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J. K. LIU
FLEXIBLE DEEP SEA BUOY

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2 Sheets-Sheet 1

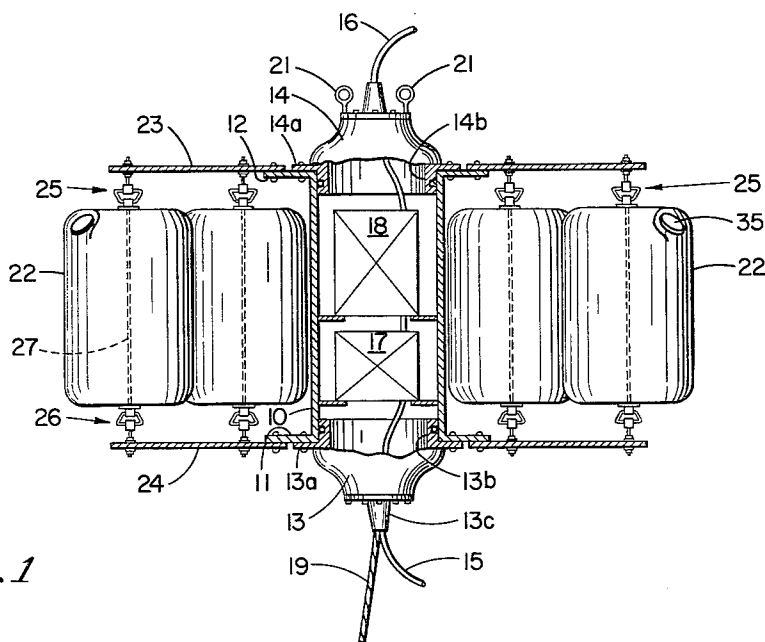


Fig. 1

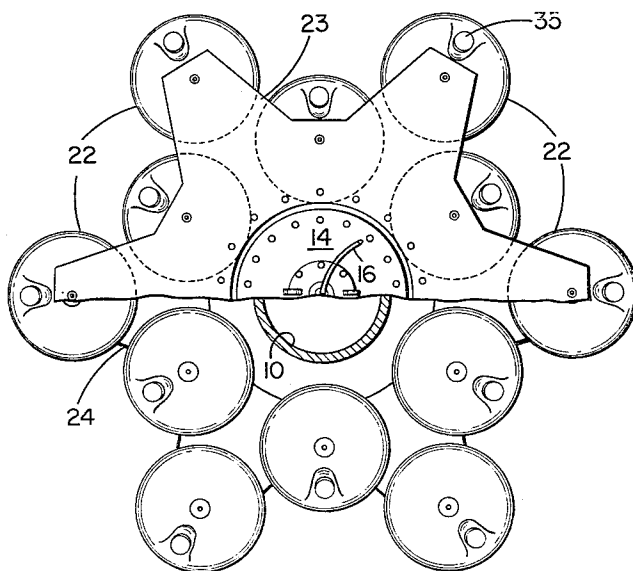


Fig. 2

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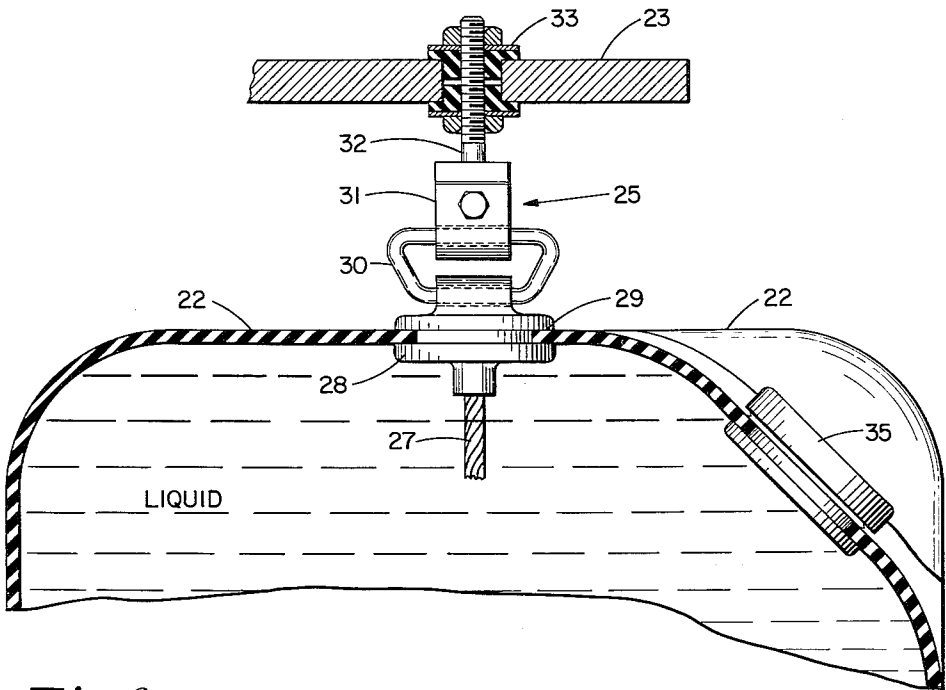


