ABSTRACT: This invention relates to a buffer system that maintains adequate separation of two ships in an alongside mooring configuration; and will accommodate the relative motions of the two ships in a rough sea, to prevent the hulls from impacting. A plurality of inflated tires are biased in an outwardly movable direction to maintain the desired spacing; and these yield in a controlled manner that is established by inflation pressure, snubber design, mechanical linkage, and the like.
BUFFER SYSTEM FOR SHIPS

BACKGROUND

In marine activities it is frequently desirable for a supply ship to fuel and provision other ships while they are on the open sea; but this requirement poses a tremendous problem for the following reasons. Each ship is pitching, rolling, yawing, moving up and down, drifting in accordance with winds and tides, and behaving in other erratic unpredictable ways. Therefore, if the two ships approach too close together, each one has the danger of physically impacting the other ship; and since their eggshell-like hulls are not designed to withstand this type of blow, the hull-plates are in danger of being damaged or ruptured.

It has therefore become the practice to provision and fuel ships by bringing them into port, and performing the provisioning and fueling operations there. Here, in general, the sea is calm; and there is a minimum of ship movement. Moreover, in port it may be necessary to have a ship-to-ship provisioning operation; since this may be more advantageously in a dock-to-ship manner, and the sturdy bulk docks can absorb a limited amount of ship movement.

However, in some instances it becomes essential that provisioning be performed on the open sea. Since no buffer systems were previously available for permitting the ships to be moored in an alongside configuration in a seaway, both ships had to maintain headway on parallel courses, separated by a safe distance; and cargo cables and fuel hoses span this separation distance. This procedure requires extremely precise seamanship and a tremendous amount of room for maneuvering, and is avoided whenever possible.

A similar seaway provisioning problem is now arising in a somewhat different field; namely that of underwater oil wells. Many proposals envision the concept of pumping the oil from wells that are below the ocean-bottom to a storage ship that is floating at a relatively fixed mooring; the mooring being flexible enough to take into account the expected winds, tides, storms, and the like.

Since continuous oil-pumping operations are imperative, the storage ship must be able to maintain its position through most of the expected storms; leaving the area only for storms of unusual violence. Under expected storm conditions, the storage ship may be exposed to a “state-4” sea as described by Wilbur Marks—characterized by winds having a velocity of about 20 knots, a significant wave height of about 9-1/2 feet, and waves having wavelength of about 100 feet and a frequency of about 5 waves per minute.

It turns out that ships and moorings can be designed for these expected seas and storm conditions; and that oil-pumping operations can therefore be continued while the ship is exposed to conditions approaching those suggested above.

However, if oil-pumping operations are to be continuous, this means that the storage ship soon becomes fully loaded; and it must be periodically off-loaded in order to continue oil-pumping operations. Therefore, a relatively empty tanker must be moored to, and loaded from the storage- vessel; but none of the prior art provisioning techniques is satisfactory for class 4 sea conditions.

Prior art buffer systems have used many different approaches; but none of them have proved completely satisfactory. One type of prior art buffer comprised a crushable material that prevented the ships from impacting; but is so compressed during this maneuver that the buffer is no longer usable. Other buffers comprise logs that eventually splinter and must be replaced; and still other buffers comprised inflatable tubes, tires, and springs—but these have the disadvantage that they rebound in such a manner as to drive the ships farther apart than is desirable.

OBJECTS AND DRAWINGS

It is therefore an object of the present invention to provide an improved buffer system for ships.

The attainment of this object and others will be realized from the following detailed description and drawings, of which:

FIG. 1 shows a plan view of two ships that are being held in close proximity;
FIG. 2 shows a front view of the two ships; and
FIG. 3 and 4 show use of the disclosed buffer system.

The present invention relates to a buffer system that is positioned between two ships in order to permit the approach and alongside mooring of two ships in exposed ocean areas in sea states up to about state 4 sea; and to remain alongside to in these exposed areas.

