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(54) Floatover arrangement and method

(57) An arrangement and method for restraining surge and sway of the barge during floatover of a topside onto a substructure. Roller bumpers provided on the substructure guide the barge during slot entry and exit without the use of secondary mooring lines and restrain sway at the floatover position. Dedicated vertical bearing surfaces are provided on the substructure at the entry to the slot. Resilient bumpers are provided on the barge. The resilient bumpers engage with the dedicated vertical bearing surfaces on the substructure and position the barge in the floatover position in the longitudinal direction. A tug boat tows the barge into the slot until the resilient bumpers engage the dedicated vertical bearing surfaces. The tug continues to pull throughout the floatover operation to hold the barge in the floatover position.

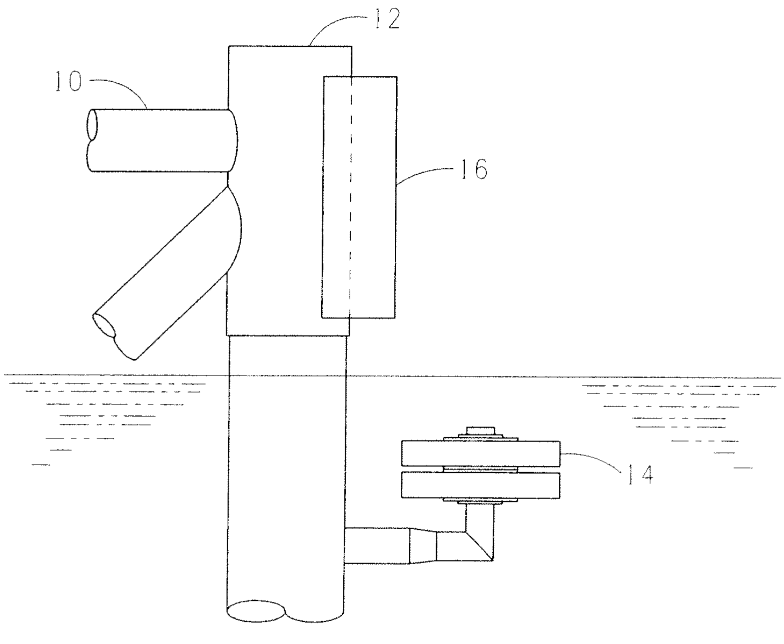

FIG. 17A

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Description

Field and Background

[0001] The present disclosure is generally related to the installation of offshore structures and more particularly, but not exclusively, to the installation of a topside structure on a substructure.

[0002] A floatover is an operation for placing a topside structure onto a substructure in an offshore environment. The substructure can be a bottom founded or a floating structure. The topside structure is loaded out onto a transport vessel (hereafter termed a barge) at the fabrication yard and towed to the installation site. At the site the barge is positioned between the legs of the substructure and the topside is lowered until the legs of the topside stab into the legs of the substructure. The topside is lowered by a combination of ballasting the barge downward and collapsing mechanical or hydraulic arrangements that support the topside above the barge deck.

[0003] In most floatovers to date a single barge hull floats between two parallel rows of legs of the substructure. The region between the two parallel rows of legs is termed the "slot". The substructure must be designed so that the slot is devoid of any framing members and the slot must be deeper than the maximum draft of the barge. When the barge is moved into the slot the barge floats over much of the substructure, hence the term floatover. The final position of the barge in the slot, where the topside can be lowered and mate with the substructure, is termed the floatover position. Fig. 1 and 2 provide an overview of a floatover using a slot.

[0004] In some cases the basic design of the substructure makes it impossible to provide a slot for the entry of the barge. For example, the substructure of a spar buoy platform is a single, large diameter, vertical cylinder. Because a slot is not possible, the topside is brought to the installation site on two parallel barges. During the floatover, the substructure fits in the space between the two barges with the topside spanning between the two barges. The two parallel barge hulls with the topside spanning between the two hulls form a catamaran. Hence, this type of operation is called a "catamaran" floatover. Fig. 3 - 5 provide an overview of a catamaran floatover for a spar buoy (FIG. 4) and a compliant tower (FIG. 5).

[0005] The barge with the topside on board moves in six degrees of freedom in response to the sea state at the installation site. Therefore, the legs of the topside are moving relative to the mating legs of the substructure. If there is too much relative motion between the mating legs of the topside and the substructure, then the floatover must wait for lower sea states. To reduce the waiting time, relative motion between the mating legs in the horizontal plane has been restrained by various devices. Other devices have been employed to reduce vertical impact loads between the mating legs.

[0006] The horizontal position of the barge as it enters and leaves the slot must be carefully controlled so that the barge does not impact the substructure and cause damage. The control of the position of the barge during slot entry and slot exit is critical to the success of the floatover. The features that control the horizontal position of the transport barge during slot entry and exit must be compatible with the features that restrain the relative motion of the mating legs at the floatover position.

[0007] The devices and methods that control the position of the transport barge in the horizontal plane during slot entry and slot exit, and the devices and methods that control the relative motion of the mating legs in the horizontal plane, while the barge is in the floatover position, provide comparative basis for at least some of the present teachings.

[0008] Primary and secondary mooring arrangements have been used alone to control the horizontal position of the transport barge during slot entry, at the floatover position, and during slot exit. The primary mooring arrangement is a spread mooring array with lines that run between winches on the barge and anchors at the sea bottom. The secondary mooring arrangement is an array of mooring lines that runs between winches or capstans on the barge and attachment points on the substructure. Fig. 6 - 10 illustrate a sequence that shows how slot entry is achieved and how the barge is restrained at the floatover position. Generally, the length of the primary mooring lines is adjusted and the secondary mooring lines (attached to the legs of the substructure) are attached to the barge in sequence as the barge and topside are moved into the slot. Slot exit is achieved by reversing the slot entry procedure. The tug pulls the barge into the slot. In some floatovers, the leading lines of the primary mooring system pass through the slot and are used to pull the barge into the slot. As Fig. 6 - 10 suggest, keeping the barge properly restrained by the primary and secondary mooring systems at all positions during a floatover operation is difficult and time consuming. Also, the many tensioned mooring lines running above the deck are a potential hazard to personnel who must work on the deck.

[0009] Cyclical motions of the transport barge caused by wave forces are only slightly affected by the actions of the primary and secondary mooring arrangements. The spread mooring array is a soft arrangement that is used to resist steady state, or slowly varying forces which are produced by constant velocity wind or ocean currents. The action of the waves causes the barge position to cycle about a mean position. The primary mooring arrangement maintains the mean position of the barge. The secondary mooring arrangement is used to restrain motions caused by the slow drift force, wind gusts, or an upset caused by a broken primary mooring line. The interface features that mate the topside legs and the substructure legs must allow for the wave induced cyclical motions, among other things. Fig. 11 and 12 illustrate how the interface features are usually designed to allow for these relative motions. The maximum allowable offset shown in Fig. 11 must be greater than the cyclical motion caused by the waves plus displacement caused by wind gusts and slow drift. If the actual offset is less than the maximum allowable offset shown in Fig. 11, then the stabbing point on the bottom of the topside structure leg will be captured by the open end of the substructure leg as the topside structure descends. The result will be the mating of the legs, as shown in Fig. 12.

[0010] Instead of relying entirely on the primary and secondary mooring arrangements, some slot type floatovers have employed bumpers to control the transverse position of the barge and restrain sway and yaw. Bumpers can either be rigid or flexible. Typically, a rigid bumper is a steel structure connected directly to the substructure (Fig. 13). In order to minimize impact loads between the barge and the rigid bumpers, the slot must be tight. That is, there cannot be too much clearance between the sides of the barge and the rigid bumper. More clearance allows the barge to develop more transverse velocity as it bounces from side to side during slot entry and exit. Of particular concern in a tight slot floatover is yaw, which can produce a prying action of the barge against the substructure (Fig. 14). The advantage of a tight slot floatover is the small motions that the rigid bumper allows in the transverse direction. The disadvantage is the large impact forces and prying action that can develop between the barge and the substructure. These forces are large enough that a tight slot floatover is only attempted in a benign environment with a substructure that is strong in the transverse direction.

[0011] A slot floatover that uses only primary and secondary mooring arrangements might be termed a "loose" slot floatover because the transverse motions that must be accommodated by the interface features are larger than those permitted by the "tight" slot floatover. Conversely, the transverse forces between the barge and the substructure are higher for the tight slot floatover than the transverse forces are for the loose slot floatover. An intermediate result is obtained when flexible bumpers are used. Typically, bumpers are made flexible with a resilient material, such as rubber. The flexible bumpers are stiffer than the secondary mooring arrangement in the transverse direction, but much less stiff than the rigid bumpers. Usually, the flexible bumpers replace the secondary mooring system during slot entry and exit, and secondary mooring lines (spring lines) are rigged to control the mean longitudinal position once the barge has reached the floatover position (Fig. 15).

[0012] The most common substructure is a jacket, as shown in Fig. 1, and elsewhere. A slot in a typical jacket produces a structure with legs that are braced in the slot, or longitudinal direction, but the legs are not braced in the transverse direction. Thus, the legs are strong in the longitudinal direction and weak in the transverse direction. Therefore, a loose slot method, or a modified loose slot method (flexible transverse bumpers are preferred for jackets, if the environment is not benign). If the substructure is inherently strong in the transverse direction, then a tight slot method can be used.

[0013] In environments that are hostile to floatovers, special features have been used to increase the utilization rate of the installation equipment, i.e., the number of days in the installation season in which the floatover can be attempted. The special features increase the utilization rate by reducing the surge and sway of the transport barge at the floatover position. These special features have been used in areas where the sea state is dominated by swells most of the year. The slots are oriented in the prevailing direction of the swells to minimize sway as much as possible, but the swells produce significant surge. During slot entry and exit the mean transverse position of the barge is controlled by some combination of primary and secondary mooring systems and flexible bumpers. During slot entry and exit the surge of the barge is not restrained.

[0014] U.S. Patent No. 5,527,132 describes an arrangement of mechanical and hydraulic devices that has been used successfully to limit sway and surge at the floatover position. However, it is a complicated and expensive arrangement to build and to maintain in an operating condition. The arrangement works in the floatover position, but does not help during slot entry and exit.

[0015] In some canal systems and entrances to some drydocks a variety of rolling bumpers are used to control the movement and position of ships and barges. Fig. 16 shows three applications for rolling bumpers, namely, for a breasting dolphin, for corner protection where a vessel is maneuvered around a corner, and for guiding a vessel into the entrance to a lock on a canal. There are a variety of types of rolling bumpers, but each type employs a resilient donut mounted on a vertical axle. For higher loads the resilient donut might be a pneumatic tire mounted on a wheel that is mounted on the vertical axle. For lower loads the resilient donut might be made of foam with the donut mounted directly on a large diameter axle without using a wheel.

