TITLE: METHOD FOR ACCOMMODATING LARGE MOVEMENTS IN A MOORING SYSTEM

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TECHNICAL FIELD

The present invention relates to mooring devices for mooring vessels and, more particularly to a method and mooring system for accommodating large relative movements between two objects moored or secured together.

BACKGROUND ART

One disadvantage of traditional mooring is the necessity to constantly adjust the mooring lines, particularly when a ship is secured to a fixed dock. This adjustment is to account for movement of the ship in response to winds, shifting tides, the addition or removal of cargo, and the like. The combination of high tidal movements and variations in ship displacement due to loading can result in a considerable vertical movement having to be accommodated by the mooring system.

With a mooring device such as that described in the co-pending application based upon New Zealand Patent application No. 501395 (which specification is incorporated herein by reference), a vacuum attachment cup assembly is fixed to the ship's hull. Mechanical means limits movement of mooring robot up and down over the full extent of the relative vertical travel. This possible movement necessitates a larger working area, with consequent complication and increased cost.

Japanese patent abstract publication no. 58206478 describes a mooring device and a method of changing the position of a vacuum cup fastening the device to the hull. When the device reaches the limits of its vertical travel the negative pressure in the vacuum cup is raised to a degree permitting the cup to slid releasing from the hull. At its limits of travel this passive method therefore offers greatly reduced mooring forces, making the moored vessel vulnerable to failure of the mooring in adverse conditions of weather and current. The seal of the vacuum cup also suffers from abrasion when the cup slides down the hull in this manner and so to avoid

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regular sliding movement during operation the mooring device is provided with increased mechanical travel in the vertical direction, with consequent added complication and expense.

It is an object of the present invention to provide a mooring system and method of operating a mooring system for accommodating a large relative vertical movement of a ship when docked, which overcomes the problems of the prior art, or which will at least provide the public with a useful choice.

Further aspects and advantages of the present invention will become apparent from the ensuing description which is given by way of example only.

DISCLOSURE OF INVENTION

Accordingly in a first aspect the present invention consists in a method of operating a mooring system, the mooring system including at least a first and a second mooring robot fixed relative to a first body, each mooring robot including a robot arm with an attachment element for releasably fastening to a surface of a second body movable relative to said first, the first and second robots including first and second attachment elements respectively, the method being a co-ordinated stepwise movement to re-position each attachment element between respective spaced apart surface fastened starting and finishing positions, the method including the steps:

(a) firstly, while maintaining the second attachment element in its respective surface fastened starting position, releasing the first attachment element from the surface;

(b) secondly, while maintaining the second attachment element in its respective starting position, actuating the first mooring robot to move the first attachment element and re-fasten the first attachment element in its respective surface fastened finishing position;

(c) thirdly, while maintaining the first attachment element in its respective surface fastened finishing position, releasing the second attachment element from the surface; and

(d) fourthly, while maintaining the first attachment element in its respective surface fastened finishing position, actuating the second mooring robot to move the second

attachment element and re-fasten the second attachment element in its respective surface fastened finishing position.

Preferably the mooring robots are mounted to a fixed or floating dock.

Preferably said surface is part of the freeboard of a ship's hull.

Preferably the mooring robots are mounted to a floating vessel.

Preferably each mooring robot provides means for at least two-dimensional movement for positioning the attachment element.

Preferably each mooring robot support said respective attractive element in a manner providing three-dimensional translational movement, the mooring robot allowing external forces to displace the second body relative to the first body, and the attachment element engaged therewith, by a distance in the horizontal plane from a selected moored position; wherein, separate from its structural components, the mooring robot includes resilient restorative means which provide a restorative force acting to restore the attachment element to the selected moored position.

Preferably the stepwise movement is performed in the vertical direction.

Preferably the stepwise movement is performed in the horizontal direction.

Preferably in addition to the first and second mooring robots at least two additional mooring robots are employed, the attachment element of each additional mooring robot remaining fastened to the surface throughout the stepwise movement of the first and second robots.

Preferably each attachment element includes an array of vacuum cups, each vacuum cup having a circumferential seal a circumferential seal member of substantially constant cross-section, said member being mountable in a support frame rigidly fixed to the attachment element, the seal member being of elastomeric material and including:

a first sealing face which has an arcuate portion between inner and outer edges wherein partial deformation of the said first sealing face is required before the said inner sealing edge contacts the surface.

In a further aspect the present invention consists in a method of operating a mooring system substantially as herein described with reference to the accompanying drawings.

In a further aspect the present invention consists in a mooring system for use in accordance with the method as hereinbefore described.

