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(54) Flotation bag assembly.

(57) An apparatus for the stable support of a structure, such as an antenna (2), in a fluid medium (W), such as the ocean. A flotation bag (1) supporting an antenna is stabilized by the following features, which can be used individually or in combination. A partially submerged ribbon fence (5) supported by a submerged damper skirt (4) dissipates the kinetic energy of the flotation bag caused by the movement of the ocean and water that encroaches upon the bag. A flexible connection (8) between the bag and the payload (3) enables the bag and the payload to undergo limited motion without affecting each other. Thus, the bag's motion is decoupled and totally independent of the payload. The housing (32) which supports the payload has a flooded chamber (33), lowering the center of mass of the apparatus. The bottom (16) of the flotation bag is inwardly arched (15), moving the bouyancy away from the center of the bottom of the bag, enhancing stability and allowing the bag to float lower in the ocean, keeping the damper skirt submerged. The payload includes an r.f. signal source (31). The apparatus is designed to constrain the motion of the antenna to within very narrow operational limits.

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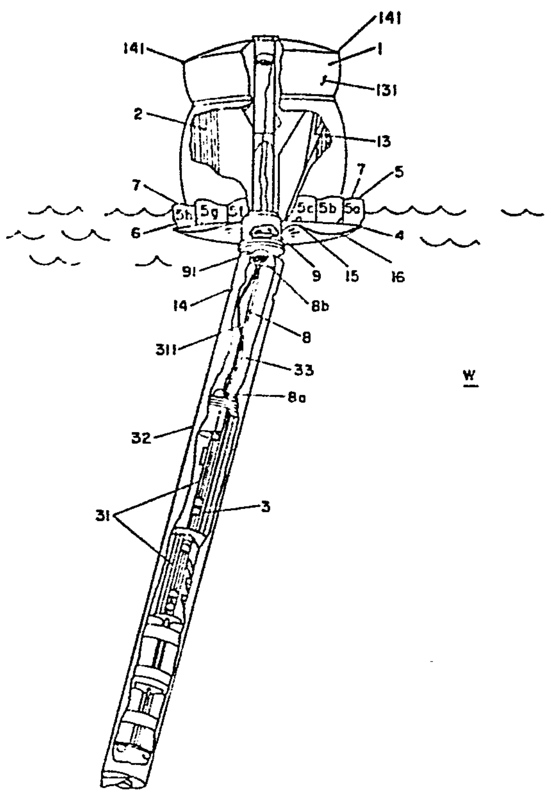
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W
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FIG. 2

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FLOTATION BAG ASSEMBLY

The Government has rights in this invention pursuant to Contract N00039-83-C-0191 awarded by the Department of the Navy, United States of America.

This invention relates generally to a stable support for structures at or above the surface of a fluid medium and in particular to a communications buoy for use in the ocean.

Many types of flotation devices exist with differing characterisitcs.

Damper plates and toroid shaped flotation devices have been used to create buoys which are wave followers. For example, see Buoy Engineering, H.O. Berteaux, John and Sons, 1976 Pg. 212-213. These surface following buoys are subject to strong heave and pitch due to the motion of the ocean.

A more stable buoy can be built by decreasing the cross section of the buoy at the water level. Such devices experience less heave. The mass of the buoy can also be distributed to create a righting moment. This will decrease the pitch.

Further stability can be obtained by surface decoupling. A buoyant cylinder with a counterweight suspended from its bottom is a typical example, Berteaux, supra. Such spar buoys cannot have much reserve buoyancy and usually have a large draft. These factors mitigate the usefulness of these types of buoys in deep water.

It is an object of this invention to provide a communications buoy having an antenna which uses the surface of the ocean as a ground plane; such buoy having structure which limits the antenna's motion with respect to the surface of the ocean to within 4 in (10 cm.) heave and 25^0 pitch.

It is another object of this invention to provide a stable buoy that can withstand ocean conditions up to and including state 5.

The buoy according to the invention may be used as part of a search and rescue system for locating downed aircraft and ships in distress. Such buoys would be carried by vehicles and be deployed when needed. Their distress signal could be received by satellites and their position located.

The bouy according to the invention could carry various other types of payloads or support various antenna structures as well. Other possible uses include oceanographic monitoring buoys and satellite linked sonobuoys.

It is an object of this invention to provide an apparatus for the stable support of a structure, such as an antenna, in a fluid medium, such as water.

It is a futher object of this invention to limit the motion of an antenna supported above the surface of the ocean, within the operational limits of the transmitting system.

It is a further object of this invention to support an electronics payload near the surface of the ocean such that the power loss between the electronics payload and an antenna supported on the surface is within operational limits and, specifically, less than 3db.