Summary

[0016] The present disclosure has been arrived at, at least in part, in view of known drawbacks of existing systems. The present teachings can provide for an arrangement and method for restraining surge and sway of the barge during floatover of a topside onto a substructure. Roller bumpers provided on the substructure guide the barge during slot entry and exit without the use of secondary mooring lines and restrain sway at the floatover position. Dedicated vertical bearing surfaces are provided on the substructure at the entry to the slot. Resilient bumpers are provided on the barge. The resilient bumpers engage with the dedicated vertical bearing surfaces on the substructure and position the barge in the floatover position in the longitudinal direction. A tug tows the barge into the slot until the resilient bumpers mounted on the barge contact the dedicated bearing surface at the entrance to the slot. The tug continues pulling to maintain the barge in the floatover position until the topside is set

on the substructure. Then another tug tows the barge out of the slot.

[0017] The various features of which differentiate the present teachings are pointed out with particularity in the claims annexed to and forming part of this disclosure. For a better understanding of the present teachings, and the operating advantages attained by its use, reference is made to the accompanying drawings and descriptive matter, forming a part of this disclosure, in which illustrative examples are presented.

Brief Description of the Drawings

[0018] In the accompanying drawings, forming a part of this specification, and in which reference numerals shown in the drawings designate like or corresponding parts throughout the same:

[0019] FIG. 1 - 16 illustrate various structures.

[0020] FIG. 17 and 17A illustrate apparatus on a substructure.

[0021] FIG. 18 and 18A illustrate apparatus on a barge.

[0022] FIG. 19 - 21 illustrate a sequence of barge positions in the slot of the substructure.

[0023] FIG. 22 illustrates an alternative structure for use with a catamaran floatover.

[0024] While the invention is susceptible to various modifications and alternative forms, specific embodiments are shown by way of example in the drawings and are herein described in detail. It should be understood, however, that drawings and detailed description thereto are not intended to limit the invention to the particular form disclosed, but on the contrary, the invention is to cover all modifications, equivalents and alternatives falling within the spirit and scope of the present invention as defined by the appended claims.

Description

[0025] The plan view of Fig. 17 illustrates the apparatus provided on a substructure upon which a deck or topside is to be placed. The center top horizontal braces 10 of the substructure are shown whole between the substructure legs 12 and the substructure top horizontal braces 10 are shown in partial view on the adjacent sections in order to be able to show the roller bumpers 14 in the center area. As seen in Fig. 17, roller bumpers 14 are also provided at each end of the substructure. Fig. 17A best illustrates the vertical bearing surface 16 that is provided on the substructure legs.

[0026] Fig. 18 and 18A illustrate the apparatus provided on a barge 18 used to install the deck or topside. Bumper boxes 20 are provided on the sides of the barge 18 and extend beyond the sides of the barge 18. A resilient bumper 22 is provided on one side of each bumper box 20. The bumper boxes 20 and resilient bumpers 22 are positioned on the barge 18 to act as a longitudinal stop to locate the barge and topside in the floatover position. While specific reference is made to a barge for supporting the topside, it should be understood that any type of floating structure that is suitably sized for the operation may be used to support and install the topside.

[0027] With use of the apparatus of the present examples, the floatover installation is carried out as follows. As seen in Fig. 19, the barge 18 is towed into position toward the substructure such that the barge is centered on the slot of the substructure and the first set of roller bumpers 14 are in contact with the barge 18. A tug, not shown, and tow bridle 24 are used to tow the barge 18. Fig. 20 illustrates the barge 18 part way into the slot and Fig. 21 illustrates the barge fully into the slot in the floatover position. The roller bumpers 14 are in contact with the sides of the barge 18 and control the transverse position of the barge 18 in the slot. As seen in Fig. 21, the resilient bumpers 22 are held in contact with the vertical bearing surfaces 16 on the substructure. The tug maintains this contact by pulling on the tow bridle 24. As the barge 18 heaves the bumpers 22 slide up and down on the vertical bearing surfaces 16.

[0028] While the arrangement greatly reduces surge, it is not fully eliminated. The resilient bumpers 22 compress and extend throughout the floatover operation. Sometimes, a small gap may open between the bumpers 22 and the vertical bearing surfaces 16. But the bollard pull of the tug and the stiffness of the bumpers 22 are such that the offset of the mating legs does not exceed the maximum allowable offset as illustrated in Fig. 11.

[0029] Sway is greatly reduced by the restraint offered by the roller bumpers 14. The stiffness of the roller bumpers 14 is such that the offset of the mating legs does not exceed the maximum allowable offset as illustrated in Fig. 11.

[0030] The disclosed arrangement eliminates the need for secondary mooring lines. Also eliminated are the winches and powered capstans associated with the secondary mooring lines. If spring lines would have been used, such as those shown in Fig. 15, these are also eliminated by the disclosed arrangement. Because of their rolling action, the roller bumpers 14 provide automatic transverse guidance during longitudinal movements in the slot. The resilient bumpers mounted on the barge boxes contacting the vertical bearing surfaces on the substructure constitute a longitudinal stop that automatically locates the barge in the floatover position. The simplicity of the operation greatly reduces the time required to perform the floatover. Personnel safety is enhanced because the tensioned secondary mooring lines running above the deck of the barge are eliminated. Also, the apparatus required is much simpler and more economical.

[0031] Fig. 22 illustrates a further example in which the principles of the present disclosure are applied to a catamaran floatover for a cylindrical structure such as a spar. While the appearance is different, the concept and method is the same as that described above for slot type floatovers. Roller bumpers 14 are provided on the cylindrical structure 26 so as to extend radially outward a suitable distance for contacting and guiding the catamaran barges 28. Bumper boxes 20 with resilient bumpers are also provided on the catamaran barges 28. Vertical bearing surfaces 30 are provided on extensions from the cylindrical structure 26 for interacting with the resilient bumpers as described above to hold the catamaran barges 28 and topside in place during the floatover operation and installation of the topside on the cylindrical structure 26.

[0032] From one viewpoint there has been disclosed an arrangement and method for restraining surge and sway of the barge during floatover of a topside onto a substructure. Roller bumpers provided on the substructure guide the barge during slot entry and exit without the use of secondary mooring lines and restrain sway at the floatover position. Dedicated vertical bearing surfaces are provided on the substructure at the entry to the slot. Resilient bumpers are provided on the barge. The resilient bumpers engage with the dedicated vertical bearing surfaces on the substructure and position the barge in the floatover position in the longitudinal direction. A tug boat tows the barge into the slot until the resilient bumpers engage the dedicated vertical bearing surfaces. The tug continues to pull throughout the floatover operation to hold the barge in the floatover position.

[0033] The drawings that illustrate the arrangement and method of the present teachings do not show any of the primary mooring lines indicated in the prior art because they are not pertinent to the disclosed techniques. Depending on the particular floatover design, some, all, or none of the primary mooring lines used by conventional techniques may be used.

[0034] While specific embodiments and/or details of the present teachings have been shown and described above to illustrate the application of the principles of the disclosure, it is understood that the invention may be embodied as more fully described in the claims, or as otherwise known by those skilled in the art (including any and all equivalents), without departing from such principles.

Claims

1. An arrangement for a floatover operation offshore wherein a topside structure supported by a floating structure is floated over a substructure and the topside is then installed onto the substructure, comprising:

    a plurality of roller bumpers attached to the substructure and extending from the substructure so as to contact the floating structure during the floatover operation;
    a vertical bearing surface attached to the substructure;
    at least two resilient bumpers attached to the floating structure and positioned so as to contact the vertical bearing surface on the substructure during the floatover operation.

2. The arrangement of claim 1, wherein the resilient bumpers are positioned on the floating structure so as to act as a longitudinal stop to position the floating structure and topside in the proper alignment for installation on the substructure.

3. A floatover method for installing a topside supported on a floating structure onto a substructure offshore, comprising the steps:

    providing a plurality of roller bumpers on the substructure such that the roller bumpers extend from the substructure and contact and guide the floating structure during the floatover operation;
    providing at least two vertical bearing surfaces on the substructure;
    providing at least two resilient bumpers on the floating structure supporting the topside such that the resilient bumpers contact the vertical bearing surfaces on the substructure during the floatover operation.

4. The method of claim 3, further comprising moving the floating structure supporting the topside into position adjacent the substructure and into contact with the roller bumpers such that the roller bumpers aid in proper positioning of the floating structure.

5. The method of claim 4, further comprising continuing movement of the floating structure into position such that the resilient bumpers contact the vertical bearing surfaces, which position aligns the topside and substructure for installation of the topside onto the substructure.

6. The method of claim 5, further comprising ballasting the floating structure down and installing the topside onto the substructure.

7. The method of claim 6, further comprising removing the floating structure.

8. The method of any of claims 3 to 7, further comprising carrying out the method steps using the arrangement of claim 1 or 2.

9. An assembled offshore structure comprising a topside and a substructure wherein the topside is delivered to the substructure using the method of any of claims 3 to 8.

