Dec. 19, 1950 E. L. HUDSPETH ET AL 2,534,716

INFLATABLE RADAR REFLECTOR BUOY

Filed Oct. 8, 1945 2 Sheets-Sheet 1

FIG. 1

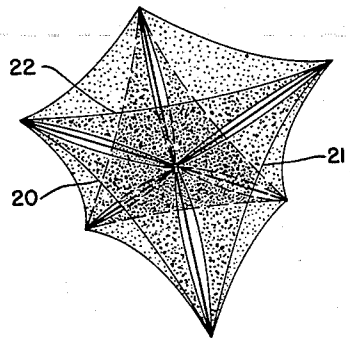

FIG. 2

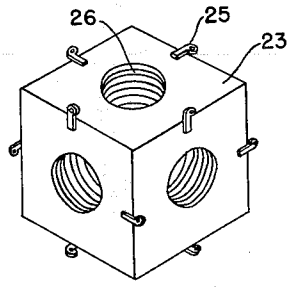

FIG. 3

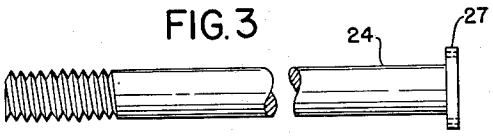

FIG. 4

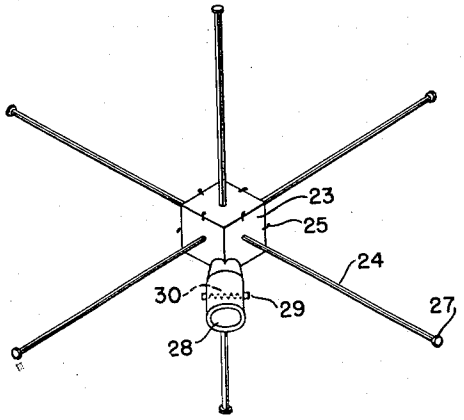

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FIG.5

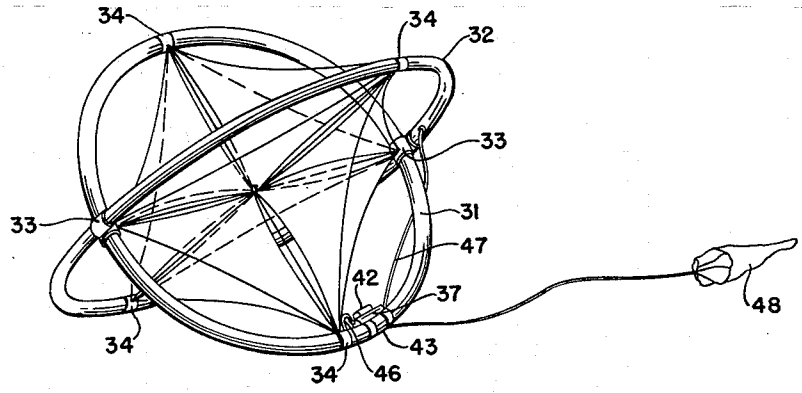


FIG.6

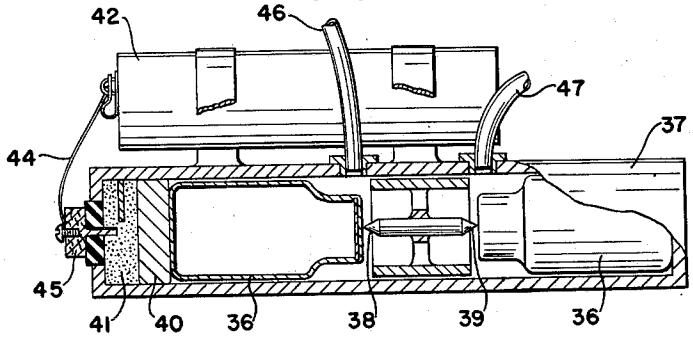
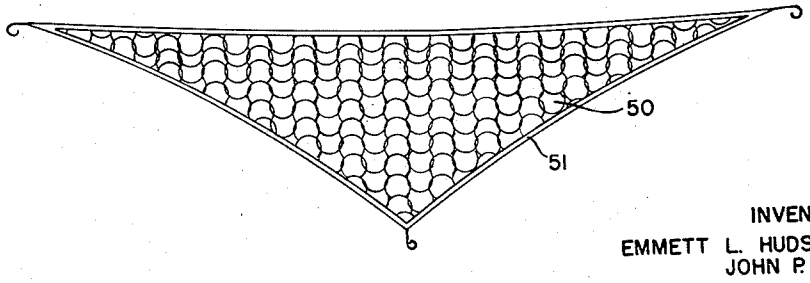


FIG.7



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INFLATABLE RADAR REFLECTOR BUOY

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13 Claims. (Cl. 9—8)

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This invention relates to a device for marking an object or location in order it may more readily be found by persons seeking such object or location. More specifically, the invention relates to a reflector adapted to reflect radio microwaves emanating from a suitable source irrespective of the lateral or vertical position of the source with respect to the reflector, within the operative range of the device.