Fig. 3

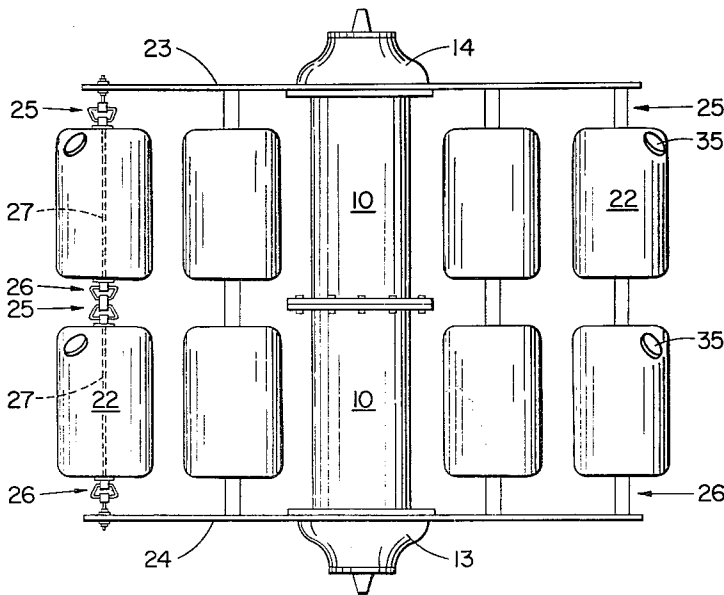


Fig. 4

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FLEXIBLE DEEP SEA BUOY

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3 Claims. (Cl. 9—8)

This invention relates to buoys generally and is directed particularly to buoys adapted for both surface as well as deep-submersion high-pressure operation.

The principal object of this invention is to provide an improved buoy which is seaworthy at the surface and is stable in pitch, roll, yaw, and heave and yet can be easily towed and can be submerged with but light drag on its anchor cable.

A further object of this invention is to provide an improved buoy which is resistant to fresh- or salt-water corrosion and is easily stripped of marine growth.

A still further object of this invention is to provide an improved compartmentalized buoy which is substantially indestructible by collision and will not sink nor fail even though compartments of the buoy may be punctured.

A still further object of this invention is to provide an improved buoy the lift of which may be varied over wide limits without major modifications of basic structure for adaptation to wide ranges of payload. Yet, buoyancy can be finely adjusted over narrow limits.

The objects of this invention are attained by a buoy comprising a balloon-like bag of tough impervious rubber-like material which is filled with a substantially incompressible liquid of lower specific gravity than the water in which the buoy is to be used. Clusters of such liquid-filled bags are grouped around a sealed container housing the electrical or other payload equipment to be carried by the buoy. The total gross lift of the buoy is adjusted by controlling the amount of liquid pumped into the bags and by adding greater or fewer bags to the cluster. Fine adjustments of the lift are made by admitting controlled amounts of water to the interior of the bags.

Other objects and features of this invention will become apparent to those skilled in the art by referring to the specific embodiments described in the following specification and shown in the accompanying drawings, in which:

FIG. 1 is an elevational view, partly sectioned, of the preferred buoy of this invention;

FIG. 2 is a plan view, partly sectioned, of the buoy of FIG. 1;

FIG. 3 is a detailed sectional view of one bag anchoring clamp; and

FIG. 4 is an elevational view of an alternative embodiment of the buoy of this invention.

