114-253. OR 3,570,441 SR

T2362

United States Patent

[11] 3,570,441

[72] Inventors Norman A. Johnson
Delta, British Columbia;
Leonard D. Hengeveld, Richmond, British Columbia, Canada

[21] Appl. No. 849,534
[22] Filed June 2, 1969
[45] Patented Mar. 16, 1971
[73] Assignee Pneuveyco Equipment Ltd.
Vancouver, British Columbia, Canada
[32] Priority June 13, 1968
[33] Great Britain
[31] 28103/68

[54] **MARINE TOWLINE SHOCK ABSORBER**
12 Claims, 10 Drawing Figs.

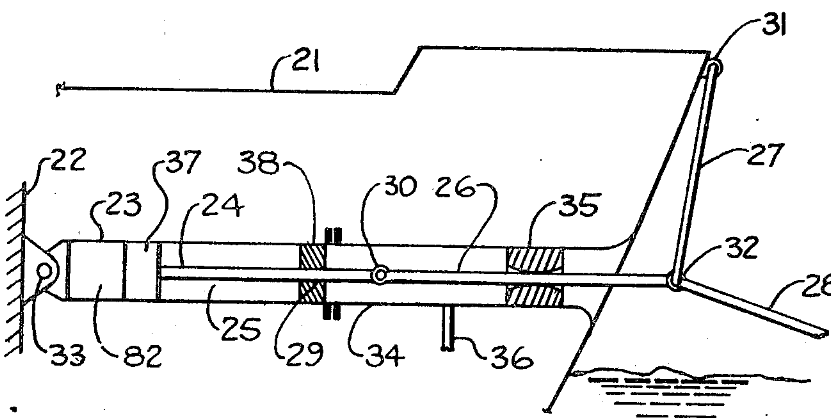
[52] U.S. Cl. 114/235
[51] Int. Cl. B63b 21/24
[50] Field of Search 114/235, 235.1, 235.2

[56] **References Cited**
UNITED STATES PATENTS

1,378,102	5/1921	Froger	114/235
1,423,576	7/1922	Miller	114/235

Primary Examiner—Trygve M. Blix

ABSTRACT: An apparatus for use at the tow end of a marine towline and adapted to absorb shock loads and damp travelling waves in said towline. A marine towline is attached to an element which is restrained by a pendant attached to a tow and by a flexible tension member attached to an extensible member of a pneumatic cylinder, another member of which cylinder is attached to the tow. The geometric relationship of the pendant and flexible tension member is such that a shock load in the towline is initially borne substantially by the pneumatic cylinder but progressively shared with the pendant as the extensible member of the pneumatic cylinder extends.



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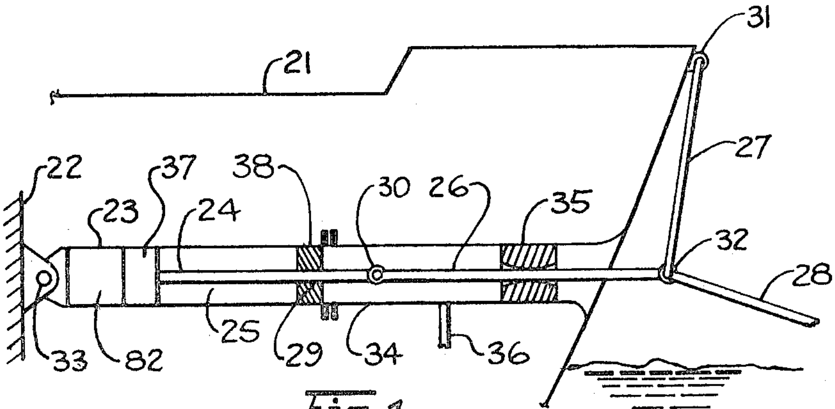

Fig. 1.

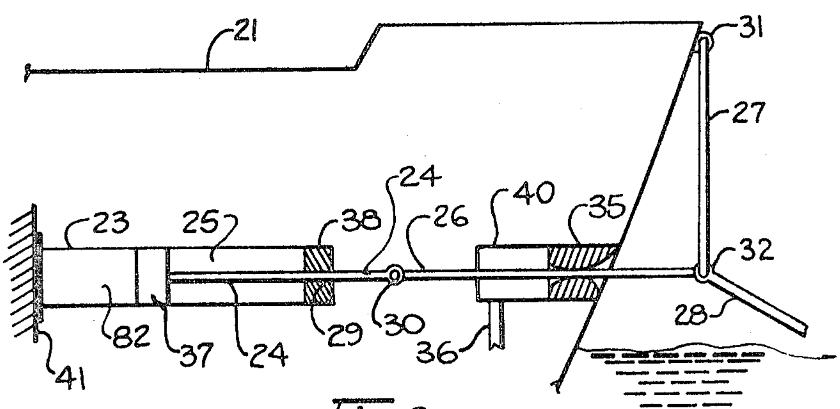

Fig. 2.

