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Cummings et al.

[11] **3,780,375**

[45] **Dec. 18, 1973**

[54] **DEPLOYABLE PARABOLIC ANTENNAS**

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[73] Assignee: **North American Rockwell Corporation,** El Segundo, Calif.

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[21] Appl. No.: **202,313**

[52] **U.S. Cl.** **343/915,** 343/840

[51] **Int. Cl.** **H01q 15/20**

[58] **Field of Search** 343/840, 912, 915

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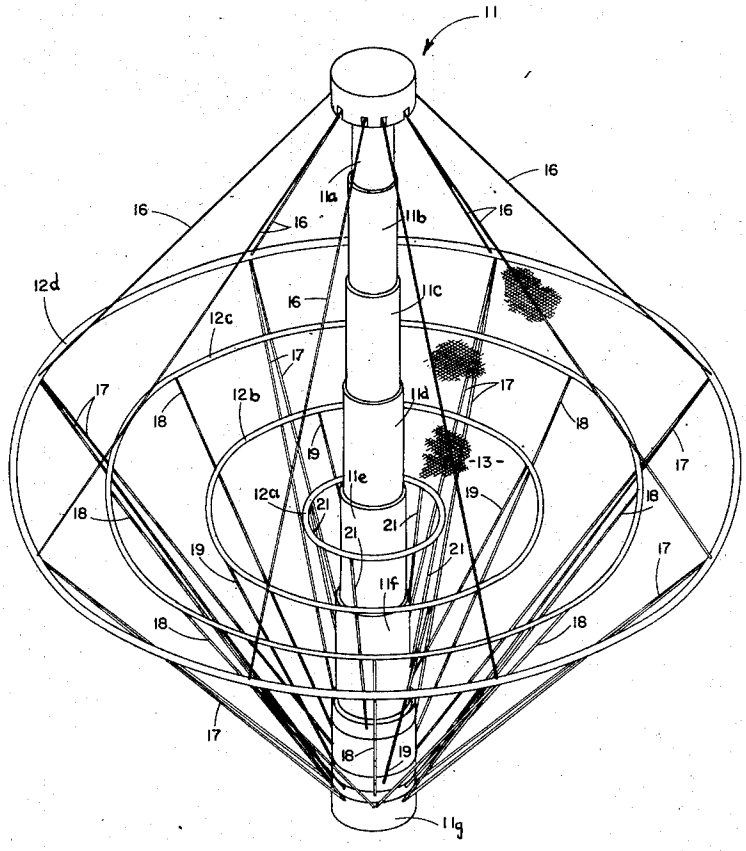
Primary Examiner—Eli Lieberman

Attorney—L. Lee Humphries et al.

[57] **ABSTRACT**

A deployable parabolic antenna is formed of a plurality of resilient rings disposed concentrically about an extensible boom wherein the outer ring is tied by a first group of tension members to the top of the boom and, also, by a second group of tension members tied to the bottom of the pole, thereby rigidly supporting the outer ring with respect to the pole. The inner rings are tied to the bottom of the pole by respective groups of tension members and to each other and the outer ring by a net-like metallic fabric member which is stretched to form a concave surface that approaches the shape of a paraboloid when fully deployed. Since the rings are resilient and the fabric and tension members are flexible, the assembly can be folded about the boom to form a compact mass for storage.

