# United States Patent

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[73] Assignee **North American Rockwell Corporation**


[54] **BUFFER SYSTEMS FOR SHIPS**
**6 Claims, 5 Drawing Figs.**


[52] **U.S. Cl.** ..... **114/220, 114/230**
[51] **Int. Cl.** ..... **B63b 21/04, B63b 21/00**
[50] **Field of Search** ..... 114/220, 221, 230, 219; 61/48



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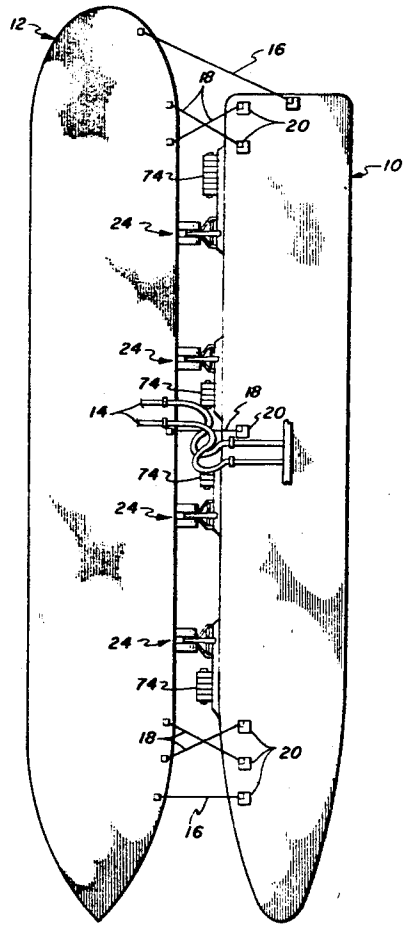
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**ABSTRACT:** This invention relates to a buffer system that maintains adequate separation of two ships in an alongside mooring configuration; and will accommodate the relative motions of the two ships in a rough sea, to prevent the hulls from impacting. 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.