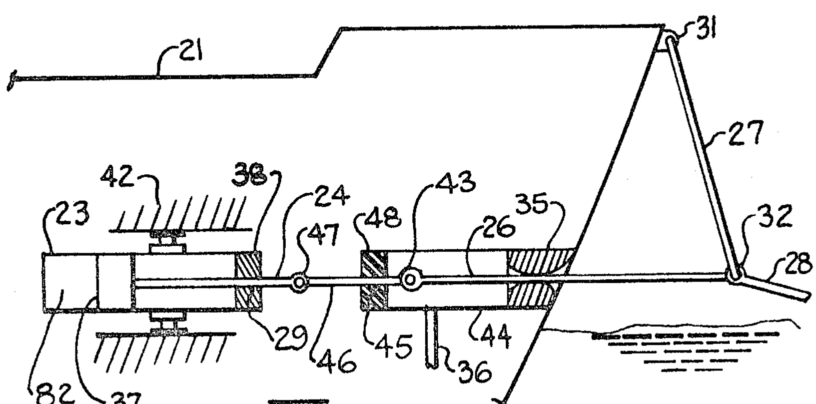

Fig. 3.

Norman A. Johnson

Leonard D. Hengwelld

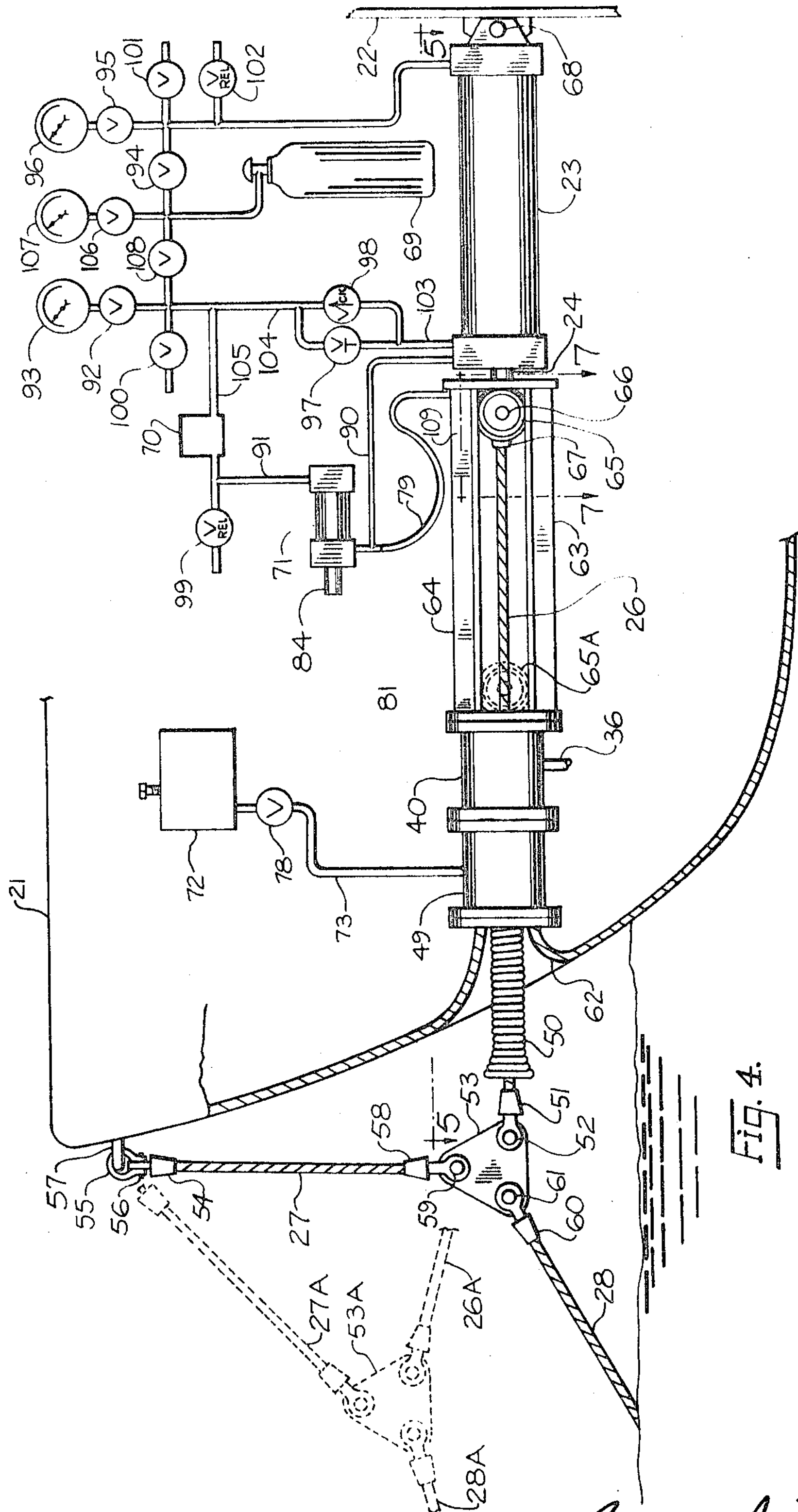

Fig. 4.

