

SYSTEM FOR TRAVERSING TROLLEY

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BACKGROUND OF THE INVENTION

The present invention relates to a system for traversing a trolley.

Fig. 1 schematically illustrates a conventional general container crane 3 for loading and unloading containers 4 to and from a container ship 1 moored at a quay 2.

The container crane 3 as shown comprises legs 5 adapted to run along the quay 2, a pair of girders 6 on top of the legs 5 and protruding toward the sea and a trolley 7 mounted between the girders 6 and adapted to be traversed or moved in traverse direction.

The trolley 7 has a spreader 8 suspended from the same through a head block 9 for gripping the container 4. The spreader 8 can be hoisted up and down by winding and unwinding the rope 10, respectively, using a hoist drum 12 in a machine room 11.

Therefore, for example, when the container 4 is to be unloaded from the container ship 1 by the container crane 3, the trolley 7 is traversed to a position above the container ship 1 and the spreader 8 is hoisted down from the trolley 7 to grip the container 4 on the ship 1. Then, the spreader 8 is hoisted up and the trolley 7 is traversed toward an unloading position on the quay 2 and is hoisted down to place the container 4 in position on the quay 2.

The trolley 7 used for the container crane 3 is traversed by towing of ropes, using a traverse drum 13 in the machine room 11. More specifically, as shown in Fig. 2, a rope 14 tied on one end of the trolley 7 is passed over a sheave 15 on one longitudinal ends of the girders 6 and is wound through sheaves 16 and 17 around the traverse drum 13. A rope 18 tied on the other end of the trolley 7 is passed over a sheave 19 on the other longitudinal ends of the girders 6 and is wound in reverse direction through sheaves 20 and 21 around the traverse drum 13. Rotation of the traverse drum 13 causes one and the other of the ropes 14 and 18 to be wound and unwound, respectively, or vice versa so that the trolley 7 is traversed longitudinally of the girders 6.

In Fig. 2, reference numeral 22 represents rails laid longitudinally of the girders 6; and 23, wheels of the trolley 7.

However, the conventional traversing system in the form of the ropes 14 and 18 towed as described above can hardly traverse the trolley 7 at higher traverse speed. Therefore, there have been strong demands on increasing the traverse speed of the trolley 7 so as to reduce cycle time of loading and unloading operations.

Furthermore, in the conventional traversing system for the trolley 7, an actual unwound amount of the rope 14 or 18 tends to become disproportionate to number of revolutions (angle of rotation) of the traverse drum 13 because of



elongation in length of the ropes 14 and 18 and/or wear of the sheaves 15, 16, 17, 19, 20 and 21 with the lapse of time, disadvantageously resulting in inaccurate control of traverse position of the trolley 7.

Moreover, when rotating speed of the traverse drum 13 is changed, it takes some time until the actual traverse speed of the trolley 7 can follow the change. This time lag results in ill responsiveness to a command of speed control. As a result, acceleration or deceleration of the trolley 7 cannot be adjusted at good timing for the purpose of effecting swing- or vibration-suppressing control of suspended cargo, i.e., offsetting any swinging or vibration of the cargo.

The ropes 14 and 18, which are liable to be worn out with short time, must be replaced once in six months or a year. This means that more cost and labor are needed for the replacement of the ropes 14 and 18. Further, in the traversing system, there are many mechanical moving parts such as a drive motor for the drum 13, reduction gears and the sheaves 15, 16, 17, 19, 20 and 21 which require frequent maintenance and inspection, resulting in much burden on workers for maintenance and inspection operation.

BRIEF SUMMARY OF THE INVENTION

The present invention was made in view of the above and has its object to provide a system for traversing a trolley in which the trolley can be traversed at higher speed



and with increased accuracy in position control and in swing-suppressing control and in which cost and burden for maintenance and inspection are reduced.

The present invention is directed to a system for traversing a trolley along girders, which comprises linear induction motor means having a primary-side component in the form of coils and a secondary-side component in the form of reaction plates, one of said primary- and secondary-side components being arranged on the girders over a transverse range of the trolley, the other of said primary- and secondary-side components being arranged on the trolley to face to said one of the components in a minute spaced-apart relationship.