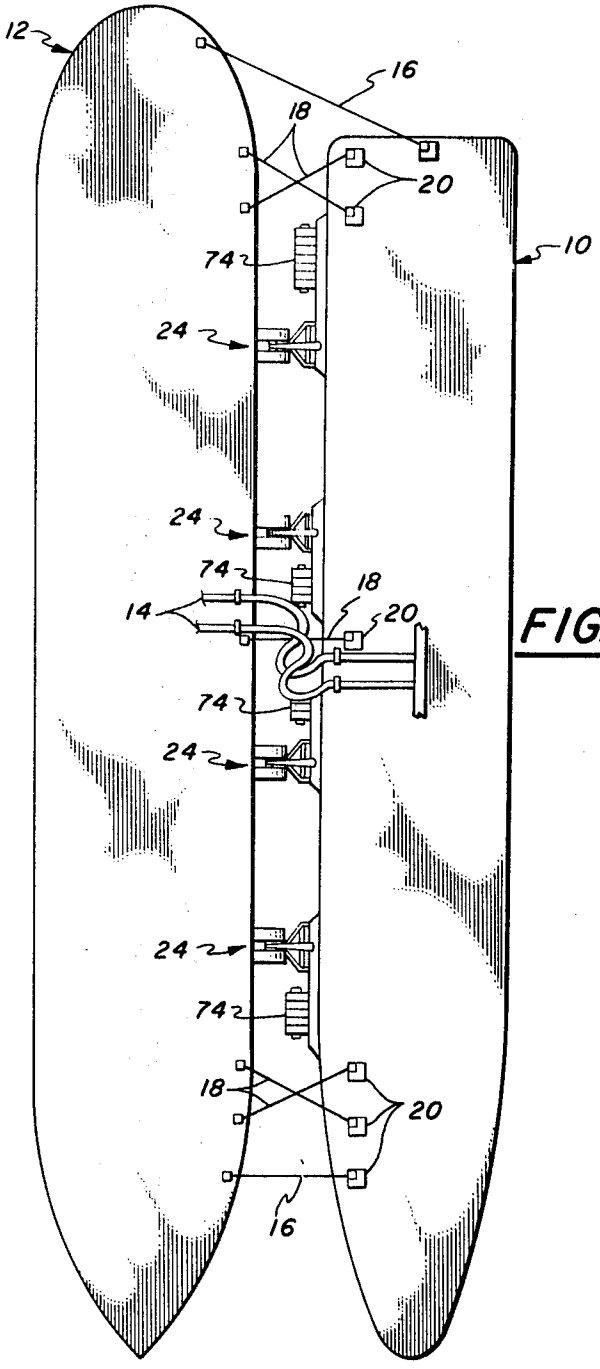



FIG. 1

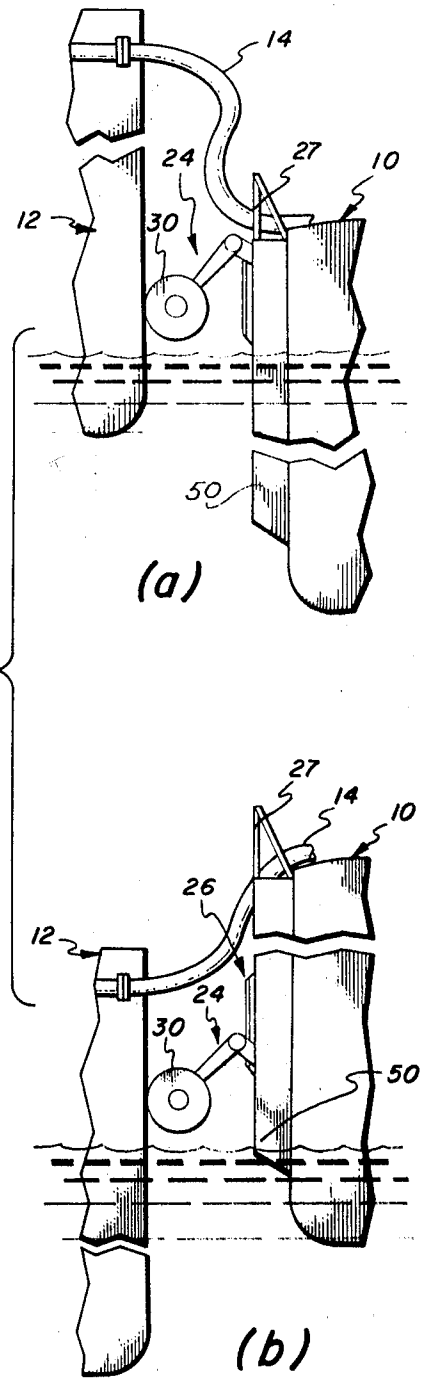



FIG. 2

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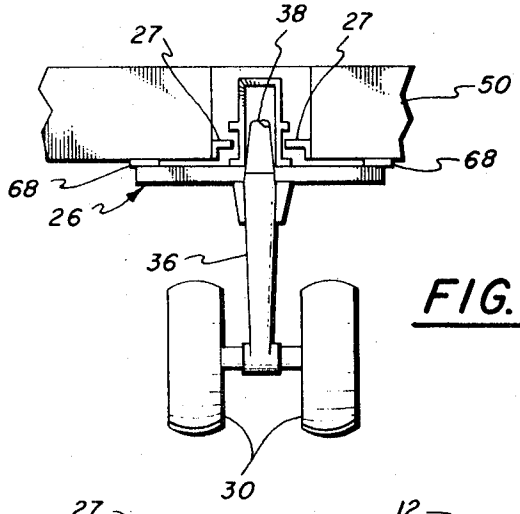