In general, this invention relates to a reflector comprising a group of corner reflectors or trihedral reflecting units so assembled as to provide as large a coverage as possible consistent with rigid construction and compact size. A corner reflector is a device for returning transmitted radio microwaves to the receiver of a radio echo detection set, and consists of three mutually perpendicular intersecting electrically conductive vanes. A complete reflector as contemplated by this invention consists in one embodiment of twelve reflecting vanes so positioned relative to each other as to form a cluster of eight trihedral reflecting units, while a second embodiment consists of eleven vanes forming a cluster of six trihedral reflecting units. Various shapes of reflecting vanes may be used, the preferred shape being that of an isoceles triangle.

An object of this invention is to provide a novel, compact, lightweight collapsible reflector which may be erected by a person in distress and which when erected presents a group of trihedral reflecting units specially adapted to reflect radio microwaves to the source from which they emanate.

A further object of this invention is to provide a reflector of the class described having reflecting surfaces formed in a novel manner and of a novel material causing the reflecting surfaces to have electrical characteristics peculiarly advantageous to the reflection of radio microwaves.

A still further object of this invention is to provide a reflector of the class described in which the reflecting surfaces are so oriented as to cause reflection of radio microwaves irrespective of the lateral or vertical orientation of the source of said microwaves with respect to the reflector, within the range of the device.

Another object of the invention is to provide a collapsible reflector fabric for reflecting electromagnetic radiation within a band of frequencies commonly used in connection with radio echo detection sets.

Still another object of this invention is to provide a reflector of the class described which may

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be dropped into the sea and which is adapted to be self-positioning and self-erecting upon partial submergence therein.

Another object of the invention is to provide a maritime buoy using the principles of corner reflection for use as a marking device.

A particular object of this invention is to provide a collapsible maritime buoy consisting of trihedral reflecting units having pneumatically expansible floats secured to the outer extremeties thereof, and provided with means automatically operable upon partial submergence for causing inflation of said floats.

Further objects and advantages of this invention, as well as its construction, arrangement, and operation, will be apparent from the following description and claims in connection with the accompanying drawings, in which;

Fig. 1 is a perspective view of one embodiment of the invention fully erected;

Fig. 2 is a perspective view of the supporting base of Fig. 1 adapted to retain supporting arms in mutually perpendicular orientation;

Fig. 3 is a side view of one of six similar arms used in connection with the supporting base shown in Fig. 2;

Fig. 4 is a perspective view of a modified supporting base adapted to be removably attached to a suitable mast;

Fig. 5 is a perspective view of a preferred collapsible form of the invention in a fully erected position, this form of the invention being adapted to be self-erecting and self-positioning upon partial submergence in sea water;

Fig. 6 is a detail view of inflation mechanism for causing the floats to automatically inflate upon submergence in sea water; and

Fig. 7 is a side view of one of the reflecting surfaces illustrating the arrangement of knitting and supporting tape on the triangular edges thereof.

Referring to Figs. 1 through 3, there is shown one form of the invention comprising a group of associated trihedral reflecting units which may be referred to as corner reflector units, each unit being composed of three mutually perpendicular similar triangular reflecting surfaces 20, 21, 22, having their inner apices symmetrically disposed with respect to a common supporting base on hub 23. A plurality of similar arms 24 of equal length are used to suspend the reflecting vanes, said arms extending along three orthogonal axes. Suitable eyes 25 and 27 respectively are provided at the center of each edge of base 23 and on the outer extremities of

the arms 24 in order to suspend the reflecting surfaces.

