Dec. 26, 1961 PER-MAGNUS L. PETRI 3,015,095

COLLAPSIBLE RADAR TARGET

Filed Oct. 24, 1960

FIG. 1

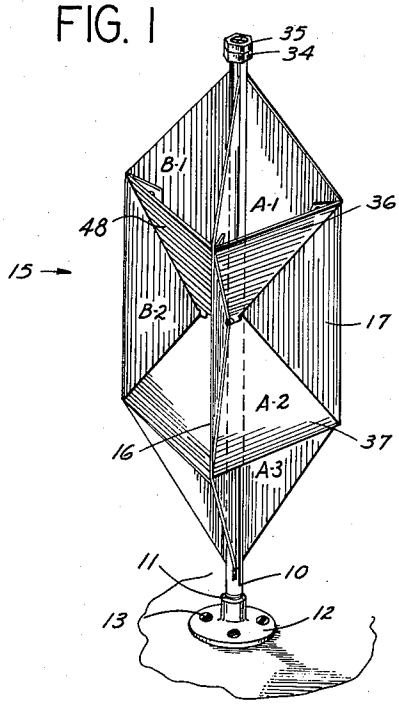


FIG. 2

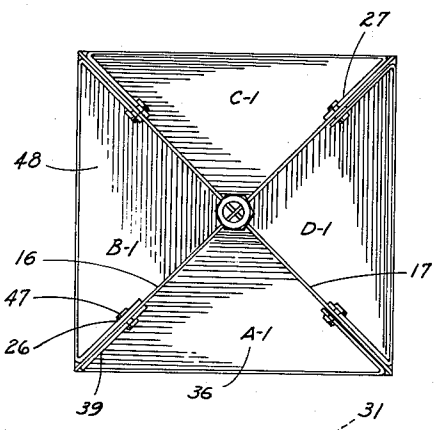


FIG. 3

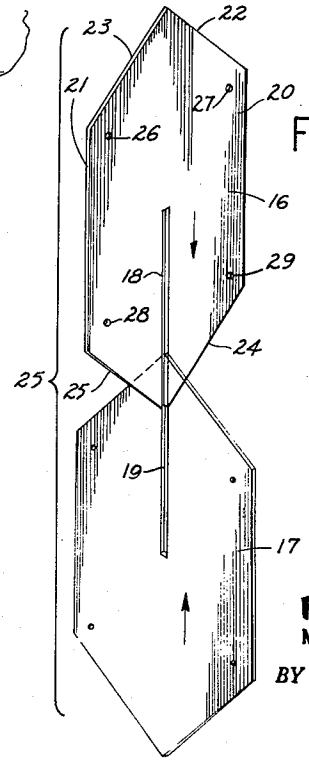


FIG. 4

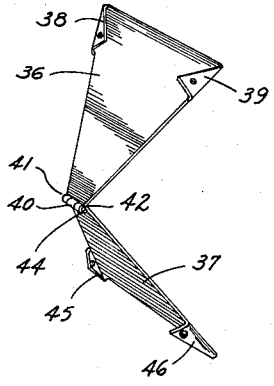
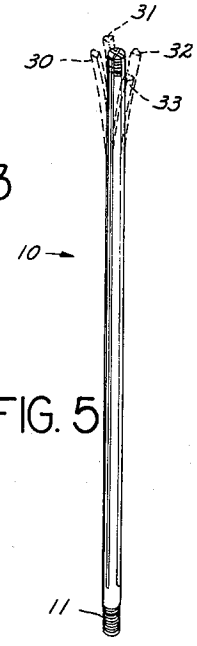


FIG. 5



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COLLAPSIBLE RADAR TARGET

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This invention relates to a collapsible energy reflector particularly intended for use as a target for radar equipment. More particularly, this invention relates to a collapsible target which is provided in its extended assembled position with an augmented reflective area so as to provide maximum ease of detection by radar equipment.

