United States Patent

Ganssle

[15] **3,717,879**

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[54] COLLAPSIBLE REFLECTOR

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[52] **U.S. Cl.** **343/915,** 350/292

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

[58] **Field of Search** 343/915; 350/292, 302

[56] **References Cited**

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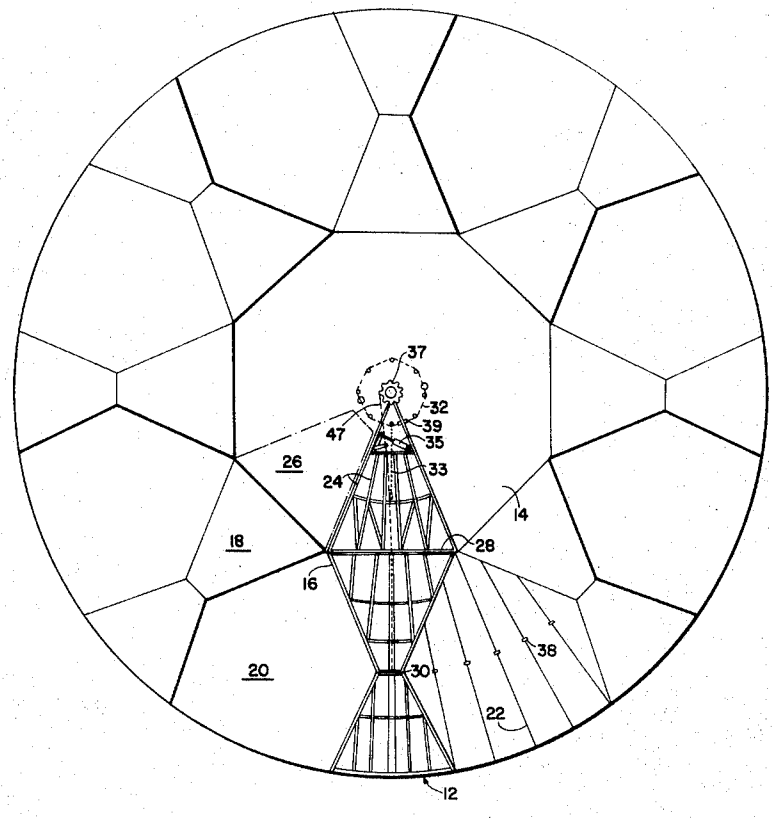
[57] **ABSTRACT**

This disclosure is directed to a collapsible reflector including a number of substantially rigid foldable panels covered with a reflecting surface spaced around a central hub and flexible reflecting material located between adjacent panels; the substantially rigid panels being folded adjacent the hub in a small volume for stowing and upon deployment providing the required stiffness and contour control for the reflector.