The invention is an apparatus for the stable support of a structure, such as an antenna, in a fluid medium, such as water. The apparatus comprises a bouyant first member and first means for engaging the structure. The first means is associated with the member. Second means are provided for channeling the fluid which encroaches upon the bouyant member due to any motion of the member with respect to the surface of the fluid medium, the encroaching fluid being channeled back into the fluid medium such that the kinetic energy of the bouyant first member is dissipated as the fluid is channeled back into the fluid medium.

Alternatively, the apparatus according to the invention may comprise a bouyant first member for supporting the structure, a payload and decoupling means for supporting the payload below the bouyant member such that any motion of the payload is decoupled from the member and any motion of the member is decoupled from the payload.

Alternatively, the apparatus according to the invention may comprise a bouyant member with an inwardly arched bottom portion, and means, associated with the bouyant member, for engaging the structure.

Alternatively, an apparatus according to the invention may comprise an antenna, a bouyant member, first means for generating an r.f. signal, second means interconnecting the first means and the antenna, and decoupling means for supporting the first means below the bouyant member such that any motion of the member is decoupled from the first means and the motion of the first means is decoupled from the member.

Alternatively, the invention may comprise a communications bouys which is stable in a fluid medium and includes structures for minimizing the heave and pitch of the bouy. Specifically, a flotation bag with a concave bottom formed by pulling in the center of the bottom of the bag with straps secured to the inside walls of the bag supports an antenna. A semi-rigid damper skirt extending around the base of the bag is submerged when the apparatus is floating in the fluid medium. The bag is provided with a ribbon fence comprising containers which have an opening above the fluid level, and an opening below the fluid level, when the apparatus is floating in the medium, allowing the fluid to flow in and out of the containers. The payload is supported in a cylindrical chamber connected to the flotation bag by a flexible cable, enabling the payload to swing.

Figure 1 is a side view of a communications bouy according to the invention deployed in water.

Figure 2 is a side view of the bouy of Figure 1 with parts broken away to illustrate internal structure.

Figure 3 is a perspective view of a communications bouy according to the invention in an undeployed state.

Figure 4 is a top view of a flotation bag according to the invention.

Figures 5a -5g are graphs illustrating the operational transmission requirements and the estimated performance of an antenna system according to the invention under varying conditions of heave and pitch.

Referring to figures 1 and 2, flotation bag 1 is an inflated balloon-like structure having a specific gravity less than the specific gravity of fluid medium W. Bag 1 encloses antenna 2 and supports a payload 3 below the surface of medium W.

Although this embodiment comprises flotation bag 1 which encloses antenna 2, the invention includes flotation devices of any type which support structures.

Figures 5a-5g compare the estimated performance 102 of an antenna such as antenna 3 under varying conditions of heave and pitch with the operational performance requirement 101 for successful transmission. Antenna 3 uses the surface of the fluid W as a ground plane. Heave and pitch disturb the relationship between the radiating antenna 3 and the ground plane, changing the radiation pattern of antenna 3. As shown by graphs 5a, 5b, and 5f, the estimated performance 102 of antenna 3 crosses and falls below the operational performance requirements for successful transmission between certain points on the graphs. In summary, successful transmission is not achieved when antenna 3 undergoes more than 4 ins (10 cms) heave or 25° pitch. The apparatus according to the invention limits the motion of the antenna relative to the ground plane to within 10 cms. heave and 25° pitch, under ocean conditions up to sea state 5.

A damper skirt 4 extends around the base of the flotation bag 1 and is made of a semi-rigid material supported in a horizontal position by ribbon fence 5.

When the apparatus is afloat, damper skirt 4 is below the surface of the medium W. The weight of the payload 3, the shape of the bottom of the flotation bag 1 and the bouyancy of bag 1, which will be described in detail below, are configured so that damper skirt 4 is below the water line when the apparatus is stable.

Damper skirt 4 increases the surface area in contact with the ocean, offering a surface which resists motion V within medium W. In order to rise or tip in response to a wave, damper skirt 4 must travel upwardly through the fluid. The resistance to upward movement of skirt 4 is caused by the fluid above the skirt 4. The energy that would otherwise cause heave and pitch of the flotation bag 1 is dissipated by this resistance and any resulting movement of skirt 4 within the medium W.

As shown particularly in figure 4, ribbon fence 5 which supports the damper skirt 4 is a series of contiguous compartments, 5a-5g. Damper skirt 4 acts as the base of the compartments 5a-5g of ribbon fence 5 and the side 1s of the flotation bag 1 forms the back wall of the compartments. The walls of the compartments in the embodiment illustrated comprise a strip of semi-rigid material connected to the side of the flotation bag 1 at spaced apart points P. The flotation bag 1, damper skirt 4 and the strip form the contiguous compartments, the combination of which is referred to herein as ribbon fence 5.