Collapsible and reflective radar target structures have in the past been used for sea, air, and land operations in order to provide a target which can be easily carried and which can be mounted in assembled operative position when needed in order to return a radar signal of higher gain than can be obtained from the object on which the target is mounted. For example, small fishing boats commonly carry such a target on board so that in foggy or inclement weather when danger of collision with larger ships exists, the target can be mounted on the mast or other portions of the boat so that the boat can be more readily detected by the navigational radars of larger ships. Such targets have a higher reflectivity than the boat itself. They can, therefore, be detected by any given radar set with greater certainty and at a greater distance than can the boat itself.

It is desirable that such a target be easily collapsible into a flat package to occupy a minimum space when not in use and that it be easily assembled into its extended or operative position. It is also desirable that when so extended the target should provide a maximum reflective surface area consistent with the compact storage and easy assembly requirements.

It is, therefore, an object of this invention to provide a collapsible radar target affording the above noted desirable features.

It is another object of this invention to provide a collapsible radar target which can be easily assembled and disassembled and readily mounted on the mast of a vessel.

It is yet another object of this invention to provide such a target affording a maximum area of reflective surfaces particularly oriented to receive and reflect radar beams making an angle of 45° or less above or below the horizontal plane so that when the target is mounted on a boat it will enhance the detection efficiency of the navigational radars of other ships to thereby preclude collision.

Other objects, features, and advantages of the present invention will be more fully apparent to those skilled in the art from the following detailed description taken in connection with the accompanying drawings in which like reference characters refer to like parts throughout and wherein:

FIGURE 1 is a perspective view of the target in assembled and extended operative position and mounted in its standard.

FIGURE 2 is a top plan view of the reflector shown in FIGURE 1.

FIGURE 3 is an exploded perspective view of two interlocking vertically disposed reflector members.

FIGURE 4 is a perspective view of one pair of hingedly connected obliquely disposed reflector members.

FIGURE 5 is a perspective view of a split central supporting rod upon which the target structure is mounted.

The collapsible reflector structure shown in the drawing is preferably made entirely from aluminum or a similar lightweight easily worked corrosion resistant material

having good reflective properties for electro-magnetic radiation of the microwave frequencies commonly used in radar systems.

The reflector comprises a central mast forming rod 10 having a solid threaded lower end 11 which is adapted to be received in a threaded aperture in a standard 12. The base member of standard 12 is secured by screws 13 to the top of the mast of a vessel or to any other surface on which it is desired to detachably mount the reflector. In use, the standard 12 is permanently left in the position in which it is secured by the screw 13 whereas the threaded end 11 of rod 10 can be readily screwed into or out of the threaded aperture in the standard in order to mount or dismount the reflector.

The reflector target 15 comprises first and second vertically disposed reflector plates 16 and 17 which, as can best be seen in FIGURE 3, are each provided with central longitudinally extending slots 18 and 19, respectively, so disposed that in assembling the reflector the plates 16 and 17 may be telescoped over each other with the planes of their surfaces intersecting perpendicularly.

Each of the members 16 and 17 is a six-sided polygon formed by a central square portion from the two opposed ends of which 45° isosceles triangles extend. That is to say, referring for example to the member 16 as shown in FIGURE 3, the edges 20 and 21 thereof each have a length equal to $2a$ (where a can be any basic unit of measure). The two edges 20 and 21 are parallel to each other and are spaced apart by a distance also equal to $2a$. The edges 22 and 23 make angles with the edges 20 and 21, respectively, each of which is equal to 135° so that the edges 22 and 23 make a right angle or 90° angle with each other. The edges 22 and 23 are, therefore, necessarily each equal in length to a $\sqrt{2}$. Similarly, the edges 24 and 25 continuing outwardly from the bottom ends of the edges 20 and 21 also meet in a right angle and are also each equal in length to a $\sqrt{2}$.

The slot 18 has a width slightly greater than the thickness of the material from which the reflector sheets 16 and 17 are fabricated and extends from the point of intersection of edges 24 and 25 upwardly to the midpoint of the square central section between the edges 20 and 21. The central square section is also provided with apertures 26, 27, 28, and 29 near the corners thereof and extending through the sheet. These apertures serve a purpose which will be described in detail below.