Figs. 2 and 3 illustrate hub 23 and one of six similar detachable arms 24, used in connection with Fig. 1 to position the reflecting surfaces in such orientation as to present a group of eight trihedral units in which each unit is provided with three mutually perpendicular reflecting surfaces. All of the units and supporting arms are symmetrically disposed with respect to common hub 23. As shown in Fig. 2 the supporting base or hub 23 is in the form of a cube having a threaded socket 26 formed in the center of each face thereof to receive one of the supporting arms 24. As previously stated, an eye 25 is fixed in the center of each edge of cube 23 in order to secure the inner apices of the triangular reflecting surfaces thereto. Support arms 24 are likewise provided with an eye 27 at the outer extremity thereof so that the outer apices of the reflecting surfaces may be removably attached thereto. It will readily be understood that hub 23, being in the form of a cube, will retain arms 24 in mutually perpendicular planes and that the reflecting surfaces 20, 21, and 22 being attached to the outer ends of rods 24 and to the center of the edge of the cube, will lie in planes at right angles to one another. In this manner there is provided a reflector the frame of which consists of a plurality of rigid members assembled to provide a multiplicity of outwardly projecting arms of equal length, the outer ends of which are equidistant from a common center and equally spaced from each other in triangular relation. When reflection surfaces are mounted on the frame within the respective spaces defined by the rigid arms, there is provided a reflector consisting of a plurality of trihedral units, the surfaces of which are oriented at ninety degrees to one another. It will readily be understood that when the reflector as disclosed in this embodiment thereof is assembled and placed on a surface such as, for example, the deck of a life raft, the outer ends of the arms will form a three-point or triangular support for the reflector irrespective of the rotative position of the reflector about its common center.

Fig. 4 illustrates a modified form of the invention wherein the reflector is adapted to be removably attached to a mast such as the hollow oar commonly used in connection with life rafts. As shown, hub 23 is formed having a supporting cylinder 28 cast integral therewith, said cylinder being adapted to slidably fit in a hollow mast and having retaining means in the form of a pair of pegs 29 slidable transverse to the axis of cylinder 28 and yieldably held in an extended position by means of a spring 30. This embodiment of the invention requires eleven reflecting vanes and presents a cluster of six trihedral reflecting units.

In order to provide a collapsible frame construction which may be folded into a compact package and which is self-erecting and self-positioning, there is shown in Fig. 5 a modified form of the invention having a pair of collapsible pneumatically inflatable supporting members 31 and 32 to which the outer apices of the reflecting surfaces are secured. As shown, the supporting members 31 and 32 comprise a pair of inflatable toroids which may be either circular or elliptical, the former form being preferred. Toroids 31 and 32 may be secured to each other as by means of a pair of straps 33, said straps being adapted to cause the toroids to lie in mutually perpendicular planes upon inflation. A plurality of similar eyes 34 are mounted on each toroid at intervals of ninety degrees in order that the outer apices of the reflecting vanes may be secured thereto. In this embodiment of the invention the inner apices of the reflecting surfaces are secured to each other at substantially a common point, and since the outer extremities are fastened to the floats at intervals of ninety degrees from each other, there is provided a self-positioning, self-erecting reflector having a symmetrical group of similar adjoining trihedral units presenting reflecting surfaces with their inner and outer apices symmetrically positioned with respect to a common center. A sea anchor 48 may be supplied to cause the buoy to remain in substantially the locality in which it is dropped.

Electrical means operable when submersed in water is provided to cause toroids 31 and 32 to become inflated thereby providing a floating support for the trihedral reflectors. As shown in Fig. 6, suitable means are provided for releasing fluid under pressure to inflate the toroid floats. One or more capsules 36 of standard manufacture containing gaseous fluid such as carbon dioxide under pressure are mounted in a container 37. These capsules are of a well-known construction and are provided with a closure adapted to be punctured by a needle 38 or double needles 38 and 39 placed adjacent the closures between the capsules. A piston 40 is slidably mounted in container 37 and a charge of explosive mixture 41 such as gunpowder is placed beneath the piston. An electric battery 42, together with casing 37 is mounted on one of the floats 31 as by means of a strap 43. An electrically conducting lead 44 extends from battery 42 to an insulating terminal 45 which has the property of becoming electrically conductive upon submersion in water. When, therefore, toroid 31 is partially submersed in water, an electric spark causes explosion of mixture 41 thereby forcing piston 40 upwardly, driving capsule 36 against needle 38 and releasing the compressed gas therefrom. Suitable hose connections 46 and 47 are provided to conduct the released gas from container 37 to floats 31 and 32. It will readily be understood that the floats are self-erecting, and also self-positioning on the surface of the water. The reflecting surfaces, being secured to each other at their inner extremities and at their outer extremities to the toroids, will likewise be self-erecting upon inflation of said toroids.