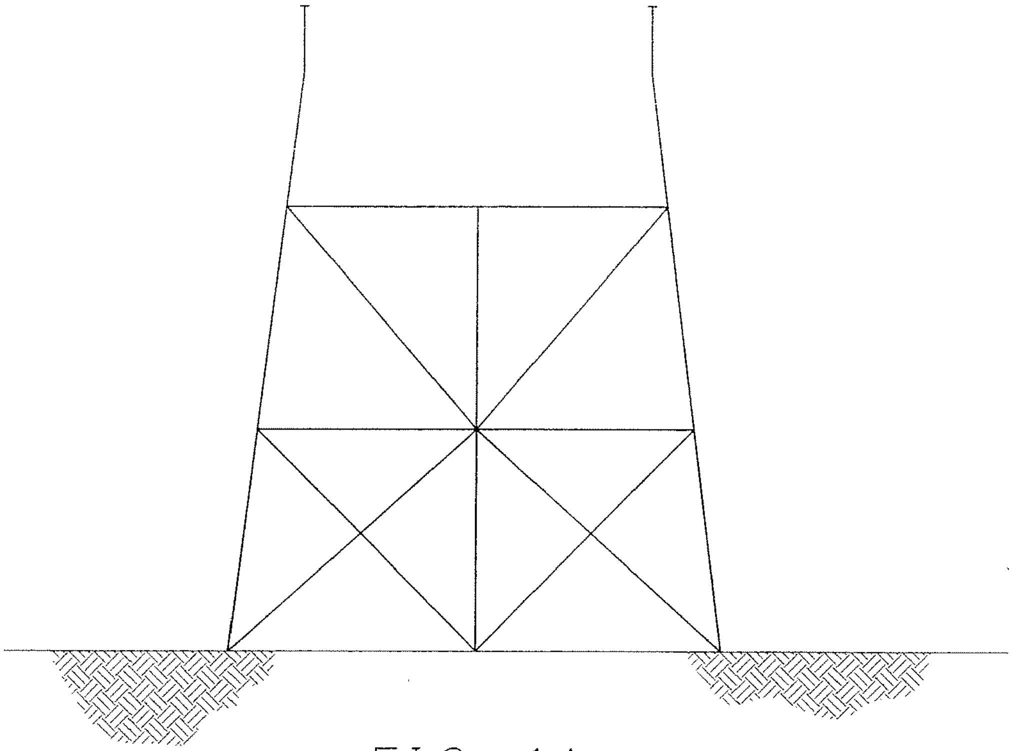

FIG. 1A

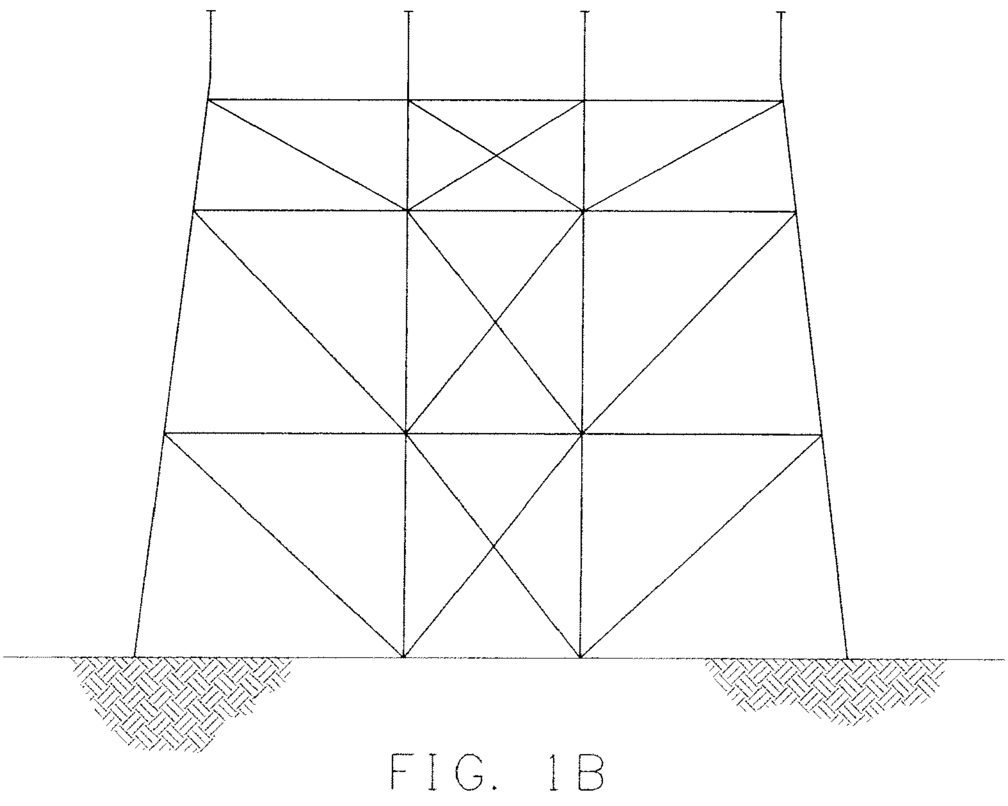

FIG. 1B

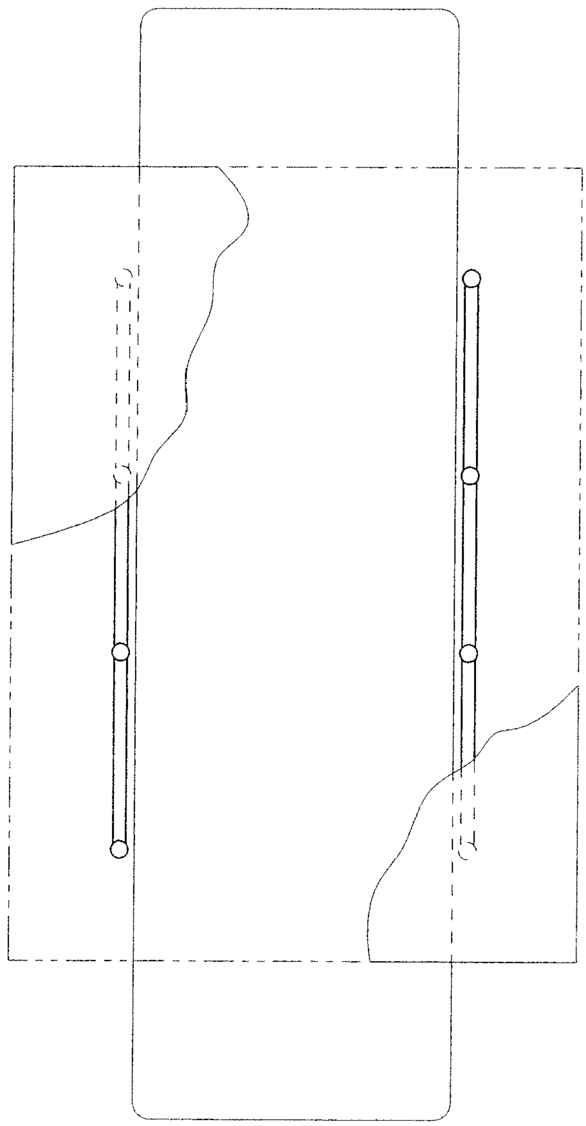

FIG. 2A

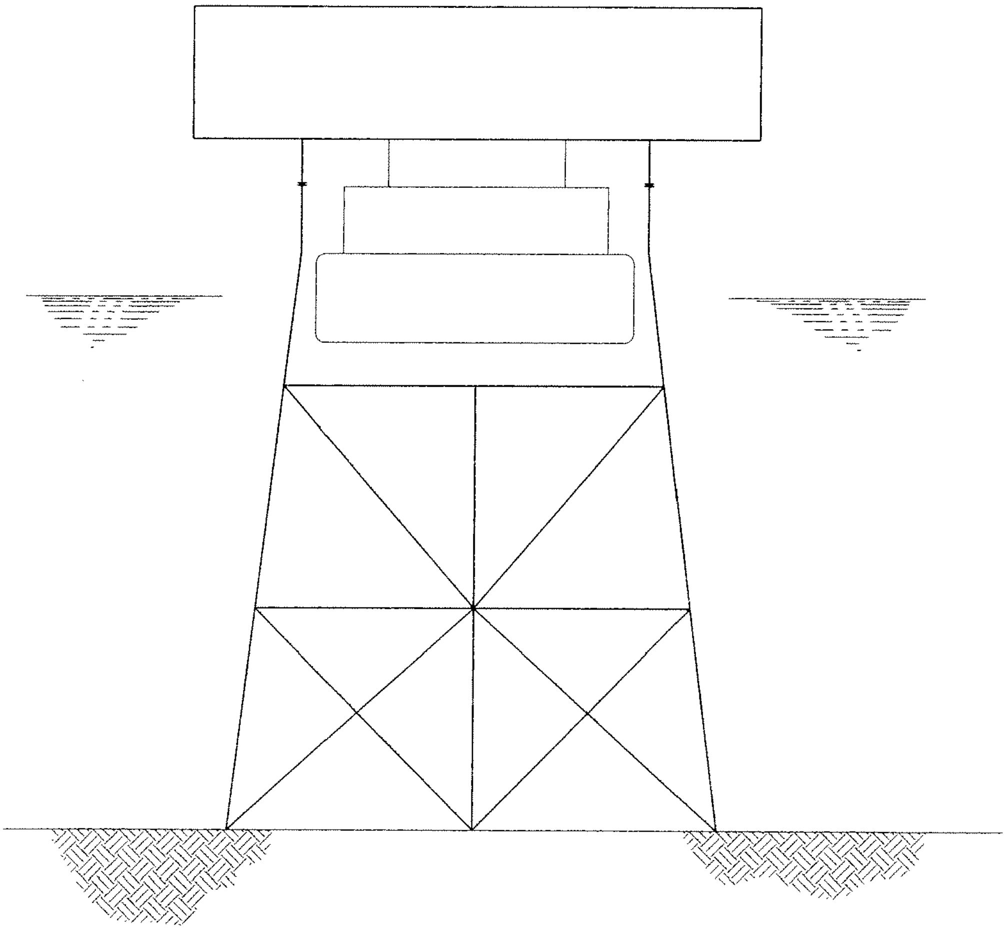

FIG. 2B

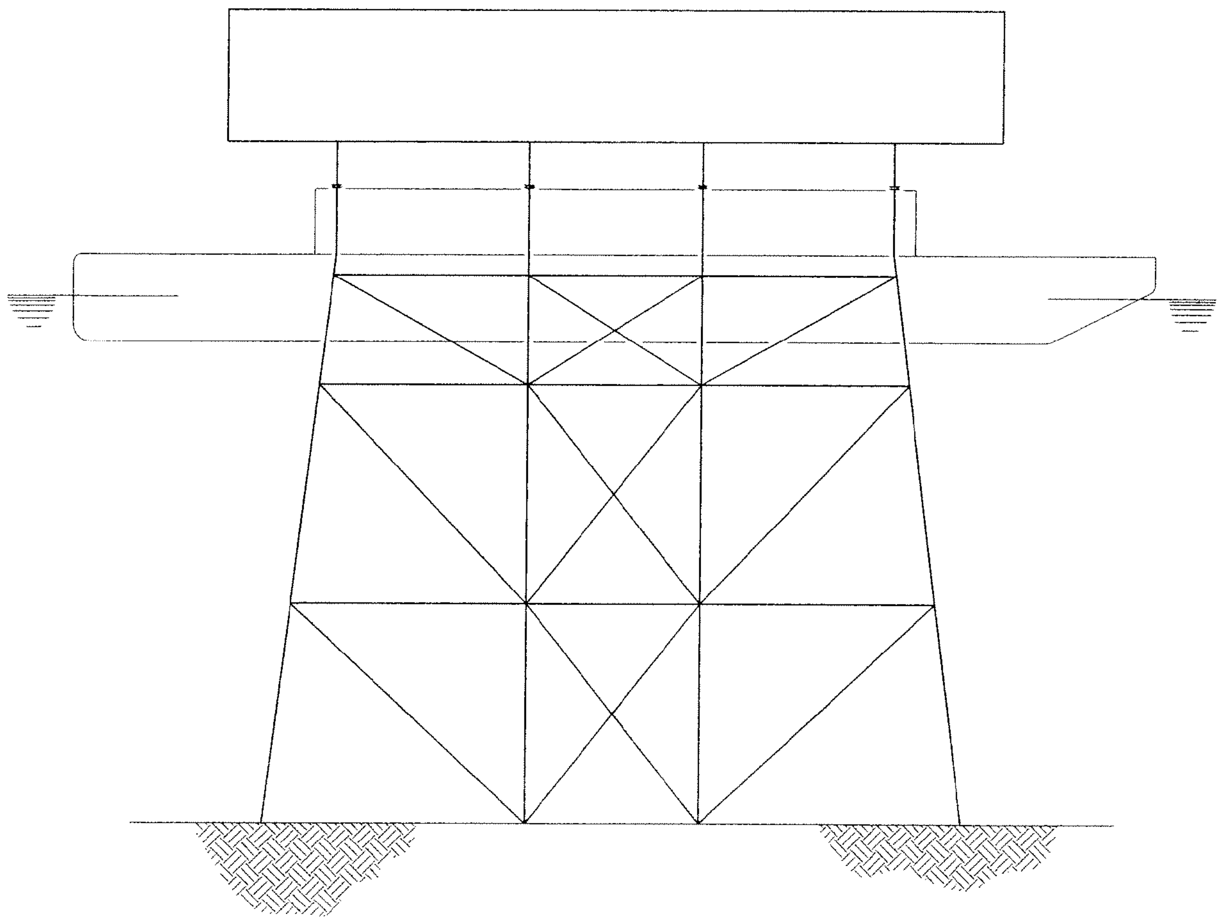

FIG. 2C

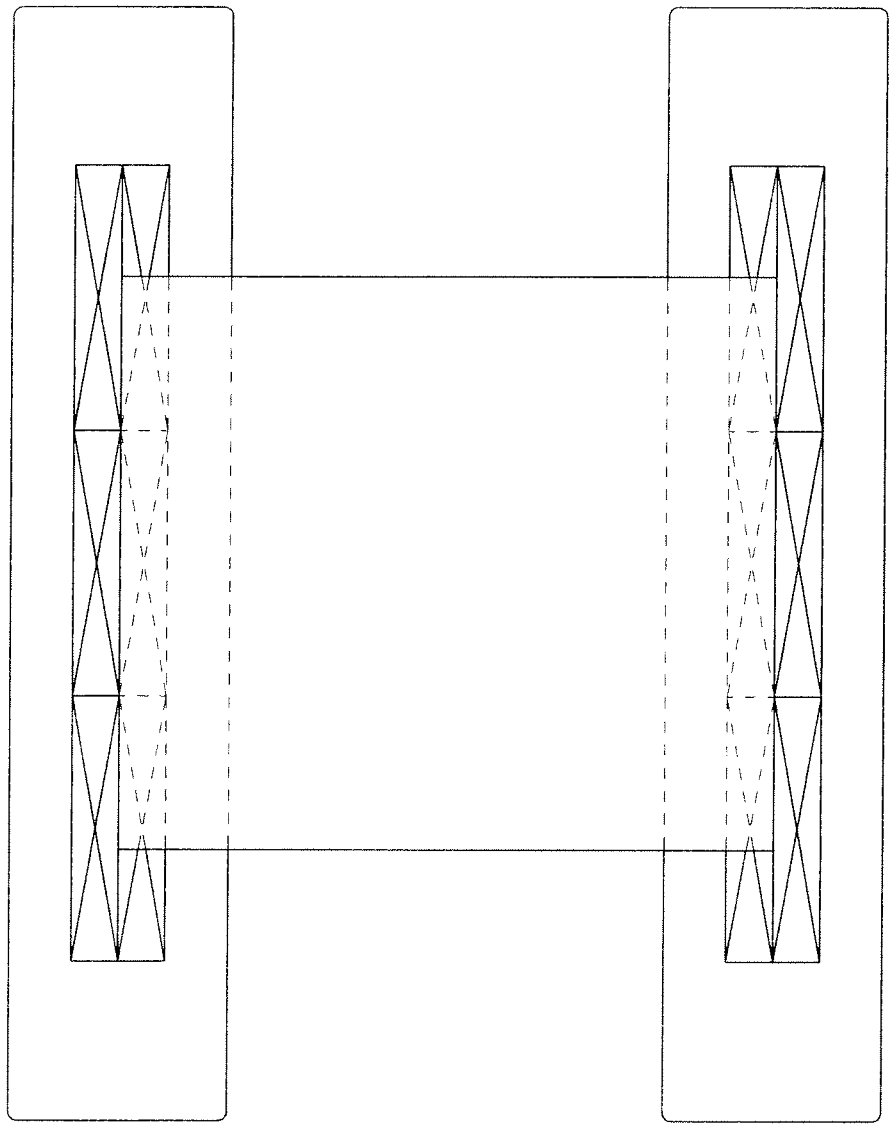