The reflector sheet or member 17 is identical with the member 16. It will be noted that in FIGURE 3 the two members are shown in opposed symmetrical relationship inasmuch as the plate 17 has been turned 180° longitudinally with respect to the plate 16 and has also been rotated 90° with respect thereto so that the slots 18 in plate 16 and 19 in plate 17 are positioned in interfitted telescoping relationship.

This relationship shown in FIGURE 3 illustrates the first step in assembling the reflector target from the flat storage position in which its parts are normally carried. As will be noted, when the plate 17 is positioned as shown in FIGURE 3 the plate 16 may be turned at right angles thereto and the slot 18 will then slide down over the slot 19 and will continue on downwardly until the two plates are in completely overlapped telescoping relationship as shown in FIGURE 1. That is to say, the slot 18 accommodates the lower solid portion of the plate 17 and the slot 19 accommodates the upper solid portion of the plate 16 to fixedly position the two plates in perpendicular relationship to each other.

The next step in assembling the reflector is to place the cross plates 16 and 17 inside the four segments 30, 31, 32, and 33 of the central rod 10. It will be noted that the rod 10 is slightly longer than the longitudinal central dimensions of the plates 16 and 17 and that this

rod is divided axially and longitudinally into four segments extending longitudinally away from a unitary end portion of the rod. These segments are preferably formed by two saw or milling cuts at right angles to each other, each cut having a thickness approximately equal to the thickness of the stock from which the reflector plates 16 and 17 are stamped. When the plates 16 and 17 have been fitted together in perpendicularly crossed relationship they may readily be slid down into the slots in the rod 10 by starting the bottom of the crossed plate assembly at the top of the split rod 10 and passing it on downwardly until it assumes the position shown in FIGURE 1.

It will be noted that the upper ends of the segments 30, 31, 32, and 33 of the rod 10 are exteriorly threaded. After the assembled reflector plates 16 and 17 have been inserted in the split rod, a pair of nuts 34 and 35 are screwed on to the top of the rod to lock the four segments together and form a mounting means for the crossed reflector plates 16 and 17.

The four quadrants formed by the crossed reflector plates 16 and 17 are each divided into three reflector horns by a pair of hingedly connected triangular plate members such as the members 36 and 37 shown in FIGURE 4. The twelve reflector horn cavities thus formed are indicated insofar as they can be seen on the drawings by a numbering system in which the characters A, B, C, and D respectively are used to indicate the four quadrants and the associated numbers 1, 2, and 3 are used to indicate the three horns of each quadrant in descending order from top to bottom. Thus, as may be seen in FIGURE 1 the upper horn in quadrant A is horn A1, the central horn in quadrant A is the horn A2, whereas the lower horn in quadrant A is the horn A3. On the other hand, the upper and central horns in the quadrant B are indicated as horns B1 and B2 respectively. Each of the twelve horns is shaped to expand outwardly from a central point at the middle of the reflector structure and to provide a plurality of surfaces for internal reflection and reradiation of microwave energy striking the target.

The plates 36 and 37 shown in FIGURE 4 are preferably initially stamped as separate members each being in its basic outline an equilateral triangle having 60° angles at each corner and each having each of its sides of a length equal to $a\sqrt{2}$ (where a is the above noted basic unit of length). Superimposed on this basic triangular configuration are a pair of oppositely disposed ear members such as the members 38 and 39 on the top corners of the plate 36 and a hinge forming loop 40 on the bottom of plate 36. Plate 37 is provided with a pair of hinge forming members 41 and 42 adapted to coact with member 40 to be seated completely around a pin 44 passing therethrough to hinge the two members 36 and 37 together. The plate 37 is also provided at its two opposite ends with ear members 45 and 46. Each of the ear members 38, 39, 45, and 46 are folded back from the major surfaces of the plates 36 and 37 so that when these plates are positioned between the main vertically disposed reflectors 16 and 17 the ear members will be flat against the surfaces of these major plates. As will be noted in FIGURE 1, the plates 36 and 37 are positioned in obliquely disposed relationship so that the angle between their own major surfaces formed at the hinge between them is a 90° angle whereas the angles formed by the planes of the surfaces 36 and 37 with the vertical direction as represented by the upright rod 10 are each 45°.