Fig. 7 illustrates an electrically conductive mesh reflecting surface 50, having characteristics making it specially suitable for reflecting radio micro-waves of the type used in connection with radio echo detection systems. Such a surface must be capable of effectively reflecting a beam of electromagnetic radiation of any polarization and frequency in the band of frequencies which is employed in connection with such systems. In addition, the collapsible reflector as contemplated by this invention requires a reflecting surface that can be folded into a small compact volume, has small wind drag, and one which exhibits sufficient resiliency so that a sheet or screen of this material, supported at only a few points about its periphery, will lie in a flat plane. Woven fabric of electrically conductive material has been found to be unsatisfactory for the reason that the weave would not hold a uniform mesh spacing, and it is not possible to make this material lie in a flat plane without stretching it carefully over a rigid framework. Knitted fab-

rics, it was discovered, when stretched at only a few points, will tend to lie in a flat plane and under tension throughout. This arises from the fact that a knitted material is made up of only a single strand. It will be readily understood that a knitted fabric, being under tension throughout the knit, will provide adequate surface contact between adjoining loops of the knit to cause the entire fabric to become electrically conductive.

Various electrically conductive materials may be used to form the reflecting surface such as copper, brass, and stainless steel, although these materials are not as satisfactory as materials such as silver-plated copper wire and Monel metal. A cotton thread wrapped with a silver-plated copper spiral has also proven satisfactory. Of all these materials Monel metal is preferred due to its characteristic resistance to corrosion and consequent ability to retain a high electrical surface conductivity under adverse conditions. Materials such as brass and copper wire are generally not as satisfactory as Monel metal or silver-plated copper wire due to the rapid oxidation of the copper and brass which results in a relatively low surface conductivity of the metal. However, these materials may be satisfactorily used when coated with a protective coating such as oil to prevent such oxidation. The contact between the knitted loops is sufficient to displace the oil or other substance at such points, exposing clear surfaces of metal to one another, yet the remaining surface is protected against corrosion and oxidation by the protective coating. A high electrical surface conductivity of the wire in the mesh is desired in order that the reflectivity of the reflector be independent of the polarization of the incident beam of electromagnetic radiation.

In order to provide a minimum of wind drag it is desirable that the spacing between the loops of the knitted fabric be as large as possible. However, the knitted fabric, being used to reflect electromagnetic radiation within a band of frequencies, must contain a sufficient number of loops per inch to reflect properly the highest frequency electromagnetic radiation that will be used in conjunction with it. It has been discovered that the spacing between the knitted loops cannot be much greater than one-sixth of a wave length of the shortest wave radiation which will be used in conjunction with the knitted fabric. Therefore, the spacing between the knitted loops cannot be much greater than substantially one-sixth of the wave length of the highest frequency radiation included in the band of frequencies to be used in conjunction with the reflector.

As shown in Fig. 7 an inelastic or elastic binder 51 such as ordinary tape of common manufacture is placed around the edges of the knitted screen to prevent "running" at the edges. These tapes are placed around the triangular edges in circular arcs and stitched to the screens. This method of laying the tape causes the knitted fabric to lie in a flat plane and assures adequate electrical contact between the loops when the fabric is placed under tension at its three apices.

While various modifications of the invention have been illustrated and described it is to be understood that other modifications and changes may be made in the invention without departing from the spirit and scope thereof as set forth in the appended claims.

What is claimed is:

1. A self-positioning maritime buoy comprising a group of similar triangular reflecting surfaces connected together to form corner reflecting units with their inner apices symmetrically positioned with respect to a common center, a pair of inflatable toroids, securing means on said toroids for fastening the outer apices of said reflecting surfaces, and means operable upon partial submergence of the reflector to inflate said toroids.

2. A reflector comprising an inflatable frame, a plurality of pliant triangular reflecting surfaces having their inner apices fastened together at a common point, a plurality of fasteners symmetrically positioned on said frame for securing the outer apices of said surfaces thereto, said fasteners being so disposed as to cause said surfaces to present symmetrically disposed trihedral reflecting units having mutually perpendicular planar surfaces upon inflation of said frame, and means operable upon partial submergence of said frame to automatically inflate said frame.

3. A reflector comprising an inflatable frame, a plurality of pliant triangular reflecting surfaces having their inner apices fastened together at a common point, means securing the outer apices of said surfaces to symmetrically disposed points on said frame, said securing means being so disposed as to cause said surfaces to present symmetrically disposed trihedral reflecting units having mutually perpendicular planar surfaces upon inflation of said frame.

4. A maritime reflecting buoy comprising a pair of inflatable toroids, means joining said two toroids and maintaining said toroids in mutually perpendicular planes, a reflecting unit disposed within the space defined by said toroids, securing means fastening said reflecting unit to said toroids, and means for inflating said toroids.