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Leonard D. Hengeveld

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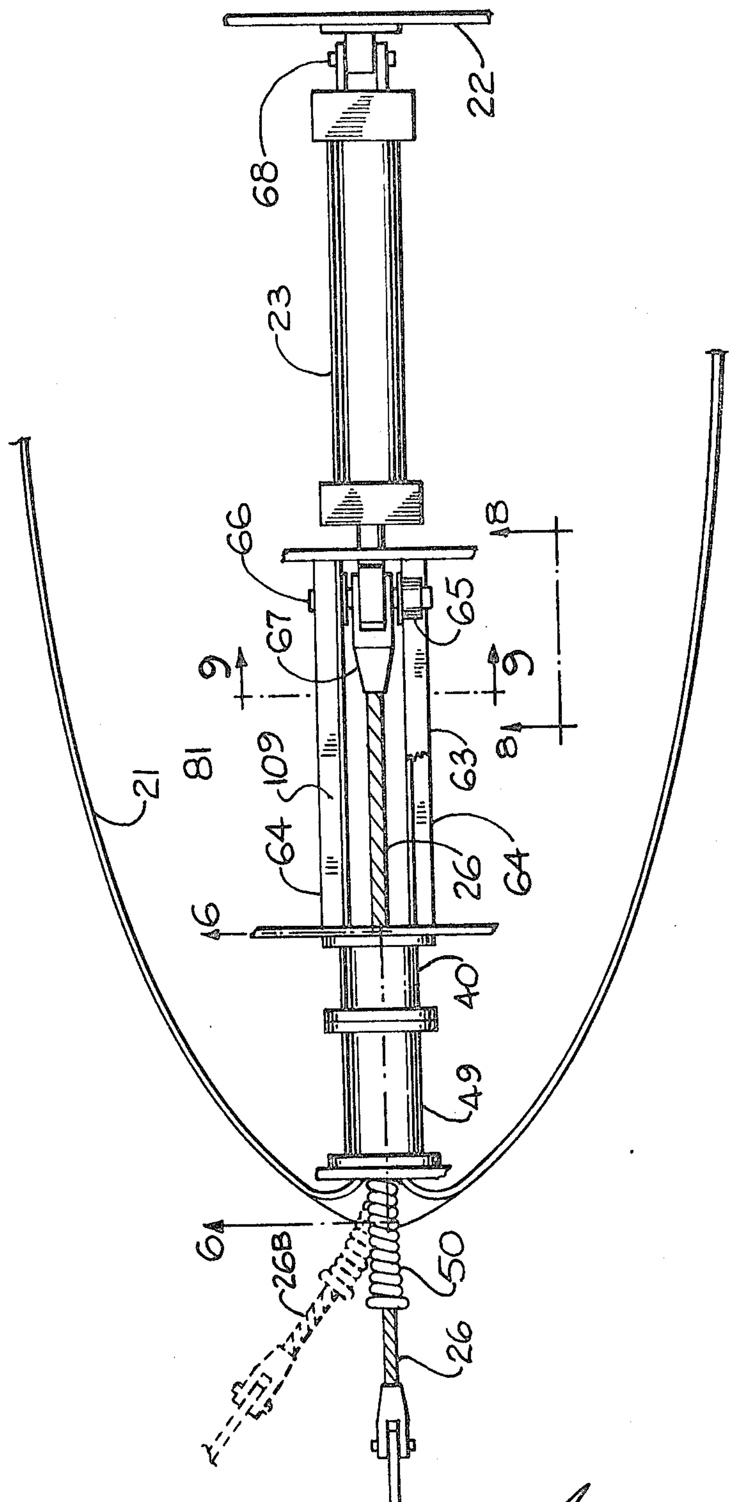

FIG. 5.

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Leonard D. Hengeveld

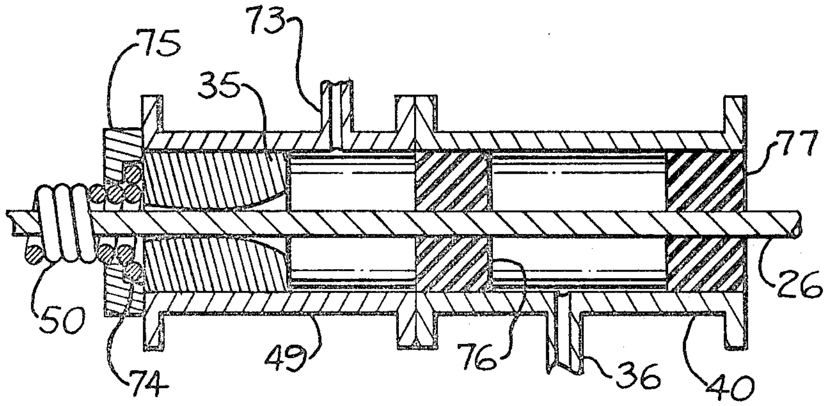

Fig. 6.

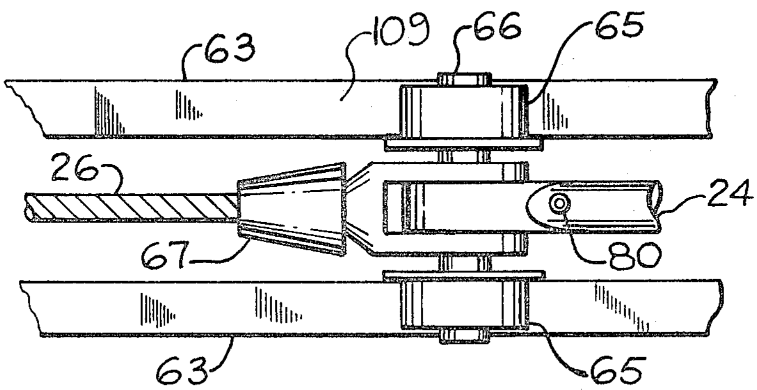

Fig. 7.