10 Claims, 6 Drawing Figures



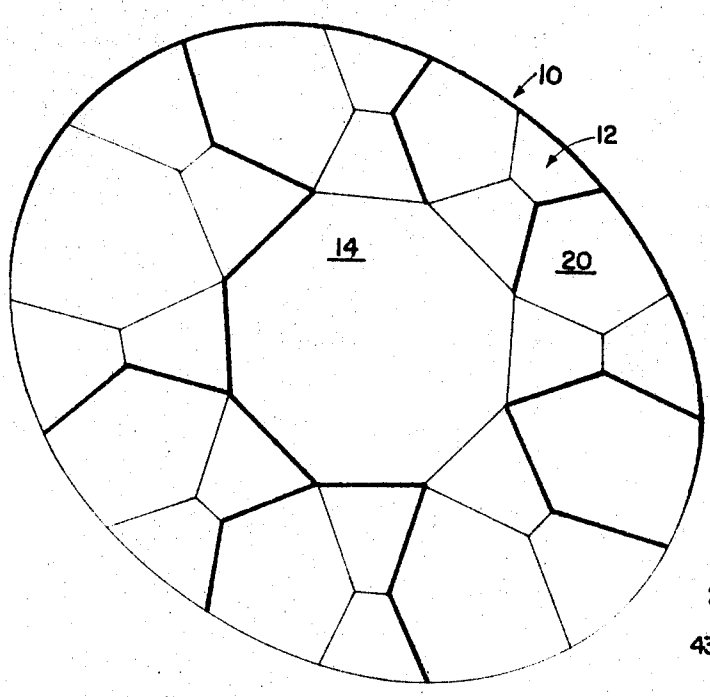


FIG. 1

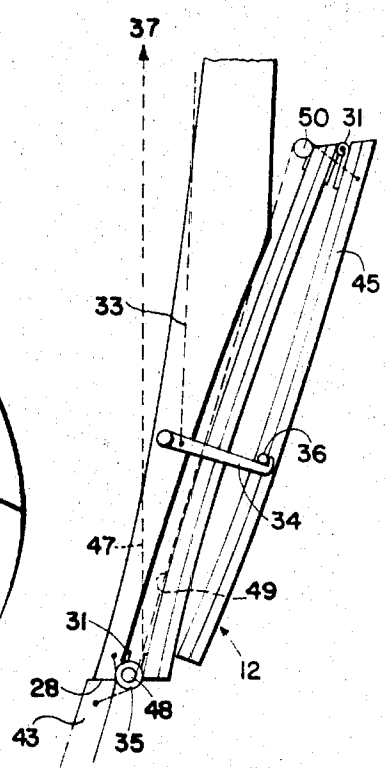
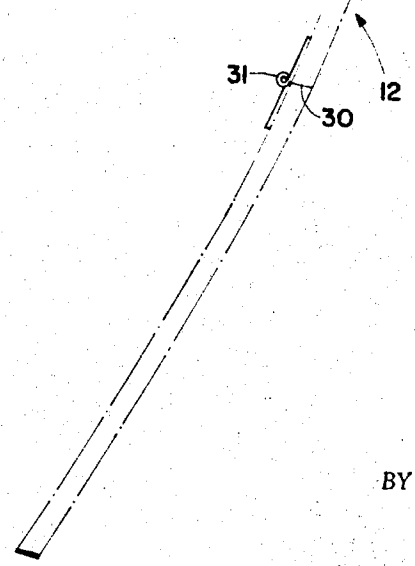


FIG. 3



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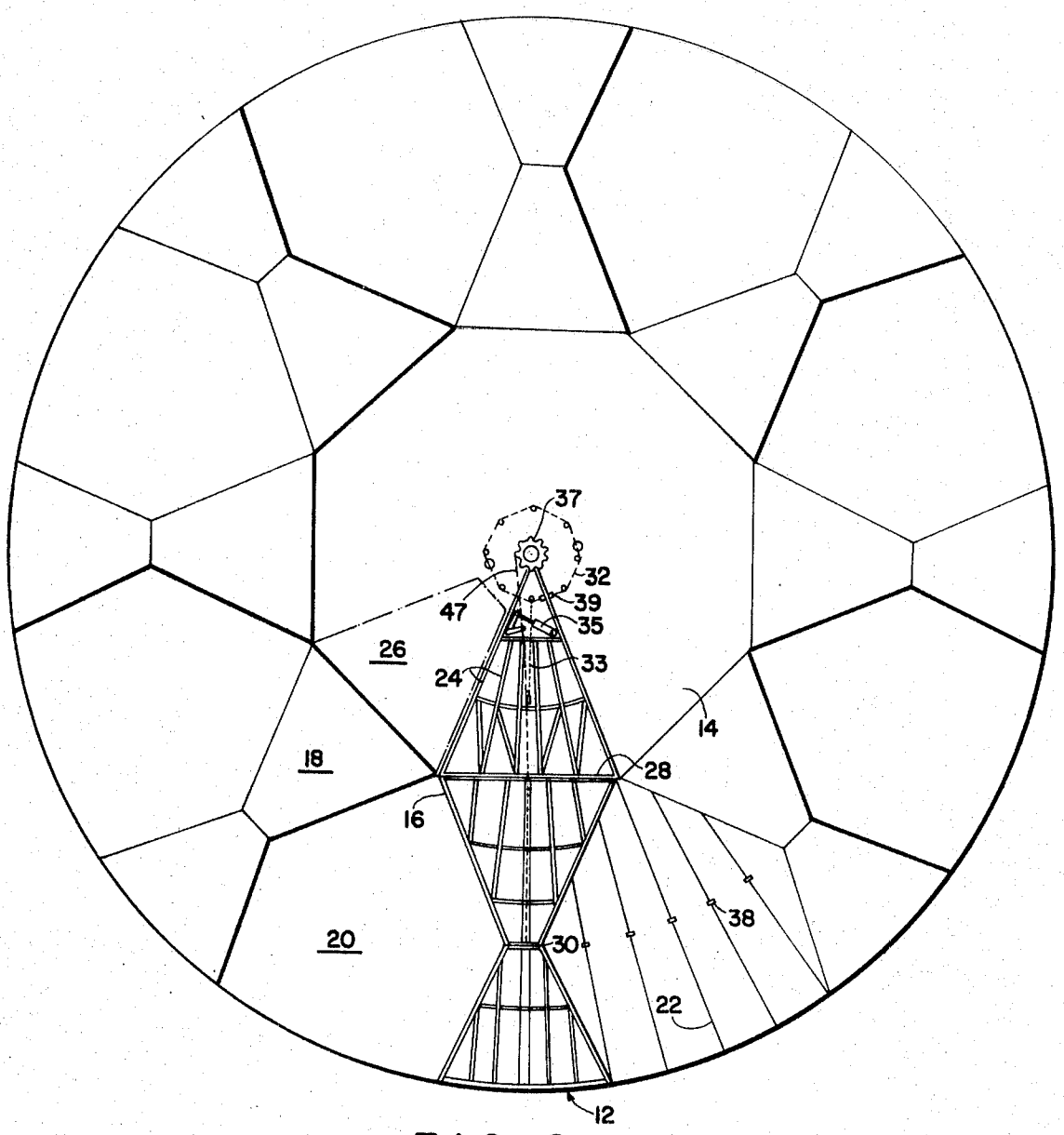