5. A reflector comprising an inflatable frame, a plurality of pliant reflecting surfaces fastened together so as to form a plurality of corner reflector units when extended, means securing points on said reflecting surfaces to said frame, said securing means being so disposed on said frame as to maintain said surfaces in an extended position in mutually perpendicular planes within said frame upon inflation of said frame.

6. A reflector comprising an inflatable frame, a plurality of pliant triangular reflecting surfaces fastened together with their inner apices substantially at a common point so as to form a plurality of corner reflector units when extended, means securing selected points on said triangular reflecting surfaces to selected points on said frame, said securing means being so disposed on said frame as to cause said surfaces to present symmetrically disposed trihedral reflecting units having mutually perpendicular planar surfaces upon inflation of said frame, a source of gaseous fluid under pressure, means for conducting said fluid under pressure to said inflatable frame, and means operable upon submergence of said reflector in a liquid to cause said fluid under pressure to be supplied from said source to said frame.

7. A reflector comprising a plurality of inflatable toroids, means maintaining each of said toroids in a fixed position with respect to the other said toroids, a plurality of collapsible reflecting surfaces fastened together so as to form a plurality of corner reflecting units when extended, means securing points on said reflecting surfaces to said toroids, said securing means being so disposed as to maintain said surfaces in

an extended position in mutually perpendicular planes upon inflation of said toroids.

8. A reflector comprising a pair of inflatable toroids, means maintaining said toroids in a fixed angular position with a common diameter, a plurality of reflecting surfaces fastened together so as to form a plurality of corner reflecting units when extended, means securing points on said reflecting surfaces to said toroids, said securing means being disposed so as to maintain said surfaces in an extended position in mutually perpendicular planes upon inflation of said toroids.

9. A self-positioning buoy comprising a group of similar triangular reflecting surfaces connected together to form corner reflecting units with their inner apices symmetrically positioned with respect to a common center, a pair of inflatable toroids, means joining said toroids and maintaining said toroids in mutually perpendicular planes, said planes intersecting along a common diameter of said two toroids, and securing means on said toroids for fastening the outer apices of said reflecting surfaces.

10. A reflector comprising a pair of inflatable toroids, means maintaining said toroids in a fixed angular position with a common diameter, a reflecting unit disposed within the space defined by said toroids, and securing means fastening said reflecting unit to said toroids.

11. A reflector comprising a plurality of inflatable toroids, means maintaining each of said toroids, in a fixed position with respect to the other said toroids, a plurality of collapsible triangular reflecting surfaces fastened together with their inner apices substantially at a common point, means securing the outer apices of said surfaces to selected points on said toroids, said securing means being so disposed as to cause said surfaces to present symmetrically disposed trihedral reflecting units having mutually perpendicular planar surfaces upon inflation of said frame.

12. A reflector adapted to float on the surface of a liquid comprising, an inflatable frame, a plurality of pliant reflecting surfaces, means securing said reflecting surfaces to a plurality of points on said frame, means securing each of said

reflecting surfaces to the other of said reflecting surfaces, and means for inflating said frame whereby said reflecting surfaces form a plurality of differently oriented reflecting units having planar surfaces upon inflation of said frame, the volumetric displacement of said frame being sufficient to support said reflecting surfaces above the surface of said liquid.

13. A reflector comprising a pair of inflatable toroids, means joining said toroids and maintaining said toroids in mutually perpendicular planes, said planes intersecting along a common diameter of said two toroids, a plurality of pliant triangular reflecting surfaces fastened together with their inner apices substantially at a common point, means securing the outer apices of said surfaces to symmetrically disposed points on said toroids, said securing means being so disposed as to cause said surfaces to present symmetrically disposed trihedral reflecting units having mutually perpendicular planar surfaces upon inflation of said toroids.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
770,626	Bell	Sept. 20, 1904
1,301,515	Smith	Apr. 22, 1919
1,635,915	White	July 12, 1927
2,151,336	Scharlau	Mar. 21, 1939
2,430,568	Hershberger	Nov. 11, 1947
2,450,417	Bossi	Oct. 5, 1948

FOREIGN PATENTS

Number	Country	Date
14,957	Great Britain	Aug. 4, 1894
25,355	Great Britain	Nov. 5, 1912
402,834	Great Britain	Dec. 14, 1933
439,608	Great Britain	Dec. 10, 1935
377,636	Germany	June 23, 1923
446,227	France	July 18, 1912