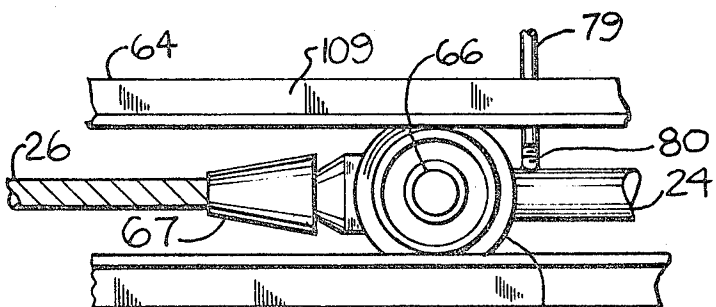

Fig. 8.

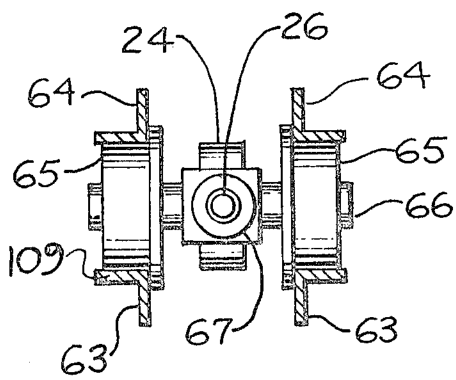

Fig. 9

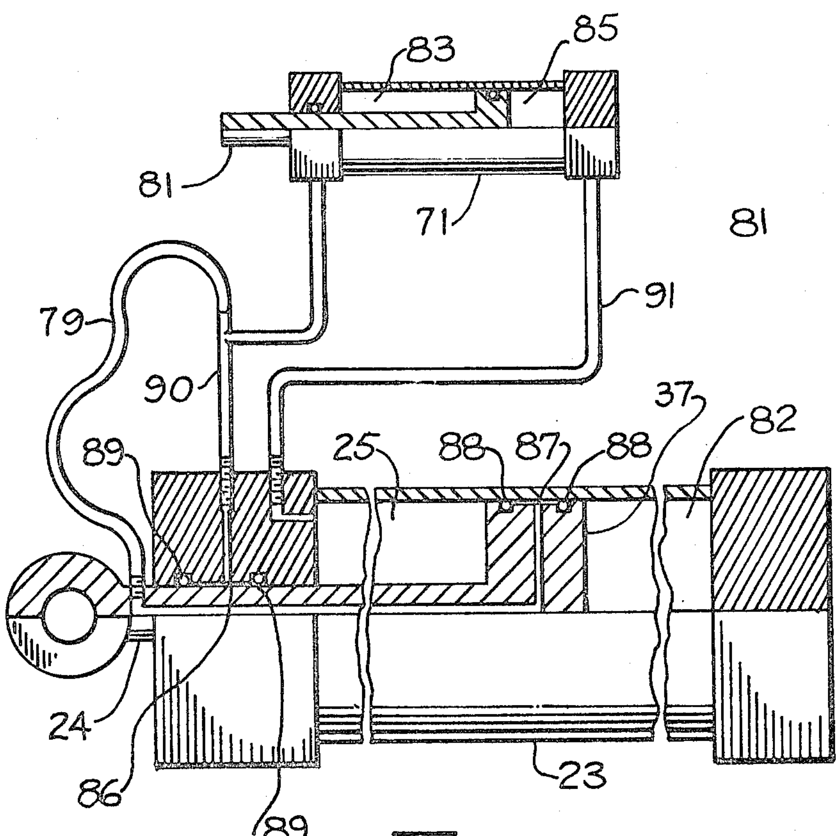

Fig. 10.

Norman A. Johnson
Leonard D. Hengweld

MARINE TOWLINE SHOCK ABSORBER

This invention relates to a novel means adapted to effect shock load and travelling wave damping in marine towlines while at the same time absorbing shock energy and returning it substantially without loss to a tugboat and tow.

In towing logs, log rafts, barges and the like, a towline extends from a tugboat to a tow. On open smooth or calm water, the tension in the towline remains nearly constant irrespective of the towline length provided the tugboat maintains a constant power output; the tugboat and tow proceed through the water at a uniform speed.

In narrow waterways, however, changes in direction and speed are required. In all waterways, winds create conditions where the tug and tow will proceed generally in one direction and at the same average speed but their instantaneous relative speeds will vary depending on towline length, wave height and direction of travel, tow mass, tugboat mass, wind velocity and direction of travel, and other such factors. Changes in the relative motion of the tugboat and tow cause longitudinal and transverse travelling waves in the towline. The most severe changes in relative speed of tugboat and tow generate what may be regarded as shock loads. Some of these shock loads occur predictably from time to time when a tugboat and tow are maneuvering in a waterway. Other such shock loads occur unexpectedly under simple or straight towing in rough seas under random slamming conditions. Severe shock loads and travelling waves are believed to contribute to the occasional failure of towlines through the mechanisms respectively of overstressing and metal fatigue. One method of towing wherein these mechanisms are inhibited uses very long towlines. Another uses heavy weights attached to the towline lengths of heavy chain forming a portion of the towline near the tow end of the towline. In both of these cases, the towline takes on the approximate shape of a catenary. As the tugboat and tow move apart the towline is raised through the water and as they move together the towline falls to a lower position. These means are inadequate in that they cannot be used effectively in narrow waterways where the towline must be short, they lead to frequent snagging of the towline on the bottom of shallow waterways, and their being dragged through water significantly impairs towing efficiency.