8 Claims, 12 Drawing Figures



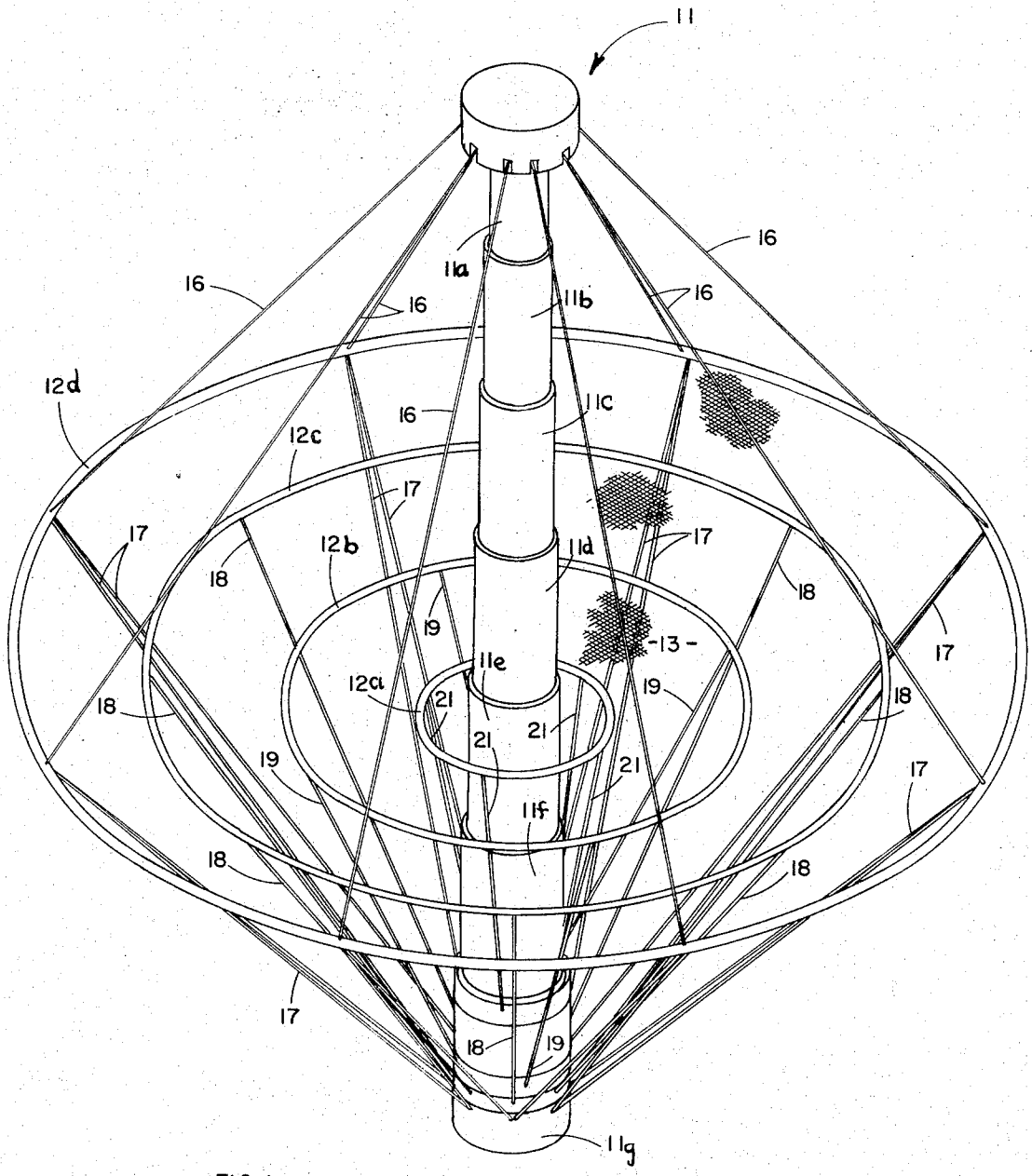

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FIG. 1

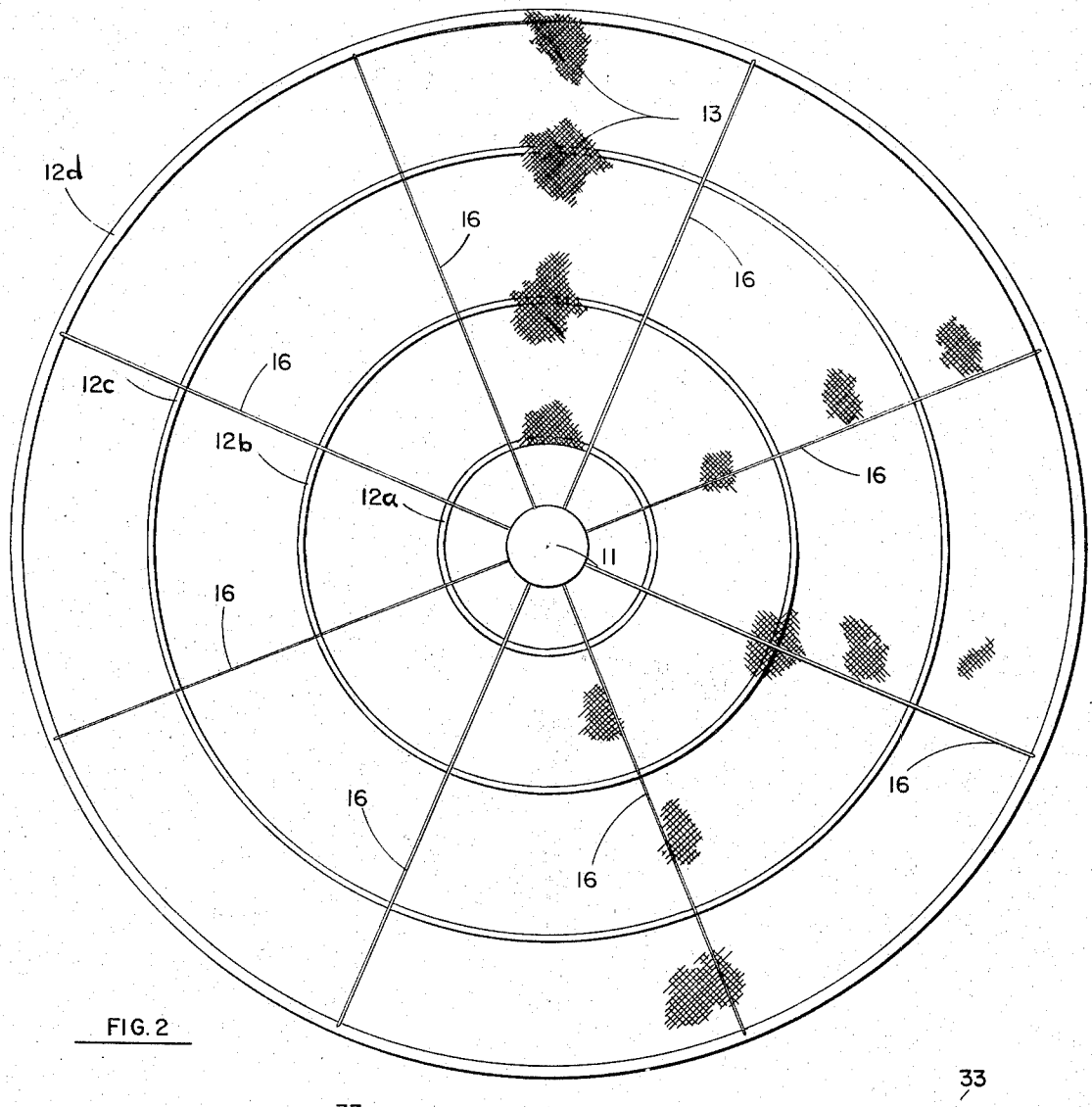


FIG. 2

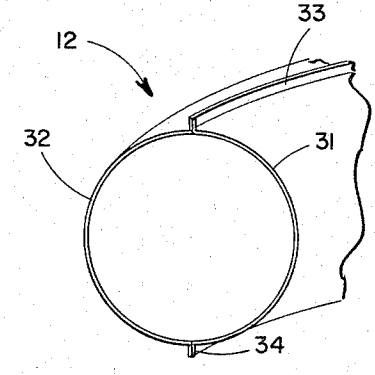