As may be seen in FIGURES 1 and 2 the obliquely disposed triangular reflector plate 36 is positioned between the vertically disposed main reflector plates 16 and 17 in quadrant A thereof to define with these plates the boundaries of the horn A1 and the upper boundary of the horn A2. The lower reflector plate 37, of course, which is hingedly connected to plate 36 forms the lower boundary of horn A2 and the upper boundary of horn A3. The mounting of the triangular obliquely disposed plates such as the plates 36, 37 is accomplished by positioning the apertured ears of these plates against the coaligned apertures of the main reflector plates 16 and 17 and passing a pin therethrough, the entire assembly then being held in position by the compression of the ears against the reflector plates 16 and 17. Thus, it will be seen that the ear 39 on plate 36 is positioned so that the aperture therein is coaligned with the aperture 26 in plate 16 and that the pin 47 passes through the ear 39, the plate 16, and the ear of the corresponding triangular reflector 48 in quadrant B. A similar coaligned aperture and pin mounting arrangement is provided for each of the corners of each of the obliquely disposed and hingedly connected triangular reflector plates. When these plates have all been mounted between the main reflector plates the reflector target assembly is completed on the rod 10 and the unitary threaded bottom portion 11 of rod 10 is then screwed into the threaded aperture in the standard 12. The reflector target has then been assembled and placed in operative position.

When it is desired to disassemble and store the target, it is only necessary to unscrew the rod 10 from the standard 12, to remove each of the pins such as the pin 47 to thereby remove the hingedly connected obliquely disposed triangular reflector plates, to then unscrew the nuts 34 and 35 so that the crossed main reflector plates may be removed from the split rod 10, and to then slide the crossed reflector plates 16 and 17 off of each other. All of the parts may then be stored flat in a compact container.

In its assembled relationship it will be noted that the main horns A2, B2, C2, and D2, that is, the central horn in each of the four quadrants are four-sided reflector horns having opposed pairs of surfaces forming 90° angles with each other respectively and having a radial axis of symmetry which extends horizontally where the axis of the rod 10 is assumed to represent the vertical direction. Furthermore, these horizontally extending axes of symmetry of each of the four main reflector horns intersect each other at right angles at the central point of the rod 10. Thus, from whatever direction a large ship bearing a navigational radar may be approaching a smaller vessel on which the reflector target is mounted, at least one of the main reflector horns will provide direct reradiation for the radar beam. Of course, if the ship is approaching from a direction lying in the plane of either of the main reflectors 16 or 17, then its radar beam will strike the other main reflector at right angles and will be directly reflected back as desired. For other intermediate angles reflection back to the source in a line parallel to that of the transmission depends upon internal reflections within the horn and reradiation therefrom. The larger reflective surface areas for a target of given overall dimensions which is achieved by the present construction by comparison with previously known constructions in practice affords in either event a greater efficiency than has hitherto been obtainable.

While a particular exemplary preferred embodiment of the invention has been described in detail above, it will be understood that modifications and variations therein may be effected without departing from the true spirit and scope of the novel concepts of the present invention as defined by the following claims.

I claim:

1. An energy reflector target comprising: an elongated mast having one unitary end portion and being split throughout the rest of its length into four contiguous longitudinally extending mast forming segments; first and second telescopically interfitting planar reflector members orthogonally intersecting along a central axis of symmetry common to said two members; said planar reflector members being formed of sheet material having a

thickness which is receivable between said mast segments to position said central axis of symmetry along the central longitudinal axis of said mast and mount said interfitted reflector members on said mast so that they form four quadrants disposed about said mast as a vertical axis of symmetry; and additional reflector means positioned to divide each of said quadrants into a plurality of reflector horns.

2. An energy reflector target comprising: an elongated mast having one unitary end portion and being split throughout the rest of its length into a plurality of contiguous mast forming segments; a plurality of vertically disposed planar reflector members positioned to intersect each other between said mast segments; fastening means to secure the top of said mast segments together to thereby lock said reflector members in said mast; and additional reflector means positioned to coact with said vertically disposed reflector members to form a plurality of reflector horns.

