STABILIZING A FLOATING VESSEL

Filed Jan. 3, 1967 2 Sheets-Sheet 1

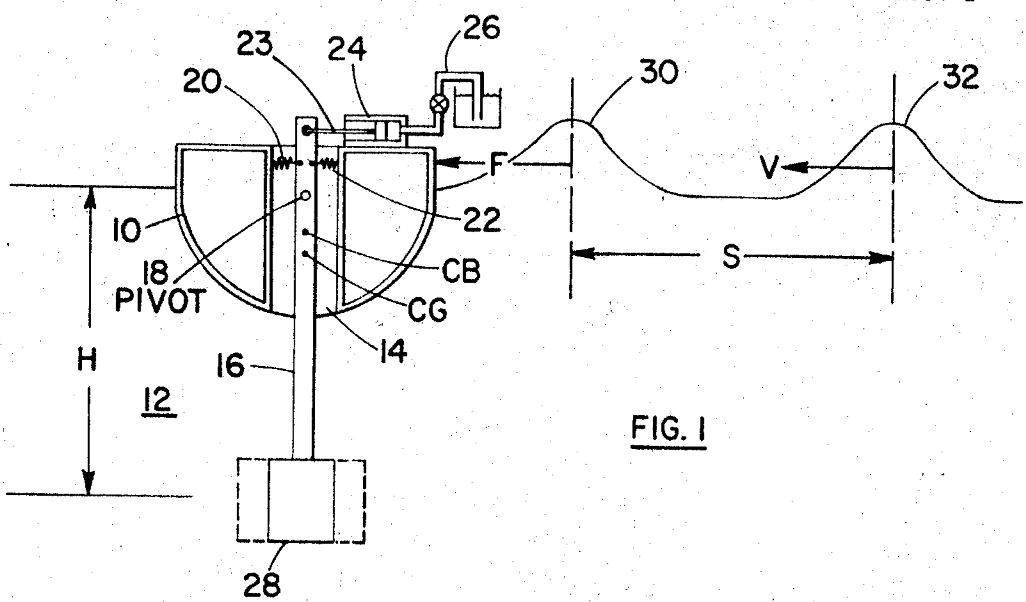

FIG. 1

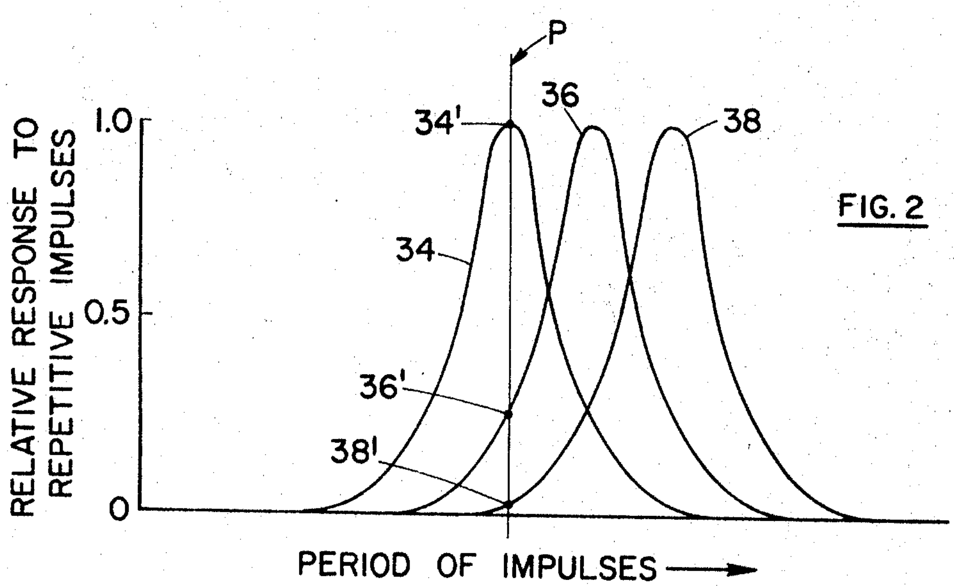

FIG. 2

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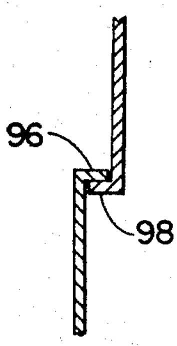
FIG 3a