Each compartment 5a-5g has an opening 6 in the lower portion thereof, where the strip joins to damper skirt 4. The compartments have an opened top 7. When stable in the ocean, the bottom hole 6, which has a cross section less than the opening at the top 7, is beneath the level of the medium W. The water line on the flotation bag when the apparatus is at rest in the ocean is approximately at the midpoint 8 of the height of the ribbon fence 5.

Compartments 5a-5h act as containers for the fluid medium. Fluid encroaching upon bag 1 can enter the compartments through hole 6 or the opened top 7 and can drain from the compartments through the hole 6. When bag 1 rises due to the motion of the ocean, sea water will drain out of the holes 6, dissipating the kinetic energy of bag 1 created by the rising motion of the ocean. Oscillating of the flotation bag 1 within the medium W are thereby damped. The compartments increase the resistance to motion of damper skirt 4 by partially enclosing the fluid and by requiring the damper skirt to lift the partially enclosed fluid in the compartments as the flotation bag 1 rises in response to a wave. This acts to further decrease the heave and pitch of the flotation bag.

The damper skirt 4 and ribbon fence 5 are described associated with each other, constructed from semi-rigid materials for the purpose of stabilizing flotation bag 1. However, the damper skirt 4 may be a submerged plate and the means for channeling fluid that encroaches on the device. Such structures may be used separately or in combination to decrease both the heave and pitch of the device.

Payload 3 comprises electronics 31 enclosed in a cylindrical housing 32. Housing 32 is connected to the bottom of the flotation bag 1 by nylon cord 8. One end of nylon cord 8 connects to a point 8a within the housing, approximately one-quarter from the top of the housing and the other end connects to the center of the bottom of the bag 8b, at bulkhead 9, which is a rigid portion. Electrical wires 311 also pass from the electronics 31 into the bulkhead 9. Beneath the bulkhead 9 is microphonics bumper 91.

Nylon cord 8 and the location of the connection between the housing 32 and the flotation bag 1, at 8a and 8b, decouple the motion of flotation bag 1 from housing 32 such that, over a certain range, the motion of bag 1 does not affect the motion of cylindrical housing 32 and the motion of cylindrical housing 32 does not affect the housing motion of bag 1. The range of motion depends on the demensions of the decoupling apparatus including the diameter of housing 32 and the distance between the top of housing 32 and microphonic bumper 91.

Housing 32 is free to swing like a pendulum until the top of the housing 32a collides with the microphonic bumper 91. Similarly, the flotation bag 1 can freely pitch until the bumper 91 collides with the top of the housing 32a.

This allows for 10^0 - 15^0 of motion of the payload 3, measured from the vertical, before contact between housing 32a and microphonic bumper 91. Bumper 91 absorbs some of the energy of any impact between bag 1 and payload 3, decreasing the effect such impact would have on the heave and pitch of the flotation bag. Bumper 91 also protects the electrical wiring that feed to the antenna, preventing interruption or interference with the transmission of a message due to impacts between the housing 32a and the bulkhead 9 through which wires 311 pass.

In the embodiment illustrated, electronics 31 is close to antenna 2 in order to minimize the power loss due to transmission of a signal from electronics 31 to antenna 2 via cable 311. Preferably, the power loss is less than 3db.

The upper portion 33, of housing 32, referred to herein as a collar, stores the entire flotation apparatus before it is deployed, as shown in Figure 3. After deployment, the upper portion 33 floods with water, through holes 14 in its sides, as shown in Figures 1 and 2. The flooding reduces the buoyancy of the payload 3 which results in payload 3 pulling the flotation bag 1 into the water, ensuring that the damper skirt 4 and bottom hole 6 of ribbon fence 5 are submerged. This increases the stability of flotation bag 1.

The flooding of upper portion 33 results in the center of mass of housing 32 being lower in the medium W, increasing the period of oscillation of housing 32. This stabilizes the entire structure and decreases the heave and pitch of flotation bag 1.

The center of the bottom of the flotation bag 1 is pulled upward by straps 13 secured at 131, along the inside wall of flotation bag 1. This reduces the buoyancy of bag 1, aiding in maintaining the necessary waterline above damper skirt 4 and at the midpoint of ribbon fence 5. The base of bag 16 is inwardly arched at its center 15 so that the greatest bouyant forces are located at the outer portions of the bag 16. This decreases the pitch of the flotation bag 1 by creating a longer torque arm which must be overcome for the flotation bag to rotate. This righting moment further aids in stabilizing the flotation bag. The adhesion caused by inwardly arched center 15 between the surface of the bottom 16 of the bag and the fluid medium W also decreases the heave of the flotation bag.