FIG. 10

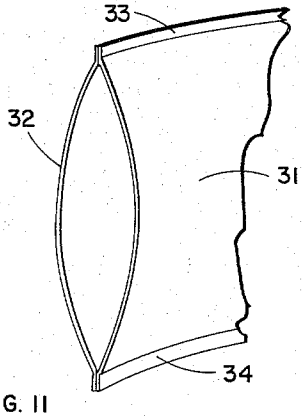


FIG. 11

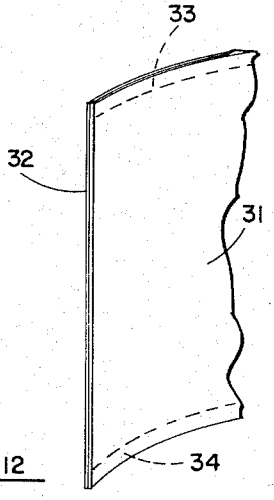


FIG. 12

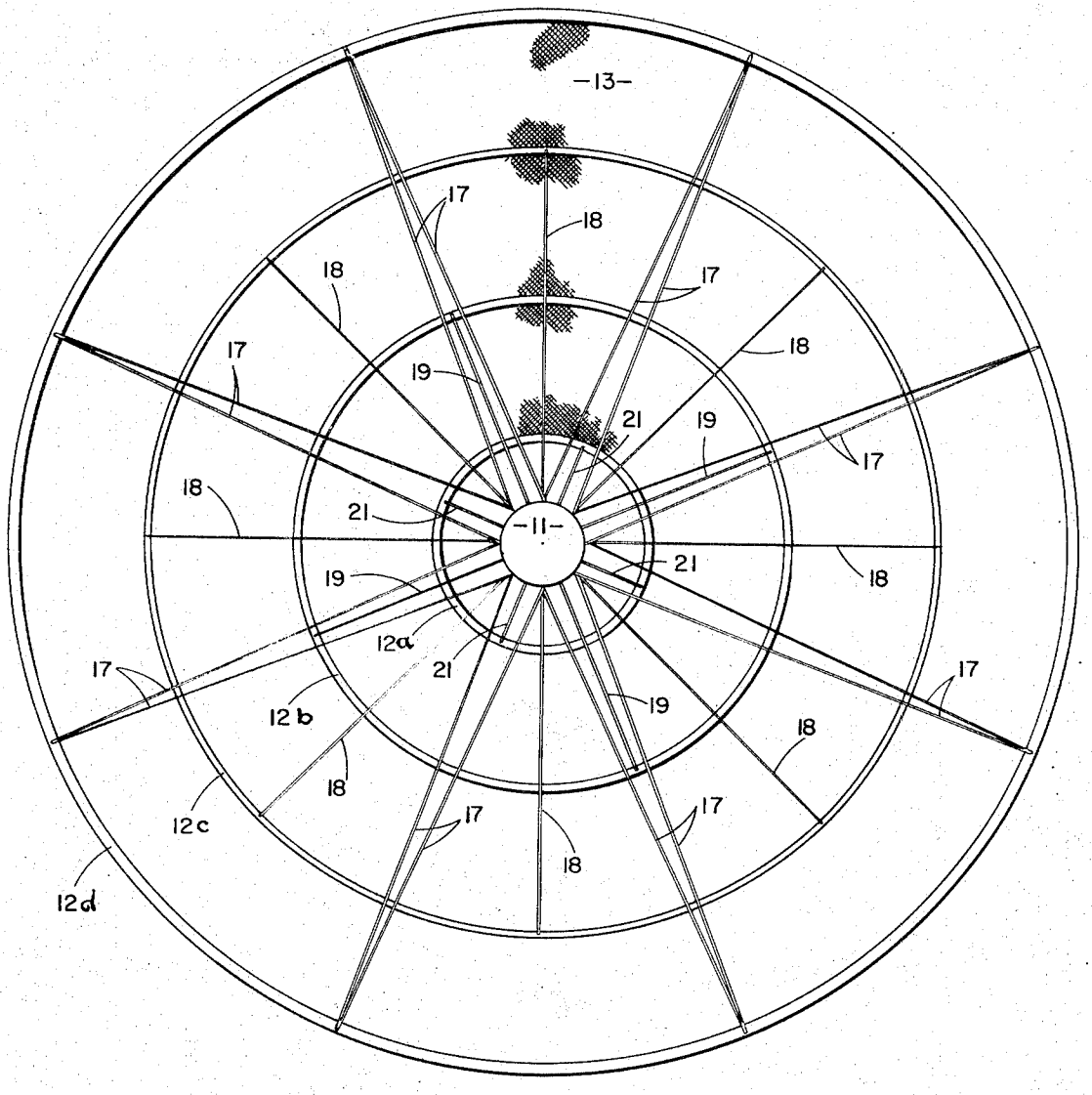

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FIG. 3