3. A collapsible energy reflector target for radar detection comprising: an elongated mast having one unitary end portion and being split throughout the rest of its length into a plurality of mast forming segments; a plurality of reflector members intersecting each other along the central axis of said mast between said segments; and fastening means to secure the ends of said mast segments together to lock said reflector members in said mast.

4. An energy reflector target for radar detection comprising: an elongated mast, said mast having a unitary bottom end and being split from the other end and throughout a major portion of its length into contiguous mast forming segments each having the same cross-sectional shape and being symmetrically disposed about the longitudinal central axis of said mast; said unitary bottom end of said mast being externally threaded to be received in a mounting fixture; first and second telescopically interfitting planar reflector members orthogonally intersecting along a central axis of symmetry common to said two members; said planar reflector members being formed of sheet material having a thickness which is receivable between said mast segments to position said central axis of symmetry along the longitudinal axis of said mast and mount said interfitted reflector members on said mast so that they form four quadrants disposed about said mast as a vertical axis of symmetry; fastening means to secure the top ends of said mast segments together to thereby lock said reflector members in said mast; and additional reflector means to divide each of said quadrants into a plurality of horn-shaped reflector cavities, at least one of said cavities having a radial axis of symmetry which is perpendicular to the axis of said mast.

5. An energy reflector target for radar detection comprising: first and second telescopically interfitting planar reflector members orthogonally intersecting along a central axis of symmetry common to said two members to form four quadrants; additional reflector means positioned to divide each of said quadrants into at least three reflector horns one of which has a radial axis of symmetry perpendicular to said central axis of symmetry common to said planar reflector members; and means to mount said reflector members with said common axis of symmetry in a vertical position.

6. An energy reflector target for radar detection comprising: an elongated mast having one unitary end portion and being split throughout the rest of its length into a plurality of contiguous mast forming segments; a pair of vertically disposed planar reflector members positioned to intersect each other in telescopically interfitted relationship between said mast segments to form four reflector quadrants; fastening means to secure the top of said mast segments together to thereby lock said reflector members in said mast; and a pair of obliquely disposed reflector members supported between each adjacent pair of vertical reflector members to divide each of said quadrants into three reflector horn cavities, said obliquely disposed reflector members being at right angles to each other and the central horn in each of said quadrants having a radial axis of symmetry which is perpendicular to the longitudinal axis of said mast.

7. Apparatus as in claim 6 wherein said vertically disposed planar reflector members and said obliquely disposed reflector members are sheet aluminum.

8. Apparatus as in claim 7 wherein each of said obliquely disposed reflector members is provided with an apertured ear and wherein each of said vertically disposed reflector members has an aperture combined with that in said ears to receive a mounting pin through both of said apertures to support said oblique reflectors from said vertical reflectors.

9. An energy reflector target for radar detection comprising: an elongated mast formed from an aluminum rod, said mast having a unitary bottom end and being split from the other end throughout a major portion of its length into four contiguous mast forming segments each having the same cross-sectional shape and being symmetrically disposed about the longitudinal central axis of said rod; said unitary bottom end of said mast being externally threaded to be received in a mounting fixture; first and second telescopically interfitting planar sheet aluminum reflector members orthogonally intersecting along a central axis of symmetry common to said two members; said planar reflector members having a thickness which is receivable between said mast segments to position said central axis of symmetry along the longitudinal axis of said mast and mount said interfitted reflector members between said mast forming segments to form four quadrants disposed about the mast as a vertical axis of symmetry; fastening means to secure the top ends of said mast segments together to thereby lock said reflector member in said mast; and a pair of obliquely positioned generally triangular reflector members mounted at right angles to each other in each of said quadrants to divide each of said quadrants into three reflector horn cavities, said triangular reflectors being formed of sheet aluminum, a corner of one reflector being hingedly connected to a corner of the other reflector at a point adjacent said mast and the outer ends of said reflectors being provided with apertured ear means to mount them to said first and second reflector members.

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