Although this particular embodiment describes a flotation bag with a concave bottom, the invention is meant to cover flotation devices of any material with a bottom of inwardly arched shape.

The apparatus and payload are ejected in the cylindrical housing 3, as shown in Figure 3. Antenna 4, flotation bag 1, ribbon fence 5 and damper skirt 4 are all stored in upper chamber 33 of the housing 32. Housing 32, which is bouyant, floats to the surface of the ocean after being ejected. The flotation bag and antenna are then deployed and the preprogrammed messages are transmitted.

CLAIMS

1. Apparatus for the substantially stable support of a device (2) in a fluid medium, said apparatus including:

a buoyant member (1); and

support means associated with the buoyant member for supporting the device (2) to be supported;

characterised by:

channel means (5) positioned to channel fluid which encroaches upon the buoyant member due to any motion of the member relative to the surface of the fluid medium, said encroaching fluid being channeled by said channel means (5) back into the body of the fluid medium such that kinetic energy of the buoyant member associated with said motion is dissipated as the fluid is channeled back into the body of the fluid medium.

2. Apparatus according to claim 1 characterised in that said channel means (5) comprises at least one compartment (5a-5g) having an upper opening (7) and a lower opening (6), the or each said compartment being connected to the buoyant member (1) with the upper and lower openings (7,6) respectively above and below the mean surface level of the fluid medium when the apparatus is floating therein, whereby encroaching fluid which enters a said compartment (5a-5g) is channeled back through the lower opening (6).

3. Apparatus according to claim 2 characterised in that the or each said compartment (5a-5g) is open at the top to provide said upper opening (7) and the or each lower opening (6) has a cross-sectional area less than the cross-sectional area of the corresponding

upper opening (7).

4. Apparatus according to any one of claims 1 to 3 characterised by a damper member (4) extending generally horizontally beneath the buoyant member (1) and below the mean level of the fluid medium when the apparatus is afloat, whereby to impede vertical motion of the apparatus relative to the fluid medium.

5. Apparatus according to claim 2 or claim 3 including a plurality of said compartments (5a-5g) surrounding said buoyant member (1), characterised by a damper skirt member (4) extending generally horizontally around said buoyant member (1) to form a base for each said compartment (5a-5g), the lower openings (6) being formed between said base and side walls of the compartments.

6. Apparatus according to any one of claims 1 to 5 characterised by a payload (3) carried by and below said buoyant member (1), said payload (3) being connected to said buoyant member by decoupling means (8) operative to decouple motions of the payload and the buoyant member from one another over a given angular range.

7. Apparatus according to claim 6 characterised in that said decoupling means is a flexible member (8) connected at an upper end (8b) to a rigid portion (9) of said buoyant member (1) and at a lower end to said payload (3), said flexible member extending through a collar (33) of a housing (32) of said payload, and in that said rigid portion (9) has a bumper (91) positioned to engage said collar (33) when relative angular movement between the rigid portion (9) and the payload

housing (32) attains a predetermined angle.

8. Apparatus according to claim 6 or claim 7 characterised in that said payload (3) has a housing (32) including a chamber (33) within which said buoyant member (1) is stored when the apparatus is in an undeployed state.

9. Apparatus according to any one of claims 6 to 8 characterised in that said device to be supported is an antenna (2) supported by said support means of said buoyant member (1), in that said payload (3) includes an r.f. signal generator (31) and in that said generator is electrically connected to said antenna.

10. Apparatus according to any one of the preceding claims characterised in that the under surface of the buoyant member (1) is substantially concave (15).

11. Apparatus according to claim 10 characterised in that the buoyant member is a flotation bag (1) having internal straps (13) connected between the bag walls (131) and the central portion of the bottom of the bag (16) to pull the under surface upwardly into said substantially concave condition (15).

12. Apparatus for the substantially stable support of a device (2) in a fluid medium, said apparatus including:

a buoyant member (1);

support means associated with the buoyant member for supporting the device (2) to be supported; and

a payload (3) positioned below the buoyant member (1);

characterised in that:

said payload (3) is connected to said buoyant member (1) by decoupling means (8) operative to decouple motions of the payload and the buoyant member from one another over a given angular range.