FIG. 5

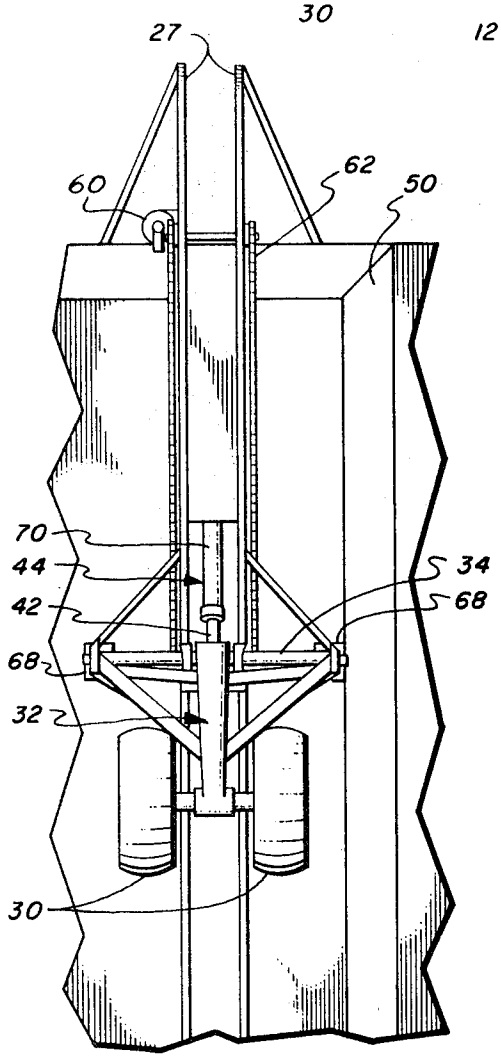



FIG. 4

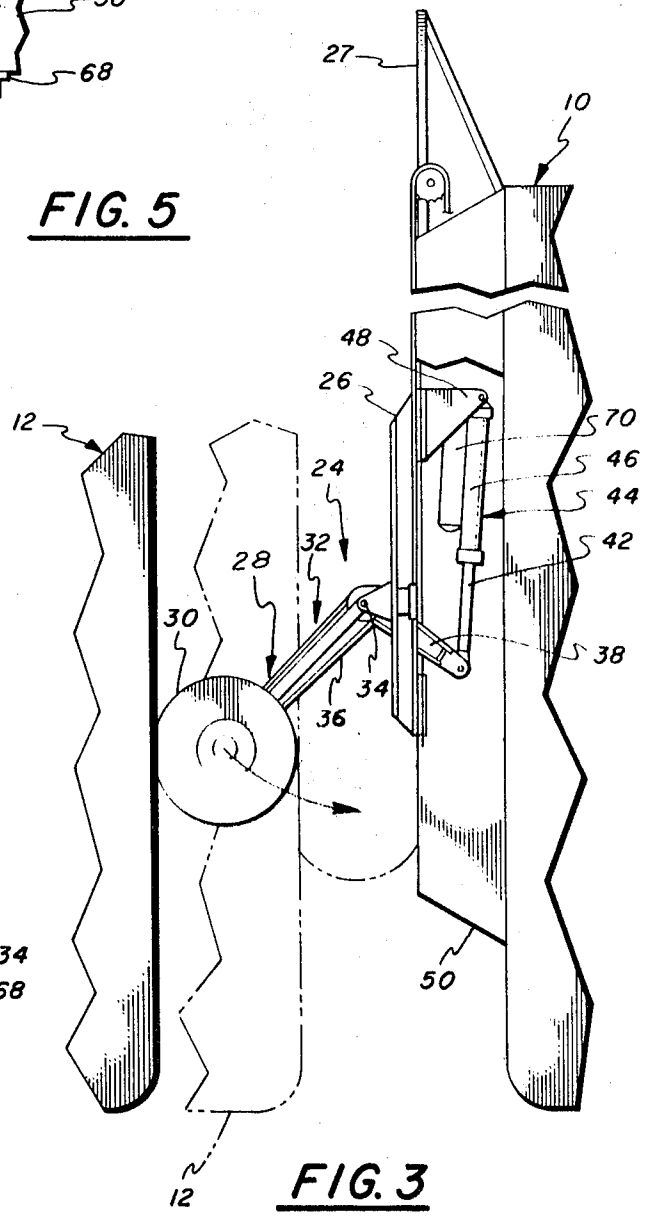



FIG. 3

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# BUFFER SYSTEMS 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 to winds and tides, and behaving in other erratic unpredictable ways. Therefore, if the two ships approach too close to each other, there is 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 to fuel ships by bringing them into port, and performing the provisioning and fueling there. Here, in general, the sea is calm; and there is a minimum of ship movement. Moreover, in port it may be unnecessary to have a ship-to-ship provisioning operation; since this may be done more advantageously in a dock-to-ship manner—and the sturdily built 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 ships to be moored in an alongside configuration in a seaway, to achieve this type of provisioning, both ships 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 s 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 9½ 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 sea 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.

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 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

FIGS. **3**, **4**, and **5** show use of the disclosed buffer systems.

## SYNOPSIS

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 thereto in these exposed areas.

Broadly stated, the invention discloses the use of inflated tires that are urged outwardly of the mother ship, in order to establish the mooring separation distance. A series of snubbers 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 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'hulls, and a portion of the buffer structure **24** positioned between them. FIG. **2***a* depicts the condition wherein storage vessel **10** is heavily loaded, and tanker **12** is practically empty; FIG. **2***a* showing their positions relative to the water line.

FIG. **2***b* 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 is such a way as to always be between the two ships; and this consideration indicated that the buffer system should always be about at the waterline. In FIG. **2***a*, due to the low position of service vessel **10**, the butter system is near the deck portion of the service vessel **10**; whereas in FIG. **2***b* 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 water line. 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 wave crest, 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 ships; under the first condition (I) the ships roll away from each other—thus

tending to move away from each other; whereas under the second condition (II) the ships roll toward each other—thus tending to move toward each other, and introducing danger of impact.