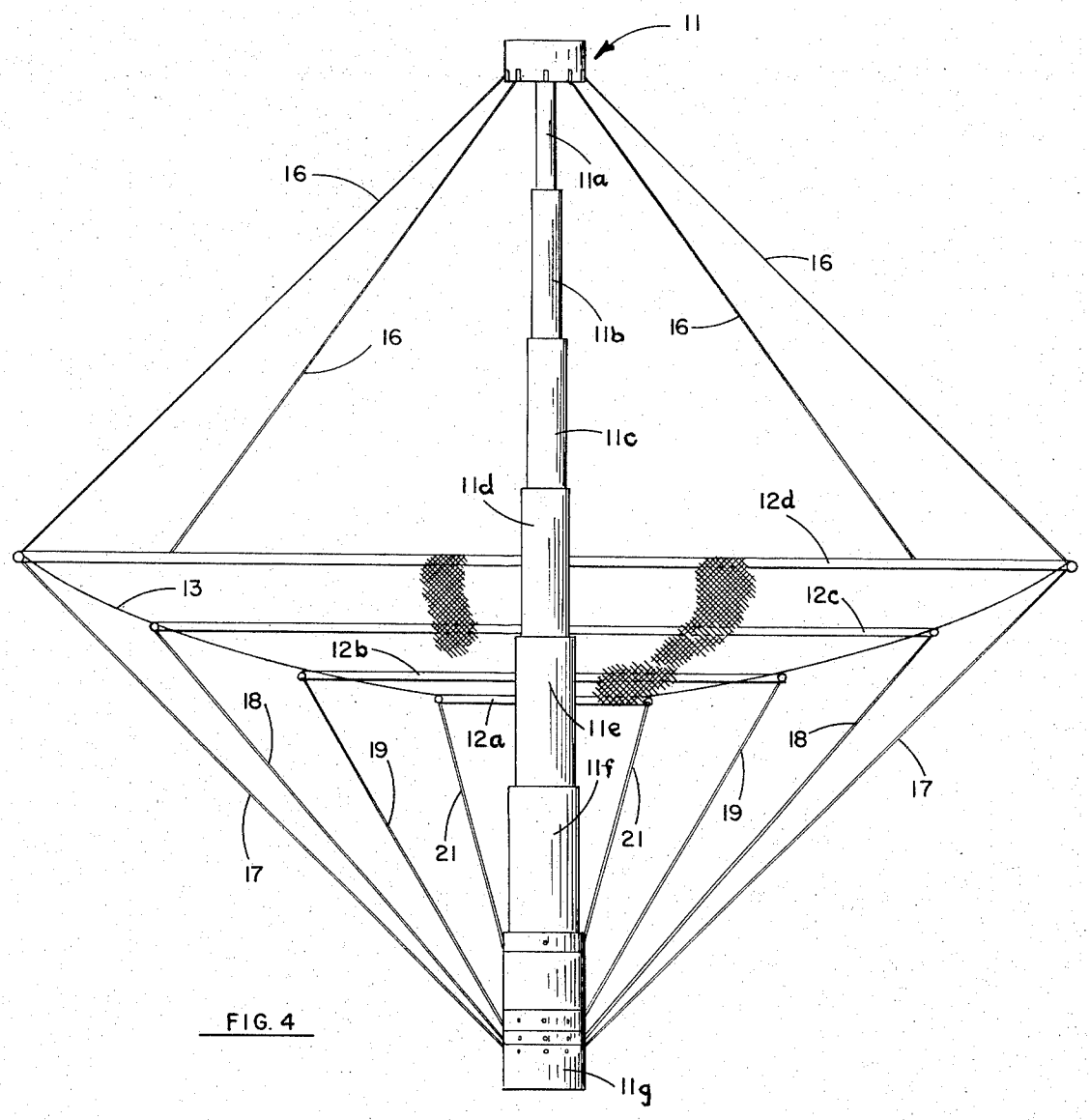

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FIG. 4

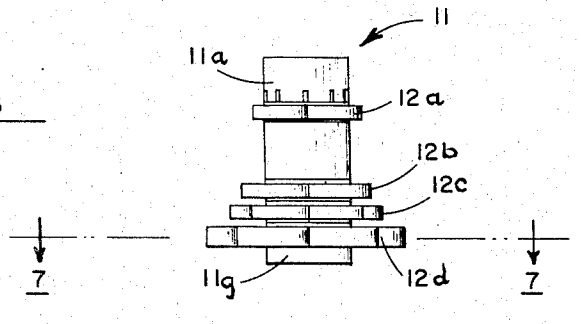

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FIG. 5

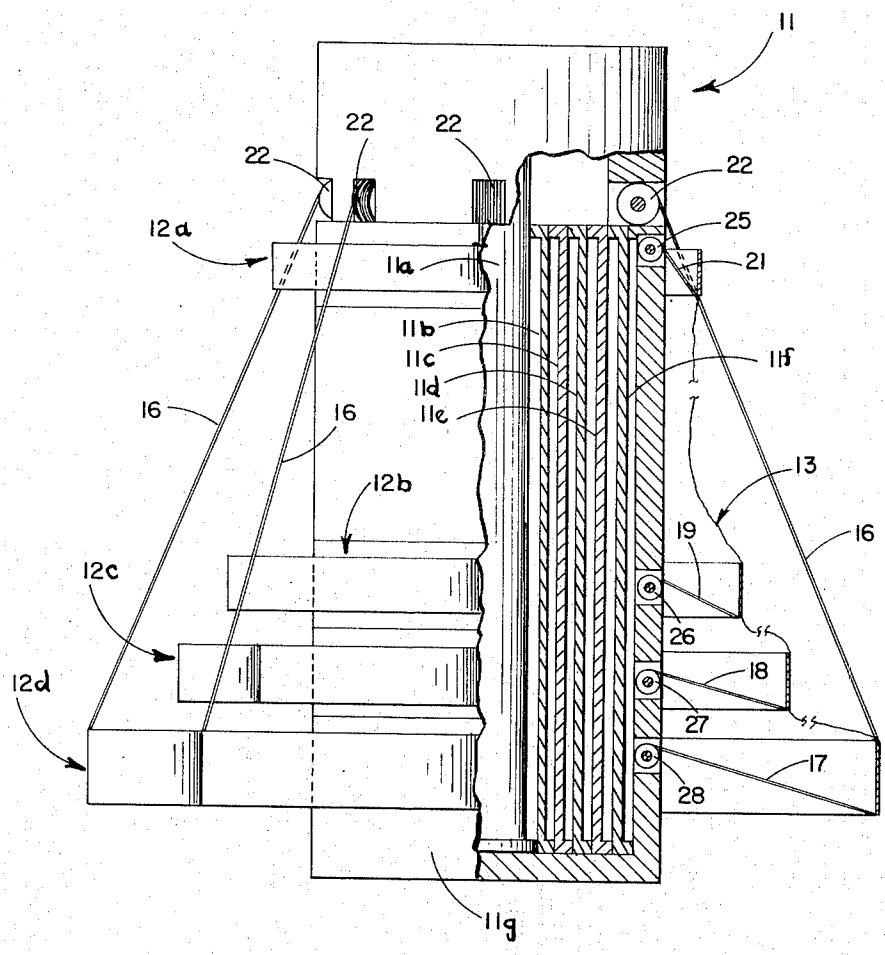

