

Nov. 15, 1966

E. KELLY
COLLAPSIBLE PARASOL-LIKE REFLECTOR UTILIZING
FLEXIBLE HONEYCOMB SHELL

3,286,270

Filed July 1, 1964

2 Sheets-Sheet 1

Fig. 1

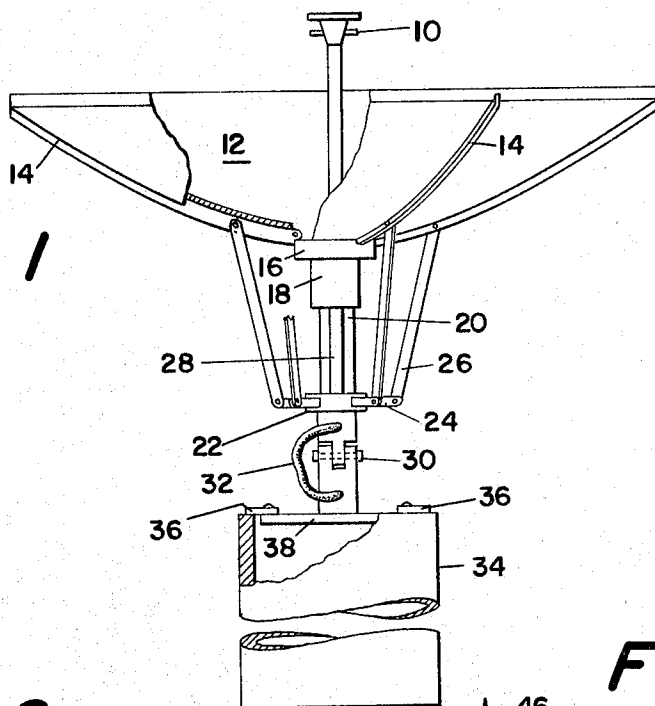


Fig. 2

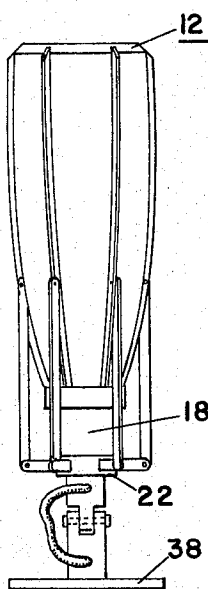
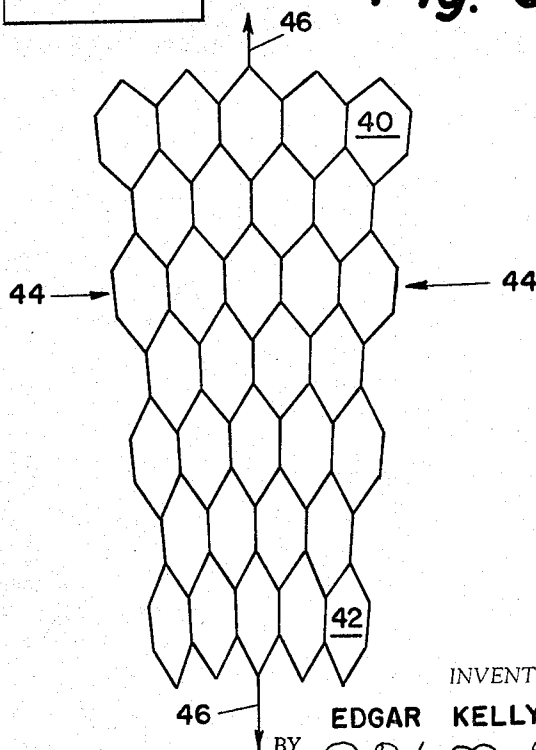


Fig. 3



INVENTOR.

