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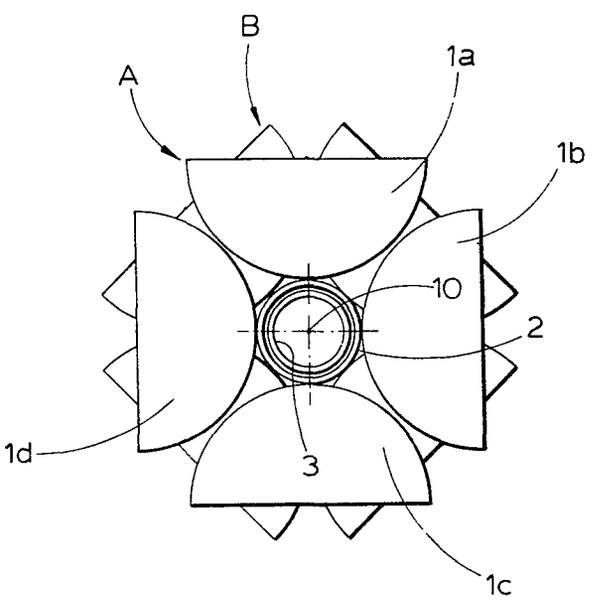
(54) Radar reflector.

(57) A radar reflector for use, for example, on small craft or buoys or for other marine purposes comprises a number of groups (A, B) of cup-shaped reflector elements (1a–1d) having an electrically conductive surface, the elements of each group being mounted in a circular arrangement with their openings facing radially outwards from an axis of symmetry (10) for the group. The groups are, in use, preferably mounted with their axes of symmetry vertical or substantially so with the groups one above the other. Each reflector element (1a–1d) has a substantially hemispherical shape with an opening the diameter of which is significantly larger than the wave length of the radar wave which is to be reflected. The reflector elements may be mounted within a protective housing of plastics material. The groups of elements are compact and provide an all round reflective response.



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VESTERALEN INDUSTRIER A/S GJE 4080/9

RADAR REFLECTOR

It is common to take various steps to facilitate the location of objects by means of radar installations. Amongst other things, the objects may be fitted with radar reflectors and radar reflectors are also used, for example, in communication systems and for navigational purposes. In this connection, radar reflectors are known which comprise a number of reflecting elements made of an electrically conductive material or at least having a reflective surface of electrically conductive material.

Existing radar reflectors, however, have not been completely satisfactory in meeting the requirements of the fishing industry and other shipping requirements as well. For example, in bad weather and poor visibility fishermen often have difficulty in locating stationary fishing gear by means of radar. Also for navigational purposes, other vessels and in particular larger ships need to be able to use radar for the exact location of buoys and other navigational marks which indicate channels and approaches to harbours amongst other things. Further, near harbours and in other congested waters there may be many small vessels which are not easily detected by means of radar. This may be due, amongst other factors, to the fact that such vessels often have hulls of plastics materials or of timber.

One form of radar reflector for use, for example, for marine purposes, comprises a plurality of hollow reflector elements each having an opening and an electrically conductive surface, the elements

being arranged in a circular group with their openings facing radially outwards from an axis of symmetry of the group. The reflector is generally mounted in use, with its axis of symmetry vertical or nearly so. A radar reflector of this form is disclosed in United States Specification No. 3,117,318. In this reflector the hollow elements have a tetrahedral or pyramid-like shape.

The main object of the present invention is to provide an effective and reliable radar reflector of the form just described for mounting for example on buoys, beacons, stationary fishing gear, booms, or on small vessels. The radar reflector may also however, be used with advantage on land or in connection with aviation, for example, on objects which are, to some extent at least, movable in a manner corresponding to the uses at sea which are described above.

An important problem which the present invention aims to overcome is caused by the fact that the objects to which the reflector is fitted are often subjected to movement, for example because of wind and waves, so that the reflection conditions vary continuously.

According to the present invention, a radar reflector of the form described, is characterized in that each of the reflector elements has a substantially hemispherical shape with an opening of a diameter significantly larger than the wave length of a radar wave to be reflected.

The statement that the opening of each reflector element has a diameter significantly larger than the wave length of the radar wave which is to be reflected, means that preferably the diameter must

be at least twice as large as the wave length. For common coastal navigation radar having a wave length of 3 cm. it is thus found practical to use a reflector element diameter of 7 cm. If the reflector is to be used in connection with radar having a wave length of for example 10 cm., the elements must be made correspondingly larger, for example with a diameter of 25 cm. A reflector having a larger diameter in relation to the wave length will give an improved radar echo.