More specifically, reaction plates may be arranged on either upper or lower surfaces of the girders and coils may be arranged on the trolley to vertically face to the reaction plates; alternatively, coils may be arranged on either upper or lower surfaces of the girders and reaction plates may be arranged on the trolley to vertically face to the coils.

The reaction plates may be arranged on side surfaces of the girders and the coils may be arranged on the trolley to laterally face to the reaction plates; alternatively, the coils may be arranged on side surfaces of the girders and the reaction plates may be arranged on the trolley to laterally face to the coils.

In the cases where, as mentioned above, the reaction plates or the coils are arranged on side surfaces of the

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girders and the coils or the reaction plates are arranged on the trolley to laterally face to said reaction plates or the coils, it is preferable that sets of the coils and the reaction plates are arranged at symmetrical positions.

Preferred embodiments of the present invention will be described in conjunction with the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 schematically illustrates a conventional general container crane;

Fig. 2 is a schematic perspective view of a traverse system for the trolley shown in Fig. 1;

Fig. 3 is a side view of a first embodiment according to the present invention;

Fig. 4 is a view looking in the direction of arrows IV in Fig. 3;

Fig. 5 is a side view of a second embodiment according to the present invention;

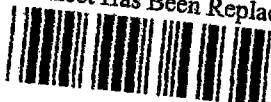
Fig. 6 is a view looking in the direction of arrows VI in Fig. 5;

Fig. 7 is a side view of a third embodiment according to the present invention;

Fig. 8 is view looking in the direction of arrows VIII in Fig. 7;

Fig. 9 is a side view of a fourth embodiment according to the present invention; and

Fig. 10 is a view looking in the direction of arrows X



in Fig. 9.

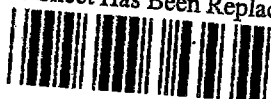
DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figs. 3 and 4 illustrate a first embodiment of the present invention in which the same components as those in Figs. 1 and 2 are referred to by the same reference numerals.

As shown in the figures, each of girders 6 has a reaction plate 25 which is attached to a lower surface of the girder 6 over a traverse range of a trolley 7 and which constitutes a secondary-side component of linear induction motor means 24. On the other hand, the trolley 7 has coils 26 which are respectively mounted on corners of the trolley 7 via brackets 27 and which constitute a primary-side component of the induction motor means 24. The coils 26 face from below to the reaction plates 25 in a minute spaced-apart relationship.

The reaction plate 25 may be a composite conductor which is a combination of a copper or aluminum plate through which induction current can easily pass with an iron plate through which magnetic flux can easily pass. In general, the iron plate is made thicker than the copper or aluminum plate from a viewpoint of strength.

One of the girders 6 has, at its inner side surface, three feeder wires 28 extending along rails 22 for guidance of travelling wheels 23 of the trolley 7. The feeder wires 28 is supplied with three-phase alternating current via an inverter from a power source (not shown).



Further, the trolley 7 is provided, at its side surface opposite to the feeder wires 28, with current collectors 29 which receive electric current in sliding contact with the feeder wires 28. The three-phase alternating current received by the collectors 29 is supplied to each of the coils 26.

Thus, with voltage and frequency of the current being adequately controlled by the inverter, the three-phase alternating current is supplied through the feeder wires 28 and the current collectors 29 to each of the coils 26 on the trolley 7, so that travelling magnetic field in traverse direction of the trolley 7 is generated on each of the coils 26. The travelling magnetic fields thus generated induce eddy currents on the reaction plates 25 on the girders 6. As a result, thrust force is generated in accordance with Fleming's left-hand rule and, in reaction thereto, the trolley 7 is traversed or moved in traverse direction with respect to the girders 6.

In order to brake the movement of the trolley 7, regenerative braking is employed in which the linear induction motor means 24 is operated to act as a power generator to convert mechanical energy generated by inertia of the trolley 7 to electric energy which in turn is sent back to the power source. Mechanical braking may be simultaneously used to maintain the traverse position.

In this embodiment, the linear induction motor means 24 is used to traverse the trolley 7 so that the traverse speed



of the trolley 7 can be increased to an extent unattainable in the prior art and cycle time of the loading and unloading operations can be reduced.