Broadly stated, the invention discloses the use of inflated tires that are urged outwardly from the mother ship, in order to establish the mooring separation-distance. A series of stubber permits a controlled approach, and reestablishes the desired spacing as soon as the wave-thrust decreases. In order to obtain optimal results, a motor-driven mechanism is used to vertically position the buffer just above the water level.

DISCLOSURE

Referring now to FIG. 1 there is shown a storage-vessel 10, assumed—for convenience—to be loaded with oil that is to be "off-loaded" to a tanker 12, using means such as off-loading hoses 14.

A buffer-system, to be described later in greater detail, is positioned between the ships 10 and 12; and the ships are held together by a mooring-line arrangement such as breast-lines 16 and spring-lines 18—these being attached to constant-tension winches 20.

In operation, the mooring lines pull the ships together; the buffer system maintaining the desired spacing.

In order to present the problem more clearly, attention is directed to FIG. 2; this showing a bow view of adjacent portions of the vessel's hulls, and a portion of the buffer-system 24 positioned between them. FIG. 2a depicts the condition wherein storage vessel 10 is heavily loaded, and tanker 12 is practically empty, FIG. 2a showing their positions relative to the waterline.

FIG. 2b on the other hand shows the situation when service-vessel 10 has been emptied, and tanker 12 is now sitting deeply in the water.

It will be realized that the buffer system must be positioned in such a way as to always be between the two ships; and this consideration indicates that the buffer system should always be about at the waterline. In FIG. 2a, due to the low position of service vessel 10, the buffer system is near the deck portion of the service-vessel 10; whereas in FIG. 2b the service vessel is fairly high in the water; and the buffer system must be lowered relative to the service vessel in order to maintain the proper relationship to the tanker.

Many prior art buffer systems sought to achieve this positioning control by causing the buffer system to float; so that it was automatically positioned at the waterline. This arrangement was quite satisfactory for prior art port usage where the winds, tides, and waves had a very small effect, but a rough sea produces the following results.

When two ships are moored alongside each other in a rough sea, each ship tends to rise on each wavecrest, and to fall at each wave trough. If a cross wave has an extremely long wavelength, the two ships tend to rise and fall together—as a unit. However, if the cross-wave has a wavelength that is approximately equal to the combined width of the two ships, each ship tends to rise and fall independently of the other; i.e., one ship may be in a trough while the other is at a crest, one ship may be rising while the other is falling, one ship may be rolling in one direction while the other is rolling in the other direction, etc. One of the worst conditions occurs when the wave crest or the wave-trough is between the ship; under the first condition (1) the ships roll away from each other—but tending to move away from each other; whereas under the second condition (II) the ships roll toward each other—tending to move toward each other, and introducing danger of impact.

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The ship-separation distance necessary to avoid impact must be at least equal to the relative sway excursions of the two vessels in the existing seaway in order to permit the necessary amount of sway and roll without damaging either ship.

These rough-water conditions mitigate against the use of a floating buffer system. For example, under condition (1) wherein a wave-crest is between the ships, and the ships roll away from each other, a floating buffer system would float upwards on the wave-crest in such a way that it was not properly positioned to protect the two ships. Under state (II) wherein a wave trough appeared between the ships, and the ships listed toward each other, a floating buffer-system would be pinched between the two ships, and would be carried so far below the water surface that it would fail to provide a buffering action. Thus, a floating buffer system would not provide the desired rough sea protection.

In order to overcome the disadvantages of prior art systems; the disclosed buffer-structures 24 are mounted on vertical tracks fastened to the storage vessel (these to be described later); and the buffer-structures 24 are physically moved upwards and downwards to assume the desired waterline position, this position being maintained for a predetermined loading interval by means of suitable braking arrangement. In this way, the disclosed buffer system is always in the optimum position to provide a desired rough-water buffering action.