EDGAR KELLY

BY

R H Quist

ATTORNEY

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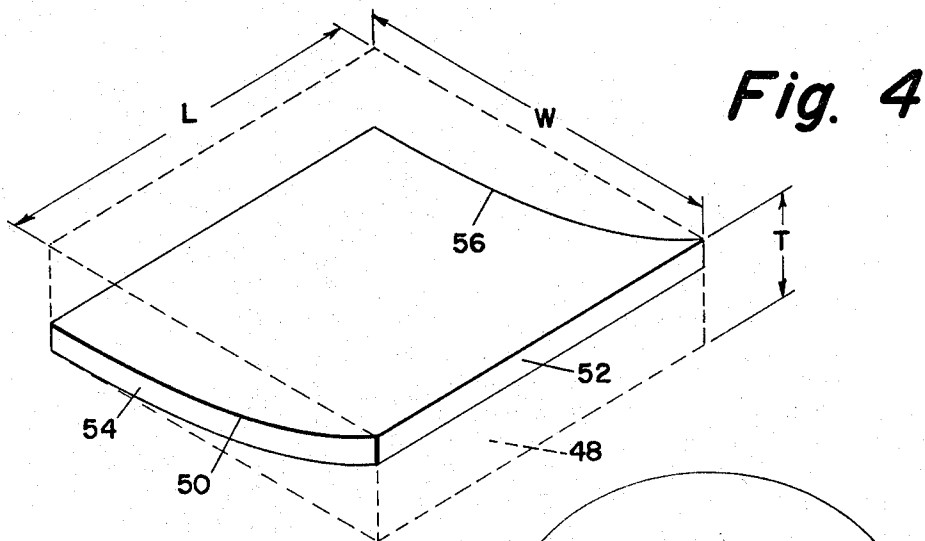


Fig. 4

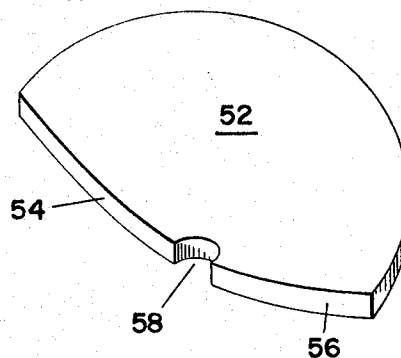


Fig. 5

Fig. 6

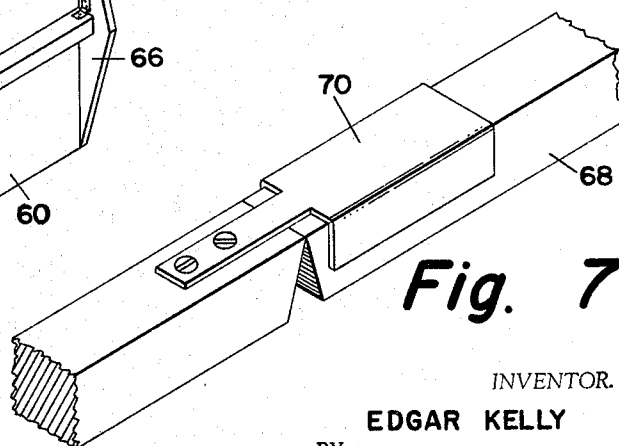
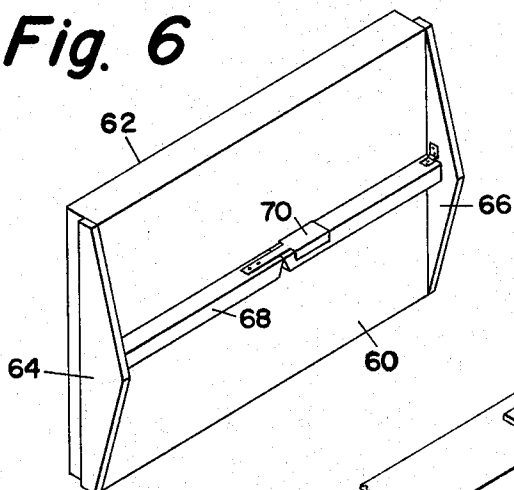


Fig. 7

INVENTOR.