The traversing system of the present invention has no undesirable influences on position control of the trolley 7 due to elongation of ropes and/or wear of sheaves with the elapse of time as are often seen in conventional rope-towing type traverse systems, so that the traverse position of the trolley 7 can be controlled at higher accuracy. Because of electrical speed control by means of the linear induction motor means 24, responsiveness to a command of speed control is also improved, so that acceleration or deceleration of the trolley 7 can be adjusted at good timing for the purpose of effecting swing- or vibration-suppressing control of suspended cargo at higher accuracy, i.e., offsetting any swinging or vibration of the cargo at higher accuracy.

Moreover, there is no need of replacing ropes as is required in the conventional rope-towing type traverse systems, and there are no mechanical moving parts such as a drive motor for a traverse drum, reduction gears and sheaves. Thus, it is not necessary to frequently perform maintenance and inspection for mechanical moving parts, which makes it possible to extensively reduce the burden on workers for the maintenance and inspection and to substantially reduce the cost therefor.

Further, there is no need of arranging a traverse drum, a drive motor, reduction gears, etc. in the machine room



unlike the conventional systems so that the machine room can be designed compact in size.

Also, in the above embodiment, the reaction plate 25 is made of a composite conductor which is a combination of a copper or aluminum plate through which induction current can easily pass with an iron plate through which magnetic flux can easily pass, and the iron plate is made thicker than the copper or aluminum plate from the viewpoint of strength. Then, electromagnetic vertical force acts as suction force between the reaction plates 25 and the coils 26, so that the coils 26 on the trolley 7 are sucked upwardly to the reaction plates 25 arranged on the lower surfaces of the girders 6 to apply floating force on the trolley 7. This can alleviate the burden of the load applied to the wheels 23 of the trolley 7.

More specifically, in the linear induction motor means 24, electromagnetic vertical force generated together with the thrust force acts as suction or repellent force in the case where the reaction plate 25 is made of magnetic or non-magnetic substance, respectively. In the case where the reaction plate 25 is a composite conductor made of magnetic and non-magnetic substances, any difference between suction and repellent forces applied to each conductor acts as electromagnetic vertical force; therefore, electromagnetic vertical force acts as suction force when, in such composite conductor made of an iron plate with a copper or aluminum plate, the iron plate is made thicker than the copper or aluminum plate which is non-magnetic and through which



induction current can easily pass.

As mentioned above, generally, the reaction plate 25 is the composite conductor with the iron plate being made thicker than the copper or aluminum plate and therefore the electromagnetic vertical force generated between the reaction plates 25 and the coils 26 acts as suction force. However, it is of course also possible that the reaction plate 25 is a composite conductor in which the copper or aluminum plate is made thicker than the iron plate and that the electromagnetic vertical force acts as repellent force. In the latter case, the reaction plates 25 are to be arranged on the upper surfaces of the girders 6, and the coils 26 on the trolley 7 are to face from above to the reaction plates 25. Thus, floating force is applied to the trolley 7 as in the case of the above embodiment, which reduces the burden of the load applied to the wheels 23 of the trolley 7.

Figs. 5 and 6 illustrate a second embodiment of the present invention in which the arrangement of the reaction plates 25 and the coils 26 is reversed from that of the first embodiment described above. More specifically, coils 26 which constitutes a primary-side component of linear induction motor means 24 are arranged on the lower surface of the girders 6 over the traverse range of the trolley 7. On the other hand, reaction plates 25 which constitutes a secondary-side component of the linear induction motor means 24 are arranged on the lower surface of the trolley 7 at its respective corners via brackets 27 to face from below to the



coils 26 in a minute spaced-apart relationship.

Of course, the reaction plates 25 in this second embodiment is made of a composite conductor which is a combination of a copper or aluminum plate through which induction current can easily pass with an iron plate through which magnetic flux can easily pass, and the iron plate is made thicker than the copper or aluminum plate from the viewpoint of strength.