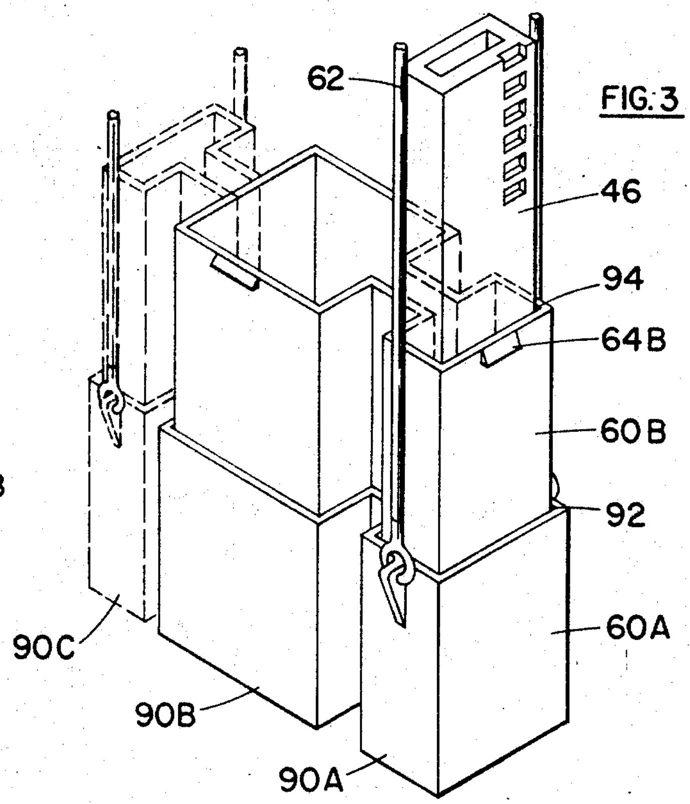


FIG. 3

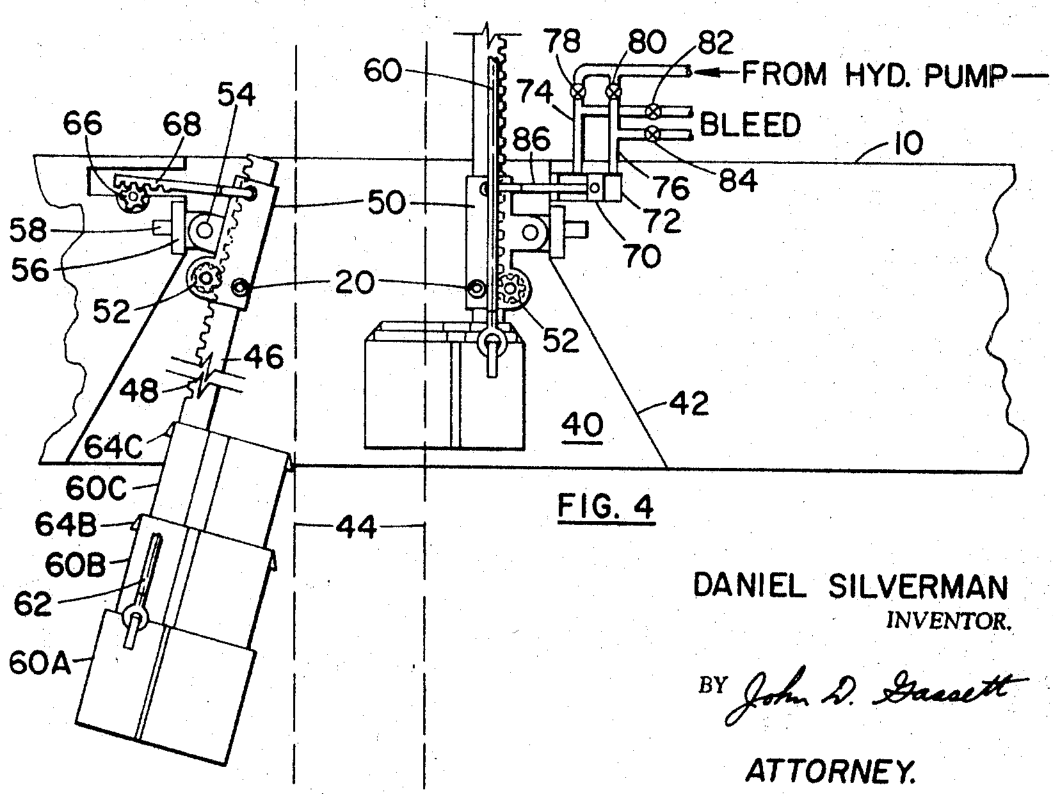


FIG. 4

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United States Patent Office

3,460,501
Patented Aug. 12, 1969

3,460,501

STABILIZING A FLOATING VESSEL

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Filed Jan. 3, 1967, Ser. No. 606,691
Int. Cl. B63b *35/44, 39/02*
U.S. Cl. 114—.5 11 Claims

ABSTRACT OF THE DISCLOSURE

An elongated vertical arm with mass at the lower end is pivoted in an opening in the vertical plane through the longitudinal axis of a drilling vessel. This increases the moment of inertia of the vessel and makes it less responsive to short period forces of the waves. The ship and the upper end of the arm are tied together by an energy storing device or they may be locked together. Various means are shown for raising and lowering the arm and for placing it out of the way of drilling operations.

This invention relates to stabilizing a floating vessel against roll. It is especially concerned with stabilizing a floating stationary drilling vessel against roll about its longitudinal axis.

Background and problems

In the last several years the search and drilling for petroleum deposits such as oil and gas has extended into marine locations. A common practice is to anchor a floating drilling vessel in the water at a point where it is desired to drill a wellbore. Drilling is then carried on from the drilling vessel, and frequently down through a vertical opening in the midsection of the vessel commonly called a moonpool.

In rough seas it is usually desired to head the ship into the waves; however, this is not always possible as it is difficult to greatly change the direction in which an anchored ship is headed. When the waves strike the side of an anchored vessel, it causes the ship to tend to roll about the center of buoyancy. As the center of buoyancy is ordinarily, for good stability, above the center of gravity, the ship tends to roll about the center of buoyancy and thus lifts the center of gravity. Such lift stores potential energy. When the wave dissipates, the unbalanced moment of the center of gravity about the center of buoyancy causes the vessel to roll back and to oscillate about the center of buoyancy at a period which depends on the moment of inertia of the vessel.