What is essential regarding the shape of the reflector elements is that at least one of these irrespective of the origentation of the group relative to the radar wave will have an area of its conductive reflecting surface which provides the desired reflection of the incident radar waves. When each element has the shape substantially of a hemisphere, the element will cover a maximum angular range both in a horizontal plane, that is a plane normal to the axis of symmetry of the group, and in a vertical plane so that the reflection effect will be asmuch as possible independent of the orientation of the reflector at any moment and of movements to which it is subjected.

An additional substantial advantage of the radar reflector in accordance with the invention is that it may be constructed with comparatively small dimensions and small weight, which is of importance when the reflector is to be mounted on spar buoys or the like, or on small craft.

An example of a radar reflector in accordance with the invention is illustrated in the accompanying drawings in which:-

Figure 1 is a plan view of the reflector;

Figure 2 is a side elevation of the reflector; and

Figure 3 is a partly sectional side view of a housing in which the reflector may be fitted.

The radar reflector comprises a central mounting tube 3 which carries four groups A, B, C and D of reflector elements one above the other. The uppermost group A which is shown fully in plan in Figure 1 comprises four reflector elements 1a, 1b, 1c and 1d each having the shape of a hollow hemisphere. Each of these elements is attached to a supporting ring 2 by means of a central rivet 4 which is best shown in Figure 2. The elements 1a to 1d in group A thus form a circular arrangement in which the opening of each element is directed radially outwards with respect to an axis of symmetry 10 of the group. The lower groups B, C and D are all similar to group A.

With the arrangement shown, each group of elements is made as compact as is practicable and is also inexpensive and strong. At the same time a very good reflection effect for radar waves is obtained.

As far as the geometrical shape of each reflector element is concerned, this need not necessarily be an exact hemisphere. Larger or smaller variations with respect to a mathematical hemispherical surface are possible. The advantageous effect is achieved by the substantially hemispherical double curvature concave-surfaced cup shape of the elements. Moreover, although in this example the reflector elements are made of aluminium sheet material, i.e. an electrically conductive material, each concave cup-shaped element may be made of an electrically non-conductive material which is provided with a thin electrically conductive reflective coating on its concave inner surface. The coating may also be on the outer surface of the element if the element is transparent to radar waves.

Although under some conditions it may be sufficient for the reflector to consist of a single group of elements, it is much preferred to provide a number of groups one above the other as already described and as best illustrated in Figure 2. With the four groups A, B, C and D as shown, there is an angular displacement of 45^{o} as seen in plan between neighbouring groups so that groups A and C have the same orientation, and groups B and D have the same orientation. The angular relationship between group A and group B is also clearly shown in Figure 1.

The mounting tube 3 is preferably made of glass fibre reinforced plastics material, for example a polyamide having a content of 20% glass fibres. However, other materials, including electrically conductive materials such as aluminium, may be used. Each group of reflector elements is fixed on the tube 3 by means of a screw or like fastener through the supporting ring 2 of the group.

With the construction described above it is easy to adjust the arrangement of the groups on the mounting tube 3 according to varying conditions and requirements. The number of groups used depends upon the range from a radar installation at which the reflector is required to be detectable. The larger the number of groups of reflecting elements that the reflector contains, the greater the range at which a reflection can be detected. As mentioned above, it is very important that the reflector should still provide reflection even though it assumes different orientations in relation to the radar installation. It is directly evident from Figure 2 that at least six of the reflector elements shown therein will present effective reflection surfaces or areas with respect to any given radar beam direction in a plane

substantially normal to the axis 10. In practice the radar scanning will in the overwhelming number of cases take place in a horizontal plane or very close to a horizontal plane. This means that the mounting tube 3 will generally be mounted in a vertical position on the object, the radar location of which is desired.

When the reflector is used in connection with fisheries or other shipping it is usually desirable to protect the reflector elements against sea water, wind and weather. A housing 30 for this purpose is shown in Figure 3. The housing 30 has a substantially cylindrical shape with end walls provided with central holes 33 and 34 respectively, corresponding to the diameter of the mounting tube 3. Further smaller holes 31 and 32 are provided in the end walls to equalize the pressures inside and outside the housing should the radar reflector get immersed in water. This can easily happen in rough weather if the reflector is mounted on a buoy or the like. It is best to have two holes 31, 32 one at each end so that the water can easily enter and can easily be drained out of the housing if it gets immersed. The material of which the container is made must of course be of such a kind that it does not give any significant attenuation of radar waves.

