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(54) **INFLATABLE BOOMS**

AUFBLASBARE AUSLEGER

BARRAGES GONFLABLES

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Description

[0001] This invention relates to inflatable booms for use as floating barriers, for example in marine spill response operations.

[0002] Buoyant inflatable booms are used in marine spill response operations as barriers to limit the spread of pollutants, such as liquid hydrocarbons, that may be left floating on a body of water following a spill. In particular, one or more such booms floating at the surface may be used for the containment of floating pollutants or for gathering and concentrating the pollutants into a confined area. Once concentrated in this way, floating pollutants can be separated efficiently from the water and recovered using skimmers or other separating devices.

[0003] An inflatable boom is a hollow elongate structure that is deflated and collapsed into a compact state for storage and transportation. Most commonly, a deflated boom is stored and transported on a reel that may be carried by a dedicated spill response vessel or by a 'vessel of opportunity', which is a non-dedicated vessel that is normally engaged in activities other than spill response. Thus, when deflated, the boom is flexible enough to allow reeling or spooling but when inflated after unreeling or unspooling, the boom becomes relatively rigid to assume and maintain its desired shape. The inflated boom then forms a long, generally sausage-shaped buoyancy tube with closed ends that floats on and extends across the water surface.

[0004] Ballast weights hanging under the buoyancy tube hold the inflated boom in a desired orientation at the water surface, partially submerged to mitigate any escape of pollutants under the boom. For this purpose, the ballast weights may act on a web or skirt that hangs underwater from the buoyancy tube and that extends the cross-section of the boom downwardly.

[0005] Typically, an inflatable boom is constructed of several panels of a substantially impermeable flexible layered sheet material such as PVC or neoprene. The panels are welded together or bonded together and are shaped to determine the desired inflated shape of the boom. The panels also define one or more internal chambers of the buoyancy tube that are filled with air at elevated pressure when the boom is inflated for use. The pressurised air in the chambers provides buoyancy and maintains the inflated shape of the boom. After use of the boom, the air is vented from the chambers so that the boom can be collapsed again for transport and storage, which most conveniently involves winding the deflated boom back onto the reel of a vessel that deployed the boom.

[0006] As flexible sheet materials may be vulnerable to damage, it is common for longer booms to be constructed of multiple individual sections joined in series so that if any one section is damaged beyond repair, it can be replaced without having to replace the remainder of the boom. For example, a boom that is 300m long may typically comprise six 50m sections in series. The use of

multiple shorter sections also makes it easier to manufacture a long boom.

[0007] It is also common for the interior of a boom to be subdivided further so that the, or each, section comprises two or more individually-inflated chambers. The use of multiple separate chambers provides redundancy and so improves the resilience of the boom to damage in use. Thus, a boom comprising multiple chambers can substantially maintain its integrity in terms of its shape, rigidity and buoyancy in the event that a panel defining any one chamber is punctured in use. Otherwise, a punctured boom could lose the shape, rigidity and buoyancy that are necessary for the boom to do its job effectively; indeed, some parts of the boom could even sink, allowing floating pollutants to breach the barrier that the boom is intended to create.

[0008] Whilst multiple separate air chambers are advantageous for the reasons above, they present significant challenges in practice. This is because each chamber has to be inflated and deflated individually during deployment and recovery using valves that are dedicated to each chamber.

[0009] When required, an inflatable boom is commonly deployed from a reel on a vessel as noted above. The boom is pulled off the reel by a separate towing vessel. Thus, a primary vessel carries the boom on a reel and a secondary vessel is used to tow the free end of the boom away from the primary vessel. It follows that the masters of the primary and secondary vessels must coordinate their actions with each other and with the operators on the primary vessel who control rotation of the reel and inflation of the boom. Such coordination may be challenging even in a training scenario performed in daylight on calm water; it is all the more difficult in an actual spill response operation that may take place in far from ideal conditions.

[0010] Unreeling and launching simple inflatable booms known in the prior art is a stepwise, intermittent process because each chamber must be inflated fully before being launched into the water. To do so, operators standing on the deck of the primary vessel inflate the individual chambers via their respective valves. To save time in what may be a time-critical emergency situation, it is common for multiple operators to work simultaneously on inflating the boom. This requires multiple operators to be available on standby in case deployment is needed and to coordinate their actions precisely during deployment, which requires frequent and expensive training. The operators must share limited deck space and in an actual spill response operation they may have to work in bad weather, potentially at night, as the vessel rolls and pitches in a choppy sea. Consequently, the boom deployment process is slow and may expose the operators to heightened safety risks.

[0011] The inflated portions of the boom are usually launched over the stern of the primary vessel. Thus, the reel must be located a considerable distance forward of the stern to leave enough deck space for the operators

to stand aft of the reel beside the boom as the boom is inflated and deployed. This disadvantageously constrains the deck layout of the primary vessel.

[0012] In an effort to mitigate these disadvantages, booms are known that can be inflated from a single point despite having multiple separate chambers to ensure high integrity. Such a boom is shown in Figures 1 and 2 of the accompanying drawings.

[0013] Figure 1 is a top plan view that shows an inflatable boom 10 being deployed from a reel 12 on a primary spill response vessel 14, using a secondary towing vessel 16 to pull the free end of the boom 10 off the reel 12. The deployment direction of the boom 10 is from left to right as illustrated.

[0014] Figure 2 is a side view of successive sections 18 of the boom 10, with each section 18 being shown shortened in length for ease of illustration. Again, the deployment direction of the boom 10 is from left to right as illustrated. Conversely, the recovery direction will be from right to left as illustrated when the boom 10 is wound back onto the reel 12 after deployment.

[0015] Each section 18 of the boom 10 comprises an inflatable buoyancy tube 20 and a skirt 22. In use of the boom 10, the skirt 22 hangs beneath the buoyancy tube 20 by virtue of the weight of ballast, such as a chain or wire, held in a ballast pocket 24 extending along the lower free edge of the skirt 22. The successive sections 18 abut each other at, and are joined by, section connectors 26.

[0016] In this example, conical flexible internal bulkheads 28 subdivide the buoyancy tube 20 of each section 18 into multiple independent chambers 30.

[0017] In the improved prior art system shown in Figures 1 and 2, the boom 10 is inflated from a single inflation point 32 on the towed, free end of the boom 10 as opposed to the reel end of the boom 10. For this purpose, the towing vessel 16 carries a high-volume inflator 34 that blows a high volume of air at low (but above ambient) pressure into a large-diameter flexible hose 36 leading to the inflation point 32. There, the flexible hose 36 is connected to an inflation cuff 38 that serves as an air duct running the full length of each section 18 of the boom 10. Connecting pipes 40 as shown in Figure 2 connect the inflation cuffs 38 of successive sections 18 to each other in series to form a continuous air duct. The pipes 40 may, for example, be defined by fabric tubes that serve as interconnecting conduits.

[0018] Individual non-return filling valves 42 communicate between the inflation cuffs 38 and the interior of each chamber 30. The filling valves 42 open in response to overpressure in the inflation cuffs 38 to allow air from the inflation cuffs 38 to enter the multiple individual chambers 30. The non-return characteristic of the filling valves 42 ensures that the air stays in the chambers 30 once introduced from the inflation cuffs 38. The inflator 34 on the towing vessel 16 is run at a rate of air delivery chosen to ensure the chambers 30 fill with air as they are deployed from the reel 12 and have sufficient buoyancy to keep the boom 10 afloat on being launched into the water.

[0019] The chambers 30 have respective deflation valves 44 to allow air to escape the chambers 30 when the boom 10 is deflated for recovery on being wound back onto the reel 12. Specifically, a deflation valve 44 is positioned toward the aft end of each chamber 30 with respect to the recovery direction, which is from right to left as illustrated.