If the period of oscillation of a ship coincides with the period of ocean wave impulses, very large roll oscillation may take place.

Brief description of the invention

A ship has a resonant frequency and period of oscillation about its center of buoyancy which depends upon moment of inertia of the vessel. As mentioned, if the period of oscillation of the ship coincides with the period of the wave impulses on the ship, very large roll oscillations will take place. I provide unique means to change the resonant frequency of a ship so that its frequency varies from that of the wave impulses. It is desired that the resonant frequency of the ship be changed so that its period of oscillation is made greater than that of the wave impulses. The greater the difference between the two periods, the less the response of the ship to the force of the wave impulses.

I obtain this change in resonant frequency in the drilling vessel by adding moment of inertia thereto in a new way. A vertical arm is supported from the vessel through the moonpool in the vertical plane through the longitudinal axis of the drilling vessel. A large mass is provided at the lower end of the arm. In a preferred embodiment, the upper end of the arm is pivotally supported from the vessel. Energy storing means such as a spring, or energy loss means such as a dash pot are provided between the arm member and the vessel to resist movement of the arm member about its pivot. There is a structure or mass at the lower end of the arm. Preferably, this takes the form of a tank submerged in the water with small openings to permit it to fill with water. Thus, the arm member, restrained by the water at the bottom, tends to stay vertical, while the ship rolls. As the two are tied together, as by a dash pot, the moment of inertia of the ship is increased. The moment of inertia (ΔI) added is approximately

$$\Delta I = HM^2$$

where H is the distance from the center of oscillation to the center of the added mass, and M is the mass added and in the preferred case is the mass of all of the water that is constrained to move with the arm member. Benefits from this invention can be obtained on ships other than those having a longitudinal axis, such other ships including circular or triangular shapes.