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FIG. 6

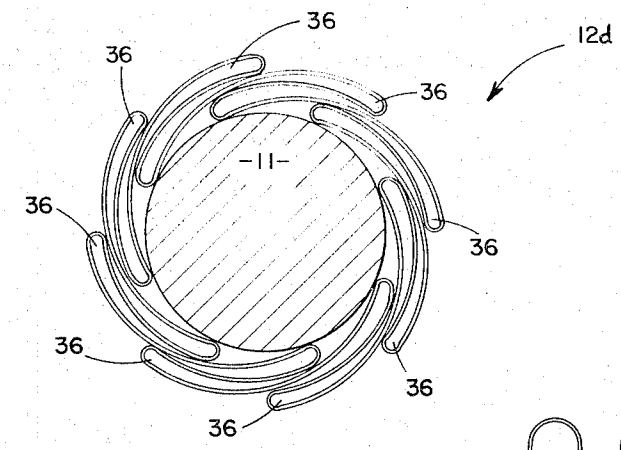


FIG. 7

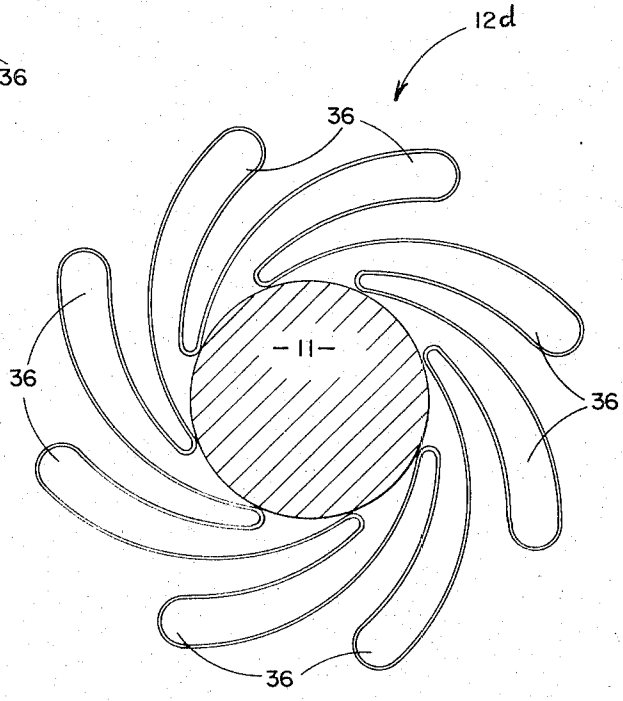


FIG. 8

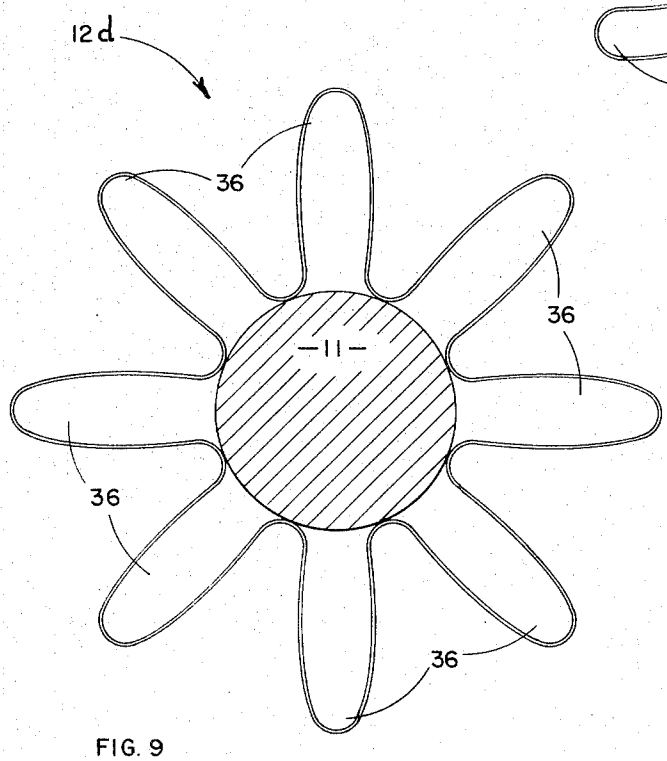


FIG. 9

DEPLOYABLE PARABOLIC ANTENNAS

FIELD OF INVENTION

This invention relates to parabolic antennas and, more particularly, to deployable parabolic antennas that are capable of being folded into a compact mass when not in use.