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 militate against the use of a floating buffer system. For example, under conditions (I) wherein the 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 condition (II) wherein a wave trough appeared between the ships, and the ship rolled 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 structure 24 comprises a framework 26 mounted on vertical guide tracks 27 fastened to the storage vessel (these to be described later); and, the buffer structure is physically moved upwards and downwards to assume the desired waterline posiiton—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 one buffer structure 24, comprising a vertically movable framework 26 that rides up and down on vertical guide tracks 27 that are in turn affixed to a sponson 50, which is a sort of "blister" structure attached to the outer hull portion of the ship. Thus, framework 26 may be positioned vertically to be at the waterline, regardless of the ship's instantaneous state of loading.

A buffer element 28 is shown to comprise a large inflated tire 30 that is about 8½ feet in diameter; tires of this size being made by General Tire and Rubber Company under the designation ND LCM wire base 37, 5—39, 32 ply. These particular tires may be inflated with a pressure that ranges between 20 and 50 pounds per square inch; the advantage of this adjustable inflation to be discussed later.

In FIG. 3, the inflated tire 30 is mounted on a bellcrank 32 that is pivoted on an axle 34; bellcrank 32 comprising on outer portion 36 and inner portion 38. Axle 34 is mounted on the previously described vertically movable support framework 26; and the inboard end of bell crank 32 is connected to piston portion 42 of a "snubber" 44 whose housing 46 is attached to framework 26 by means of a suitable bracket 48. In this way the buffer element 28 has its snubber and its associated mechanism protected by sponson 50.

As previously discussed, the buffer element 28 is preferably positionable in a vertical direction; and FIG. 4 shows that one way to achieve this vertical movement, is to mount framework 26 in guide tracks 27 that are affixed to the hull. A motor 60 drives a chain 62 that raises and lowers the support frame 26 and the buffer element 28.

In order to provide better load characteristics, a pair of tires 30—rather than a single tire—is used, the tires 30 being assembled in a substantially diamond-shaped mechanical arrangement that comprises a pair of outboard guide shoes 68 that provide lateral stability. In this way, vertical movement and lateral stability are obtained.

The operation of the active buffer arrangement 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 30; and assume further that tires 30 are softly inflated.

It should be realized that for these mooring conditions the service vessel 10 will generally be heavily loaded; so that it will sit deeply in the water, and have greater stability than the generally lighter loaded tanker. As contact is made between tanker 12 and tires 30, the mooring load causes the soft tires to flatten out at the point of contact in a "one plane" manner; thus increasing their "foot print," and distributing the force over a larger area of the hull of tanker 12. As tanker 12 approaches even closer to service vessel 10, the bellcrank 32 pivots, and tires 30 are moved inwardly toward the position indicated by the dotted lines. During this movement interval, bellcrank 32 pivots about its axle 34; and the inner portion 38 of the bellcrank "strokes" or compresses snubber 44—thus providing a second buffer action. Snubber 44 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 the compressive action forces a hydraulic fluid through a pattern of apertures during the impact interval—thus absorbing impact energy. Since snubber 44 is an air-oil arrangement the gas therein is compressed, and directed to an accumulator 70; the fluid being forced through the apertures into a sump area of the snubber. The use of pressurized air and pressurized hydraulic fluid permits the snubber to be reextended in a nonrebound manner to the desired distance.

As tire 30 is moved to the location indicated in FIG. 3 by the dotted line, its other side impinges upon sponson 50; and the tire now compresses on two sides. In this way there is a triple-buffer action, comprising (a) a one-sided compression of the tire, (b) the compression of the snubber 44, and (c) the two-sided compression of the tire. Thus, the rate-of-closure between the two hulls is controlled—utilizing a long snubber stroke and an appreciable tire compression.

As the approaching ship is slowed, and eventually stopped, the air and oil pressures in snubber 44 and in accumulator 70 expand the snubber in a minimized-rebound manner; thus moving tires 30 toward their original positions, and moving tanker 12 to the desired spacing, where it is held by means of the mooring lines discussed previously. If desired, controlled-pressure gas and oil tanks may be used to further minimize rebound. In this way, the disclosed buffer system 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 pressure of tires 30 and/or snubber 44 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 30 will be constantly wet from wave action; and, since the friction of the wet rubber tires is low, no particular compensation is necessary to take care of the lateral motion; that is, the wet tires merely slide longitudinally over the wet hull of the adjacent tanker; but, if desired, the tires may be obtained with slick outer peripheries.

As discussed above, as the tanker is loaded, there will be a major vertical repositioning of the two ships; and tires 30 readily roll along vertically the tanker's hull as part of this vertical movement.