The reflector described with reference to the drawings may be subject to modifications other than those mentioned above. Thus each group of elements may consist of a smaller number or preferably a higher number of elements than the four elements shown here, which is however the preferred number. In any case the arrangement of elements results in good flexibility which makes possible the adaption and adjustment of the radar reflector in a simple and

inexpensive way according to requirements and conditions.

CLAIMS

1. A radar reflector for use, for example, for marine purposes, comprising a plurality of hollow reflector elements each having an opening and an electrically conductive surface, the elements being arranged in a circular group with their openings facing radially outwards from an axis of symmetry (10) of the group, characterized in that each of the reflector elements (1a - 1d) has a substantially hemispherical shape with an opening of a diameter significantly larger than the wave length of a radar wave to be reflected.

2. A radar reflector according to Claim 1, characterized in that the elements (1a - 1d) in the group (A-D) are fixed at their centres to a supporting ring (2).

3. A radar reflector according to Claim 1 or Claim 2, characterized in that there are a plurality of groups (A-D) of elements arranged one above the other on a common mounting tube (3), the axis of which extends along the axis of symmetry (10) of the groups, the mounting tube (3) consisting of glass fibre reinforced plastics material.

4. A radar reflector according to Claim 3, in which the elements in one group are angularly offset from those in adjacent groups .

5. A radar reflector according to any one of the preceding Claims in which there are at least four elements in each group.

6. A radar reflector according to any one of the preceding Claims, characterized in that the elements (1a - 1d) are surrounded by a housing (30) of a material giving a minimum of attenuation of radar waves, the housing (30) having at least one and preferably two

holes (31, 32) for pressure equalization inside and outside the housing.