[0020] The system shown in Figures 1 and 2 has the advantage over earlier prior art that during deployment, minimal effort is required by the crew of the primary spill response vessel 14 that carries the reel 12. A single operator on the primary spill response vessel 14 controls the speed of deployment of the boom 10 by controlling the rotational speed of the reel 12, whose rotation is suitably powered. Inflation of the boom 10 is under the control of an operator on the secondary towing vessel 16. Consequently, the system works well: fewer operators and less deck space are needed on the primary spill response vessel 14, yet a boom of 300m in length can typically be deployed offshore within fifteen minutes. It will be appreciated that speed and ease of deployment is important to ensure that the boom 10 is available for duty in containing a marine spill as quickly as possible.

[0021] However, the system shown in Figures 1 and 2 still has challenges. Again, the masters of the primary and secondary vessels 14, 16 must coordinate their actions with each other, with the operator on the primary vessel 14 who controls rotation of the reel 12 and with the operator on the secondary vessel 16 who controls inflation of the boom 10. Additionally, the inflator 34 on the secondary vessel 16 requires careful control. If the inflator 34 is run too slowly, the boom 10 can sink and could become entangled; conversely, if the inflator 34 is run too quickly, the boom 10 may become inflated all the way back to the reel 12, which can itself cause problems.

[0022] Particular challenges arise when the boom 10 is being recovered by being wound back on to the reel 12, when it is necessary to evacuate the air from each individual chamber 30 of the boom 10 in turn. Specifically, to deflate the boom 10, it is necessary to open each deflation valve 44 and then to evacuate the air from each chamber 30 through the open deflation valve 44. If insufficient air is removed from a chamber 30, this results in excess bulk of the boom 10 on the reel 12 and may even result in the chamber 30 bursting by being over-pressurised when it is drawn on the reel 12, as shown in Figure 3. Consequently, each deflation valve 44 is opened as soon as it becomes accessible to an operator leaning out from the stern of the spill response vessel 14. This maximises the opportunity for the air to be evacuated from the associated chamber 30 before the chamber 30 is wound on to the reel 12. Finally, each deflation valve 44 must be reset into a closed state. This ensures that when the boom 10 is wound on to the reel 12, all of the deflation valves 44 are closed ready for prompt re-inflation of the chambers 30 on the next deployment of the boom 10.

[0023] It will be apparent that recovery of the boom 10 onto the reel 12 is far slower than deployment and re-

quires multiple operators to work together. As each successive portion of the boom 12 is lifted from the water and approaches the reel 12 during recovery, a cap 46 of each deflation valve 44 has to be removed, as shown in Figure 4, as soon as it comes within reach of an operator 48 on board the spill response vessel 14. That operator 48 then has to manipulate the internal mechanism of the deflation valve 44 to allow air to escape from the associated chamber 30 as soon as the leading end of that chamber 30 starts to narrow on approaching the reel 12. This manipulation involves turning part of the mechanism of the deflation valve 44 to lock the deflation valve 44 temporarily into an open state. Typically, a further operator working forward of the reel 12 then has to re-set the deflation valves 44 to close them and to replace their caps 46 so that the boom 10 is ready for the next deployment. The deflation valves 44 have to be reset and their caps 46 have to be replaced before further rotation of the reel 12 will render them inaccessible. Failure to complete these operations may hinder the next deployment.

[0024] If deck space on board the spill response vessel 14 is limited, it may be difficult to provide sufficient space around the reel and deck length between the reel and the stern for the necessary operators to work. Also, operations involved in opening and closing the deflation valves 44 are tricky as they are typically performed while the operators stand on a pitching and rolling vessel 14 while interacting with a flexible, moving and slippery boom 10. They also require manual dexterity, which will be impaired if the operator is tired or has cold, wet or oily hands. Leaning out to access the deflation valves 44 for opening presents other safety challenges, particularly if the deck of the vessel 14 is slippery with oil or the water is rough.

[0025] Whilst speedy recovery may seem less critical than speedy deployment of a boom, it is a fact that every deployment must eventually be followed by recovery. Also, fortunately, booms are deployed and recovered much more frequently in training exercises than in actual spill response operations. Training exercises need to be completed as quickly and cost-effectively as possible and without jeopardising operator safety.

[0026] US 2011/0318109, EP 2927375, WO 92/09750, WO 2013/156998 and US 9512585 disclose other examples of containment systems comprising booms, wherein EP2927375 discloses a boom according to the preamble of claim 1. WO 2011/019873 discloses a tidal barrier. GB 1284418 discloses an air blower for inflating structures such as booms.

[0027] It is against this background that the present invention has been devised.

[0028] Briefly, the invention involves an inflatable boom that comprises a series of chambers and an air duct extending along the boom to communicate with the chambers. In accordance with the invention, a power line such as a high-pressure air line extends along the boom to an air blower such as an airflow amplifier that draws in atmospheric air and exhausts that air into the air duct

to inflate the chambers. Thus, the chambers are inflated by supplying power along the boom in one direction to drive an air blower, which exhausts air to flow in the opposite direction along the boom to inflate the chambers.

[0029] Broadly, therefore, the invention provides an elongate inflatable boom, comprising: a longitudinal series of chambers; an air duct extending along the boom to communicate with the chambers; and a power line extending along the boom to an air blower. The air blower has: an airflow intake for drawing in atmospheric air when power is provided to the air blower along the power line in use; and an airflow outlet communicating with the air duct to exhaust the drawn-in air into the air duct to inflate the chambers.

[0030] Preferably, the air blower is an airflow amplifier and the power line is a high-pressure air line extending along the boom to a high-pressure air inlet of the airflow amplifier, such that atmospheric air is drawn in to the airflow intake of the airflow amplifier when high-pressure air is supplied through the high-pressure air line to the high-pressure air inlet in use.

[0031] An airflow amplifier is preferred over other air blowers for its compactness, lightness, simplicity and effectiveness. However, in principle, it would be possible for the power line to be an electrical or hydraulic power line for supplying electrical or hydraulic power to an electrical or hydraulic motor that drives an impeller of an air blower. It would also be possible for pneumatic power to be supplied in the form of high-pressure air to a rotary expander or other pneumatic motor that drives such an impeller.

[0032] The air blower is advantageously located adjacent to a first end of the boom and the air duct and the power line extend substantially along a full length of the boom. In that case, the power line may extend from the air blower to a coupling adjacent to a second end of the boom, opposed to the first end, for connection to a source of power such as a high-pressure air source.

[0033] A sea anchor or drogue is conveniently attached to the boom adjacent to the first end to pull the boom into water without requiring a separate towing vessel.

[0034] Advantageously, the air blower is supported by a buoyant body attached to the boom. In that case, the buoyant body is suitably arranged to hold the airflow intake of the air blower above water in which the buoyant body floats in use.

[0035] In the boom of the invention, power conveniently flows in the power line in a first direction along the boom and the drawn-in air flows in the air duct in a second direction along the boom, opposed to the first direction.

[0036] The inventive concept embraces a combination of the boom of the invention and a reel around which the boom is wound. In that case, the air blower is located adjacent to a free end of the boom remote from the reel.

[0037] The reel preferably comprises a rotary power coupling between a source of power and the power line of the boom. For example, where high-pressure air is used to power the air blower, the reel may comprise a

rotary airflow coupling between a high-pressure air source and a high-pressure air line extending along the boom. The reel may further comprise a power connection such as an air duct extending between the rotary power coupling and the source of power.

[0038] The inventive concept extends to a vessel carrying the boom of the invention or the combination of a boom and reel of the invention. That vessel preferably comprises a source of power for supply to the power line of the boom, such as a high-pressure air source connected to a high-pressure air line extending along the boom.

[0039] The invention may also be expressed as a corresponding method of inflating a longitudinal series of chambers in an elongate boom. The method comprises: supplying power along the boom in a first direction to drive an air blower that draws in atmospheric air and exhausts the drawn-in air to flow in a second direction along the boom, opposed to the first direction, to inflate the chambers.