In order to eliminate unnecessary excitation of the coils 26 at positions away from the present position of the trolley 7 and to reduce power consumption and heating as much as possible, it is preferred that the coils 26 are arranged in longitudinal blocks on the lower surfaces of the girders 6 so as to selectively energize the blocks and that three-phase alternating current is supplied from the power source via the inverter only to the selected blocks of coils 26 corresponding to the traverse position of the trolley 7.

Thus, with voltage and frequency being adequately controlled by the inverter, three-phase alternating current is supplied to the selected blocks of coils corresponding to the traverse position of the trolley 7 to thereby generate, on the selected blocks of coils 26, movable magnetic fields in traverse direction of the trolley 7. This induces eddy currents on the reaction plates 25 on the trolley 7, so that thrust force is generated in accordance with Fleming's left-hand rule and, in reaction thereto, the trolley 7 is traversed or moved in traverse direction with respect to the



girders 6. Therefore, the second embodiment can attain the same effects as in the first embodiment as described above.

Figs. 7 and 8 illustrate a third embodiment of the present invention in which reaction plates 25 constituting a secondary-side component of linear induction motor means 24 are arranged symmetrically on inner side surfaces of girders 6 at positions lower than rails 22 for guidance of the wheels 23 of the trolley 7 and over the traverse range of a trolley 7. On the other hand, coils 26 constituting a primary-side component of the linear induction motor means 24 are arranged symmetrically on opposite ends of the trolley 7 to laterally face to the reaction plates 25 in a minute spaced-apart relationship.

Similarly to the first embodiment described above, one of the girders 6 has, on its inner surface at positions higher than the rails 22, three feeder wires 28 extending along the rails 22. Three-phase alternating current is supplied to the feeder wires 28 via the inverter from the power source (not shown).

At positions on the trolley 7 opposed to each of the feeder wires 28, current collectors 29 are arranged to receive current in sliding contact with the feeder wires 28, and three-phase alternating current received by the collectors 29 is supplied to each of the coils 26.

Thus, with voltage and frequency being adequately controlled by the inverter, three-phase alternating current is supplied to each of the coils 26 on the trolley 7 via the



feeder wires 28 and the collectors 29 to thereby generate movable magnetic field in traverse direction of the trolley 7 on each of the coils. This induces eddy currents on the reaction plates 25 on the girders 6, so that thrust force is generated in accordance with Fleming's left-hand rule and, in reaction thereto, the trolley 7 is traversed or moved in traverse direction with respect to the girders 6. Thus, almost the same effects as in the first and second embodiments can be attained by the third embodiment. In the third embodiment, sets of the coils 26 and the reaction plates 25 constituting primary- and secondary-side components of the linear induction motor means 24 are arranged at symmetrical positions at opposite sides of the trolley 7, so that electromagnetic vertical forces generated in mutually opposite directions at opposite sides of the trolley 7 can be offset.

Figs. 9 and 10 illustrate a fourth embodiment of the present invention in which the arrangement of the reaction plates 25 and the coils 26 in the third embodiment is reversed. More specifically, coils 26 constituting a primary-side component of linear induction motor means 24 are arranged symmetrically on inner side surfaces of girders 6 at positions lower than rails 22 over the traverse range of a trolley 7. On the other hand, reaction plates 25 constituting a secondary-side component of the linear induction motor means 24 are arranged symmetrically on opposite ends of the trolley 7 to laterally face to the reaction plates 25 in a



minute spaced-apart relationship.

In this case, as in the case of the above-mentioned second embodiment, in order to eliminate unnecessary excitation of the coils 26 at positions away from the present position of the trolley 7 and to reduce power consumption and heating as much as possible, it is preferred that the coils 26 are arranged in longitudinal blocks on the lower surfaces of the girders 6 so as to selectively energize the blocks and that three-phase alternating current is supplied from the power source via the inverter only to the selected blocks of coils 26 corresponding to the traverse position of the trolley 7.

Thus, with voltage and frequency being adequately controlled by the inverter, three-phase alternating current is supplied to the selected blocks of coils 26 corresponding to the traverse position of the trolley 7 to thereby generate, on the selected blocks of coils 26, movable magnetic fields in traverse direction of the trolley 7. This induces eddy currents on the reaction plates 25 on the trolley 7, so that thrust force is generated in accordance with Fleming's left-hand rule and, in reaction thereto, the trolley 7 is traversed or moved in traverse direction with respect to the girders 6. Therefore, the fourth embodiment can attain the same effects as in the third embodiment as described above.