FIG. 3A

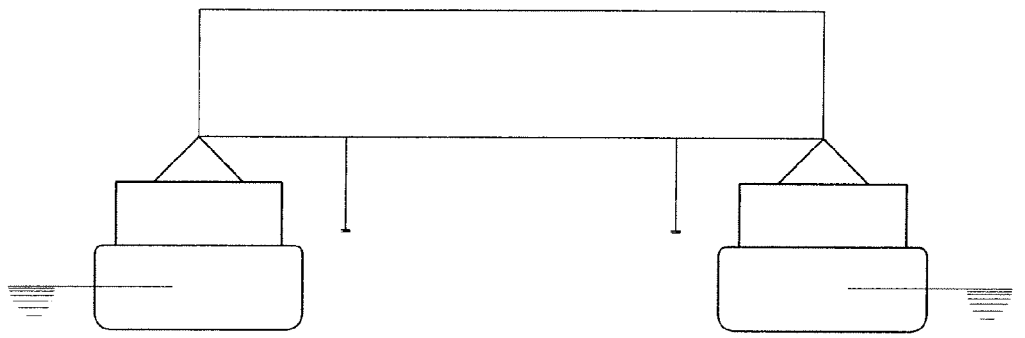

FIG. 3B

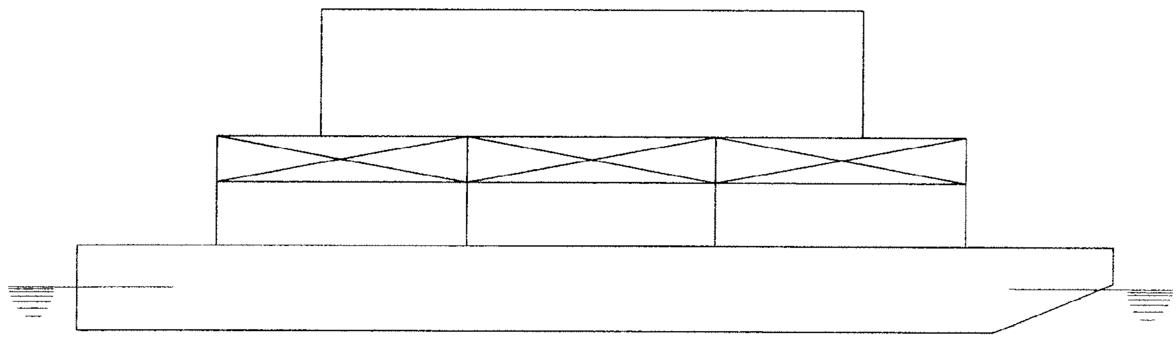

FIG. 3C

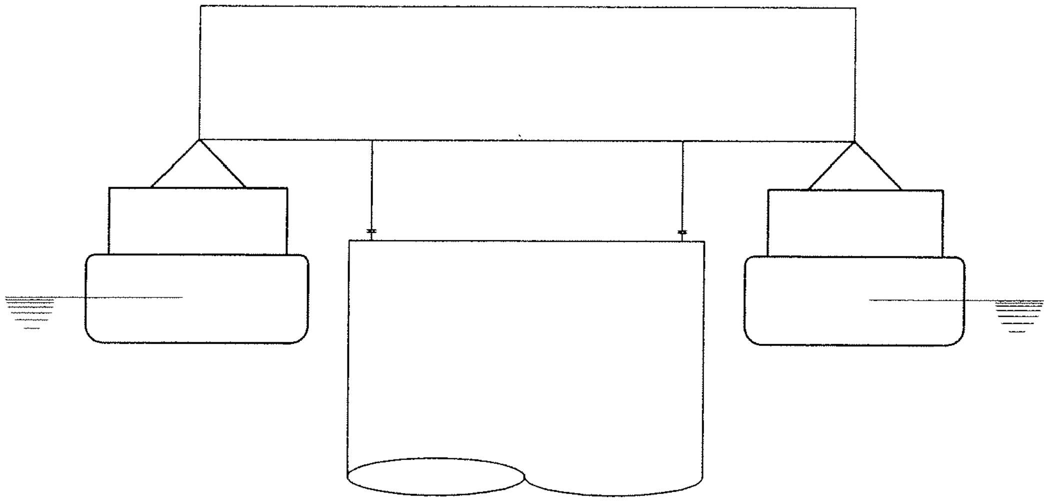

FIG. 4

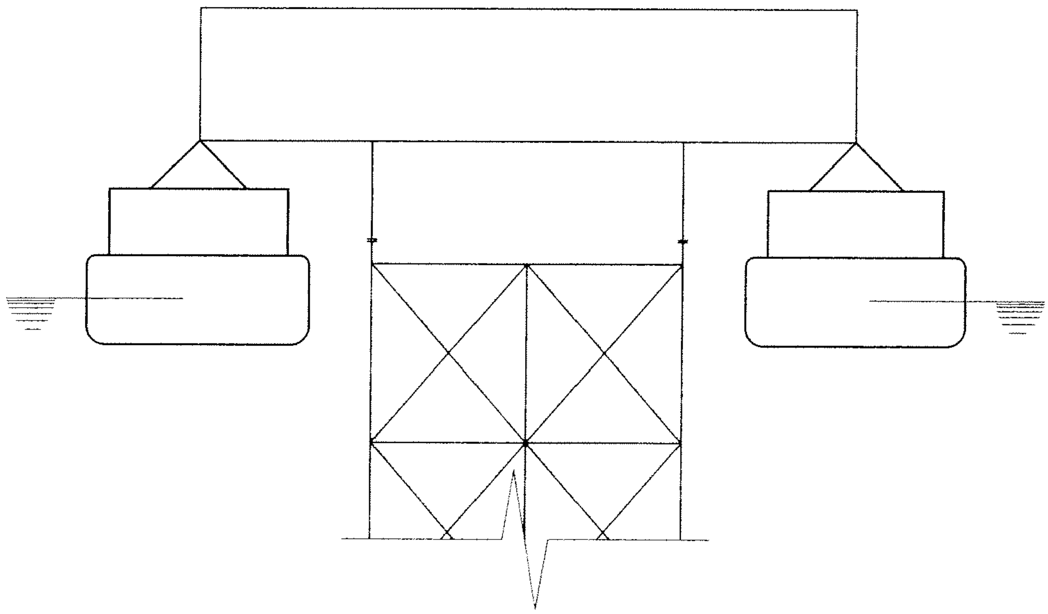

FIG. 5

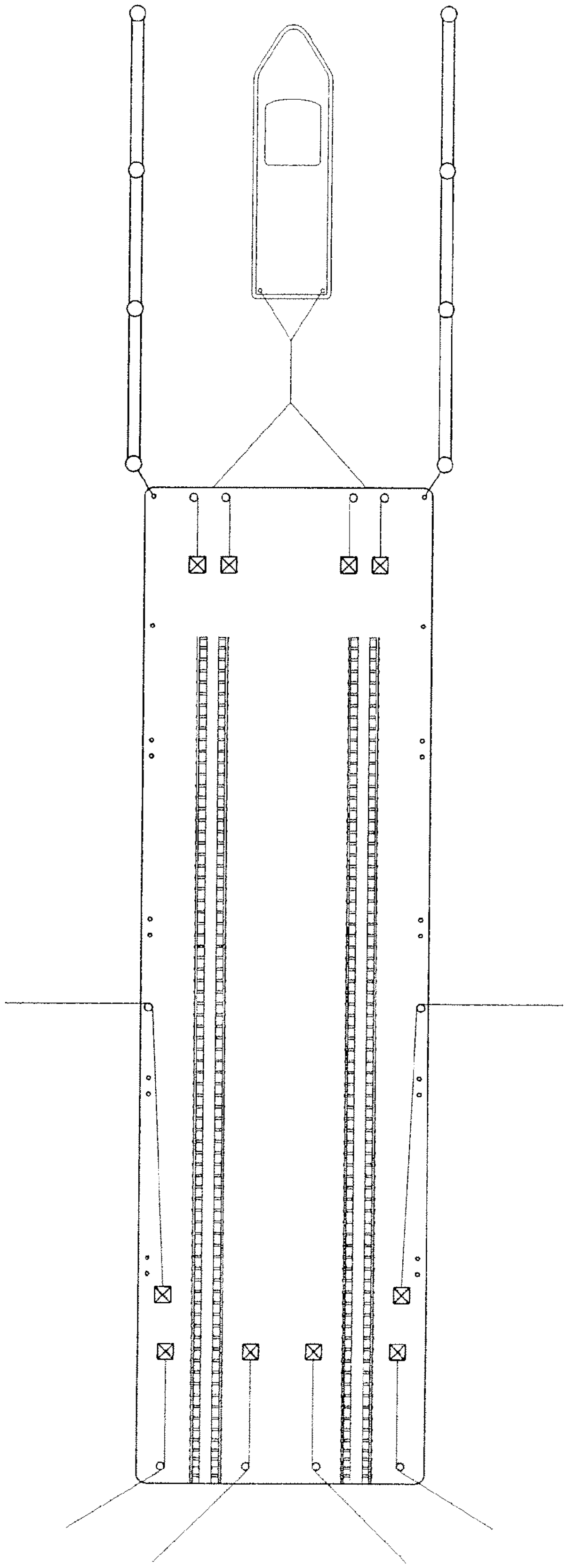

FIG. 6

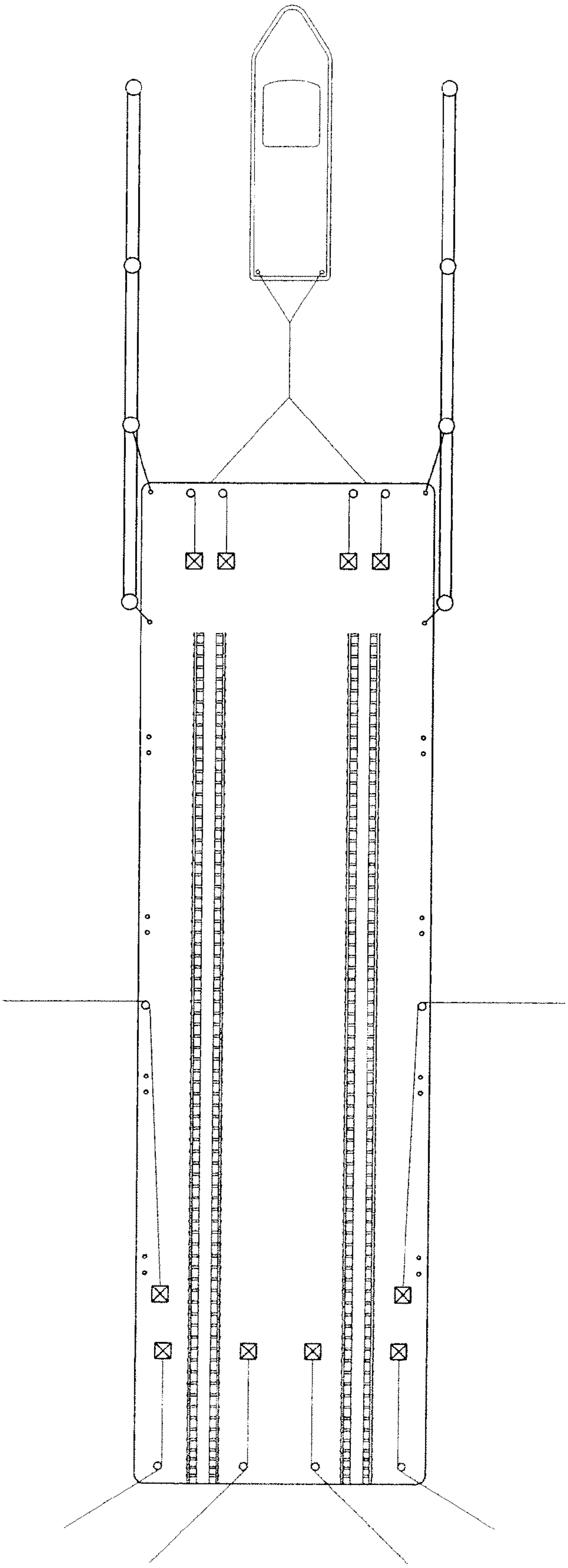