[0040] Preferably, the method comprises launching the boom into a body of water in the first direction, conveniently while also inflating the chambers. The boom is apt to be launched from a reel carried by a vessel floating on the body of water, in which case power may conveniently be supplied to the boom from a source carried by the vessel and may be supplied to the boom through the reel.

[0041] The boom may be pulled in the first direction by virtue of drag force arising from relative movement between the boom and the body of water. The air blower may be floated on the body of water.

[0042] Preferably, power is supplied as a flow of high-pressure air to a high-pressure air inlet of an airflow amplifier, such that atmospheric air is drawn in to the airflow intake of the airflow amplifier when high-pressure air is supplied to the high-pressure air inlet in use.

[0043] To give an understanding of the prior art, reference has already been made to Figures 1 to 4 of the accompanying drawings, in which:

Figure 1 is a top plan view of an inflatable boom being deployed from a reel on a spill response vessel in a system known in the prior art;

Figure 2 is a side view of successive sections of the boom shown in Figure 1;

Figure 3 is a side view of the spill response vessel of Figure 1 recovering the boom of the prior art after deployment; and

Figure 4 is an enlarged detail view of an operator on board the spill response vessel of Figure 3 manipulating a deflation valve of the boom during recovery of the boom onto the reel.

[0044] In order that the invention may be readily understood, reference will now be made, by way of exam-

ple, to the remainder of the accompanying drawings, in which:

Figure 5 is a top plan view of an inflatable boom being deployed from a reel on a spill response vessel in a system according to the invention;

Figure 6 is a schematic enlarged detail top view of the reel and the reel end of the boom shown in Figure 5, during deployment;

Figure 7 is a schematic enlarged detail side view of the free end of the boom shown in Figure 5, showing details of an inflation post at that end; and

Figure 8 is a longitudinal sectional view showing the general features of an airflow amplifier that may be used in the inflation post shown in Figure 7.

[0045] Referring next, then, to Figures 5 to 8 of the drawings, like numerals are used for like parts. Here, a powered reel 12 on a spill response vessel 14 carries an inflatable boom 50 in accordance with the invention. Like the boom 10 of the prior art shown in Figures 1 to 4, the boom 50 has internal conical bulkheads 28 defining multiple chambers 30 for redundancy and hence high integrity. The boom 50 may also comprise a series of individually-replaceable sections like the sections 18 of the boom 10 shown in Figures 1 to 4; however, the boom 50 is shown in Figures 5 to 7 as a single length for simplicity.

[0046] The boom 50 again provides for single-point inflation of the chambers 30 via respective non-return filling valves 42 communicating with a common inflation cuff 38 extending along the boom 50, but in a different way to inflation of the prior art boom 10 as will be explained. As will also be explained, the invention provides for easier, safer and more rapid deflation of the chambers 30 when the boom 50 is being recovered after deployment.

[0047] A notable difference, and advantage, of the boom 50 over the prior art boom 10 is that only one vessel 14 is required to deploy the boom 50. Consequently, it is not necessary to use the towing vessel 16 of the prior art shown in Figure 1 to pull the boom 50 off the reel 12. This greatly simplifies the deployment operation by removing the complication of co-ordinating the movements of two vessels 14, 16 as in the prior art. As a result, the speed and safety of deployment are improved because there are fewer operations to go wrong.

[0048] Instead, the boom 50 of the invention is deployed by launching a sea anchor 52 at the free end of the boom 50 into the water, either as the vessel 14 moves forward through the water or as the vessel 14 is moored at a stationary position in a current of water. The sea anchor 52 acts as a drogue to create drag upon movement relative to the water and so applies tension to the boom 50. This tension pulls the boom 50 aft to deploy into the water, with increasing separation between the vessel 14 and the sea anchor 52, as the boom 50 is in-

flated while the reel 12 turns. Thus, after launching the sea anchor 52, an operator begins to rotate the reel 12 at a slow speed and the force exerted on the free end of the boom 50 by the sea anchor 52 begins to pull the boom 50 off the reel 12. The same operator can then begin to inflate the boom 50 by turning on a supply of compressed air, as will be explained.

[0049] To save time, deployment of the boom 50 may be initiated and may proceed even while the vessel 14 is travelling at speed to the scene of a spill. The vessel 14 then tows the partially- or fully-deployed boom 50 directly to where it will be needed. Thus, the boom 50 can be in the water ready to do its job as quickly as possible on arrival of the vessel 14 at the scene.

[0050] As inflation of the boom 50 may be controlled by the operator who also controls the reel 12, in principle this allows a single operator to deploy the boom 50. This means that the operator of the reel 12 can undertake inflation of the boom 10 independently, without interaction with other operators, and can deploy the boom 10 at a rate to suit its rate of inflation.

[0051] Air to inflate the boom 50 is supplied from a compressed air source 54 on board the vessel 14, such as an air compressor and/or a bank of high-pressure air cylinders. The compressed air source 54 supplies air at high pressure to a rotary swivel coupling 56 on the reel 12 so that the high-pressure air is available continuously to the boom 50 as the reel 12 rotates. Specifically, the reel 12 contains a duct 58 to receive the high-pressure air from the rotary swivel coupling 56 and to deliver that air into a high-pressure air line 60 that extends along substantially the full length of the boom 50, from the reel end to the free end of the boom 50. The high-pressure air line 60 can be uncoupled from the duct 58 to remove the boom 50 from the reel 12 on completion of deployment.

[0052] The high-pressure air line 60 is notably narrower than the inflation cuff 38, which conveys a much larger volume of air at lower pressure than in the air line 60.

[0053] The high-pressure air line 60 is shown in Figures 6 and 7 attached externally to the inflation cuff 38 of the boom 50 for ease of illustration. However, the high-pressure air line 60 can be attached to or incorporated in any part of the boom 50, either externally or internally.

[0054] The high-pressure air line 60 communicates with a buoyant inflation post 62 at the free end of the boom 50. The inflation post 62 with the attached free end of the boom 50 is deployed over the stern of the vessel 14 immediately after the sea anchor 52.

[0055] The inflation post 62 has a buoyant upper end 64, for example of solid foamed plastics, and a ballasted lower end 66, for example containing an iron weight. This is to ensure that the inflation post 62 floats substantially upright in the water with the upper end 64 protruding well above the water surface.

[0056] A generally-tubular airflow amplifier 68 positioned in the upper end of the inflation post 62 receives high-pressure air from the high-pressure air line 60. The

high-pressure air enters the airflow amplifier 68 through a high-pressure air inlet 70 positioned between an airflow intake 72 and an airflow outlet 74 of the airflow amplifier 68. The airflow intake 72 draws in atmospheric air from above the water surface. The airflow outlet 74 exhausts that air, plus air entering through the high-pressure air inlet 70, as a high volume, high-velocity flow that enters the inflation cuff 38 to inflate the chambers 30 via the filling valves 42.

[0057] With reference now also to Figure 8, the airflow amplifier 68 (known variously in the art of pneumatics as a vacuum pump, an air accelerator or an air amplifier) works by directing the incoming high-pressure air from the high-pressure air inlet 70 around an internal annular chamber 76. The high-pressure air in the annular chamber 76 is then throttled through a ring nozzle 78 to form an annular high-velocity primary airstream within the airflow amplifier 68. The primary air stream adheres to an annular outwardly-tapering venturi-shaped coanda profile 80 on the radially inner side of the airflow amplifier 68, which directs the primary airstream toward the airflow outlet 74. As a result, a low-pressure region is created at the centre of the annular primary air stream, which region extends between the airflow intake 72 and the ring nozzle 78. The low pressure in the airflow intake 72 draws in a high-volume flow of surrounding atmospheric air, which is entrained into the primary air stream. The combined air flows exhaust with high volume and high velocity from the airflow outlet 74 of the airflow amplifier 68.

[0058] It will therefore be evident that some of the air flowing out of the airflow outlet 74 originates from the high-pressure air supplied to the high-pressure air inlet 70. However, the primary function of that high-pressure air supply is to provide pneumatic power to drive the airflow amplifier 68, causing the airflow amplifier 68 to draw in substantially more air through the airflow intake 72. This is fundamentally different to simply providing a supply of air as the sole source of inflation.