FIG. 3 shows a side-view of a C 4 for spacing the ships 10 and 12 at a suitable separation-distance from each other. As indicated above, buffer-structure 24 is to be vertically positionable, and comprises an A-shaped framework 28 that moves along a set of vertically oriented guide tracks 30; suitable guide shoes or rollers 32, 34, coaxing with the guide tracks 30. Framework 28 comprises a main strut 36 that is pivotally attached to the upper guide element 32; the axle 38 of an inflatable tire 40 (typically four feet in diameter) being attached to the outer-end of the main-strut 36 in such a way that tire 40 can rotate in a vertical plane. The outer-end of main-strut 36 is also pivotally attached to an arm 42 that is affixed to the piston-portion 44 of a "snubber" 46 (to be discussed in greater detail later), whose housing-portion 48 is in turn pivotally attached to the second guide-element 34.

A supporting-strut 50 is connected between lower guide-element 34 and main-strut 36, in order to provide stability, and to hold snubber 46 in an optimal horizontal orientation. An arrangement for moving the framework-assembly vertically is best seen in FIG. 4. Here, for example, a motor 60 rotates a shaft 62 by a suitable belt or gear drive 64; and this in turn drives suitably mounted gears 66 along a fixedly positioned gear-rack 68. A suitable motor-braking-arrangement 70 holds the framework in any desired position.

FIGURE 4 is a plan view of the buffer-structure 24 that shows the use of a plurality of tires 40 on the suitable framework 28 having a plurality of main-struts, supporting-struts, and snubbers. The entire structure of FIG. 4 is cross-braced to minimize lateral displacement.

The operation of the active buffer-element 26 will best be understood by referring back to FIG. 3. Assume here that ship 12 is approaching sidewise, under the influence of the mooring-line arrangement, and has just contacted tires 40. It should be realized that for these mooring conditions the service-vessel 10 will generally be heavily loaded; so that it will sit deeper in the water, and have greater stability than the generally lighter-loaded tanker. As contact is made between tanker 12 and tires 40, the mooring load causes the tires to flatten at the point of contact, thus increasing their "footprint", and distributing the force over a larger area of the hull of tanker 12.

As tanker 12 approaches even closer to service vessel 10, tires 40 are moved inwardly toward the position indicated by the dotted lines of FIG. 3. This movement "strokes" a snubber 46; which may be, for example, one of the type described in the article "Air-Oil Shock Absorbers" by Charles W. Bert in the Dec. 22, 1960 issue of Machine Design. Basically, these comprise a piston-cylinder arrangement wherein a hydraulic fluid is forced through a pattern of apertures during the impact interval.

Since snubber 46 is an air-oil arrangement, the gas therein is compressed and directed through tubing 70 to a gas tank; and the fluid is forced through the apertures of the snubber and through tubing 70 to a fluid tank. Thus, the tire/snubber action may have a long stroke that is particularly effective in protecting against impact damage.

In this way there is a double buffer-action, comprising (a) a compression of the tire, and (b) a compression of the snubber 46. Thus, the rate-of-closure between the two hulls is controlled.

As the approaching ship is slowed, and eventually stopped, the controlled air pressure and oil pressure in snubber 46 expand the snubber in a nonrebounding manner; thus moving tires 40 toward their original positions; and moving tanker 12 to the desired spacing, where it is held by means of the mooringlines discussed previously. In this way, the disclosed buffer element 26—having controlled approach and nonrebounding characteristics permits alongside mooring in a rough sea.

It will be realized that a different amount of snubbing may be required for different-sized and differently loaded ships; and to achieve this variation, the gas and oil pressures of snubber 46 may be controlled.

It will also be realized that as the two ships sway and roll as discussed above, there will be a minor lateral movement. It has been found that tires 40 will be constantly wet from wave action; but, since the friction of the wet rubber is low, no particular compensation is necessary to take care of the lateral motion—that is, for the minor longitudinal motion, the wet tires merely slide longitudinally over the wet hull of the adjacent tanker—but for the major vertical motion the wheels rotate.

It should be noted that the entire buffer-structure 24 may be raised to the deck of the service vessel and hauled aboard for storage and/or maintenance as these become necessary.