FIG. 7

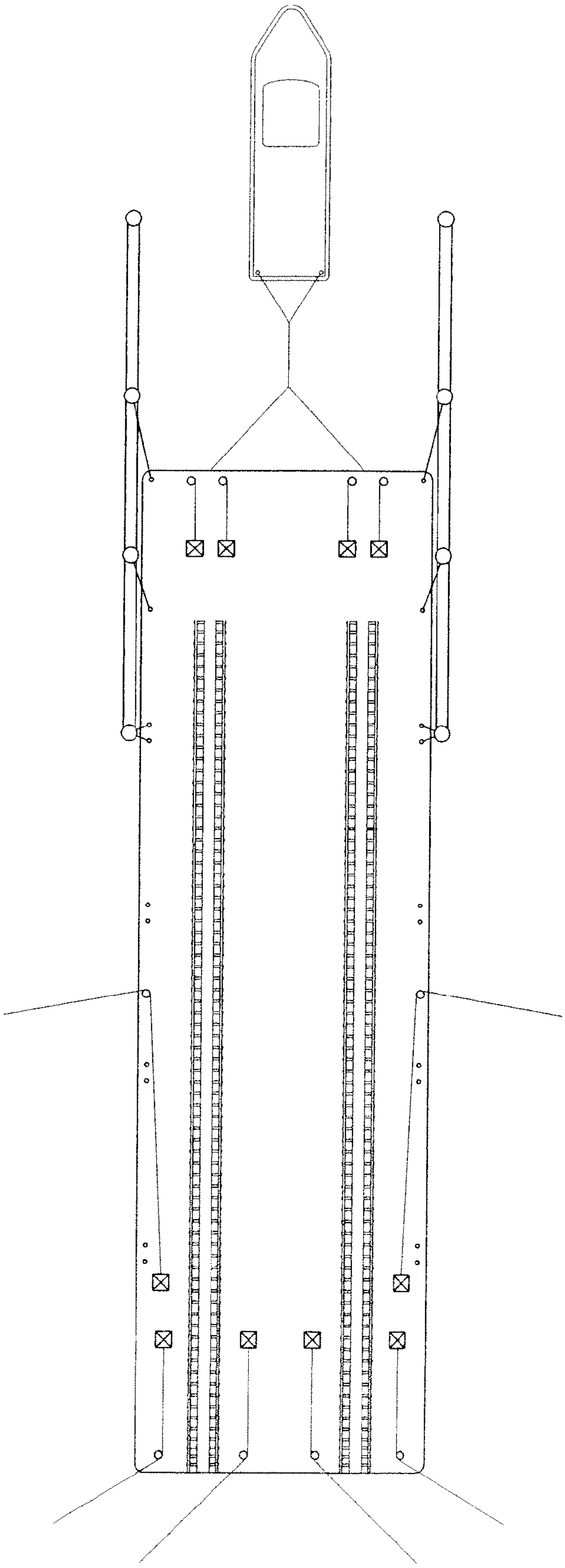

FIG. 8

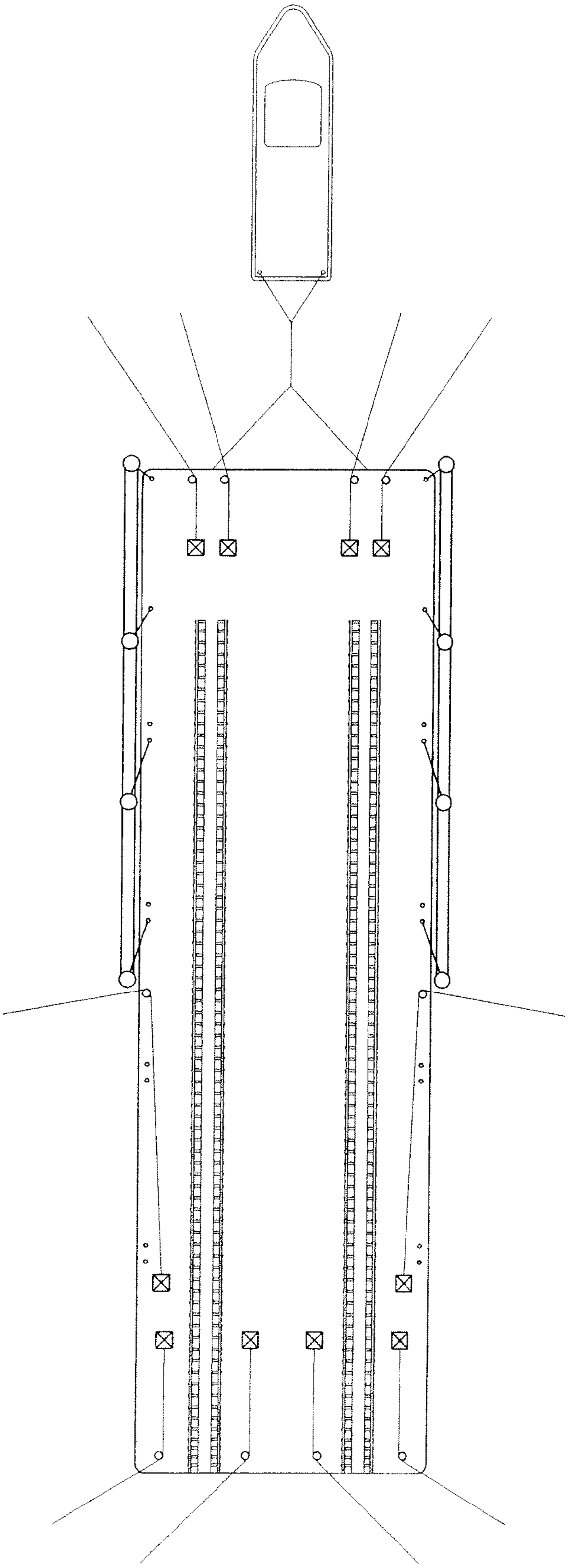

FIG. 9

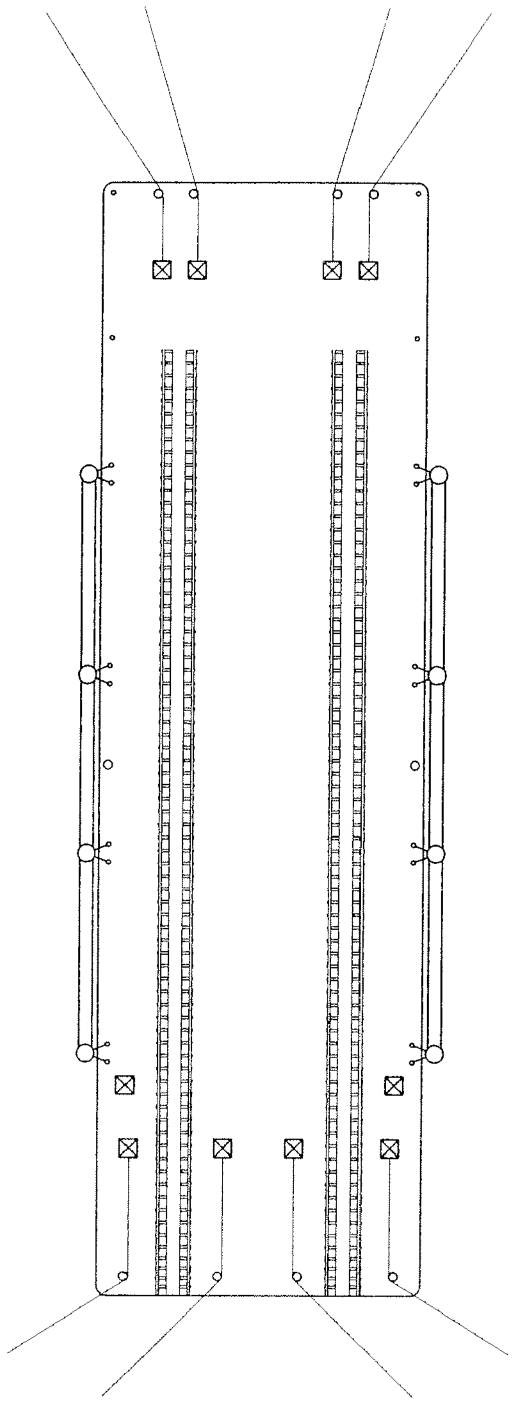

FIG. 10

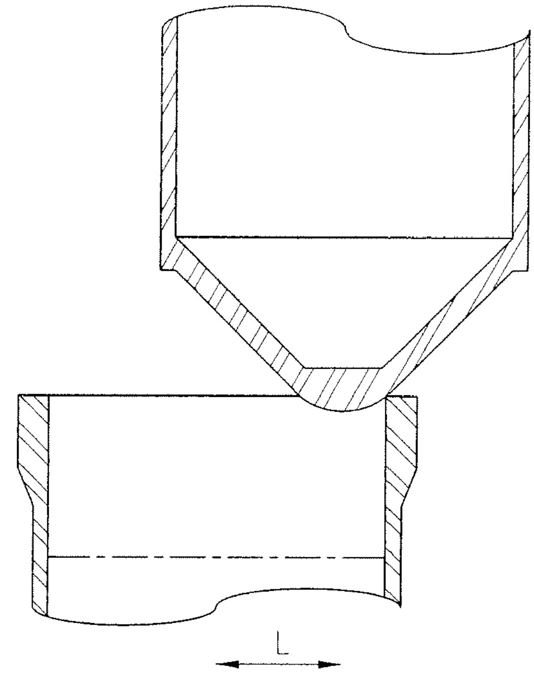

FIG. 11

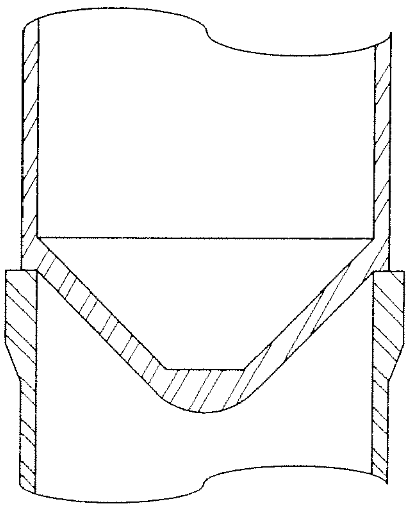

FIG. 12