Still other means for overcoming shock loading and travelling waves in towlines include a tugboat winch which pays out and retracts towline according to towline loads or other self-rendering devices which can be clamped to a towline at a tugboat. These means have had limited application due to space limitations on a tugboat and to towline wear which is inevitable when a towline is continuously dragged back and forth over the back of a tugboat and unwound and rewound on a winch. Other means have been devised where handling of heavy and awkward shock absorbing means and the exposure of sensitive elements to water and weather have limited their application. Other means have been devised wherein the use of hydraulic fluid in a cylinder would not permit rapid response to shock loads. Still other means have been devised wherein a combination of springs, hydraulic cylinders, cables, and pulleys have created large friction losses and large differences between payout and retraction towline forces.

According to this invention, the limitations of known means are overcome by providing a towline shock absorbing and wave damping means which can be inserted between a towline and a tow. Connecting means, adapted to balance several coplanar forces, joins ends of a towline, a pendent means, and a flexible tension member. The towline is attached at its other end to towing means. The pendant means is attached at its other end to a tow. The flexible tension member passes through a guide and is attached at its other end to an extensible member of pneumatic cylinder means. The guide aligns the axis of a portion of the flexible tension member with the axis of the extensible member while permitting the end of the flexible tension member attached to the connecting means to be moved freely by the towline, subject to constraint of the pendant means and flexible tension member. Gas is maintained within the pneumatic cylinder by structure and at a pressure such that the extensible member restrains the flexible tension members. The pressure within the cylinder, is however, at a level which permits the extensible member quickly to react extensibly to changes in towing force, absorb shock loads, and dampen travelling waves in the towline. The gas in the cylinder stores shock and surge energy and returns it to the towing means and tow when a shock load in the towline has subsided. The pendant means and flexible tension member share a geometric relationship and the pressure within the pneumatic cylinder is such that a normal towline force is substantially supported by the pneumatic cylinder but a severe shock load is substantially shared by the pendant means and the pneumatic cylinder.

It is the first object of this invention to absorb shock loads in a towline.

It is another object of this invention to dampen travelling waves in a towline.

It is another object of this invention, through the use of a short towline without weights, not only to reduce power lost in dragging a long towline and heavy weights through water but also to reduce the possibility of snagging such a long or weighted towline on the bottom of a shallow waterway.

It is still another object of this invention to provide simple and effective means for connecting and disconnecting a towline at a tow.

It is another object of this invention to provide shock absorption and wave damping means which respond quickly to towline load changes.

It is still another object of this invention to provide energy conserving means which will store and return surge and shock energy to a towing means and tow.

These and further objects will be evident from a study of the following disclosure and the accompanying drawings which illustrate several preferred embodiments of the invention. These embodiments are merely exemplary, in that the invention is capable of expression in structure other than that particularly described and illustrated, and are not intended to detract from the full scope of the invention as set out in the annexed claims.

In the drawings:

FIG. 1 shows a schematic side view of an apparatus according to the present invention;

FIG. 2 shows a modification of FIG. 1;

FIG. 3 shows a modification of FIG. 1;

FIG. 4 shows a side view of one preferred embodiment of the present invention;

FIG. 5 shows a plan view taken along line 5–5 in FIG. 4;

FIG. 6 shows a sectional view of flexible tension member seal, guide, and lubrication chamber taken along line 6–6 in FIG. 5;

FIG. 7 shows a plan view of a torsional guide taken along line 7–7 in FIG. 4;

FIG. 8 shows an elevation taken along line 8–8 of FIG. 5;

FIG. 9 shows a view taken along line 9–9 of FIG. 5;

FIG. 10 shows a sectional view of a pneumatic cylinder and seal arrangement.

Referring now to the drawings, FIGS. 1, 2, and 3 show embodiments of the present invention at the bow of a barge 21. In FIG. 1, pneumatic cylinder 23 having as integral parts rod 24 and piston 37 is fixed to an internal structural member 22 of the barge by pivotal means 33. FIGS. 2 and 3 show alternative means of mounted cylinder 23 in a barge, namely rigidly 41 or by trunnion 42 respectively, Clearly the gas pressure in region 25 of cylinder 23 must be at a pressure sufficient to withstand the force in flexible tension member 26 which is balanced with the forces in pendant 27 and towline 28. While the rod 24 is a rigid smooth-surfaced member such as a steel rod so as to effect good sealing in region 29, it is clear that the flexible tension member 26 allows for changes in direction and position of towline 28. Hence the rod 24 is connected to flexible tension member 26 by conventional pin and shackle means 30, pendant 27 is connected to barge 21 by conventional staple, shackle, and pin means 31, flexible tension member 26 and pendant 27 being connected to towline 28 by conventional connection means 32, such as a triangular flounder plate with provisions for three pin connections.

In FIG. 1, seal chamber 34 catches any water which passes through annular guide 35, said water being drained overboard through drain pipe 36. Guide 35 maintains alignment of the force in flexible tension member 26 with respect to rod 24 even when the towline 28 is pulled well off to one side of the barge or rod 24 is fully extended. Clearly the effectiveness of seals in region 29 will depend on the surface characteristics of rod 24 and the condition of materials in the cylinder head 38. Consequently, it is advised that these parts are exposed to water in seal chamber 34 and should be suitably corrosion resistant.