Referring back momentarily to FIGURE 1, it will be seen that there are a plurality of such buffer-structures 24 mounted on the service vessel 10 to form a buffer system; and are distributed in such a way as to share the load of spacing the tanker 12 from the service vessel 10. Thus it is only necessary to have suitable tracks in order to use as many or as few of the disclosed buffer assemblies as may be necessary.

The above disclosed buffer system is such that it constantly urges the two ships to a predetermined spacing; which is then maintained by the mooringlines. If desired, the spacing may be more precisely controlled by measuring the position of the snubber's piston; which then produces an electrical signal that controls the pressure of the hydraulic and gas systems to either extend or contract snubber. Alternatively a liquidometer may be used to indicate the amount of liquid in the snubber; and this signal may be then used to control the hydraulic pneumatic system.

There is always the possibility that an unusual combination of wind/tide/wave/etc. will produce a momentarily abnormally large roll or sway that may be larger than the disclosed system can handle. To overcome this problem, a passive buffer system 74 may be additionally used. This is shown, in FIG. 1, to comprise sets of inflated tires mounted on common axles. These tires have an inflated outer-diameter that is just large enough to extend beyond the dotted line representative of tire 40 in FIG. 3.

In use, the passive buffer array is merely lowered over the side of the ship, to float at the water level; and here it acts as a passive buffer when the active buffer has been compacted to its design length. In this way, a plurality of passive buffers are used to take care of those rare situations wherein a particular combination of sea conditions momentarily exceeds the rated capacity of the active buffer system.

1. A buffer system for rough-sea alongside-mooringlines interconnecting said ships, comprising:
A. means for spacing one of said ships from the other of said ships, said spacing means having
I. at least one vertically oriented guide-track positioned on the outside hull portion of one of said ships;
II. a structural framework adapted to move vertically along said vertically oriented guide-track;
III. means for providing lateral stability of said spacing-means, comprising a plurality of guide-elements positioned on said framework, and coacting with said guide-track;
IV. means for vertically positioning said framework along said guide-track;
V. means for braking said framework at a desired vertical position along said guide-track at substantially the waterline in correspondence with the instantaneous draft of said ships;
VI. a buffer element positioned on each framework comprising:
a. at least one inflatable tire, mounted on said framework for rotation in a vertical plane, for rotating along said other ship's hull as the relative vertical positions of said ships change in a rough sea;
b. impact-minimizing means, mounted effectively between said tire and said framework, for absorbing impact-energy, said means comprising a gas/fluid snubber protruding from and disposed normal to said one ship's hull during activation thereof, and wherein said impact forces said fluid through apertures and compresses said gas for providing a long strike dual snubbing action produced by tire-compression and by snubber action;
c. minimized-rebound means for urging said tire outwardly toward the other ship for establishing a separation-distance between said ships, said urging means comprising the pressurized gas in said gas/fluid snubber.

2. The combination of claim 1 wherein said structural framework comprises
a. a main strut having its inboard-end pivotably attached to one of said guide-elements, said tire being attached to the outboard-end of said main-strut;
b. said snubber being pivotably attached between said tire and another of said guide-elements;
c. support-strut means, having its inboard-end pivotably attached to said other guide-element and having its outboard-end pivotably attached to said main strut, for maintaining said snubber in a substantially horizontal position.

3. The combination of claim 2 wherein said structural framework further comprises a plurality of parallel mainstruts, a plurality of associated support struts, and a plurality of associated snubbers.

4. The combination of claim 3 including a source of controllable-pressure gas and a source of controllable-pressure fluid; and means for providing said snubbers with said controllable-pressure gas and fluid.