In a further aspect the present invention consists in a mooring system to be used in accordance with the method as hereinbefore described.

It will be appreciated that one of the cups of the each mooring robot is sufficient to hold that portion of the ship moored, during the operation of the above described method. Thus very large vertical movements of a vessel can be accommodated, without the need to re-moor a vessel and without risking the security of the mooring system.

BRIEF DESCRIPTION OF DRAWINGS

Further aspects of the present invention will become apparent from the following description which is given by way of example only and with reference to the accompanying drawings in which:

Figure 1 is a plan view of a pair of mooring robots, being a first preferred arrangement for performing the stepwise movement method according to the present invention;

Figure 2 is a front elevation illustrating the vertical travel of the vacuum cups of the mooring robots according to Fig. 1;

Figure 3 is front elevation of the vacuum cups of Fig. 2 at an intermediate stage in the stepping movement of the present invention;

Figure 4 is a sectional view of a vacuum cup provided with a seal according to the present invention in a released position, and

Figure 5 is a sectional view of a vacuum cup provided with a seal according to the present invention fully engaged with a hull surface.

BEST MODES FOR CARRYING OUT THE INVENTION

Referring to Fig. 1 of the drawings, a device for performing the method of the present invention comprises the first preferred embodiment of a mooring system 500, as described in the co pending PCT application based upon New Zealand Patent application No. 501395 is illustrated in plan view. The description of the mooring robot and mooring system in the co-pending application is hereby incorporated by reference.

Other preferred embodiments (not illustrated) include a mooring system 500 wherein mooring robots 100 are fixed to the ship S allowing the ship S to be readily fastened to a bearing plate fixed to the dock 50 or to another ship S. It will be appreciated, however, that this as well as other robot type mooring devices may be employed for performing the method of the present invention.

In the following description 100a, 100b have been used to refer to two specific examples of the mooring robot 100. Fig. 1 shows a first mooring robot 100a and a second mooring robot 100b fixed to the dock 50 for mooring a ship S. The mooring system 500 includes at least two pairs of mooring robots 100a, 100b at spaced positions along a mooring face of the dock 50. Each mooring robot 100 has two separate vacuum cups 1 pivotally fixed to a robot arm 10 and permitting accurate positional control of the vacuum cups 1 in three dimensions.

The method of operating the mooring system 500 providing a stepwise movement is described below with reference to Fig. 2. To accommodate a ship S falling or rising relative to the dock 50 (Fig. 1), the vacuum attachment cups 1 fixed to the hull are raised or lowered respectively. It will be appreciated, however, that the same stepwise movement method applies to other relative movement such as moving the vacuum attachment cups 1 from side-to-side in the longitudinal direction, so the following description should not be seen a limiting.

Before mooring the ship S, each vacuum attachment cup 1 is initially free (Figs. 1 and 4). From initial engagement each cup 1 moves through partial engagement (not shown) to complete engagement (Fig. 5) wherein both the seal 60 and the abutment member 61 are fully compressed.

Referring to Figs. 2 & 3, the vacuum attachment cups 1 of both mooring robots (100a, 100b) are fixed to the hull at approximately the same height H2 and the mooring robots (100a, 100b) are able to accommodate a limited degree of vertical travel either side of height H2, between an upper limit of travel at height H1 and a lower limit of travel at H3. The heights H1, H2, H3 are absolute heights relative to the fixed dock 50.

When the controls (not shown) of the mooring system 500 detects a requirement to raise the mooring robots 100, due to a mooring robot (100a, 100b) approaching the limit of its downward travel H3 (through either a falling tide or the addition of cargo) the stepwise movement of the vacuum attachment cups 1 is then initiated.

Fig. 3 shows an intermediate stage during the process of raising the vacuum cups 1 from height H3 to height H4. The vacuum cups 1 of the first mooring robot 100a have been released and the vacuum cups 1 raised to height H4. Before moving the vacuum attachment cups 1 they are completely released from engagement with the hull (to a position as shown in Fig. 4) thereby allowing the movement to be completed more quickly, as is desired.

Next the vacuum cups 1 of the first mooring robot 100a are fully engaged (Fig. 5). On indication of complete engagement, the second mooring robot 100b is also raised to height H4 in the same manner.

A first preferred embodiment of a seal 60 according to the present invention is shown in Fig. 6. The seal 60 provides a continuous seal around the circumference of each vacuum cup 1, to which it is rigidly fixed. The seal 60 is made from elastomeric material, preferably neoprene. It includes a first arcuate sealing face 62 between an inner sealing edge 63 and on outer sealing edge 61.

