pair of sheaves disposed at each end of the trolley and through one of the sheaves disposed at the corresponding end of the spreader headblock, a wire rope reeved through each pair of sheaves disposed midway between the end pairs of sheaves on



the trolley and through one of the sheaves disposed midway between the end pair of sheaves on said spreader headblock, and wire rope drums mounted on said crane for driving the wire rope reeving the sheaves mounted on the trolleys being movable apart during use of the system to incline the reeving with respect to the spreader headblock to inhibit sway of the load.

12. A method of arresting sway of a load suspended from a gantry crane including suspending a lifting spreader by wire ropes reeved from movable sheaves mounted on at least one trolley disposed on said gantry, and moving the sheaves apart when lifting a load attached to said spreader to incline the lifting ropes with respect to the spreader to inhibit sway of the load.

13. A method according to claim 12 wherein the sheaves are mounted on a pair of trolleys which are moved apart when lift-

ing a load attached to the spreader to incline the lifting ropes with respect to the spreader to inhibit sway of the load, and moving the trolleys synchronously in the spaced apart relation along said gantry when moving the load between its pickup and deposition area.

14. A variable centres rope suspension system constructed and arranged to operate substantially as herein described with reference to and as illustrated in the accompanying drawings.

15. A method of arresting sway of a load suspended from a gantry crane substantially as herein described with reference to the accompanying drawings.

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(9818)

Printed in Scotland by Her Majesty's Stationery Office
at HMSO Press, Edinburgh, 1972.

Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY,
from which copies may be obtained.



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