[0059] There are alternative types of airflow amplifiers or air accelerators within the inventive concept, such as those that utilise an annular array of discrete nozzles. Such nozzles are arranged to produce an annular high-velocity air stream. The effect is similar to the ring-nozzle type described above.

[0060] The key benefit of the airflow amplifier 68 is that a comparatively low-volume air flow at high pressure generates a pressure difference that moves a much larger volume of air to inflate the chambers 30. The volume of air leaving the airflow amplifier 68 in the exhaust flow through the airflow outlet 74 is far in excess of the volume of compressed air supplied into the high-pressure air inlet 70. The majority of the air in the exhaust flow does not come from the high-pressure air line 60 but instead is atmospheric air that enters the airflow intake 72. In this way, a high volume of atmospheric air is used for inflation of the boom 50 even though a much smaller volume of high-pressure air is supplied from the spill response vessel 14.

[0061] Consequently, compressed air from the high-pressure air line 60 is expanded in the airflow amplifier 68 to draw a much larger volume of air into the airflow intake 72. The expanded air combines with the larger volume of drawn-in air to direct a high-volume, relatively low pressure (but still above ambient pressure) flow of air from the airflow outlet 74 into the inflation cuff 38 and from there into the chambers 30 through the respective filling valves 42.

[0062] Purely by way of non-limiting example, compressed air in the high-pressure air line 60 may be at a gauge pressure of about 6 to 10 bar. Air exhausting from the airflow outlet 74 of the airflow amplifier 68 used for inflation of the boom 50 may be at a gauge pressure of up to about 103mbar (1.5psi) with a typical flow rate of about 6m³/hr, representing airflow multiplication of 4x to 5x.

[0063] The airflow amplifier 68 shown in Figure 8 has the optional feature of an internally-threaded tubular body 82 engaged with an externally threaded tubular insert 84 that defines the outwardly-tapering venturi-shaped coanda profile 80. The annular opening of the ring nozzle 78 can be adjusted, if required, by turning the insert 84 within the body 82 as shown to move the insert 84 axially with respect to the body 82. This allows the airflow characteristics of the airflow amplifier 68 to be adjusted if needs be.

[0064] The buoyancy of the inflation post 62 prevents the free end of the boom 50 sinking in the water in the event of incomplete inflation and so keeps the airflow intake 72 of the airflow amplifier 68 clear of the water to draw in atmospheric air. Nevertheless, provision may be made to trap and to drain away any water that may inadvertently enter the airflow intake 72, preferably before that water can enter the inflation cuff 38.

[0065] Being at the free end of the boom 50, the inflation post 62 provides a convenient fixing point for the sea anchor 52, which is attached to the inflation post 62 by a bridle and rope 86. The inflation post 62 is attached, in turn, to the free end of the boom 50 by a boom connector plate 88.

[0066] To ensure that the boom 50 cannot be damaged by over-inflation, a blow-off valve 90 automatically limits the maximum air pressure that can be supplied by the airflow amplifier 68. The blow-off valve 90 is conveniently situated in the airflow channel between the airflow outlet 74 of the airflow amplifier 68 and the inflation cuff 38. Of course, it may be possible instead for each chamber 30 to be fitted with a respective blow-off valve, or for deflation valves 92 of each chamber 30 to have blow-off functionality.

[0067] Again, a deflation valve 92 is positioned toward the aft end of each chamber 30 with respect to the recovery direction, which is from right to left as illustrated. Thus, when the boom 50 is being wound onto the reel 12, the end of the chamber 30 with the deflation valve 92 is wound on last.

[0068] The invention has various advantages in addition to those mentioned above. For example, multiple

boom systems can be deployed from multiple reels on the same vessel, all without requiring a separate towing vessel. Also, deployment over the port or starboard side of the vessel is more easily undertaken, and safety is increased, due to not having to delegate inflation of the boom to a secondary vessel.

[0069] The system of the invention is particularly suitable for operation in hazardous environments, in particular to contain and recover flammable pollutants. This is because the system may use hydraulic and pneumatic, and hence non-electrical, auxiliary power systems of the deploying vessel.

[0070] The system of the invention lends itself to being retrofitted to existing inflatable booms, which may be adapted by the addition of an inflation post at the free end of the boom to feed atmospheric air into the inflation cuff, and a high-pressure air line extending along the boom to supply the inflation post.

Claims

1. An elongate inflatable boom (50), comprising:

a longitudinal series of chambers (30);
an air duct (38) extending along the boom (50) to communicate with the chambers (30); and
an air blower (68),

characterised in that it further comprises a power line (60) extending along the boom (50) to the air blower (68), the air blower (68) having:

an airflow intake (72) for drawing in atmospheric air when power is provided to the air blower (68) along the power line (60) in use; and

an airflow outlet (74) communicating with the air duct (38) to exhaust the drawn-in air into the air duct (38) to inflate the chambers (30).

2. The boom (50) of Claim 1, wherein the air blower (68) is an airflow amplifier and the power line (60) is a high-pressure air line extending along the boom (50) to a high-pressure air inlet (70) of the airflow amplifier, such that atmospheric air is drawn in to the airflow intake (72) of the airflow amplifier when high-pressure air is supplied through the high-pressure air line to the high-pressure air inlet (70) in use.

3. The boom (50) of Claim 1 or Claim 2, wherein the air blower (68) is located adjacent to a first end of the boom (50) and the air duct (38) and the power line (60) extend substantially along a full length of the boom (50).

4. The boom of Claim 3, wherein the power line (60) extends from the air blower (68) to a coupling adja-

cent to a second end of the boom, opposed to the first end, for connection to a source of power (54).

5. The boom (50) of any preceding claim, wherein the air blower (68) is supported by a buoyant body (62) attached to the boom (50). 5
6. The boom (50) of Claim 5, wherein the buoyant body (62) is arranged to hold the airflow intake (72) of the air blower (68) above water in which the buoyant body (62) floats in use. 10
7. The boom (50) of any preceding claim, arranged such that power flows in the power line (60) in a first direction along the boom (50) and the drawn-in air flows in the air duct (38) in a second direction along the boom (50), opposed to the first direction. 15
8. In combination, the boom (50) of any preceding claim and a reel (12) around which the boom (50) is wound, wherein the air blower (68) is located adjacent to a free end of the boom (50) remote from the reel (12). 20
9. The combination of Claim 8, wherein the reel (12) comprises a rotary power coupling (56) between a source of power (54) and the power line (60) of the boom (50). 25
10. A vessel (14) carrying the boom (50) of any of Claims 1 to 7 and/or the combination of the boom (50) and the reel (12) of Claim 8 or 9. 30
11. A method of inflating a longitudinal series of chambers (30) in an elongate boom (50), the method comprising: supplying power along the boom (50) in a first direction to drive an air blower (68) that draws in atmospheric air and exhausts the drawn-in air to flow in a second direction along the boom (50), opposed to the first direction, to inflate the chambers (30). 35 40
12. The method of Claim 11, comprising launching the boom (50) into a body of water in the first direction.
13. The method of Claim 12, comprising inflating the chambers (30) while launching the boom (50). 45
14. The method of Claim 12 or Claim 13, comprising deploying the boom (50) from a reel (12) carried by a vessel (14) floating on the body of water and/or comprising supplying the power through the reel (12). 50
15. The method of any of Claims 12 to 14, comprising floating the air blower (68) on the body of water. 55
16. The method of any of Claims 11 to 15, wherein the air blower (68) is an airflow amplifier and the power

is supplied as a flow of high-pressure air to a high-pressure air inlet (70) of the airflow amplifier, such that atmospheric air is drawn in to the airflow intake (72) of the airflow amplifier when high-pressure air is supplied to the high-pressure air inlet (70) in use.