It is to be understood that a system for traversing a trolley according to the present invention is not limited to the embodiments described above and that various changes and



modifications may be made without departing from the spirit and the scope of the present invention. For example, the invention may be applied to a trolley traversed on girders in an overhead crane or a mono-rail type trolley on a single girder.

As described above, a system for traversing a trolley according to the present invention can attain the following superb effects:

- (I) Linear induction motor means is used to traverse the trolley so that the traverse speed of the trolley can be increased to an extent unattainable by the prior art and cycle time of the loading and unloading operations can be reduced.
- (II) Lack of undesirable influences on position control of the trolley due to elongation of ropes and/or wear of sheaves with the elapse of time as are seen in conventional rope-towing type traverse systems, makes it possible to control the traverse position of the trolley at higher accuracy. Moreover, electrical speed control by the linear induction motor means improves responsiveness to a command of speed control, so that acceleration or deceleration of the trolley can be adjusted at good timing for the purpose of effecting swing- or vibration-suppressing control of suspended cargo at higher accuracy, i.e., offsetting any swinging or vibration of the cargo at higher accuracy.
- (III) There is no need of replacing ropes as is required in the conventional rope-towing type traverse systems, and there



are no mechanical moving parts such as a drive motor for a traverse drum, reduction gears and sheaves. Thus, it is not necessary to frequently perform maintenance and inspection for mechanical moving parts, which makes it possible to extensively reduce the burden on workers for the maintenance and inspection and to substantially reduce the cost therefor.

(IV) There is no need of arranging a traverse drum, a drive motor, reduction gears, etc. in the machine room unlike the conventional systems so that the machine room can be designed compact in size.

(V) In a case where electromagnetic vertical force generated between the reaction plates and the coils acts as suction force, the reaction plates or the coils are arranged on the lower surfaces of the girders, and the coils or the reaction plates are arranged on the trolley to face from below to the reaction plates or the coils on the girders; alternatively in a case where electromagnetic vertical force acts as repellent force, the reaction plates or the coils are arranged on the upper surfaces of the girders, and the coils or the reaction plates are arranged on the trolley to face from above to the coils or the reaction plates on the girders. As a result, floating force is applied to the trolley to alleviate the burden of the load applied to the wheels of the trolley.

(VI) In a case where the reaction plates or the coils are arranged on side surfaces of the girders and the coils or the reaction plates are arranged on opposite ends of the trolley to laterally face to the reaction plates or the coils on the



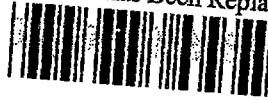
girders, respectively, sets of the coils and the reaction plates are arranged at symmetrical positions at opposite sides of the trolley. This can offset electromagnetic vertical forces generated in mutually opposite directions at opposite sides of the trolley.

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What is Claimed is:

1. A system for traversing a trolley along girders, which comprises linear induction motor means having a primary-side component in the form of coils and a secondary-side component in the form of reaction plates, one of said primary- and secondary-side components being arranged on the girders over a transverse range of the trolley, the other of said primary- and secondary-side components being arranged on the trolley to face to said one of the components in a minute spaced-apart relationship.
2. A system according to claim 1 wherein the reaction plates are arranged on either upper or lower surfaces of the girders and the coils are arranged on the trolley to vertically face to the reaction plates.
3. A system according to claim 1 wherein the coils are arranged on either upper or lower surfaces of the girders and the reaction plates are arranged on the trolley to vertically face to the coils.
4. A system according to claim 1 wherein the reaction plates are arranged on side surfaces of the girders and the coils are arranged on the trolley to laterally face to the reaction plates.



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5. A system according to claim 1 wherein the coils are arranged on side surfaces of the girders and the reaction plates are arranged on the trolley to laterally face to the coils.

6. A system according to claim 4 wherein sets of the coils and the reaction plates are arranged at symmetrical positions.

7. A system according to claim 5 wherein sets of the coils and the reaction plates are arranged at symmetrical positions.

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