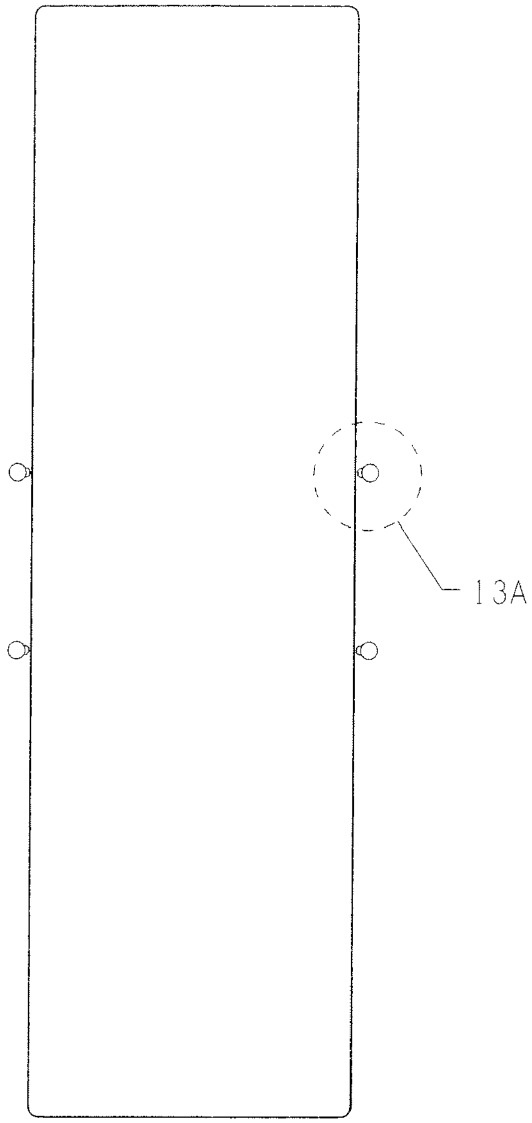

FIG. 13

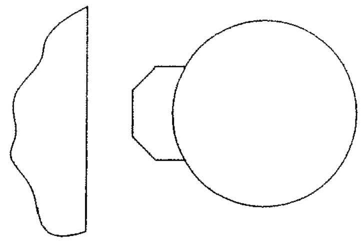

FIG. 13A

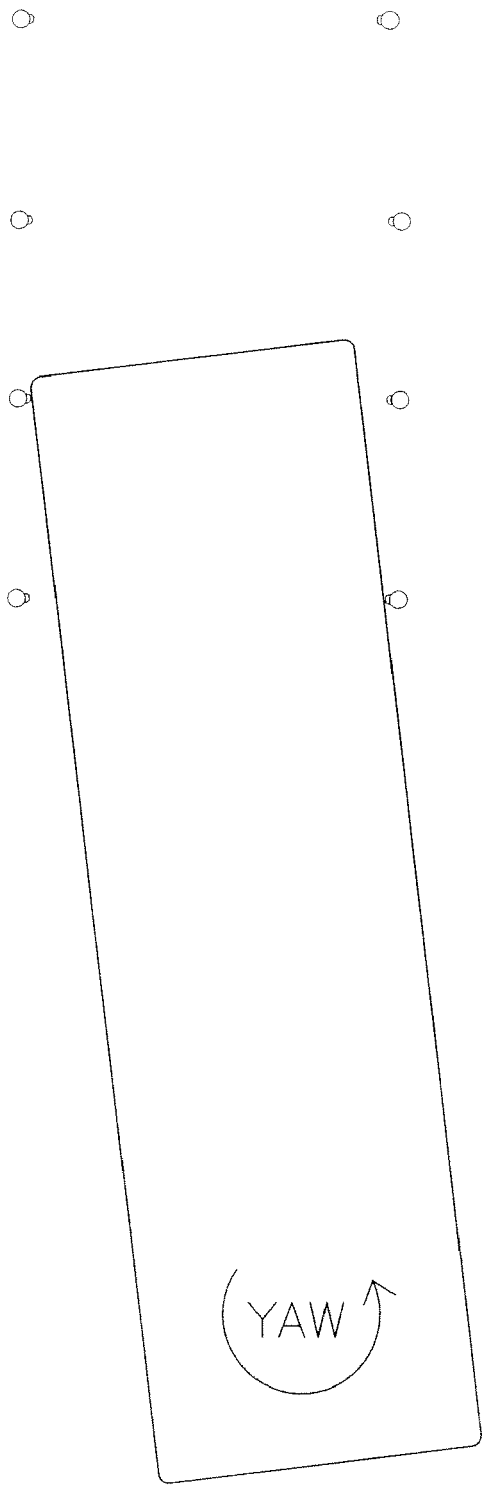

FIG. 14

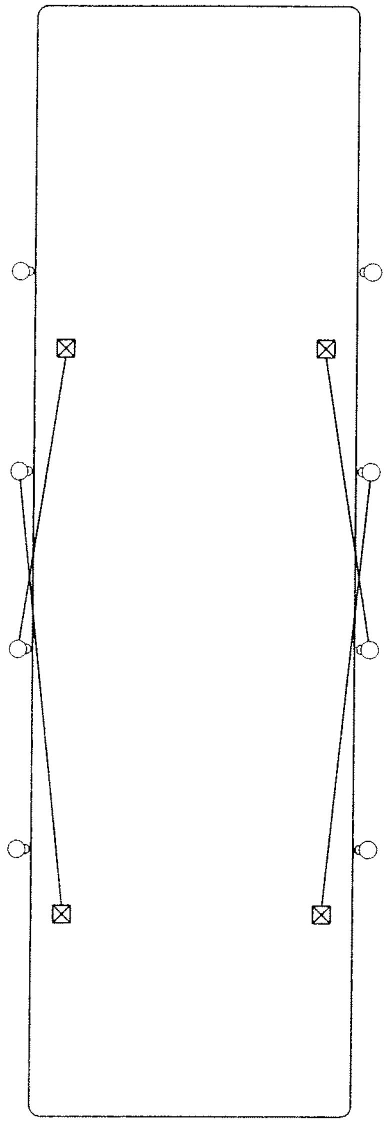

FIG. 15

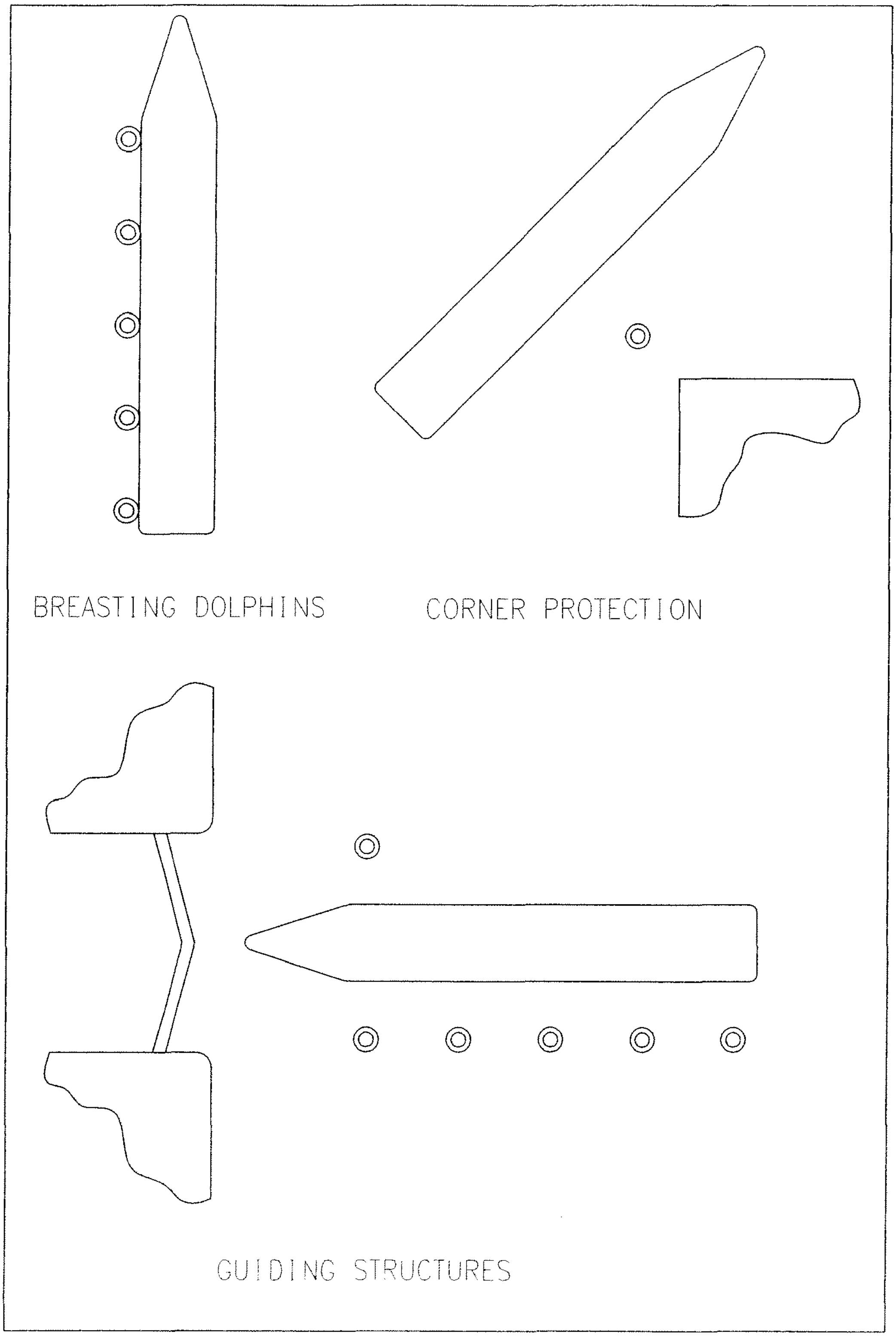
BREASTING DOLPHINS
CORNER PROTECTION
GUIDING STRUCTURES