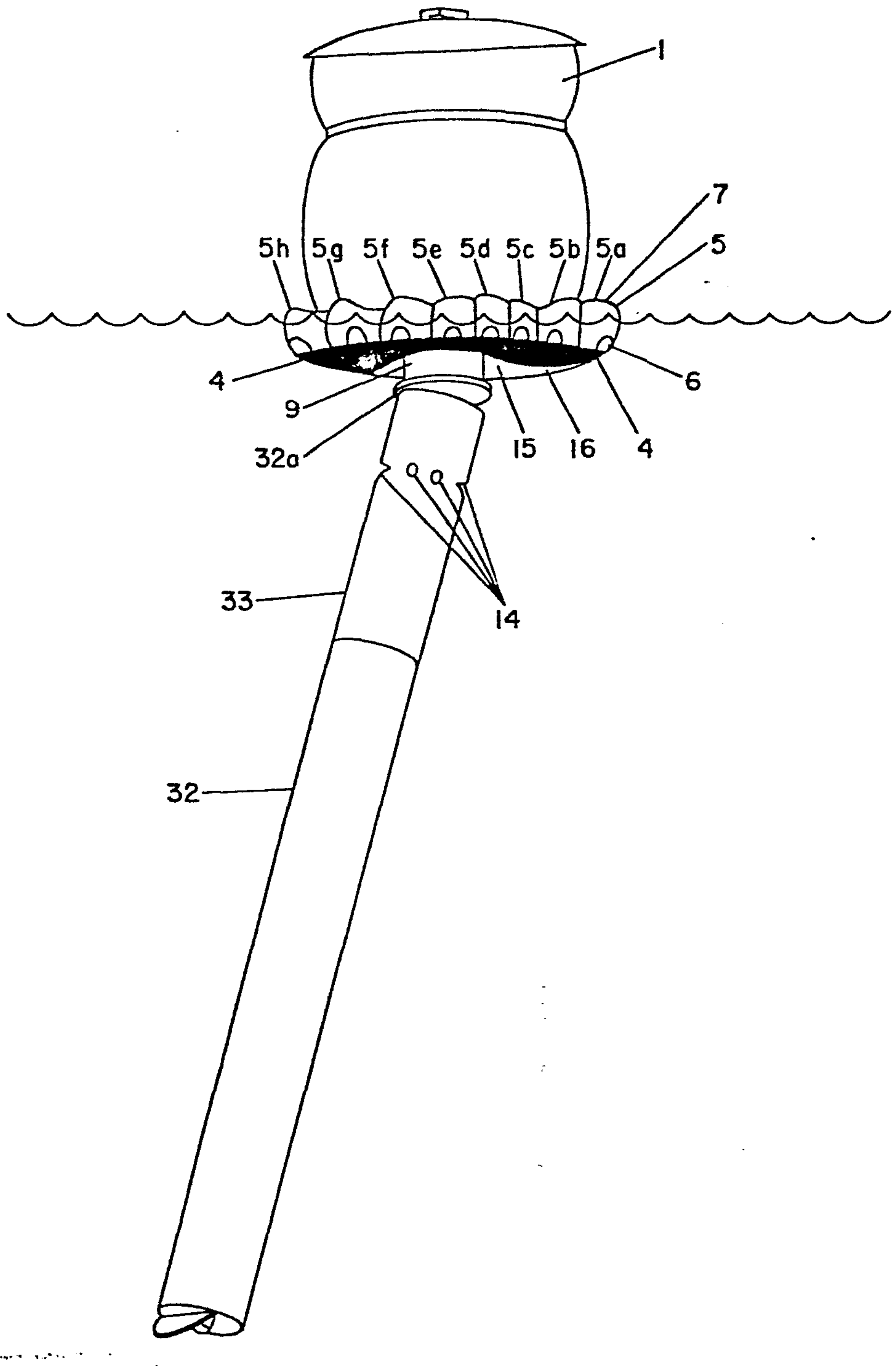