Patentansprüche

1. Länglicher aufblasbarer Ausleger (50), Folgendes umfassend:

eine Längsreihe von Kammern (30);
einen Luftkanal (38), der sich entlang des Auslegers (50) erstreckt, um mit den Kammern (30) in Verbindung zu stehen; und
ein Luftgebläse (68), **dadurch gekennzeichnet, dass** es ferner eine Stromleitung (60) umfasst, die sich entlang des Auslegers (50) zum Luftgebläse (68) erstreckt, wobei das Luftgebläse (68) Folgendes aufweist:

einen Luftstromeinlass (72) zum Ansaugen von atmosphärischer Luft, wenn dem Luftgebläse (68) entlang der verwendeten Stromleitung (60) Strom zugeführt wird; und
einen Luftstromauslass (74), der mit dem Luftkanal (38) in Verbindung steht, um die angesaugte Luft in den Luftkanal (38) abzugeben, um die Kammern (30) aufzublasen.

2. Ausleger (50) nach Anspruch 1, wobei das Luftgebläse (68) ein Luftstromverstärker und die Stromleitung (60) eine Hochdruck-Luftleitung ist, die sich entlang des Auslegers (50) bis zu einem Hochdruck-Lufteinlass (70) des Luftstromverstärkers erstreckt, sodass atmosphärische Luft in den Luftstromeinlass (72) des Luftstromverstärkers eingesaugt wird, wenn Hochdruckluft durch die Hochdruck-Luftleitung zu dem verwendeten Hochdruck-Lufteinlass (70) zugeführt wird.
3. Ausleger (50) nach Anspruch 1 oder Anspruch 2, wobei das Luftgebläse (68) angrenzend an ein erstes Ende des Auslegers (50) angeordnet ist und der Luftkanal (38) und die Stromleitung (60) sich im Wesentlichen über eine gesamte Länge des Auslegers (50) erstrecken.
4. Ausleger nach Anspruch 3, wobei sich die Stromleitung (60) von dem Luftgebläse (68) zu einer Kuppelung erstreckt, die an ein zweites Ende des Auslegers angrenzt, das dem ersten Ende gegenüberliegt, um an eine Energiequelle (54) angeschlossen zu werden.
5. Ausleger (50) nach einem vorhergehenden An-

spruch, wobei das Luftgebläse (68) von einem Schwimmkörper (62) gestützt wird, der an dem Ausleger (50) befestigt ist.

6. Ausleger (50) nach Anspruch 5, wobei der Schwimmkörper (62) angeordnet ist, um den Luftstromeinlass (72) des Luftgebläses (68) über Wasser zu halten, in dem der Schwimmkörper (62) bei der Benutzung schwimmt. 5
7. Der Ausleger (50) eines vorhergehenden Anspruchs, der so angeordnet ist, dass die Leistung in der Stromleitung (60) in einer ersten Richtung entlang des Auslegers (50) und die angesaugte Luftströmung in dem Luftkanal (38) in einer zweiten Richtung entlang des Auslegers (50) entgegen der ersten Richtung fließt. 10
8. In Kombination mit dem Ausleger (50) eines vorhergehenden Anspruchs und einer Rolle (12), um die der Ausleger (50) gewickelt ist, wobei das Luftgebläse (68) angrenzend an ein freies, von der Rolle (12) entferntes Ende des Auslegers (50) angeordnet ist. 15
9. Kombination nach Anspruch 8, wobei die Rolle (12) eine drehbare Kraftkupplung (56) zwischen einer Energiequelle (54) und der Stromleitung (60) des Auslegers (50) umfasst. 20
10. Schiff (14), das den Ausleger (50) nach einem der Ansprüche 1 bis 7 und/oder die Kombination aus dem Ausleger (50) und der Rolle (12) nach Anspruch 8 oder 9 trägt. 25
11. Verfahren zum Aufblasen einer Längsreihe von Kammern (30) in einem länglichen Ausleger (50), wobei das Verfahren Folgendes umfasst:
Zuführen von Energie entlang des Auslegers (50) in einer ersten Richtung, um ein Luftgebläse (68) anzutreiben, das atmosphärische Luft ansaugt und die angesaugte Luft abgibt, um in eine zweite Richtung entlang des Auslegers (50) zu strömen, die der ersten Richtung entgegengesetzt ist, um die Kammern (30) aufzublasen. 30
12. Verfahren nach Anspruch 11, umfassend das Einsetzen des Auslegers (50) in ein Gewässer in der ersten Richtung. 35
13. Verfahren nach Anspruch 12, umfassend das Aufblasen der Kammern (30) während der Inbetriebnahme des Auslegers (50). 40
14. Verfahren nach Anspruch 12 oder Anspruch 13, umfassend das Entfalten des Auslegers (50) von einer Rolle (12) aus, die von einem Schiff (14) getragen wird, das auf dem Gewässer schwimmt, und/oder umfassend das Zuführen der Energie durch die Rolle 45

(12).

15. Verfahren nach einem der Ansprüche 12 bis 14, umfassend das Schwimmen des Luftgebläses (68) auf dem Gewässer.
16. Verfahren nach einem der Ansprüche 11 bis 15, wobei das Luftgebläse (68) ein Luftstromverstärker ist und die Leistung als Hochdruckluftstrom einem Hochdruck-Lufteinlass (70) des Luftstromverstärkers zugeführt wird, sodass atmosphärische Luft in den Luftstromeinlass (72) des Luftstromverstärkers eingesaugt wird, wenn Hochdruckluft dem verwendeten Hochdruck-Lufteinlass (70) zugeführt wird.

Revendications

1. Barrage gonflable allongé (50), comprenant :

une série longitudinale de chambres (30) ;
une conduite d'air (38) s'étendant le long du barrage (50) servant à communiquer avec les chambres (30) ; et
une soufflante d'air (68), **caractérisé en ce qu'il** comprend en outre une ligne d'alimentation (60) s'étendant le long du barrage (50) vers la soufflante d'air (68), la soufflante d'air (68) comportant :

une entrée de flux d'air (72) servant à aspirer de l'air atmosphérique lorsque la soufflante d'air (68) est alimentée le long de la ligne d'alimentation (60) en cours d'utilisation ; et
une sortie de flux d'air (74) communiquant avec la conduite d'air (38) pour évacuer l'air aspiré dans la conduite d'air (38) afin de gonfler les chambres (30).

2. Barrage (50) selon la revendication 1, dans lequel la soufflante d'air (68) est un amplificateur de flux d'air et la ligne d'alimentation (60) est une conduite d'air à haute pression s'étendant le long du barrage (50) jusqu'à une entrée d'air à haute pression (70) de l'amplificateur de flux d'air, de sorte que l'air atmosphérique soit aspiré dans l'entrée de flux d'air (72) de l'amplificateur de flux d'air lorsque de l'air à haute pression est fourni à travers la conduite d'air à haute pression à l'entrée d'air à haute pression (70) en cours d'utilisation. 45
3. Barrage (50) selon la revendication 1 ou 2, dans lequel la soufflante d'air (68) est adjacente à une première extrémité du barrage (50), et dans lequel la conduite d'air (38) et la ligne d'alimentation (60) s'étendent sensiblement sur toute la longueur du barrage (50). 50