BACKGROUND OF THE INVENTION

As one skilled in the art knows, parabolic antennas operate somewhat like a reflecting telescope. As a parabolic mirror collects light rays and focus them to a spot, a parabolic antenna collects microwaves and focus them to a spot. Therefore, the total energy collected increases as the area of the parabolic surface increases to increase the signal to noise ratio. On earth, the construction of parabolic antennas having 100 foot diameters is relatively simple, but in outer space the task is next to impossible. Therefore, the antennas are assembled on earth and stowed in a compact form in a space craft to be deployed in outer space. Prior art antennas using this procedure inherently limit the size and efficiency of the antenna.

OBJECTS OF THE INVENTION

An object of this invention is to provide a deployable parabolic antenna that can be made larger and more efficient than the prior art.

Another object of this invention is to provide a deployable antenna of minimum weight that is foldable or collapsible into a small compact size.

Another object is to provide a pliable surface that can be formed into a rigid surface having a shape substantially conforming to a paraboloid of revolution.

These and other objects and features of advantage will become more apparent after studying the following description of the preferred embodiment of the invention together with the appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 pictorially shows a novel parabolic antenna;

FIG. 2 is a view of the antenna looking at the concave surface thereof;

FIG. 3 is a view of the antenna looking at the convex surface thereof;

FIG. 4 is an axial section through the antenna;

FIG. 5 shows an elevation of the antenna in the folded and stowed position having substantially the same scale as FIG. 1–4;

FIG. 6 is an enlarged elevation in partial section of the antenna, also in a folded and stowed position;

FIG. 7 is a section view taken on line 7—7 of FIG. 5 and in the direction of the arrows;

FIG. 8 is the same view as FIG. 7 showing the outer resilient ring unfolding;

FIG. 9 is the same view as FIG. 8 showing the outer resilient ring further unfolding;

FIG. 10 is a pictorial section for any one of the resilient rings in the deployed position;

FIG. 11 is another pictorial section of the ring of FIG. 10 showing it partially collapsed;

FIG. 12 is another pictorial section of the ring of FIG. 10 showing it fully collapsed.

DETAILED DESCRIPTION OF THE DRAWINGS

A pictorial view of the deployable parabolic antenna is shown in FIG. 1 and the antenna comprises a centrally disposed boom 11 which is, preferably, made collapsible in a standard manner to be described hereinafter. Around the boom 11 are disposed a plurality of resilient rings, i.e., four rings, 12*a*, 12*b*, 12*c*, and 12*d* that are connected together with a net or mesh-like fabric 13 as shown more clearly in FIG. 3. Since the rings are resilient, the fabric 13 is stretched rigidly outward from the boom by the rings and especially the outer ring 12*d*. This outer ring 12*d* is held stationary with respect to the boom by tension members or tie lines 16 made of, for example, eight dacron threads connected between the forward end of the boom and the outer ring 12*d* and by tie lines 17 made of, for example, sixteen dacron threads connected between the other rearward end of the boom and the outer ring 12*d*, substantially, as shown in FIG. 3. The parabolic surface for the fabric 13 is proximated by installing additional tie lines 18, 19, and 21 from the respective rings 12*c*, 12*b*, and 12a to the rearward end of the boom 11. As shown in FIG. 4, tie lines 18 are connected between ring 12*c* and the boom. Tie lines 19 are connected between the ring 12*b* and the boom, and tie lines 21 are connected between ring 12*a* and the boom. The pattern of the tie lines 17, 18, 19, and 21 is more clearly shown in FIG. 3. As one can observe, a fewer number of tie lines are needed to position the inner rings than the outer rings. The pairs of tie lines 17 emanating from the same point or place on the outer ring 12d and also from the same point on the boom 11 provide torsional stiffness in the same manner that the spokes of the wheel provide torsional stiffness. To provide a better approximation of the parabolic surface taken by the fabric 13, more resilient rings could be added concentrically to the four resilient rings described. One will note, in FIG. 4, that the fabric 13 is placed tangent with respect to the inner rings 12*a*, 12*b*, and 12 *c* to ensure a better approximation of the parabolic surface.