In FIG. 2, seal chamber 40 is such that connection 30 between rod 24 and flexible tension member 26 is in a protective region of the barge 21 shared by cylinder 23. Hence rod 24, connection 30, and cylinder head 38 are not exposed to the same corrosive conditions inherent in the arrangement shown in FIG. 1.

In FIG. 3, seal chamber 44 is such that it permits the use of a solid and substantially inflexible member 46 between rod 24 and flexible tension member 26. Member 46 is connected by means of conventional pins and shackles to rod 24 at connection 47 and to flexible tension member 26 at connection 43. Sealing means as depicted in FIG. 3 provides that rod 24, cylinder head 38 and connection 47 are in the same protective area as cylinder 23 inside the hull of barge 21. Clearly, even though seal 45 is not as critical as seal 29, member 46 and seal head 48 should be designed to withstand forces transmitted by flexible tension member 26 and also designed to resist corrosion and erosion of water and weather. Annular guide 35 will maintain alignment of flexible tension member 26 with member 46, seal head 48, and cylinder rod 24 irrespective of the direction of pull on towline 28.

FIG. 4 shows a side view and FIG. 5 a plan view of a preferred embodiment of the present invention in combination with a pneumatic-hydraulic circuit, and a lubrication means for flexible tension member 26. Pneumatic cylinder 23 is pivotally connected by means of pin 68 with 1° of rotational freedom to structural member 22 substantially on a central axis of barge 21. Connected to the cylinder rod 24 is flexible tension member 26. Flexible tension member 26 passes through bow seal 40, lubrication and annular guide chamber 49, and spring guide 50, ultimately to be connected by means of shackle 51 and pin 52 to triangular plate 53. The annular guide in chamber 49 and spring 50 permit flexible tension member 26 to be moved in any direction, up, down and sideways, except as limited by pendant 27, while still maintaining alignment of that portion of flexible tension member 26 nearest to rod 24 with the axis of rod 24, thus substantially avoiding bending in rod 24. Auxiliary and safety pendant 27 restricts the movement of triangular plate 53 in a vertical direction in that the direction of the force in towline 28 and towline 28 itself is normally forward and downward as shown. Pendant 27 is connected by means of eye 54, pin 56, and shackle 55 to bow staple 57 thereby enjoying 3° of rotational freedom and permitting free movement of towline 28 in a direction to either side of the central axis of the barge 21, there being substantially simple tensile stresses in pendant 27. The other end of pendant 27 is connected by means of shackle 58 and pin 59 to triangular plate 53. Connected also to the triangular plate 53 is towline 28 by means of shackle 60 and pin 61. Clearly, triangular plate 53 will occupy a position such that the forces in flexible tension member 26, pendant 27, and towline 28 will be substantially coplanar and balanced, as well as coaxial respectively with the flexible tension member, pendant, and towline. The bow of barge 21 at the exit of flexible tension member 26 is shaped as a trumpet 62 to prevent excessive bending or kinking of flexible tension member 26 when towline 28 is pulled hard off to one side as shown by flexible tension member position 26B in FIG. 5, or even backwards during maneuvers where a tugboat tries sharply to turn or stop a barge.

When a wire rope towline 28 is subjected to axial forces, it tends to unwrap. Attachments such as shackle 60 fix the ends of the fibers of a wire rope thus preventing actual unwrapping but still permitting motion rotatably with respect to the axis of a wire rope towline. This motion can be inhibited by axial guide means 109 comprising pairs of guides 63 and 64 separated by open spaces in vertical and horizontal planes as shown in FIGS. 4 and 5 respectively. Wheels 65 at either end of pin 66, which pin passes through shackle 67 and an eye at the end of rod 24, resist torsion transmitted through towline 28 and flexible tension member 26. Alignment of guides 63 and 64 and rod 24 is very important if bending in rod 24 is to be prevented. Moreover, the wheels 65 will ride on the top rail on one side of rod 24 and on the bottom rail on the other side; hence it is necessary to ensure that the torsional load is substantially equally distributed between these wheels to prevent further bending in rod 24.

With reference again to FIGS. 4, 6, and 10 a pneumatic circuit is provided which comprises a number of valves and gauges, gas source 69, gas accumulator 70, and seal charger 71. Seal charger 71 provides a positive seal at the dynamic junctions between rod 24 and cylinder 23 and between piston 37 and cylinder 23; the details of this sealing system will be dealt with in detail presently. A tank 72 provides lubrication by gravity or under pressure regulated by valve 78 via duct 73 to chamber 49, which lubrication is intended to reduce wear on flexible tension member 26, guide 35, and spring 50.

Having now dealt generally with the basic elements of the present invention let us turn to the details thereof. FIG. 6 shows a sectional view of seal chamber 40, lubrication chamber 49, annular pendant guide 35 and the aft end of spring 50. Spring 50 has at its extreme aft end a coil 74 which is wound around an inner coil. This coil is fixed to lubrication chamber 49 and guide 35 by means of annular ring 75. Guide 35 should itself be fixed to chamber 49 and should be of a corrosion-resistant and wear-resistant material selected also to suit the material and physical characteristics of flexible tension member 26. For flexible tension member 26 comprising a wire rope and shackles as shown, guide 35 can be of such materials as hard manganese alloy steel or lignum vitae wood. Seal chamber 40 has at either end rubber seals 76 and 77. Water which passes through spring 50, guide 35, lubrication chamber 49 and rubber seal 76 will drain overboard through duct 36, no significant amount of water being passed through seal 77.