The seal 60 is optionally used to form the perimeter of each vacuum cup 1 used in the method of the present invention. However, it will be appreciated by those skilled in the art that other seals may also be used without departing from the scope of the inventive method.

This configuration of the seal 60 allows it to absorb irregularities in the surface to which cup 1 is attached. During engagement of the seal 60, an initial seal is attained with partial deformation of the outer sealing edge 61 at the partial engagement stage (nor shown) before the inner sealing edge 61 contacts the hull of the ship S. With this seal 60 there has been found to be a predictable relationship between the amount of deformation at the partial engagement stage and the vacuum applied to the vacuum cups 1.

In the partial engagement stage the arcuate face 62 is readily adapted for sliding engagement with the hull of a ship S or another surface.

The above method of operating a mooring system has been described with reference to vessel moored to a dock, which may be either fixed or floating. However, it will be appreciated that the dock may be replaced by a vessel (so that there is vessel to vessel docking and relative movement). Also, it will be appreciated that the mooring system, described herein as affixed to the dock, may be fixed to the vessel. The operation is the same except that the surface is a surface affixed to the dock.

Also, the above method of operating a mooring system has been described with reference to vessel moored to a dock. It will, however, be appreciated that another type of vessel or object may be moved relative to a second object, for example under water, etc without departing from the scope of the invention.

Aspects of the present invention have been described by way of example only and it should be appreciated that modifications and additions may be made thereto without departing from the scope thereof.

CLAIMS

1. A method of operating a mooring system, the mooring system including at least a first and a second mooring robot fixed relative to a first body, each mooring robot including a robot arm with an attachment element for releasably fastening to a surface of a second body movable relative to said first, the first and second robots including first and second attachment elements respectively, the method being a co-ordinated stepwise movement to re-position each attachment element between respective spaced apart surface fastened starting and finishing positions, the method including the steps:

(a) firstly, while maintaining the second attachment element in its respective surface fastened starting position, releasing the first attachment element from the surface;

(b) secondly, while maintaining the second attachment element in its respective starting position, actuating the first mooring robot to move the first attachment element and re-fasten the first attachment element in its respective surface fastened finishing position;

(c) thirdly, while maintaining the first attachment element in its respective surface fastened finishing position, releasing the second attachment element from the surface; and

(d) fourthly, while maintaining the first attachment element in its respective surface fastened finishing position, actuating the second mooring robot to move the second attachment element and re-fasten the second attachment element in its respective surface fastened finishing position.

2. A method of operating a mooring system as claimed in claim 1 wherein the mooring robots are mounted to a fixed or floating dock.

3. A method of operating a mooring system as claimed in claims 1 or claim 2 wherein said surface is part of the freeboard of a ship's hull.

4. A method of operating a mooring system as claimed in any one of claims 1 to 3 wherein the mooring robots are mounted to a floating vessel.

5. A method of operating a mooring system as claimed in any one of claims 1 to 4 wherein each mooring robot provides means for at least two-dimensional movement for positioning the attachment element.

6. A method of operating a mooring system as claimed in claim any one of claims 1 to 5 wherein each mooring robot support said respective attractive element in a manner providing three-dimensional translational movement, the mooring robot allowing external forces to displace the second body relative to the first body, and the attachment element engaged therewith, by a distance in the horizontal plane from a selected moored position; wherein, separate from its structural components, the mooring robot includes resilient restorative means which provide a restorative force acting to restore the attachment element to the selected moored position.

7. A method of operating a mooring system as claimed in any one of claims 1 to 6 wherein the stepwise movement is performed in the vertical direction.

8. A method of operating a mooring system as claimed in any one of claims 1 to 7 wherein the stepwise movement is performed in the horizontal direction.

9. A method of operating a mooring system as claimed in any one of claims 1 to 8 wherein in addition to the first and second mooring robots at least two additional mooring robots are employed, the attachment element of each additional mooring robot remaining fastened to the surface throughout the stepwise movement of the first and second robots.

10. A method of operating a mooring system as claimed in claim 1 wherein each attachment element includes an array of vacuum cups, each vacuum cup having a circumferential seal a circumferential seal member of substantially constant cross-section, said member being mountable in a support frame rigidly fixed to the attachment element, the seal member being of elastomeric material and including:

a first sealing face which has an arcuate portion between inner and outer edges wherein partial deformation of the said first sealing face is required before the said inner sealing edge contacts the surface.

11. A method of operating a mooring system substantially as hereinbefore described with reference to the accompanying drawings.

12. A mooring system for use in accordance with the method as claimed in any one of claims 1 to 10.

13. A mooring system to be used in accordance with the method as claimed in any one of claims 1 to 10.