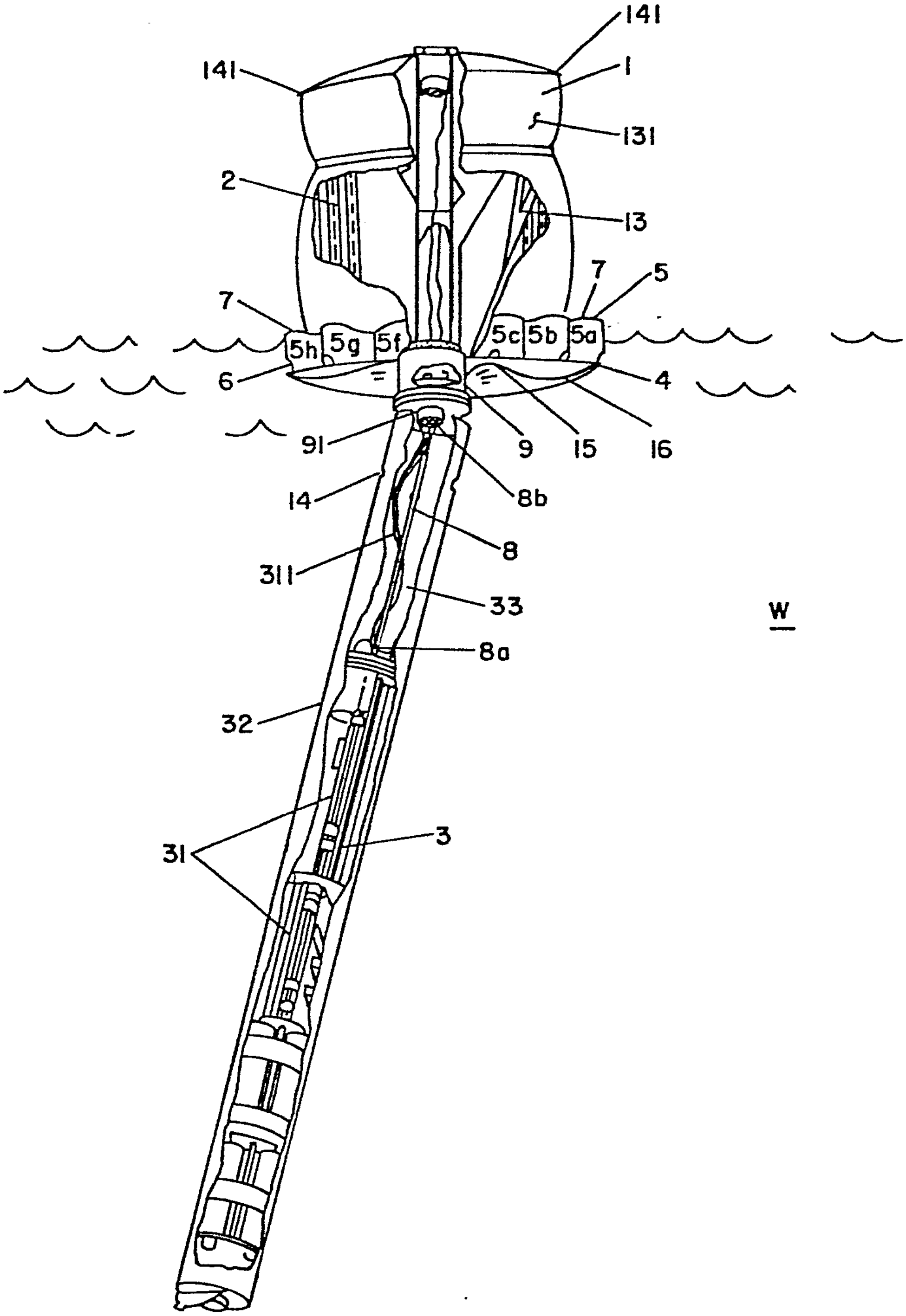