4. Barrage selon la revendication 3, dans lequel la ligne d'alimentation (60) s'étend de la soufflante d'air (68) à un raccord adjacent à une seconde extrémité du barrage, opposée à la première extrémité, pour le raccordement à une source d'alimentation (54). 5
5. Barrage (50) selon l'une des revendications précédentes, dans lequel la soufflante d'air (68) est supportée par un corps flottant (62) fixé au barrage (50). 10
6. Barrage (50) selon la revendication 5, dans lequel le corps flottant (62) est conçu pour maintenir l'entrée de flux d'air (72) de la soufflante d'air (68) au-dessus de l'eau sur laquelle le corps flottant (62) flotte pendant son utilisation. 15
7. Barrage (50) selon l'une des revendications précédentes, conçu de telle sorte que l'énergie circule dans la ligne d'alimentation (60) dans une première direction le long du barrage (50), et que l'air aspiré circule dans la conduite d'air (38) dans une seconde direction le long du barrage (50), opposée à la première direction. 20
8. Barrage (50) selon l'une des revendications précédentes, et bobine (12) autour de laquelle le barrage (50) est enroulé, en combinaison, la soufflante d'air (68) étant située à proximité d'une extrémité libre du barrage (50) à distance de la bobine (12). 25
30
9. Combinaison selon la revendication 8, dans laquelle la bobine (12) comprend un raccord d'alimentation rotatif (56) entre une source d'alimentation (54) et la ligne d'alimentation (60) du barrage (50). 35
10. Navire (14) transportant le barrage (50) selon l'une des revendications 1 à 7 et/ou combinaison du barrage (50) et de la bobine (12) selon la revendication 8 ou 9. 40
11. Procédé de gonflage d'une série longitudinale de chambres (30) dans un barrage allongé (50), le procédé consistant à :
fournir une alimentation le long du barrage (50) dans une première direction pour entraîner une soufflante d'air (68) qui aspire l'air atmosphérique et évacue l'air aspiré pour qu'il s'écoule dans une seconde direction le long du barrage (50), opposée à la première direction, afin de gonfler les chambres (30). 45
50
12. Procédé selon la revendication 11, consistant à lancer le barrage (50) dans une masse d'eau dans la première direction.
13. Procédé selon la revendication 12, consistant à gonfler les chambres (30) lors du lancement du barrage (50). 55
14. Procédé selon la revendication 12 ou 13, consistant à déployer le barrage (50) à partir d'une bobine (12) transportée par un navire (14) flottant sur la masse d'eau et/ou comprenant l'alimentation en énergie à travers la bobine (12).
15. Procédé selon l'une des revendications 12 à 14, consistant à faire flotter la soufflante d'air (68) sur la masse d'eau.
16. Procédé selon l'une des revendications 11 à 15, dans lequel la soufflante d'air (68) est un amplificateur de flux d'air et l'alimentation est fournie sous forme de flux d'air à haute pression à une entrée d'air à haute pression (70) de l'amplificateur de flux d'air, de sorte que l'air atmosphérique soit aspiré dans l'entrée de flux d'air (72) de l'amplificateur de flux d'air lorsque de l'air à haute pression est fourni à l'entrée d'air à haute pression (70) en cours d'utilisation.

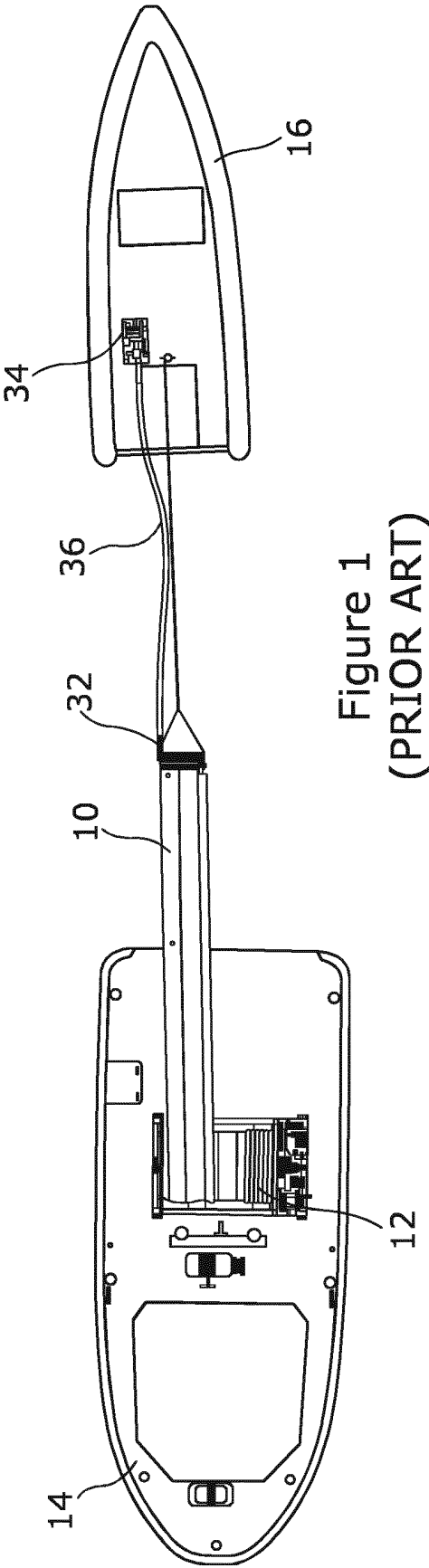


Figure 1
(PRIOR ART)

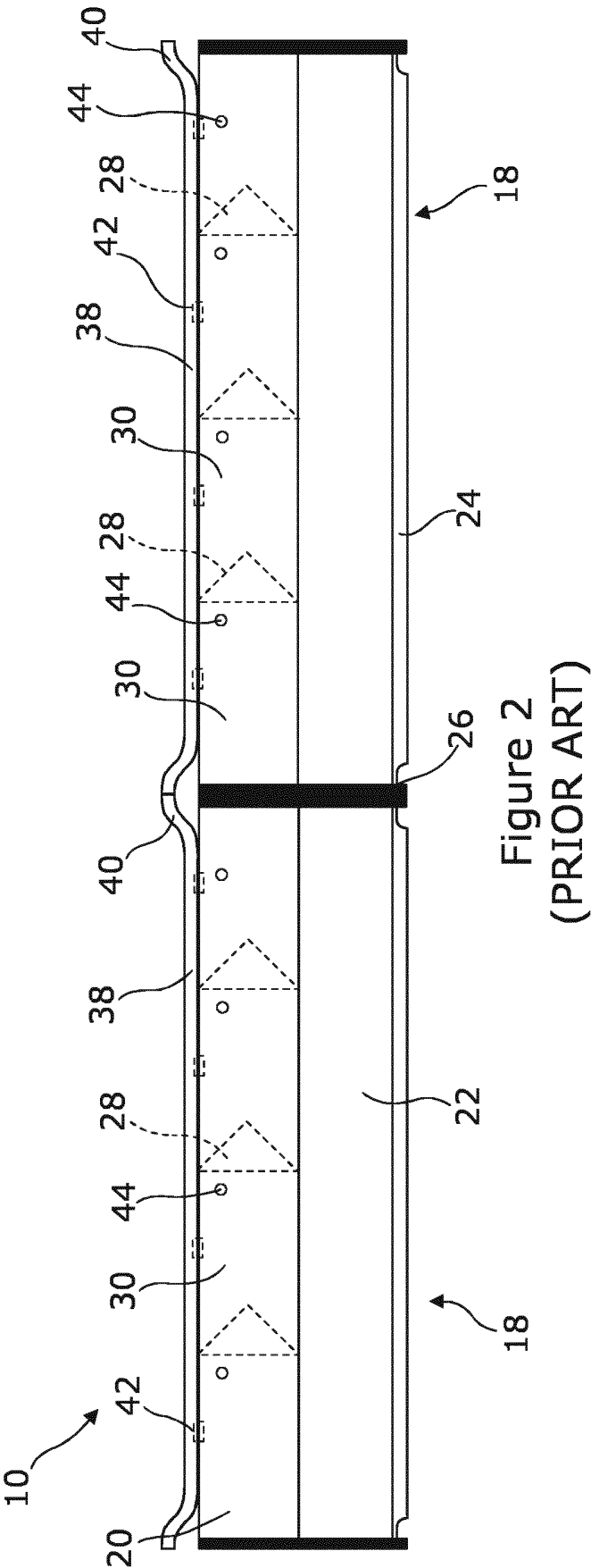


Figure 2
(PRIOR ART)

Figure 4
(PRIOR ART)