Various objects and a better understanding of the invention can be had from the following description taken in conjunction with the drawings in which:

FIGURE 1 is a diagrammatic sketch of a drilling ship and the spacing between crests of waves of the body of water supporting the ship;

FIGURE 2 shows several resonance curves of oscillation of the ship showing different periods of oscillation of the floating ship;

FIGURE 3 illustrates means for providing telescoping tank-like means in the lower end of the vertical arm for obtaining an effective increase of mass to the arm;

FIGURE 3A is an enlarged cut-a-way view showing a portion of means limiting the telescoping extension of the tank-like member of FIGURE 3; and,

FIGURE 4 illustrates means of raising and lowering the vertical arm through the moonpool, including means for moving the tank-like member at the lower end of the arm out of the way for drilling operations.

Attention is first directed to FIGURE 1 which shows a schematic cross-section of a ship **10** supported by a body of water **12** and having an opening **14** in a vertical plane through the longitudinal axis of the drilling vessel. A vertical elongated support means such as arm member **16** is supported within such opening **14**. It is supported from ship **10** by pivot **18**. Energy storing means such as springs **20** and **22** are placed between the upper end of the arm and the wall of the ship in opening **14**.

Means are also provided for effectively locking arm **16** in a fixed position on pivot **18**. This includes rod **23** connecting the ship to a dash pot **24**. This dash pot has a control valve **26** which by closing can prevent fluid from leaving the dash pot, thus effectively locking the dash pot. If there is danger of the system building up forces in the arm of too great a magnitude, then one would want to render dash pot **24** at least partially ineffective, i.e., the piston in the dash pot could move within the cylinder. The energy storing means **20** and **22** would then aid in preventing the structural members from being over-stressed. The lower end of arm **16** supports a mass-adding structure such as a shell or tank-like member **28**. As will be explained, tank-like member **28** can take on various shapes. The tank-like member has openings to permit it to fill with water. It is preferred that tank member 28 be enclosed as much as possible so as to carry as much water as possible. Thus it is desirable to have a bottom, although much benefit is still obtained without a bottom. The openings are kept rather small so that when the arm tends to move, there is very little movement of water out of tank 28. In other words, the water is more or less effectively trapped therein and functions as a large mass on the lower end of arm 16. Also, the flat surfaces of the tank member should be oriented perpendicular to direction of motion of the tank so as better to drive water with it as it moves.

Also shown in FIGURE 1 are a first wave 30 and a second wave 32, having spacing therebetween. These waves are travelling toward vessel 10. The spacing S, shown on the drawing, between crests of waves 30 and 32 and the velocity V of the surface waves determine the period P between the impulses. As the waves break against the vessel 10, they create a force F. As the wave force F is applied to the side of the vessel, the ship tends to roll about the center of buoyancy (CB). This lifts the center of gravity (CG), storing potential energy. When wave 30 dissipates, the unbalanced movement of the center of gravity about the center of buoyancy causes the vessel to roll back and to oscillate about a longitudinal axis through the center of buoyancy at a period which depends on the moment of inertia of the vessel. If the period of oscillation of the ship coincides with the period of wave impulses, very large roll oscillations of the ship will take place. If this does occur, then one must change the period of the ship so they do not coincide. An object, then, is to shift the resonant curve of the ship away from that of the impulses of the waves. This can probably be explained more clearly by reference to FIGURE 2. Shown thereon are three curves plotted where the abscissa is the periods of impulses and the ordinate is the roll relative response of a ship to repetitive impulses. The period of the waves (at a given time) is indicated by line P. There are shown roll response curves of the ship 34, 36 and 38. If the curve 34 is the actual response curve of the ship, it is seen that curve 34 shows the amplitude of oscillation of the ship for wave impulses of different period. Then the maximum amplitude of oscillation 34′ occurs with the period P of the waves. This provides for maximum roll of the ship, which is to be avoided.

To prevent maximum roll of the ship, I change the moment of inertia so that the period of response of the ship is not the same as the period of the waves. Response curves 36 and 38 reflect shifting of the resonance to a lower and lower frequency, i.e., longer and longer periods. At period P (of the waves), response curve 36 shows an amplitude of oscillation of 36′ which is about ⅕ of that of 34′. Similarly, response curve 38 shows an amplitude of oscillation represented at 38′ which is practically zero. It is thus seen that it is desired to shift the response curve of ship roll to longer and longer periods. This is accomplished by adding moment of inertia to the ship. The moment of inertia added is approximately $\Delta I = HM^2$. H is illustrated in FIGURE 1 and as shown above is the distance from the center of oscillation to the center of the added mass, M.