FIG. 1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131
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5h
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5c
5b
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14
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311
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W
8a
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FIG. 2

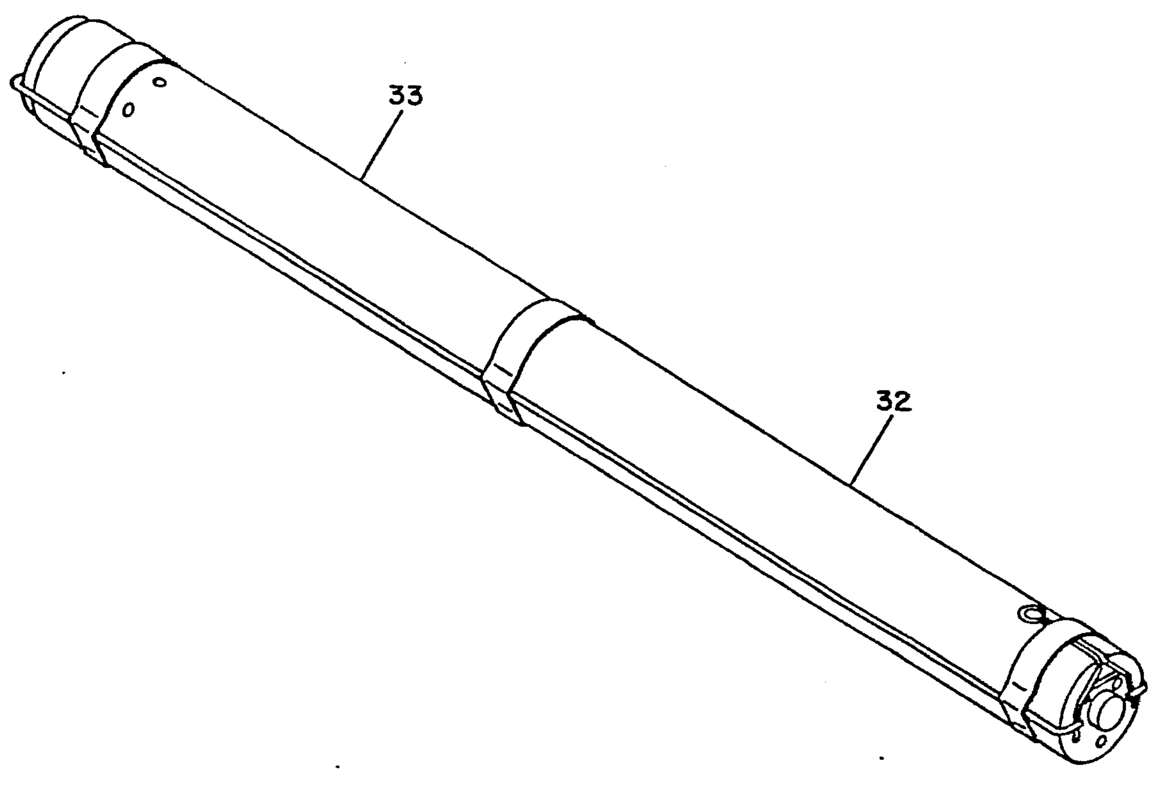