EDGAR KELLY

BY

R H Quist

ATTORNEY

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COLLAPSIBLE PARASOL-LIKE REFLECTOR UTILIZING FLEXIBLE HONEYCOMB SHELL

Edgar Kelly, Levittown, Pa., assignor to General Electric Company, a corporation of New York
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1 Claim. (Cl. 343-915)

This invention relates to collapsible electromagnetic radiation reflectors and the method of making them.

It is well known that electromagnetic radiation can be transmitted to or received from a distant location more effectively if a suitable reflector is utilized. As the size of the reflector is increased, its effectiveness also increases.

Although large reflectors can be easily utilized if their location is permanent, when the reflector must be transportable, large size is a problem. In addition, for certain applications, such as submarine antennas, it is desirable to be able to stow the antenna when it is not in use.

An obvious approach to the solution of these problems is to provide reflectors which can be collapsed for transport and then erected for use at the desired locations. The design of such reflectors is not so obvious.

Previously collapsible paraboloidal reflectors have been disclosed. In U.S. Patent 3,064,534, for example, a reflector is disclosed having a number of individual sectors which are separately moved to collapsed and erected positions.

The prior art reflectors have had disadvantages of various types such as complexity, heaviness and inaccuracy, which make desirable reflectors which overcome such disadvantages.

It is, therefore, an object of this invention to provide a lightweight reflector which can be collapsed to a compact form for transporting and erected to operative position when desired.

It is also an object of this invention to provide a collapsible reflector having an uncomplicated design of high reliability.

In a preferred form of the invention, a honeycomb material is utilized to form a paraboloidal reflector for electromagnetic radiation. The reflector is prepared by selecting a honeycomb material, for example of aluminum, in the form of a rectangular block or hobe. Such honeycomb material is characterized by the capability of being collapsed and expanded in an accordion-like manner in one direction transverse to its thickness. The collapsing of the material is accompanied by an elongation in a direction transverse to its thickness which is generally perpendicular to the first direction. This elongation is negligible with proper reflector design. The thickness of the material remains constant throughout such collapse and expansion. The cells or perforations in the block run through in the thickness dimension.

While retaining the honeycomb material in a compressed form, it is machined to present a profile approaching that of a parabolic generatrix. The machined honeycomb block is then expanded about a vertical axis until the opposite edges meet. A paraboloid has then been formed. The paraboloid will be truncated, leaving an opening at the vertex for a radiation feeder.

Supports are then attached to the paraboloid in a manner which will not restrict the expansion or collapse of the individual honeycomb elements. With appropriate linkages attached, the outermost edge of the paraboloid can be moved towards and away from the vertical axis.

The dimensions of the individual honeycomb cells should be selected so as to cause most of the impinging radiation to be reflected. The wavelength of the radiation is consequently considered.

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The invention will be better understood from the following description taken in connection with the accompanying drawings in which:

FIGURE 1 is a schematic elevation, partly in section, of an erected paraboloidal radiation reflector according to the invention,

FIGURE 2 is a schematic elevation of the reflector of FIGURE 1 in a collapsed position;

FIGURE 3 is a diagram of a hexagonal honeycomb;

FIGURE 4 is a schematic isometric of a machined hobe of honeycomb material;

FIGURE 5 is a schematic showing the hobe of FIGURE 4 partially expanded;

FIGURE 6 is a schematic isometric of a flat radiation reflector according to this invention; and

FIGURE 7 is a schematic isometric of a detail of FIGURE 6.

Referring to FIGURE 1, the overall configuration of a collapsible paraboloidal reflector will now be described. As is well known, a paraboloidal reflector when used for transmission collimates the radiation received from an antenna so that a narrow beam is produced. The antenna is positioned so that its radiation is emitted from the focus of the paraboloid and is directed towards the paraboloid.

A dipole antenna 10 is therefore positioned at the focus of paraboloid 12. Support for paraboloid 12 is provided by a plurality of braces 14. Braces 14 only provide support in a radial direction. No circumferential restriction is provided to paraboloid 12 except for the spacing of braces 14. Telescoping circumferential rings might be added if desired on large reflectors.