In FIG. 1, the cargo or payload carrying container of the buoy of this invention is designed to withstand high hydrostatic pressure and comprises the relatively heavy metal cylinder 10 with radial end flanges 11 and 12. The end bells 13 and 14 for closing the ends of the cylinder are convexed outwardly and are each provided with a flat radial flange and with a cylindrical coaxial flange. The radial flanges are shown at 13a and 14a and the cylindrical flanges are shown at 13b and 14b. The matching flanges of the cylinder and the end bells are machined and fitted together for pressure-sealing the cylinder. Centrally in the bulbous portion of one or both of the end bells are insulating bushings for sealing lead-in wires 15 and 16.

A typical use of the buoy of this invention is to carry electronic equipment. In "sonobuoys," a radio transmit-

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ter is provided for radiating a high-frequency signal modulated by signals derived from a sound-to-electrical transducer suspended on a cable below the buoy. In FIG. 1, the electronic equipment shown at 17 and 18 is suitably mounted on and anchored to internal shelves in the cylinder. In the embodiment of FIG. 1, it is contemplated that the lead-in conductor 15 terminates at its lower end in a transducer and enters the pressurized cylinder space through the end bushing 13c containing the insulating bushing mentioned as well as a mechanically strong attachment for the anchor cable 19. At the upper end of the cylinder, the bushing 20 insulatedly receives the lead-in conductor 16, the lead-in conductor being connected to suitable antenna, not shown, but mounted on the buoy. Eye bolts 21 are preferably provided by strong threaded connections to the upper end bell to which lifting cables may be attached for hoisting the buoy into and out of the water. The buoy of FIG. 1 is adapted for either surface or submerged operation.

Lift for the equipment container is provided, in FIG. 1, by a plurality of bags 22 of tough, flexible rubber-like material. The bags in unstressed condition are generally cylindrical in shape. Extending centrally through each bag is the reinforcing stay 27 which is attached to the end walls of the bag and to the load to be carried. The stay-to-bag attachment may comprise bushings 29, one specific embodiment of which is shown in FIG. 3. With the spacing between opposite extremities of the bag positively fixed, the stresses produced in the bag by the buoyancy of liquid in the bag is uniformly distributed throughout the bag and minimizes distortion of the bag. The bags are vertically disposed and are attached at their upper and lower ends, respectively, to platform structures 23 and 24. The platform structures of the specific embodiment shown in FIG. 1 comprises flat, annular plates bolted along their inner periphery to the flanges 11 and 12 of the container. Other platform structures may, of course, be employed. A desirable characteristic of the platforms shown is that they are flexible to a limited extent so that bending force applied to the platforms will not fracture or break the platforms.

According to an important feature of this invention, the bags 22 are attached at their upper and lower ends to the platforms 23 and 24 by link and clamp assemblies 25 and 26. The clamp assemblies at the upper and lower ends of each bag are joined by the metal stay 27 which is strong in tension and may comprise a relatively heavy steel cable. As better shown in FIG. 3, the stay 27 of each bag is embedded in the bushing 28 to which the periphery of the hole in the end of the bag may be sealed liquid-tight at 29. The bushing 28 is coupled through link 30 to the clamp 31. The link 30 is preferably flattened so that the link will rotate a limited amount in both the bushing 28 and in the clamp 31. The clamp 31 is mounted on one end of the threaded bolt 32 which passes through rubber bushings 33. Thus, while the bag-to-platform attachment is strong in tension to support the heavy weights of the liquid-filled bags, the attachment is yieldable in a direction perpendicular to the payload container. Since the bag-to-platform attachment is non-rigid and will yield under forces applied horizontally to the bags, the bag-to-platform attachment shown makes the buoy and the cargo container particularly safe against damage by collision. In one embodiment constructed and tested in fresh water, a moving boat was driven into violent contact with the buoy. The bow of the boat struck first the side of the nearest rubber bag, flexing the side of the bag. The link mechanisms 25 and 26 at the ends of the bags pivoted, but since the links were solidly tied together by the stay 27, the impact force was transmitted to the rubber bushing 33 (FIG. 3) and then to the platforms 23 and 24 and the cargo container. The

buoy was bumped sidewise without damage. The flexible bag with the yieldable linkage to the platform structures cooperates to absorb the shock and protect the payload equipment within the container.