FIG. 16

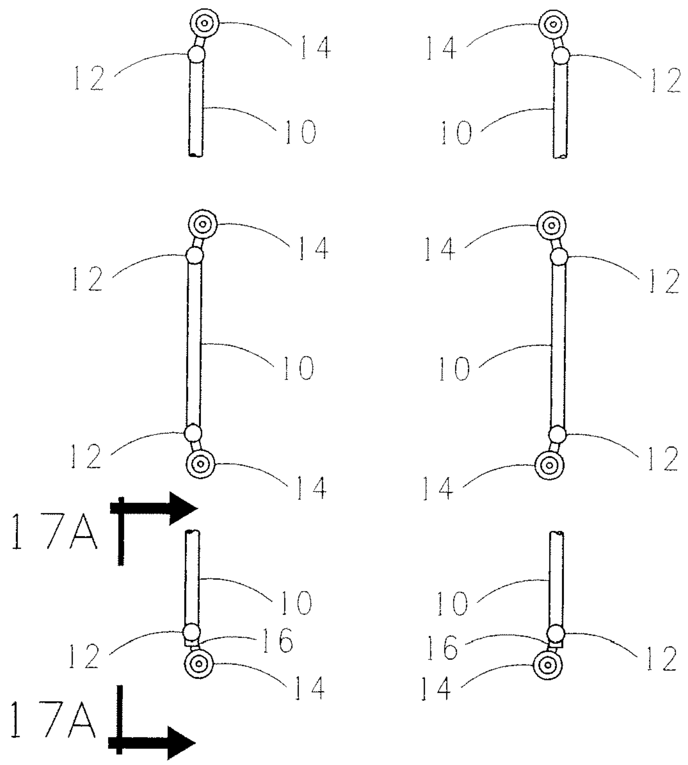

FIG. 17

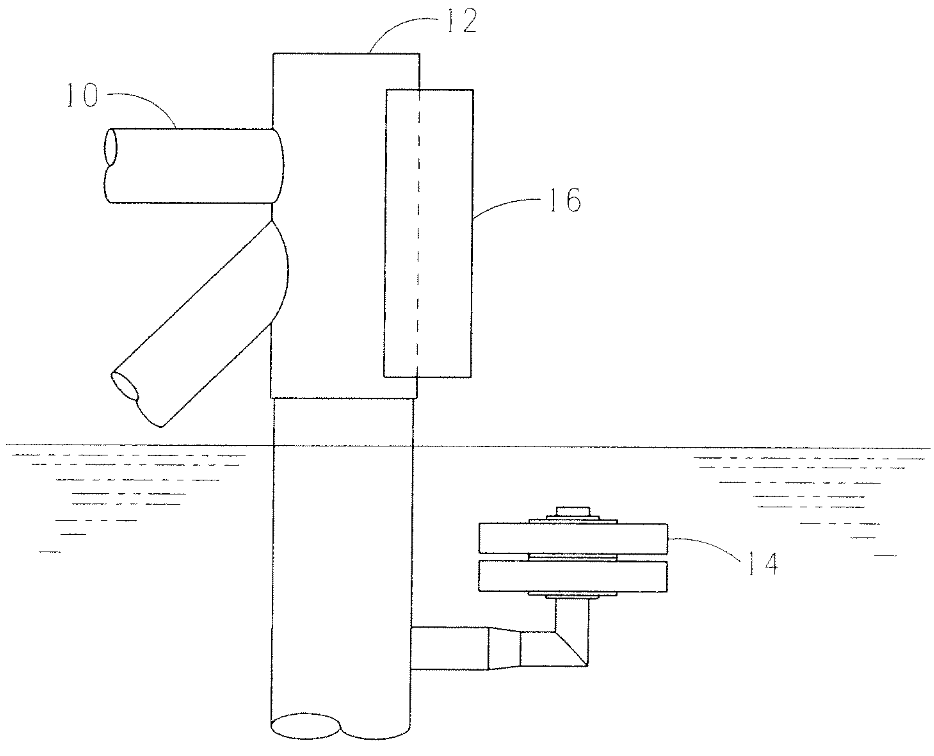

FIG. 17A

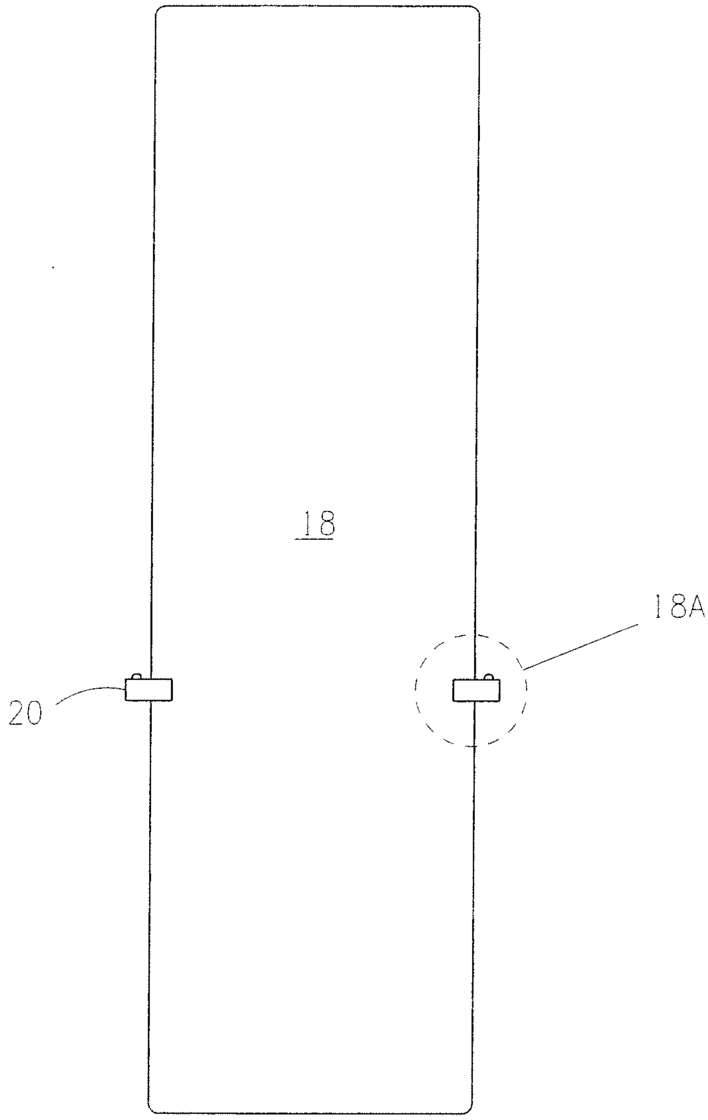

FIG. 18

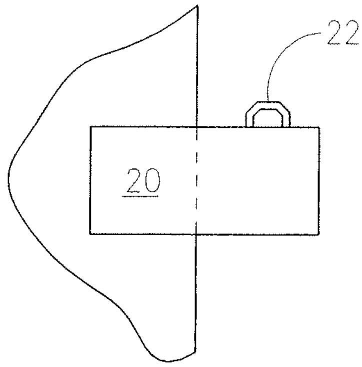

FIG. 18A

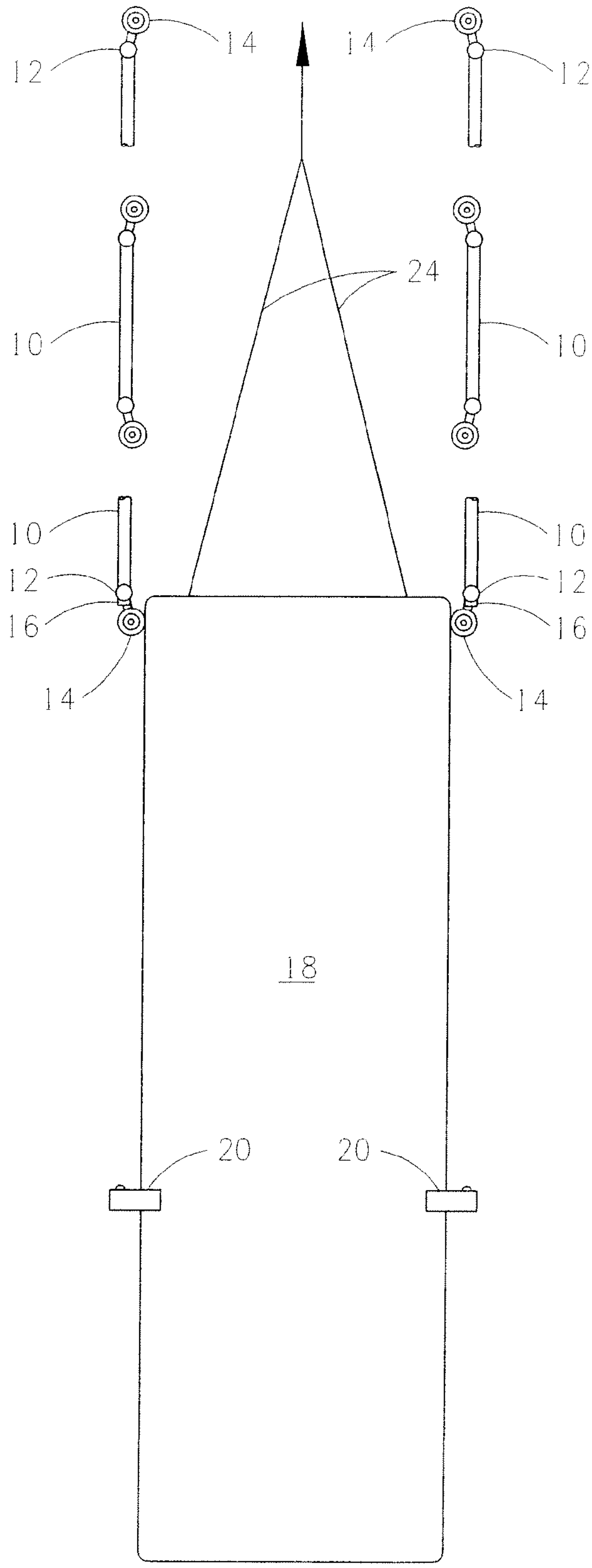

FIG. 19