FIGURES 3 and 4 illustrate telescoping or collapsible-type tanks which can be retrieved and entirely concealed within the contour of the ship while it is underway. The left side of the FIGURE 4 illustrates a telescoping tank in an extended position and tilted out of the way of drilling operations. The right side indicates the arm and tank in a retrieved position for traveling. In FIGURE 4 there is illustrated a portion of vessel 10 with a moonpool 40 having a downwardly and outwardly tapered wall 42. The dashed lines 44 in the center of the moonpool indicate the clearance space needed for the riser pipe and other equipment in drilling operations. Means are provided so that when the arm and tanks are extended they are tilted so as to remain outside of this clearance space.

Arm 46 with gears 48 is supported through guide brackets 50. Mounted as a part of bracket 50 is a drive gear 52 which meshes with gears 48 of arm 46. Motor means (not shown) are provided for driving gears 52. Bracket 50 is mounted for rotation about a horizontal pivot 54 which has an axis in a plane perpendicular to the longitudinal axis of the ship. In this embodiment, energy storing means 20 and 22 are mounted between the wall of the moonpool and bracket 50 in a plane perpendicular to the longitudinal axis of the ship. Pivot 54 is supported by bracket 56 which is mounted from the structure of vessel 10 by pivot 58 which has an axis in a plane perpendicular to the axis of pivot 54. Pivot 54 gives bracket 50 (and the arm connected thereto) a large freedom direction of movement.

Arm 46 can be raised and lowered through bracket 50 by rotation of drive gear 52 with arm 46 either in a vertical position or tilted by means discussed hereinafter. This is useful in raising and lowering the mechanism from its lowermost position. As mentioned above, the lower end of arm 46 is provided with telescoping tank means such as bucket segments 60A, 60B and 60C. Lower segment 60A is connected by line 62 which extends to power drums on the surface of the vessel not shown. By pulling up on line 60 and rotating gear 52, arm 46 can be brought into retrieved position shown in the right side of FIGURE 4 which is the position which one would have when moving from one location to another. Segments 60B and 60C have lips 64B and 64C to engage the upper shoulder of segment 60A and 60B, respectively, so that they can be supported and carried up by the adjacent lower segment as the lower segment 60A is raised by line 62.

Attention will now be directed toward means for tilting tank-like segments 60A, 60B and 60C so that clearance space 44 is provided in the moonpool for the riser pipe. One form of such means is illustrated on the left hand side of the moonpool of FIGURE 4. This includes a drive gear 66 mounted from the ship 10 and a mounting rack gear 68 which is connected to rack or bracket 50. Rotation of gear 66 drives rack gear 68 to cause bracket 50 to rotate about pivot 54. Tilting of bracket 50 also causes tilting of arm 46.

The right side of FIGURE 4 illustrates another means of tilting bracket 50. This includes a hydraulic motor having a piston 70 within cylinder 72. Lines 74 and 76 connect to the cylinder 72 on opposite ends of piston 70. Lines 74 and 76 lead through valves 78 and 80, respectively, to a hydraulic power source. These conduits 74 and 76 also are connected through valves 82 and 84, respectively, to bleed to atmospheric pressure. Thus, by proper manipulation of valves 78, 80, 82 and 84 in an obvious manner, piston 70 can be made to take any position desired. Piston 70 is connected to bracket 50 through connecting rod 86. Thus, movement of piston 70 causes bracket 50 and vertical arm 46 to tilt accordingly.

FIGURE 3 shows in perspective form extensible tanks such as those shown in FIGURE 4. Only segments 60A and 60B are shown thereon. Lower segment 60A is shown composed of two separated sub-sections 90A and 90B. Intermediate section 60B likewise has sub-sections. If desired, additional sub-sections, such as indicated by dotted line 90C, can be added. It is seen that water can enter space 92 between segments 60A and 60B, for example. Section 60A has a bottom in it but sections 60B may (but not necessarily) have a bottom and then water will enter it through the top at 94, for example. 64B protrudes so as to be caught by the upper end of lower segment 60A when the lower segment is pulled up by line 62. Means are also provided so that when lower section 60A is lowered it will not drop off the end of section 60B. This is conveniently provided, as shown in FIGURE 3A, by providing a downwardly facing shoulder 96 on section 60A and upwardly facing shoulder 98 on upper section 60B.