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 again to FIG. 1, it will be seen that there are a plurality of buffer structures 24 mounted on the service vessel 10; 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 mooring lines. If desired, the spacing may be more precisely controlled by measuring the position of the piston of the snubber; the piston's position producing an electrical signal that controls the pressure of the hydraulic and gas systems to either extend or contract snubber. Alternately a liquidometer may be used to indicate the amount of liquid in

the snubber; and its signal may be used to control the hydraulic pneumatic system. There is always the possibility that an unusual combination of wind/tide/wave/etc. will produce a momentary abnormally large roll or sway that may be larger than the disclosed system can handle. To overcome this problem, an additional "passive" buffer system **74** may be used. This is shown, in FIG. **1**, to comprise a plurality of inflated tires mounted on a common axle. These tires have an inflated outer diameter that is just large enough to extend beyond the dotted line representation of tire **30** in FIG. **3**.

In use, the passive buffer array or arrays is 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.

What I claim is:

**1**. A buffer system for rough sea alongside mooring of two ships having a plurality of mooring lines 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;

VI. a buffer element comprising:

a. a bellcrank pivotably mounted on said framework;

b. at least one soft-inflated tire, mounted on the outboard end of said bellcrank, for rotation in vertical plane, for rotating along said other ships hull as the relative vertical positions of said ships change in a rough sea.

**2**. The combination of claim **1** including

a. impact-minimizing means, comprising a gas/fluid snubber mounted between the inboard end of said bellcrank, and said framework, for producing a long stroke absorption of the impact energy due to the relative sidewise motions of said ships in a rough sea, the impact forces causing the fluid of said snubber to flow through apertures, and compressing the gas of said snubber;

b. minimized-rebound means for urging said tire outwardly toward the other ship for establishing a separation distance between said ships, said urging means comprising said gas/fluid snubber for causing said buffer element to have a triple action produced by one-sided tire compression, by snubber action, and by two-sided tire compression.

**3**. The combination of claim **2** wherein said inflatable tire is about 8 feet in diameter.

**4**. 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 sponsons affixed to the outside hull portion of one of said ships;

II. set of vertically oriented guide tracks positioned on respective sponsons;

III. a plurality of structural frameworks, respective frameworks positioned along respective sets of said vertically oriented guide tracks, each of said framework having a plurality of guide elements positioned to coact with respective guide tracks;

IV. means for vertically positioning said frameworks along respective said guide tracks;

VI. a buffer element positioned on each said framework, comprising:

a. a bellcrank mounted on each said framework;

b. at least one inflatable tire mounted on the outboard end of each of said bellcranks, for tire rotation in a vertical plane;

c. means for urging said tires outwardly toward the other ship for establishing a separation distance between said ships, said urging means comprising an air-fluid snubber mounted between the inboard end of said bellcrank and said framework;

d. minimized-rebound means for absorbing impact energy due to relative sidewise motion of said ships in a rough sea, said absorbing means comprising said air-fluid snubbers.

**5**. 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, said carriage including a portion extending along the track;

a bellcrank pivoted to the carriage means, said bellcrank having a first arm and a second arm fixed to and angulated from the first arm;

a resilient bumper mounted on the end of said first arm of said bellcrank; and

a shock absorber, having one end pivotally connected to the end of said second arm of said bellcrank, and having its other end pivotally connected to said carriage means, said shock absorber being at a position substantially displaced from the pivotal connection between the bellcrank and carriage means.

**6**. 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. a sponson affixed to the outside hull portion of one of said ships;

II. a set of vertically oriented guide tracks positioned on said sponson;

III. carriage means, comprising a first and a second guide element, movably mounted on said track for movement along said track, said carriage means comprising a first bracket and a second bracket;

IV. a bellcrank, having a first arm and a second arm fixed to and angulated from the first arm, pivotally mounted by means of a bellcrank axle on one of said brackets;

V. a resilient bumper mounted on the end of said first arm of said bellcrank, said resilient bumper comprising an inflatable tire mounted for rotation in a vertical plane for rotating along other ships' hull as the relative vertical positions of said ships change in a rough sea;

VI. a pair of secondary struts positioned between the end of said first arm and respective ends of said bellcrank axle;

VII. a guide element positioned between respective ends of said bellcrank axle and said sponson for providing lateral stability;

VIII. a pair of tertiary struts positioned between respective ends of said bellcrank axle and said carriage means;

IX. impact-minimizing means, comprising a shock absorber having one end pivotally connected to said second arm of said bellcrank, and having its other end pivotally connected to said second bracket, said second bracket and said shock absorber being at a position substantially within said sponson; and

X. motor means for vertically positioning said carriage means along said guide.