FIG. 7 shows a plan view of rod 24, flexible tension member 26, shackle 67, pin 66 and wheels 65. Wheels 65 rest on guides 63. A flexible duct from seal charger 71 connects to rod 24 at port 80. FIG. 8 shows a side view of FIG. 7. FIG. 9 shows a front view of FIG. 7.

FIG. 10 shows a schematic sectional view of cylinder 23, seal charger 71, and the sealing system employed in the present invention. Gas pressure in region 25 is higher than that in regions 81 and 82. Lubricant in region 83 of seal charger 71, by means of different piston areas due to rod 84, is held at a higher pressure than the gas in region 85. Gas in region 85 of seal charger 71 is maintained, via duct 91, at substantially the same pressure as the gas pressure in region 25 of cylinder 23. Lubricant from region 83 is therefore maintained, via duct 90 and flexible duct 79, respectively, in seal barriers 86 and 87 at a pressure higher than the gas pressures in regions 25, 82 and 81 of cylinder 23. It is well known that a viscous lubricant will leak or seep past conventional seals 88 and 89 much more slowly than would a gas. Hence, barriers 86 and 87 are means especially well suited to the inhibition of gas losses from region 25 of cylinder 23. It would be noted, however, that gas losses may not be a concern where gas pressure in region 25 is low or where a constant supply of gas is available to cylinder 23 at prescribed pressures. Other means of lubricating the dynamic boundaries between cylinder 23 and rod 24 and cylinder 23 and piston 37 should be provided if the barriers 86 and 87 are not employed.

Now, with reference to FIGS. 4, and 10, let us examine the operation of the present invention. Assume that we start with no force in towline 28 and no gas in cylinder 23. Gas is charged into region 25 of cylinder 23, accumulator 70, and region 85 of seal charger 71 from gas source 69. This is accomplished by opening valves 108 and 92 until gauge 93 reads a pressure value designed to maintain rod 24 in the fully retracted position when subjected to towing forces encountered in calm or smooth water and straight towing. Valves 108 and 92 should then be closed. A small quantity of gas should be charged into region 82 of cylinder 23 to provide cushioning when rod 24 has been extended and is being retracted by the gas pressure in region 25 as against piston 37. Valve 94 should be opened to accomplish this end and valve 95 should be opened to read the pressure in region 82 of cylinder 23 as indicated on gauge 96. Once a desired pressure has been reached in region 82 valves 94 and 95 should be closed. It should be noted that cylinder 23 should be designed with suitable known means to cushion impact of piston 37 at either end of cylinder 23.

Oil in region 83 of seal charger 71 is at a pressure higher than the gas in region 25 of cylinder 23 and region 85 of seal charger 71 and lubricant in region 83 of seal charger 71 is therefor forced through duct 90 and flexible duct 79 respectively into barriers 86 and 87 as shown in FIG. 10. Initially, gas trapped in ducts 79 and 90 will be forced through the conventional sealing means on either side of each of barriers 86 and 87, thus eventually automatically bleeding the seals. However, bleeding or priming these barriers would probably be advisable in some cases. For example, where lubrication were necessary from the start of operation of an embodiment of the present invention, bleeding or priming the barriers would be advisable.

Accumulator 70 should be sized to provide a specific variation in resistance to forces in towline 28 while allowing employment of the full extensibility of rod 24 of cylinder 23. It has been found that an accumulator volume approximating the volume of region 25 of cylinder 23 when rod 24 and piston 37 are fully retracted is satisfactory. Relief valve 99 provides protection to the pneumatic cylinder and pneumatic circuit. Valve 100 serves as a means for lowering the pressure in region 25 of cylinder 23. Valve 101 serves as a means to lower the pressure in region 82 of cylinder 23. Both valves 100 and 101 may be used to empty system of gas. Relief valve 102 ensures that the pressure in region 82 of cylinder 23 cannot rise above a desireable cushioning level. Pressure in gas source 69 may be read on gauge 107 by cracking valve 106.

Clearly, the above hydraulic-pneumatic circuit is only one practical means by which gas pressures and lubricating seals in the present invention may be serviced initially and maintained over the working life of an embodiment of this invention. For instance, gas source 69 could be either a bottle of nitrogen or a compressor supplying air as required by the system. Seals in cylinder 23 could be devised wherein the seal charger 71 may not be required. Accumulator 70 would not be required if cylinder 23 had a very long bore and a steep rise in resistance force were desired. Obviously many combinations of these elements, valves, and gauges could be devised satisfactorily to serve the essential requirements of the present invention as herein disclosed.

Now with reference to FIG. 4, let us examine the operation of the present invention. During normal towing in smooth water, flexible tension member 26 and rod 24 of pneumatic cylinder 23 will not move with respect to barge 21. During normal towing on rough water, it has been observed that the force in a towline 28 rises and falls cyclically in a somewhat regular fashion. Under such towing conditions, depending on the pressure in region 25 of cylinder 23, rod 24 will extend and retract cyclically over a portion of its available extension in cylinder 23. Gas from region 25 of cylinder 23, as rod 24 is extended, flows freely through ducts 103, 104, and 105, and through valves 97 and 98 into accumulator 70. At the same time the gas in region 25 is compressed and the gas in region 82 of cylinder 23 is decompressed. As rod 24 retracts, gas flowing from accumulator 70 expands and flows through ducts 105, 104, and 103 but is throttled through valve 97. Clearly in this embodiment of the invention, the friction encountered by flexible tension member 26 in seal chamber 40, guide 35, and spring 50 is complemented by the resistance to retraction encountered by the gas as it passes through valve 97. Hence, cyclic hunting in the present invention is inhibited and travelling waves in towline 28 are damped.