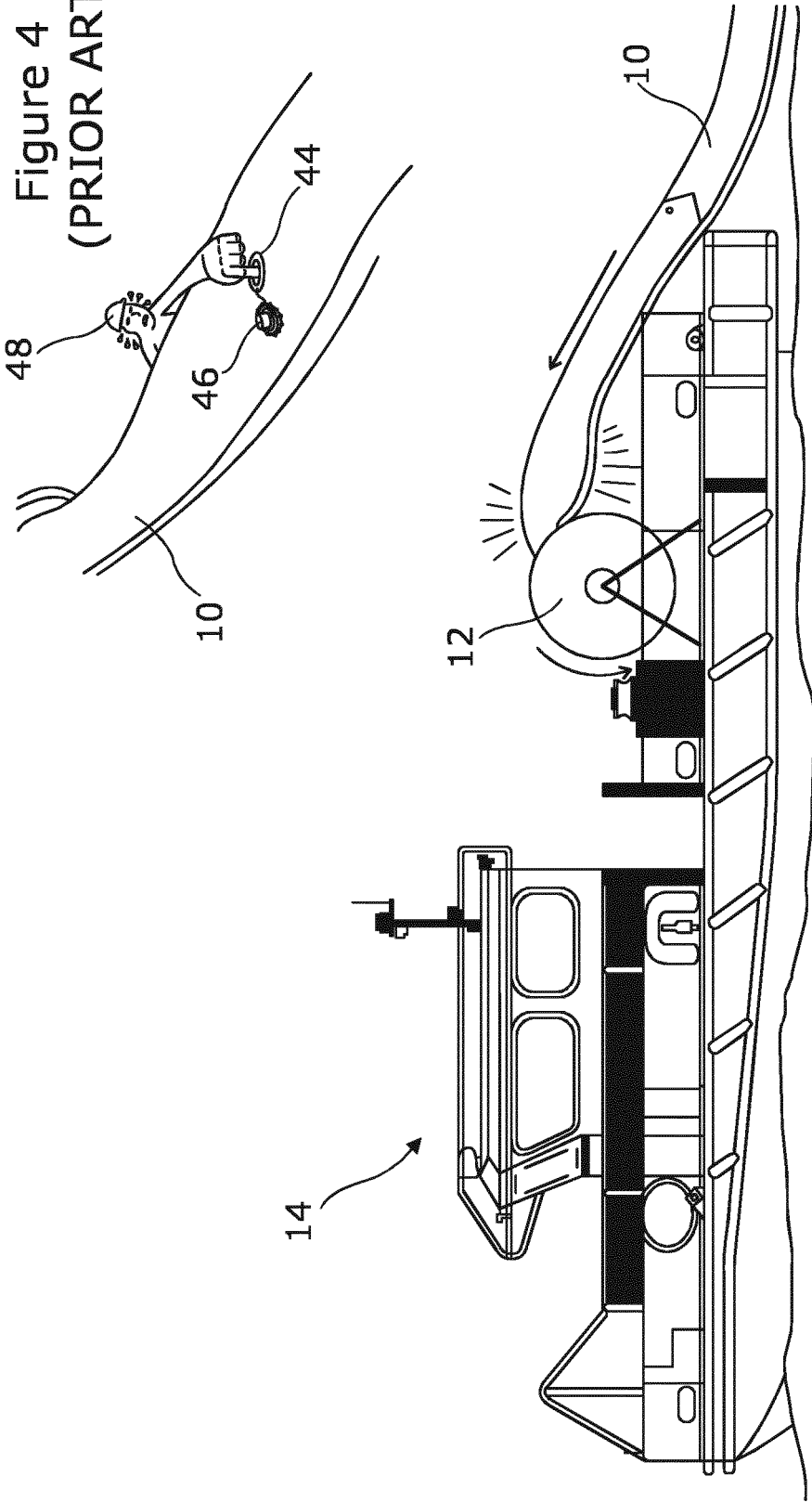


Figure 3
(PRIOR ART)