Braces 14 are pivotally connected at the bottom to collar 16. Collar 16 is secured to sleeve 18. Sleeve 18 is slidably mounted on tube 20.

At a lower position on tube 20 is secured collar 22 having a number of arms 24 of equal length extending radially therefrom. To the end of each arm 24 is pivotally connected one end of a bar 26. The other end of each bar 26 is pivotally connected to the brace 14 above it at a point between the extremes of the brace. A symmetrical arrangement about the vertical axis of paraboloid 12 is thereby formed of these elements.

It will be observed that downward movement of sleeve 18 on tube 20 will tend to cause the upper ends of braces 14 to move towards the vertical axis of paraboloid 12. Sleeve 18 is prevented from moving down on tube 20 by block 28 inserted between sleeve 18 and collar 22.

Tube 20 is provided with a pivot 30 to permit paraboloidal reflector 12 to be adjusted in elevation. The reflector actually constructed is small enough to be manually moved to a desired azimuth, but it is within the skill of the prior art to provide means for rotating tube 20 and thus reflector 12 mounted thereon.

Conductor 32 provides an electrical connection for antenna 10 between the upper and lower parts of tube 20.

Container 34 is provided to hold reflector 12 when it is in a collapsed position. Dogs 36, pivoted on platform 38, support platform 38. When reflector 12 is in a collapsed position, dogs 36 may be pivoted to clear container 34 and permit the entire apparatus to be dropped into container 34. If desired, mechanical means may be provided to move reflector 12 in and out of container 34 as well as to permit remote positioning of reflector 12. Such additional means is desirable when large reflectors are fabricated.

In FIGURE 2, reflector 12 is shown in its collapsed position. Block 28 has been removed and sleeve 18 has descended to collar 22. Reflector 12 now extends out only about as far as platform 38.

Movement of reflector 12 from the erected position to the collapsed position is performed generally in the man-

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ner an umbrella is closed. The essential and important difference is that this is accomplished without folding of the reflector material. In accordance with the invention, a honeycomb material is utilized in fabricating the reflector, the honeycomb itself constituting a circular ring member.

FIGURE 3 is a diagram of a honeycomb. It is not a representation of honeycomb material although it approximates a plan view of such material. The individual cells in this honeycomb such as 40 and 42 have different shapes, since cell 42 is compressed while cell 40 is more greatly expanded; but the lengths of similar edges of the cells are equal. If such a honeycomb is constructed of a material which is sufficiently flexible, it could be collapsed completely together in the direction indicated by 44 and extended in the opposite direction as shown. Collapse of the honeycomb material in the direction indicated by 44 causes an elongation in the direction indicated by 46.

Aluminum honeycomb material meeting the foregoing characteristics is presently available from many sources such as Hexcel Products, Inc., of Havre de Grace, Maryland.

A paraboloid has been constructed from this material according to the process now to be described.

Referring to FIGURE 4, a block or hobe 48 of honeycomb material (indicated by broken lines) is selected having a thickness T, a width W, and a length L. The length is measured in the direction in which the honeycomb may be expanded and collapsed. Block 48 should have a length L sufficient in expanded condition to extend the length of the completed reflector. This length, in a paraboloidal reflector, is the maximum circumference.

Block 48 is maintained in a collapsed condition while the upper surface is machined to have a profile of parabolic generatrix 50. To eliminate excess weight, the bottom surface may be machined to yield a completed block 52 of constant thickness. The finished thickness is selected primarily from a mechanical standpoint. The rigidity in this direction, which is inherent in a honeycomb structure, should be retained.

A paraboloid is formed from machined block 52 by holding edge 54 fixed and extending edge 56 around until it meets edge 54. The two edges are secured together to form the paraboloid. FIGURE 5 shows block 52 partially extended. It will be noted that in extending edge 56 around to meet edge 54, a hole 58 is formed. The paraboloid produced is thus truncated. The profile machined into block 48 of FIGURE 4 is not that of a semi-parabola since the vertex portion is not included in the finished product.