FIG. 3

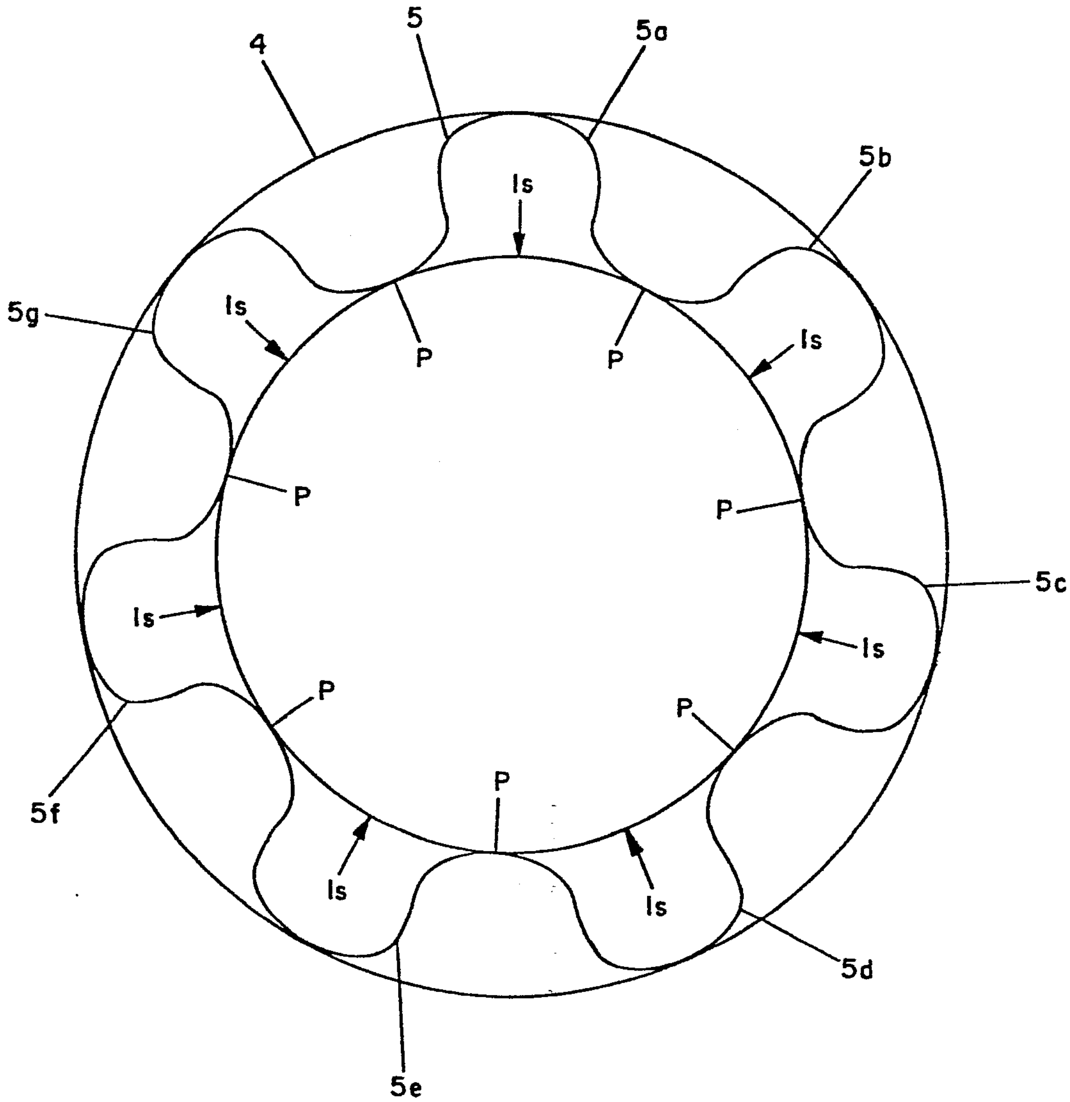

FIG. 4

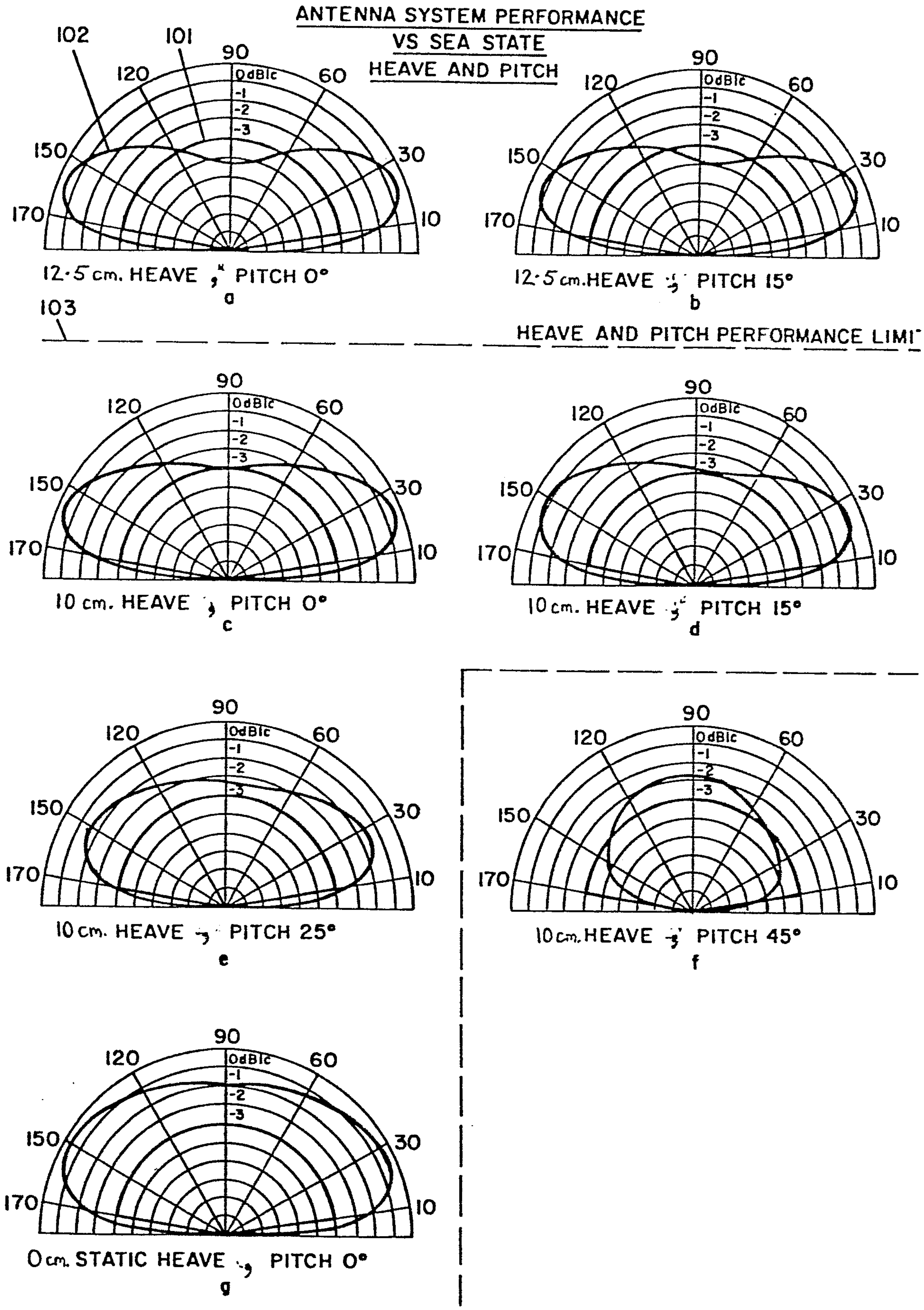
ANTENNA SYSTEM PERFORMANCE
VS SEA STATE
HEAVE AND PITCH
102
101
90
120
60
150
30
170
10
0dBlc
-1
-2
-3
12·5 cm. HEAVE PITCH 0°
a
12·5 cm. HEAVE PITCH 15°
b
103
HEAVE AND PITCH PERFORMANCE LIMI
10 cm. HEAVE PITCH 0°
c
10 cm. HEAVE PITCH 15°
d
10 cm. HEAVE PITCH 25°
e
10 cm. HEAVE PITCH 45°
f
0 cm. STATIC HEAVE PITCH 0°
g

FIG. 5