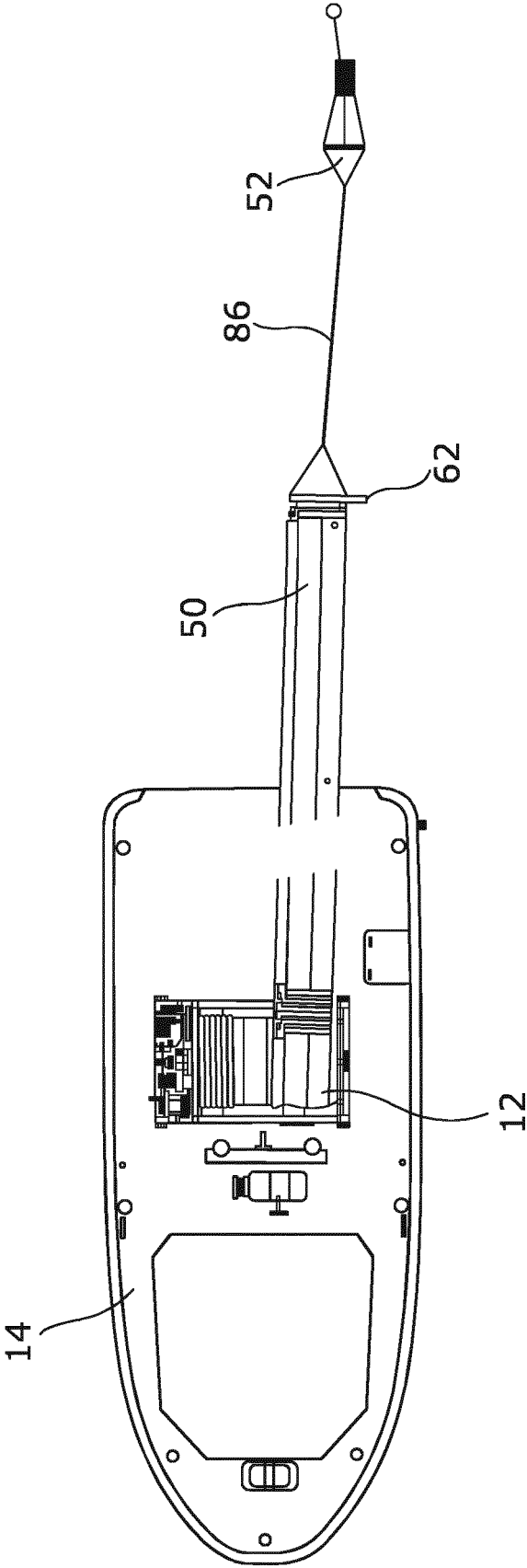


Figure 5

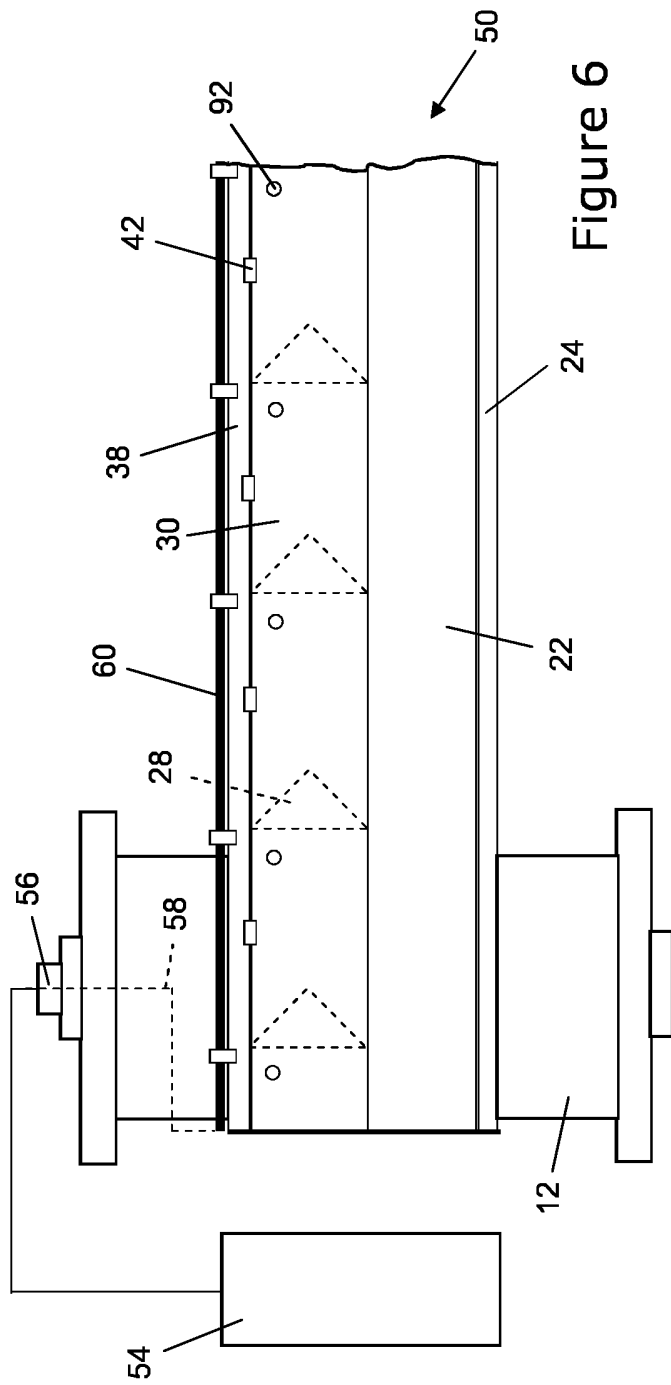


Figure 6

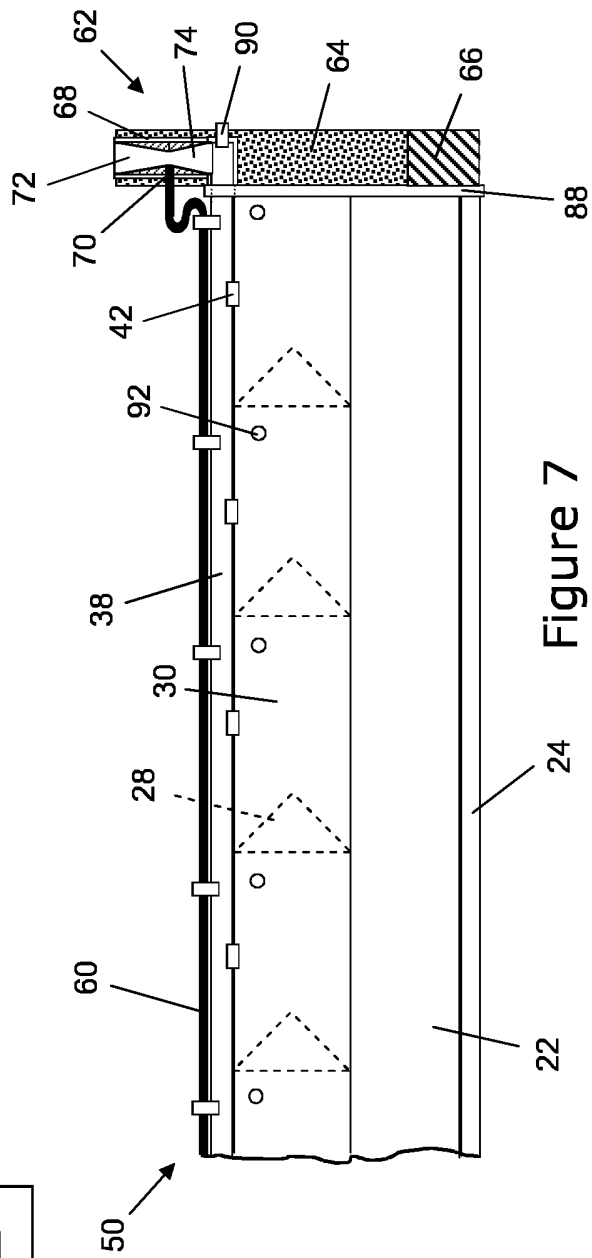


Figure 7

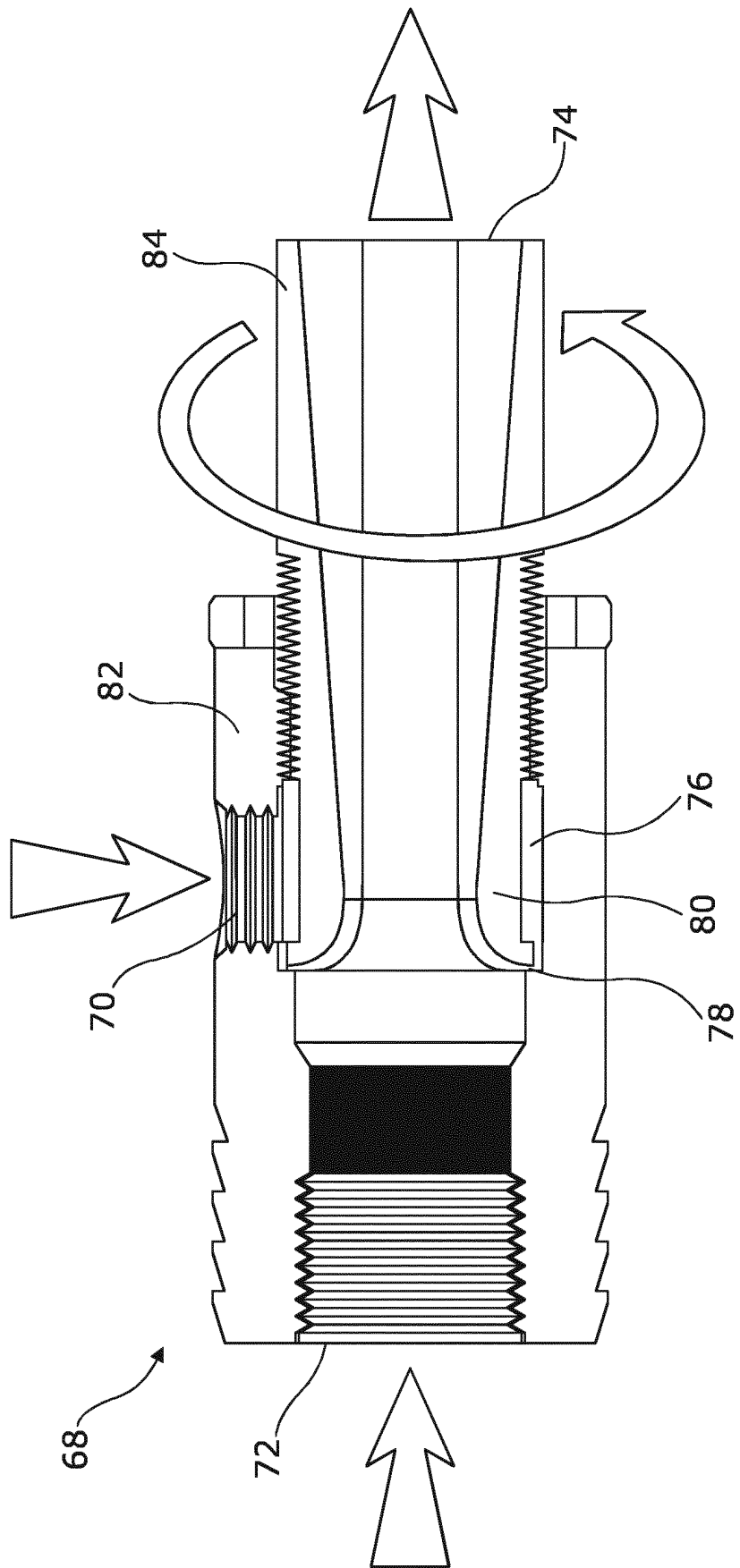


Figure 8

REFERENCES CITED IN THE DESCRIPTION

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