Each bag is filled with a liquid which has a lower specific gravity than the fresh- or salt-water in which the buoy is to operate. Gasoline, kerosene, or debutanized naphtha are examples of such liquids. Where fire hazard may be a factor, it may be preferred to fill the bags with the more inexpensive diesel fuels. Diesel fuel No. 4, for example, has a specific gravity of about .90. The liquid is admitted to each bag through the filler opening 35, with conventional screw-threaded cap, at the top of the bag. It is preferred that all air in the bags be displaced. Since the sides of the bag are flexible, the volume of the bag is easily adapted to the measured quantity of liquid for each bag, without entrapped air. If the bags are not completely filled, the bags will, of course, shrink by wrinkling.

The balloon bag material is preferably of relatively strong, reenforced, natural rubber or plastic material which will not stiffen at ocean water temperatures. The bags of one buoy were made of a synthetic fabric commercially known as "nylon," which fabric was impregnated with a synthetic rubber commercially known as "neoprene." The walls of bags of fifty or more gallons capacity should be at least $\frac{3}{16}$ inch thick.

Considerable latitude is possible with the buoy of this invention in the matter of lift since greater or lesser quantities of fluid can be pumped into the bags, the quantity being easily calculated from its specific gravity to produce a predetermined lift. It is merely necessary to approximately equally divide the fluid among the several bags to level the buoy in the water.

Fine adjustments of lift may be effected by admitting measured quantities of water to some or all of the bags. Thus, each bag can be filled to round out the sides of the bags while at the same time permitting adjustment of the lift of each bag. Since the walls of the bag are flexible, the pressure inside and outside the bag walls are always equal and tensional strains are never placed on the bag walls. Deep sea pressures, up to 10,000 pounds per square inch, may be applied to the buoy of this invention without affecting the bags nor their seals. The buoyancy of the bag remains virtually constant at all depths. Slight differences of compressibility of water and oils can generally be ignored even at such pressures.

According to an important and characteristic feature of this invention, all exposed side walls of the cargo container are covered and are protected against collision damage by the rubber bags. Preferably, the bags are arranged symmetrically in circles about the container 10. In the example shown in FIG. 2, six bags are placed immediately adjacent the container while an additional

six bags are arranged in a circle outside the first circle with the bags staggered radially, as shown. The outer periphery of the platforms are serrated as shown in FIG. 2 to expose all filler caps. Thus constructed, no parts of the platforms protrude beyond the bags and are protected from collision damage.

Size, weight and lift of the buoy of this invention can be adapted for a wide range of payloads. As shown in FIG. 4, two or more cylinders 10 may be bolted end-to-end and the bags correspondingly multiplied in end-to-end arrays. The center of lift may be kept well above the center of gravity, for stability in the water by judicious water loading of the lower bags. The inventory of parts for a large assortment of buoys may thus be limited to a single standardized cylinder, end bell, and bag, thus simplifying assembly repair and maintenance in the field.

What is claimed is:

1. A buoy comprising a tubular cargo container, two spaced parallel platform structures encircling said container, a plurality of rubber-like bags distributed about said container between said platform structures, a stay extending centrally through each bag and flexibly attached at each end to said platforms, said bags being attached at opposite extremities to said stays, said bags containing a liquid of relatively low specific gravity, the quantity of said liquid being sufficient to give a net lift to said buoy equal to or greater than the gross weight of the buoy.

2. An impact-resistant buoy comprising a cargo container, said container being generally cylindrical in shape, two spaced parallel platforms encircling said cylinder and attached to opposite ends of said container, a plurality of bags of generally cylindrical shape and of rubber-like material between said platform structures and spaced about said container to cover the cylindrical wall of said container, bushings in opposite ends of said bags, said bushings having non-rigid attachments to the outer peripheral portions of each of said platform structures.

3. A buoy comprising two spaced platform structures, a plurality of rubber-like bags disposed between said platform structures, each bag being approximately cylindrical in shape, a filling cap in each bag, a support bushing in opposite ends of said bag, a non-rigid clamp structure connected to each bushing, and a rubber bushing intermediate each clamp structure and one of said platform structures for absorbing impact shock imparted to said bags.

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