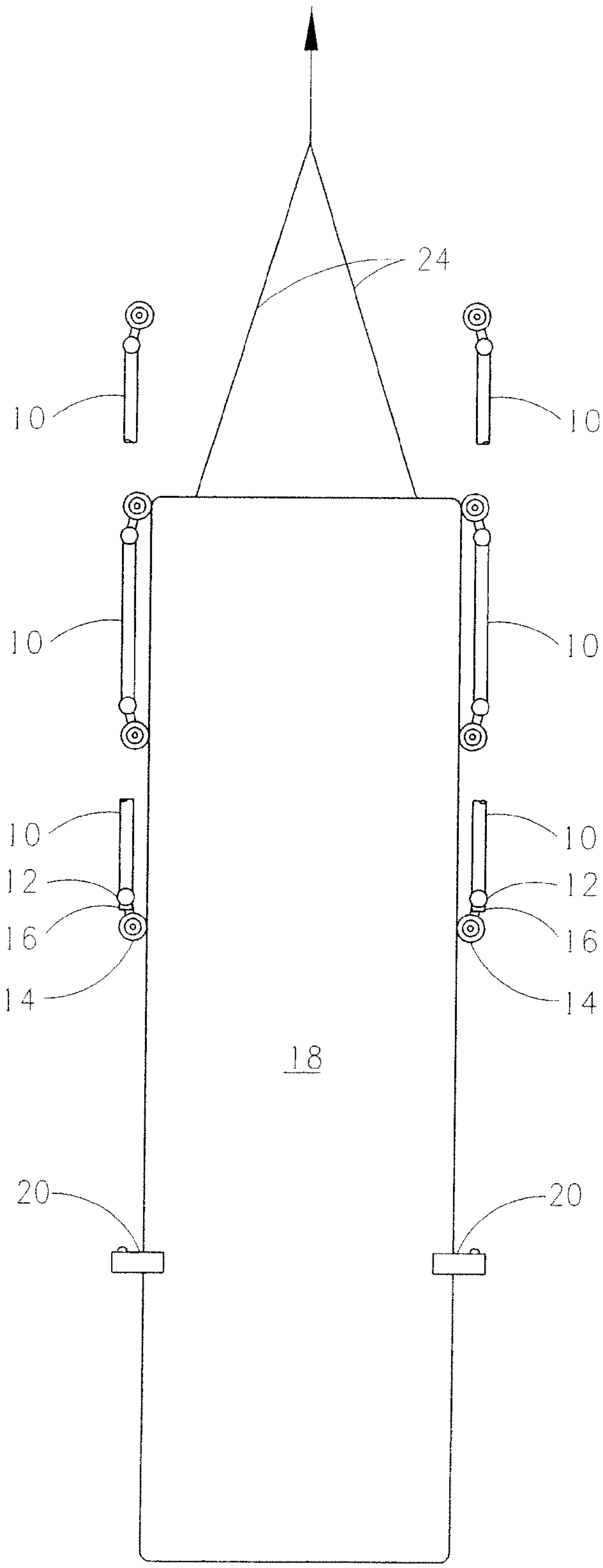

FIG. 20

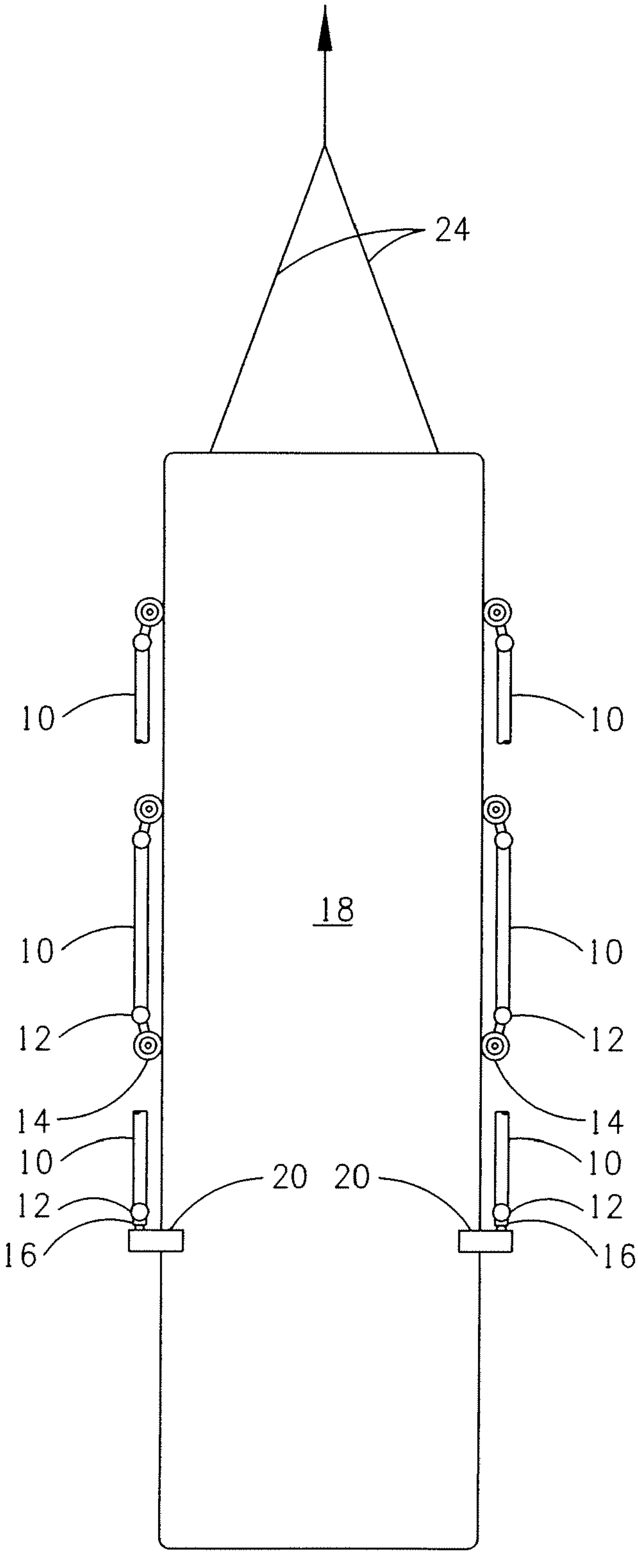

FIG. 21

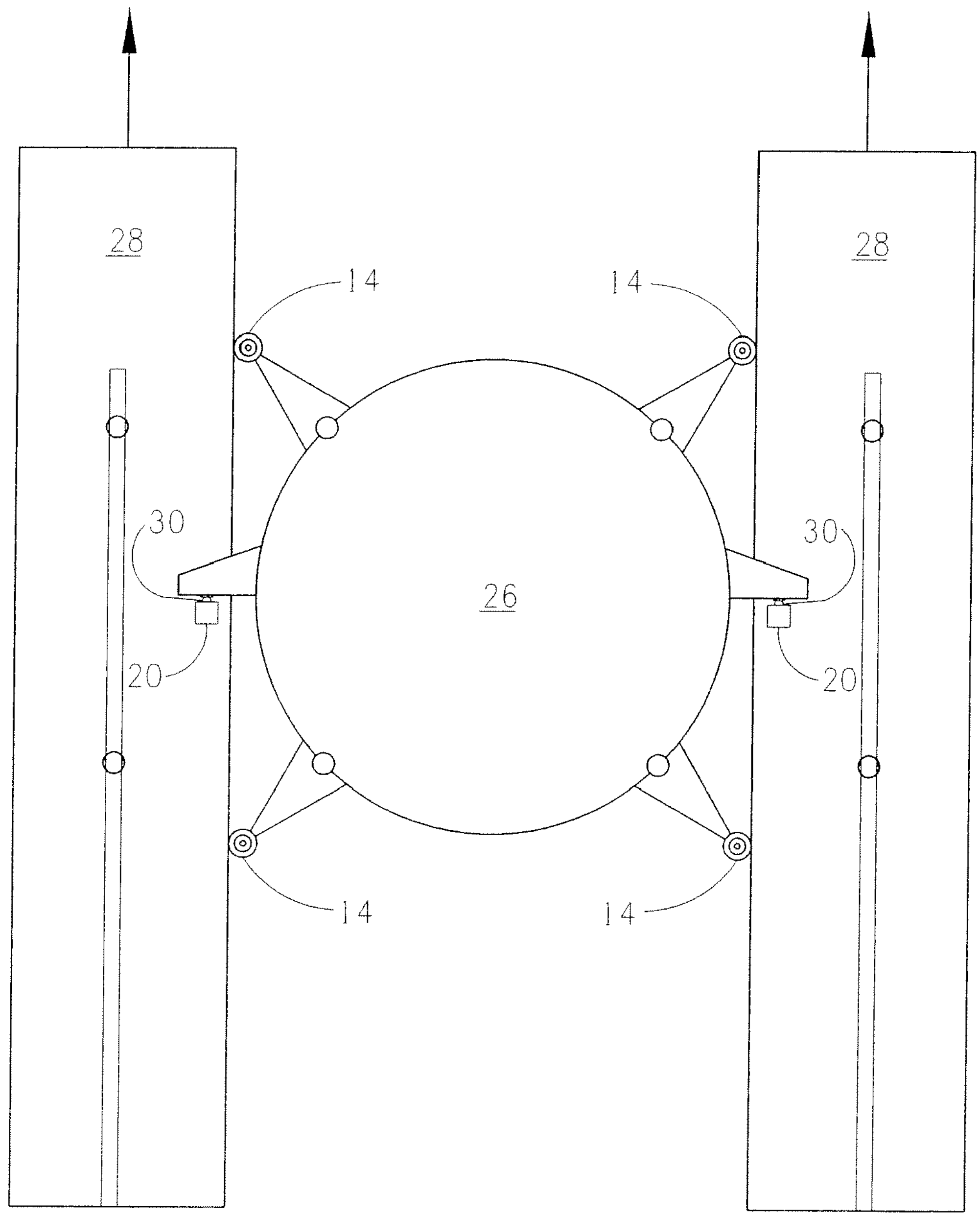

FIG. 22

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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