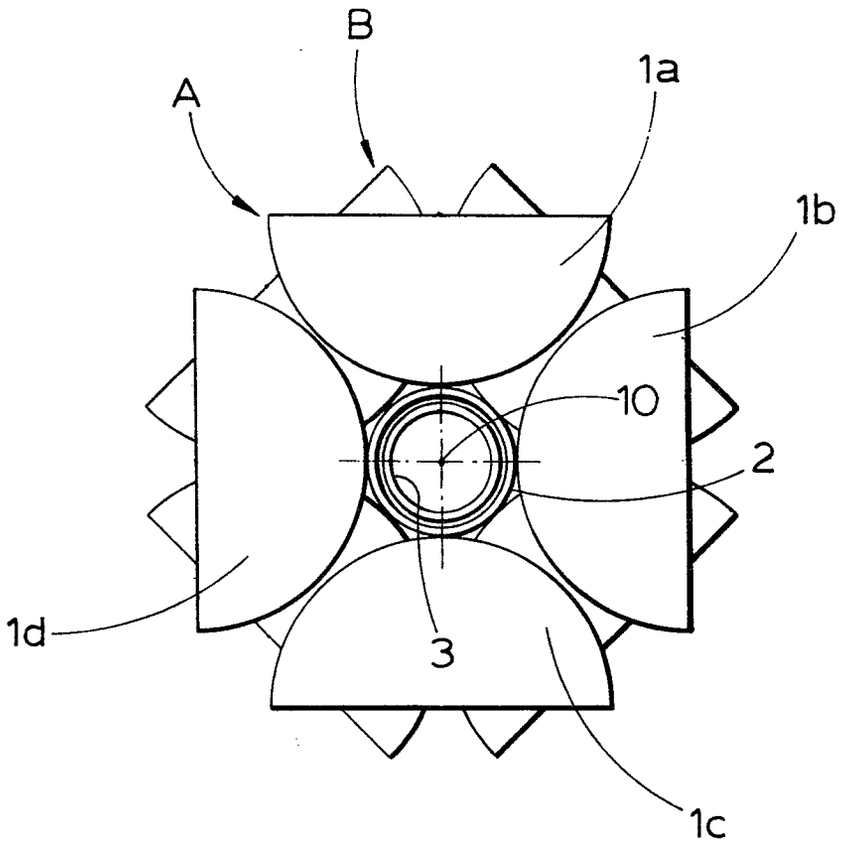

Fig .1

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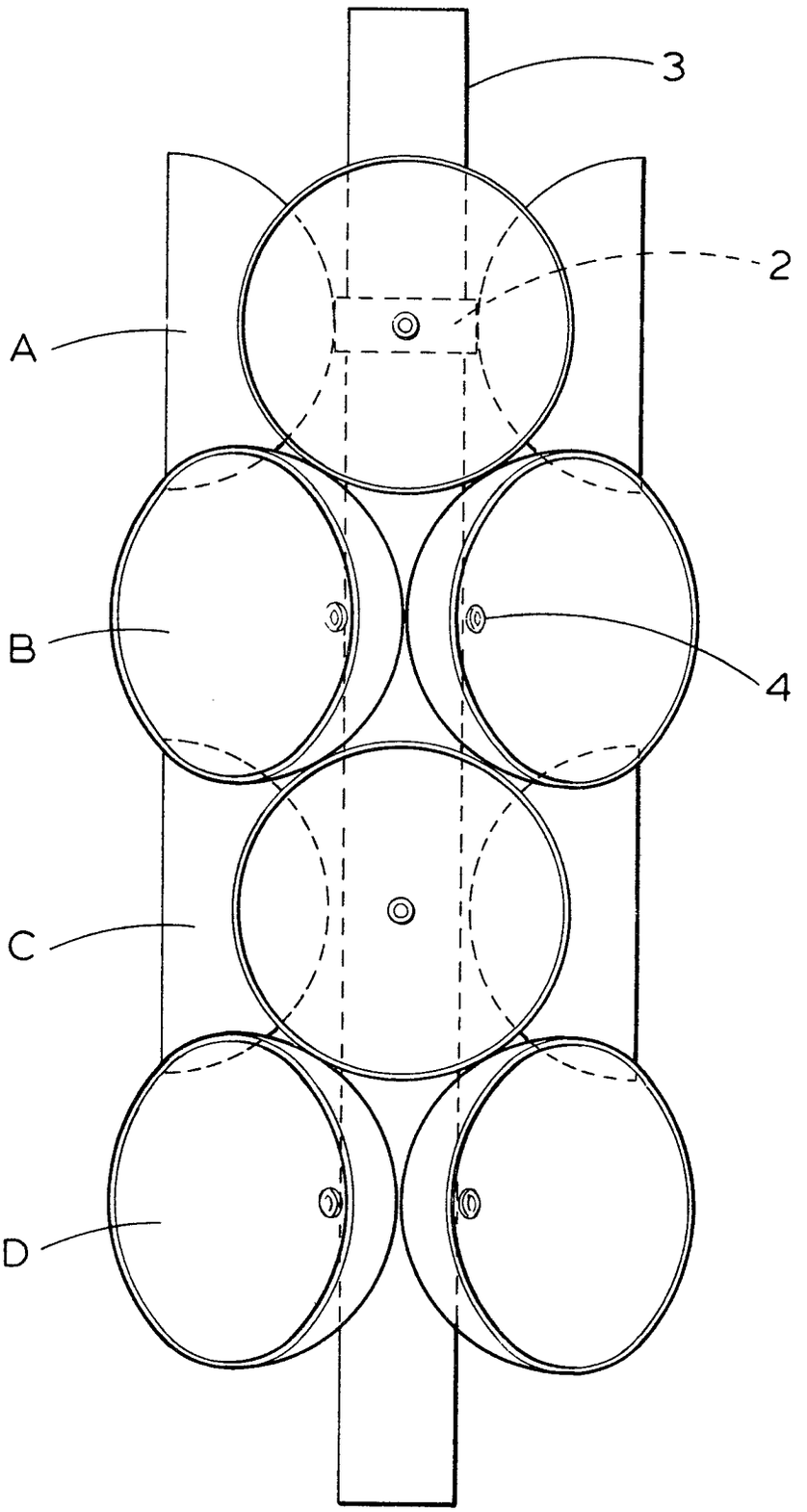