In constructing a paraboloid, it was discovered that collapse was not attended by an elongation along the axis of elongation which is significant. This result obtains since the distance any one cell moves in expanding is small when many cells, side by side, are used to form the paraboloid.

A double curved surface has therefore been produced by machining a first curve into honeycomb material and then extending the material into the second curve. Obviously this technique can be applied to make hemispherical surfaces or other surfaces of revolution.

The braces 14 of FIGURE 1 are added to the machined block 52 by splitting the back of the honeycomb material at appropriate locations, inserting the braces, and gluing or otherwise fastening the braces in place. It might be mentioned that sections of honeycomb material can be secured together to achieve the desired dimensions if a suitable sized block is not readily available.

A paraboloidal reflector has been first shown and described since the double curved surface presents a most difficult design problem. Single curved or even flat reflectors can be constructed as well which can also be collapsed.

FIGURE 6 shows a flat electromagnetic radiation reflector 60 in its extended position. The reflecting surface 62 is of the same material as that utilized for the para-

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boloidal reflector of FIGURE 1. Reflector 60 is provided with braces 64 and 66 at either end. Bar 68 maintains the spacing between braces 64 and 66 to hold reflector 60 in its extended position. Bar 68 is hinged at both ends and split in the middle. A simple bracket 70, shown in detail in FIGURE 7, permits the two halves of bar 68 to be swung up and apart so that braces 64 and 66 may be moved towards each other when it is desired to collapse reflector 60.

It should be recognized that this invention is primarily concerned with the mechanical aspects of electromagnetic radiation reflectors. The character of the radiation to be reflected imposes certain additional requirements upon a reflector. The use of a perforated surface to reflect electromagnetic radiation is old. The SCR-584 anti-aircraft radar antenna utilizes a perforated reflector. See Radar System Engineering, volume 1 of the Radiation Laboratory Series, first edition, McGraw-Hill Book Company, Inc., page 285. The size of the perforations should be small relative to the wavelength of the radiation to be reflected. In general, the honeycomb cells should be no larger than one-eighth of the wavelength of the radiation to be reflected. In the reflector constructed, the honeycomb material used was designated by the manufacturer, Hexcel Corporation, as $\frac{3}{16}$ -5052-.0013P. The $\frac{3}{16}$ is the length of a honeycomb cell in inches.

The honeycomb material of which the reflector is constructed also depends on the character of the radiation as well as physical requirements such as flexibility and weight. Aluminum has been used with success, and metal or metal coated material would usually be desired.

While particular embodiments of collapsible electromagnetic radiation reflectors have been illustrated and described, it will be obvious that changes and modifications can be made without departing from the spirit of the invention and the scope of the appended claim.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

A collapsible and erectable paraboloidal electromagnetic wave reflector comprising:

- (1) a circular ring member of electrically conductive honeycomb material comprising a plurality of hexagonal cells each of whose sides is common to two adjacent such cells, each such cell having two opposite sides lying radially with respect to the said circular ring, one face of the said member defining a concave paraboloid;
- (2) a plurality of rigid radial braces of equal length extending at least from the inner circular boundary to the outer circular boundary of the circular ring member, each said brace being attached at a plurality of points to the said circular ring member on the side of the member away from the said paraboloid defining face;
- (3) means for maintaining the said braces in a circularly symmetrical radial relationship and for changing the diameter of the circle determined by the ends of the said braces, a minimum value of such diameter corresponding to a collapsed state of the said reflector, and a maximum value of such diameter corresponding to an erected state of the said reflector.

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HERMAN KARL SAALBACH, *Primary Examiner.*

M. NUSSBAUM, *Assistant Examiner.*

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,286,270

November 15, 1966

Edgar Kelly

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 45, for "hobe" read -- "Hobe" ("Hobe" is the trademark for unexpanded honeycomb produced by Hexcel Products, Inc.) --; column 3, line 25, for "hobe" read -- "Hobe" --.

Signed and sealed this 12th day of September 1967.

(SEAL)

Attest:

ERNEST W. SWIDER

Attesting Officer

EDWARD J. BRENNE

Commissioner of Patents