Shock loading in towline 28 can occur under several circumstances. One such circumstance is where a tugboat with a barge on a short towline attempts abruptly to turn or stop the barge. Other circumstances include towing under random slamming conditions and towing in rough water, when from time to time, apparently the tug gains momentum in a forward direction as it travels down one side of a wave while the barge, climbing the opposite side of the same or another wave, loses momentum. When such shock loads occur, flexible tension member 26 and rod 24 of cylinder 23 will extend as far as the pressure in region 25 of cylinder 23 will allow. Under severe shock conditions, the pressure in region 25 of cylinder 23 should be such that wheel 65 occupies position 65A, triangular plate 53 occupies position 53A, pendant 27 occupies position 27A, flexible tension member 26 occupies position 26A, and towline 28 occupies position 28A.

It is apparent from the foregoing that the present invention not only serves to damp travelling waves in towlines but it also stores, conserves, and returns to a towing means and tow energy generated by shock loads in a towline.

Many variations of the present invention based on the above teachings will be evident to one skilled in this art. For instance, the shock absorbing and wave-damping apparatus disclosed will serve equally as well for various types of towlines, for several tows towed in a series or train, and with more than one tugboat. The apparatus disclosed above can be used without such auxiliary elements as a spring guide, without flexible tension member lubrication, without main cylinder hydraulic seals, without an accumulator, and without throttling and check valves in the pneumatic circuit. On the other hand, embodiments of the invention wherein other than a wire rope flexible tension member and pendant, more than one pneumatic cylinder, more than one pendant, the employment of pulleys, and other variations of the present invention can be devised. An arrangement according to this invention can be devised wherein the rod of the pneumatic cylinder acts as a compression member, or where the rod is fixed to the barge and the flexible tension member is attached to the cylinder.

Therefore, while preferred embodiments of the invention have been disclosed, the invention is not to be construed as limited to the specific details illustrated and described above.

We claim:

1. In a towed vessel, an apparatus having connection means adapted to join the ends of towline means, pendant means, and a flexible tension member, said towline secured at its other end to a towing means, said pendant means secured at its other end to a tow, said flexible tension member secured to an extensible member of pneumatic cylinder means, another member of said pneumatic cylinder means being secured to said tow, said connecting means being adapted to balance coplanar forces in said towline means, pendant means, and flexible tension member, said flexible tension member passing through guide means, said guide means allowing movement of said connection means under influence of said towline means subject to constraint of said pendant means and said flexible member, said guide means adapted to maintain alignment as between an axis of that segment of said flexible tension member nearest said pneumatic cylinder means and the axis of said extensible member of said pneumatic cylinder means, said pneumatic cylinder means comprising gas-filled cylinder means and piston means in said cylinder means, said piston being movable along said axis of said extensible member, said gas in said cylinder means resisting movement of said extensible member.

2. In a towed vessel, apparatus as described in claim 1, further where said pneumatic cylinder means is located within a forward hold of said vessel and where a seal between said guide and said pnuematic cylinder means is adapted substantially to avoid leakage or seepage into said hold along or around said flexible tension member.

3. In a towed vessel, apparatus as described in claim 2, further wherein the end of said flexible tension member opposite said connection means is attached to one end of a tension member passing through substantially positive sealing means and being itself attached at its other end to said extensible member of said pneumatic cylinder means.

4. In a towed vessel, apparatus as described in claim 1, further where said pneumatic cylinder means is located on an exposed surface of said vessel, said pendant means being secured to structure of said vessel generally above said pneumatic cylinder.

5. In a towed vessel, apparatus as described in claim 1, further having another guide means adapted to resist torsional and transverse forces accompanying axial forces in said towline means or said flexible tension member.

6. In a towed vessel, apparatus as described in claim 1, further wherein said guide means is adapted, shaped, and formed to match the characteristics of said flexible tension member.

7. In a towed vessel, apparatus as described in claim 1, further wherein said flexible tension member is substantially round in cross section, said guide means being a coiled spring adapted to accommodate movements of said connecting means and said flexible tension member.

8. In a towed vessel, apparatus as described in claim 1, further wherein a pneumatic circuit is adapted to permit servicing, maintaining, and monitoring of pressures at either side of said piston means within said gas-filled cylinder means.

9. In a towed vessel, apparatus as described in claim 8, further wherein a volumetric accumulating means is adapted to receive gas from said pneumatic cylinder means as said piston means changes position within said gas-filled cylinder means.

10. In a towed vessel, apparatus as described in claim 9, further wherein throttling and check-valving means are adapted to effect free flow of gas in one direction and restricted flow of gas in the opposite direction as between said volumetric accumulating means and said pneumatic cylinder means.

11. In a towed vessel, apparatus as described in claim 8, further wherein gas storing means is adapted to store gas at a pressure higher than that required to raise the pressure on either side of said piston and further adapted automatically or manually to admit said gas into said pneumatic circuit.

12. In a towed vessel, apparatus as described in claim 8, further wherein gas compressing means are adapted to function either continuously or intermittently, and further adapted automatically or manually to admit compressed gas into said pneumatic circuits.