Fig. 2

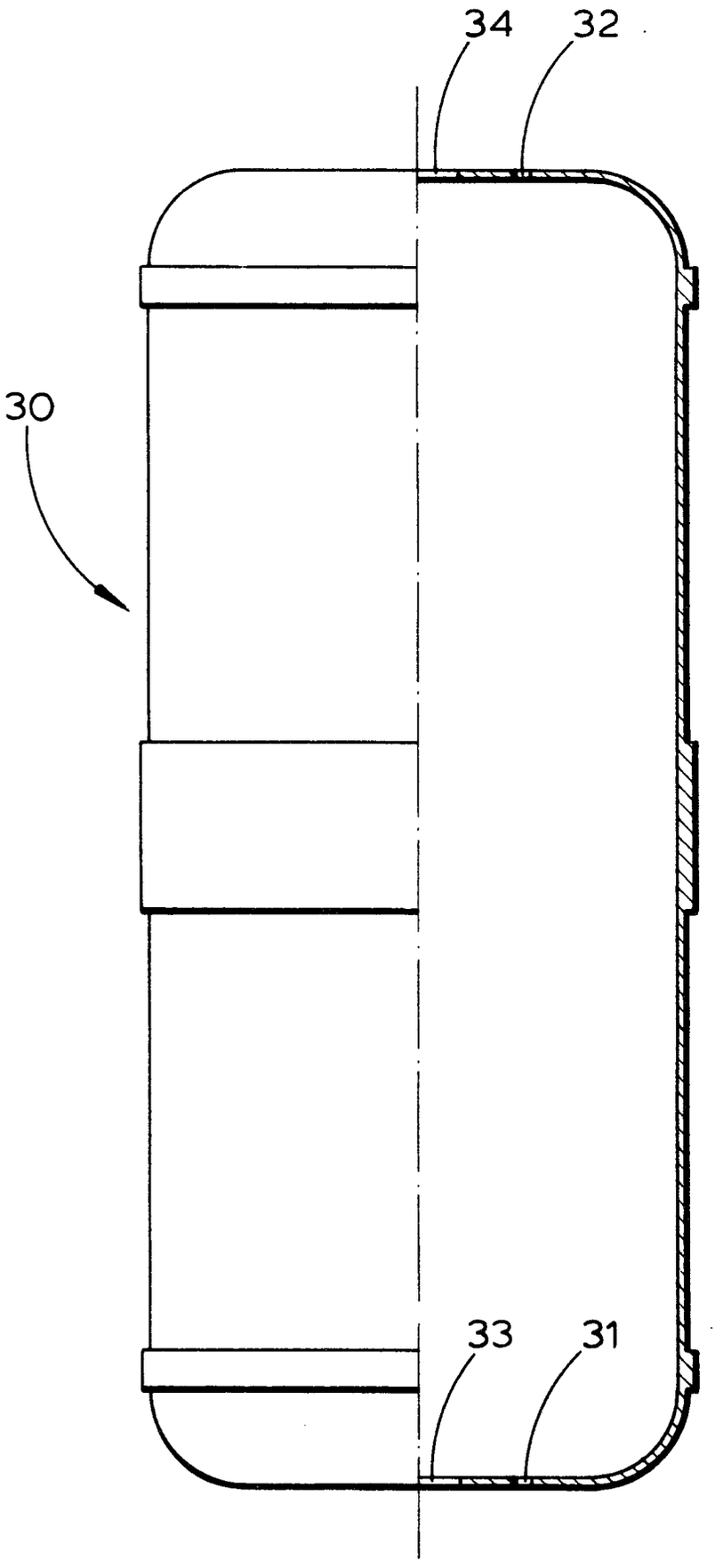

Fig . 3

European Patent Office

EUROPEAN SEARCH REPORT

Application number 0032604

EP 80 30 0155

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
X	NO - A - 92 752 (KJELD GJERTSEN) * Figure 2; claims 1,2 *	1,3,4
	GB - A - 582 168 (G.W. WALTON) * Figures 1-14;page 16, lines 29 - page 18, line 52 *	1
	US - A - 3 413 636 (P.N. MIDGAL) * Column 3, lines 25-30 *	1
	GB - A - 696 834 (MARCONI) * Whole document *	3-5
	DE - A - 2 524 684 (W. KLOECKNER) * Page 10, lines 20-24 *	6
DA	US - A - 3 117 318 (W.L. JONES)	
A	US - A - 4 148 033 (H.E. SPECKTER)	
A	DE - C - 837 972 (E. SCHELLENBACH)	
A	US - A - 2 520 008 (A.P. KING)	

CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)

H 01 Q 15/14

TECHNICAL FIELDS SEARCHED (Int.Cl. 3)

H 01 Q 15/14
15/16
15/18
21/20
1/34
G 01 S 13/02

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

☒ The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	12-09-1980	CHAIX DE LAVARENE

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