5. A buffer system for rough-sea alongside-mooring of two ships comprising:
A. a first ship;
B. a second ship;
C. a plurality of mooring lines interconnecting said ships;
D. means for spacing said first ship from said second ship, said spacing means having
   I. a plurality of sets of vertically oriented guide-tracks positioned on the outside hull portion of one of said ships;
   II. a plurality of structural frameworks, respective frameworks positioned along respective sets of said vertically oriented guide-tracks, each said framework having at least a pair of two vertically spaced guide-elements positioned to coact with respective guide-tracks;
   III. motor means for vertically positioning said frameworks along respective said guide-tracks;
IV. means for braking said motor means at a desired vertical position along respective said guide-tracks at substantially the waterline in correspondence with the instantaneous draft of said ships;
V. a buffer-element positioned on each framework, comprising:
a. at least a plurality of inflatable tires mounted on each said framework for tire-rotation in a vertical plane;
b. impact-minimizing means for absorbing impact-energy, said means comprising a long-stroke gas/fluid snubber, protruding from and disposed normal to said one ship's hull and between said tires and said framework;
c. minimized-rebound means for urging said tires outwardly toward the outer ship for establishing a separation-distance between said ships, said means comprising said gas/fluid snubber;
d. means for controlling the air and fluid pressures of said snubber, for controlling the approach and separation of said ships.

6. The combination of claim 5 wherein:
1. said framework comprises a plurality of parallel mainstruts having their upper inboard-ends pivotably attached to respective said upper-disposed guide-elements, said tires being attached to the lower outboard-end of respective mainstruts;
2. said impact-minimizing means comprises a plurality of snubbers pivotably attached between said tires and respective said lower-disposed guide-elements;
3. a like plurality of support-struts having their inboard-ends pivotably attached to respective lower-disposed guide-elements and having their outboard-ends pivotably attached to said main-strut.

7. In a buffer system for rough-sea alongside-mooring of two ships having a plurality of mooring lines interconnecting said ships, and having at least one vertically oriented guide-track positioned on the outside hull-portion of one of said ships, the combination comprising:
carriage means, movably mounted on the track, for movement therealong;
amain strut having an upper end pivoted to the carriage means, and having lower end free;
a resilient bumper mounted on said lower end of the main strut; and a shock absorber having one end pivotally connected to said lower end of said main strut, and having its other end pivotally connected to said carriage means, said shock absorber being at a position substantially displaced below the pivotal connection between the main strut and carriage means so that said shock absorber is disposed normal to the hull of said one ship.

8. The combination of claim 7, wherein said carriage means comprises first and second guide-elements pivotably to said main strut and to said shock absorber, said guide-elements being displaced from each other along said track; a stabilizing-strut having one end pivoted to said second guide-element having the other end pivotally connected to the midpoint of the main strut and said stabilizing strut being half as long as said main strut.

9. A buffer system for rough-sea alongside-mooring of two ships having a plurality of mooring lines connecting said ships, comprising:
A. means for spacing one of said ships from the other of said ships, said spacing means having
   I. at least one vertically oriented guide-track positioned on the outside hull-portion of one of said ships;
   II. carriage means, comprising vertically spaced upper and lower guide elements that are movably mounted on said respective track for movement along said track;
   III. a structural framework mounted on said carriage means, said framework having
      a. a main strut having an upper end pivotally connected to the upper guide-element, and having a lower end free;
      b. a stabilizing strut having a lower end pivotally connected to the lower guide element, and having an upper end pivotally connected to an intermediate portion of said main strut;
IV. a resilient bumper mounted on said lower end of said main strut, said resilient bumper comprising an inflata-
ble tire mounted for rotation in a vertical plane for rotating along the other ship's hull as the relative verti-
cal positions of said ships change in a rough sea;
V. impact-minimizing means, comprising a shock ab-
sorber having one end pivotally connected to said lower end of said main strut, and having its other end pivotally connected to the lower guide-element, so that said shock absorber is disposed substantially normal to and protrudes from the hull of said one ship as said bumper moves towards or away from said one ship;

VI. motor means for vertically positioning said carriage means along said guide-track;
VII. means for braking said carriage means at a desired vertical position along its guide track at substantially the waterline in correspondence with the instantaneous draft of said ships.
10. The combination of claim 9 including a source of controllable-pressure gas; a source of controllable-pressure fluid; and means for providing said shock absorbers with said control-
able pressure gas and fluid.