While only a limited number of embodiments have been shown, it is possible to produce various modifications without departing from the spirit or scope of the invention.

I claim:

1. A stabilizing system for a ship supported by a body of water in which said ship has at least one vertically disposed opening in the midsection of the ship comprising:
  a relatively rigid elongated support means supported by said ship and mounted substantially vertically in said opening and adapted to extend downwardly through said opening into the water beneath the ship and terminating above the bottom of said body of water, said elongated support means pivoted about a horizontal longitudinal axis supported by said ship;
  structural mass-adding means attached to the lower end of said elongated support means for greatly increasing the mass of such lower end, and
  compliance means restraining said elongated support means from rotation about said axis.

2. A stabilizing system for a ship supported by a body of water in which said ship has at least one vertically disposed opening in the midsection of the ship comprising:
  a first and second relatively rigid elongated support means supported by said ship and mounted diametrically opposite each other in said opening and adapted to extend downwardly through said opening into the water beneath the ship and terminating above the bottom of said body of water, and
  structural mass-adding means attached to the lower end of each said elongated support means for greatly increasing the mass of such lower end.

3. A stabilizing system for a ship supported by a body of water in which said ship has at least one vertically disposed opening in the midsection of the ship comprising:
  a relatively rigid elongated support means supported by said ship and mounted substantially vertically in said opening and adapted to extend downwardly through said opening into the water beneath the ship and terminating above the bottom of said body of water;
  structural mass-adding means attached to the lower end of said elongated support means for greatly increasing the mass of such lower end, and said structural mass-adding means including rectangular shell means;
  the walls of said opening being flared downwardly and outwardly so that said rectangular shell means can be tilted to provide a clearance space for a riser pipe downwardly through said opening.

4. A stabilizing system for a ship supported by a body of water comprising:
  (a) at least one vertically disposed opening in the midsection of said ship;
  (b) a relatively rigid elongated structural support means supported by said ship and retractively mounted substantially vertically in said opening and adapted to extend downwardly through said opening into the water beneath the ship and terminating above the bottom of said body of water;
  lower end of :
  (c) structural water-holding means attached to the lower end of said support means of dimensions large compared to the transverse dimension of said support means for enclosing a large volume of water;
  (d) means to retract said support means and said water-holding means into said opening;
  (e) pivot means for pivoting said support means about a longitudinal horizontal axis above the center of gravity of said ship.

5. An apparatus as defined in claim 4 including dashpot means for restraining said elongated structural support means against rotation about said longitudinal horizontal axis.

6. An apparatus as defined in claim 4 in which said structural support means includes tank means comprising a plurality of telescoping sections which can be extended to greatly enlarge the mass of water constrained therein and including means for extending and retracting such telescoping sections.

7. An apparatus as defined in claim 4 including tilting means for tilting said elongated structural support means at a selected angle from the vertical within the longitudinal vertical plane of the ship.

8. An apparatus as defined in claim 4 in which said ship has a longitudinal axis and said support means includes one pivot about and axis perpendicular to a vertical plane to the longitudinal axis of said ship, and a second pivot horizontal and perpendicular to said axis of said first pivot.

9. An apparatus as defined in claim 4 in which said means to retract said support means includes:
  gears on said elongated structural support means;
  a support bracket for said elongated structural support means;
  second support means for supporting said support bracket from said ship;
  a drive gear means supported from said support bracket and meshing with the gears of said elongated support means.

10. An apparatus as defined in claim 4 including compliance means restraining said elongated structural means from rotation about said axis.

11. A stabilizing system for a ship supported by a body of water comprising:
  (a) at least one vertically disposed opening in the midsection of said ship;
  (b) a relatively rigid elongated structural support means supported by said ship and retractively mounted substantially vertically in said opening and adapted to extend downwardly into said opening into the water beneath the ship and terminating above the bottom of said body of water, said support means being pivoted about a horizontal transverse axis within said opening;
  (c) structural water-holding means attached to the lower end of said support means of dimensions large compared to the transverse dimension of said support mans for enclosing a large volume of water;
  (d) means to retract said support means and said water-holding means into said opening, said opening being large enough to enclose said water-holding means.

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