Since the four rings 12*a*, 12*b*, 12*c*, and 12*d* are resilient and a boom 11 is collapsible, the unit can be folded into a compact package as shown in FIG. 5 and in more detail in FIG. 6. The boom 11 is made up of seven standard nestable sections 11*a*, 11*b*, 11*c*, 11*d*, 11*e*, 11*f*, and 11*g*. However, section 11*a* is modified to carry eight pulleys 22 onto which the respective lines 16 are wound when the unit is in a folded position. Section 11*g* has been modified to carry the pulleys onto which the other respective lines are wound. For example, each of the four lines 2 is wound onto respective pulley 25. Each of the four lines 19 is wound onto respective pulley 26. Each of the eight lines 18 is wound onto respective pulley 27. While each pair of the eight pair of lines 17 may be wound onto a respective pulley 28, the respective group of pulleys 25, 26, 27, and 28 are located at the same axial position around the section 11*g* for obvious reasons. Four rings 12*a*, 12*b*, 12*c* and 12*d* are wrapped about the boom in a manner as shown in FIGS. 7, 8, and 9 which shows only outer ring 12*d*. In order to make the rings have maximum stiffness in a deployable position and minimum stiffness in a folded position, the rings are made as shown in FIGS. 10, 11, and 12. The rings in the deployed position form hollow toroids as shown in FIG. 10. The respective toroid is made of two mating, warped, thin sheets of spring metal, each forming a half toroid 31 or 32 that are joined at seams 33 and 34. The seams 33 and 34 preferably lie substantially in the same cylinder when deployed to ensure that the toroidal shape is assumed.

Each half toroid **31** and **32** have a warped surface and are pre-formed before assembly. With the seams deployed, as described, the rings may be flattened as shown in FIG. **11** and, finally, as shown in FIG. **12.** Since, for example, the outer ring **12***d* may be flattened, it may be made to assume the shape shown in FIG. **9** forming eight cusps **36** radiating from the boom section **11**g. These cusps **36** can be wrapped around section **119** as shown in FIG. **8** and, finally, as in FIG. **7.** The other three rings, since they are similarly constructed, may be similarly folded. The fabric **13,** since it is a net, folds conveniently around the collapsed boom as shown in FIG. **6.** If additional rings are required, they may be similarly stowed against the boom section **11***g* as described with ring **12***d* and in FIG. **7** the required space is shown for these rings. If additional rings are not required, obviously, one skilled in the art would not provide this spacing.

One skilled in the art can readily make the described structure into an antenna by simply making the fabric **13** out of, for example, flexible copper mesh and a boom **11** out of a suitable material (such as plastic or metals) that is strong and does not interfere with the microwaves. Also, one skilled in the art can provide typical dipole or wave-guide horn in a proper place as required to supply or receive the microwaves. One can observe that the above description explains how to make a deployable concave surface that is capable of being folded into a small package and can be opened like an umbrella to form a concave surface that approximates, preferably, a paraboloid of revolution which surface can be transformed into an antenna to receive and transmit microwaves. Thus, the invention is not limited to the described embodiment, but includes all embodiments falling within the scope of the claims.

What is claimed is:

1. An antenna deployable from a retracted stowed position to an extended deployed position, comprising:

an elongated boom having a plurality of telescopically extendible sections;

an outer ring disposed concentrically around said boom in the deployed position;

a reflective fabric attached to and disposed wtin said outer ring with said boom extending therethrough;

a first group of tie lines connecting said outer ring to one end of said boom;

a second group of tie lines connecting said outer ring to the other end of said boom;

an inner ring means disposed concentrically around said boom within said outer ring, said reflective fabric being attached to said inner ring means;

a third group of tie lines connecting said inner ring means to said other end of said boom; and

means on said boom permitting controled extension of said tie lines a predetermined extent upon extension of said boom from its retracted stowed position whereby said reflective fabric is caused to assume a substantially concave surface over said inner ring means.

2. The antenna set forth in claim **1** wherein said inner ring means comprises a plurality of inner concentric rings with said reflective fabric being substantially in tangential contact therewith.

3. The antenna set forth in claim **2** wherein said outer and inner rings are hollow toroids of resilient metal.

4. The antenna set forth in claim **3** wherein said hollow toroids are formed of two half toroids joined together by diametrically opposed seams that are disposed substantially in a cylindrical surface when deployed.

5. The antenna set forth in claim **4** wherein said hollow toroidal rings may be flattened to form cylindrical elements concentric about said boom.

6. The antenna set forth in claim **5** wherein said flattened toroidal rings may be convoluted to form cusps that may be wrapped around said boom in the stowed position.

7. The antenna set foth in claim **1** wherein said second group of tie lines includes pairs of lines connecting each connection point on the outer ring to each connection point on the boom in the manner of wheel spokes to thereby provide torsional stiffness to said outer ring.

8. The antenna set forth in claim **1** wherein said tie line extension means comprises pulleys on said boom.

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