FIG. 2

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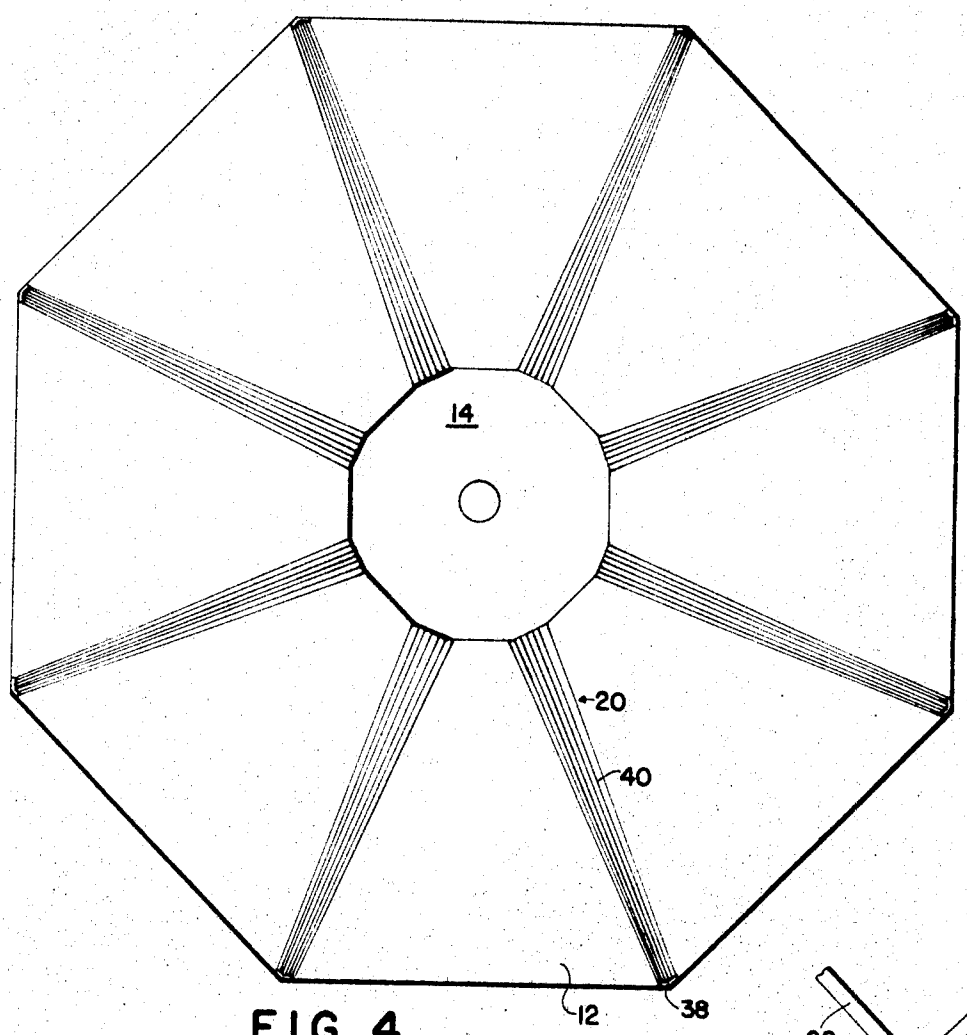

FIG. 4

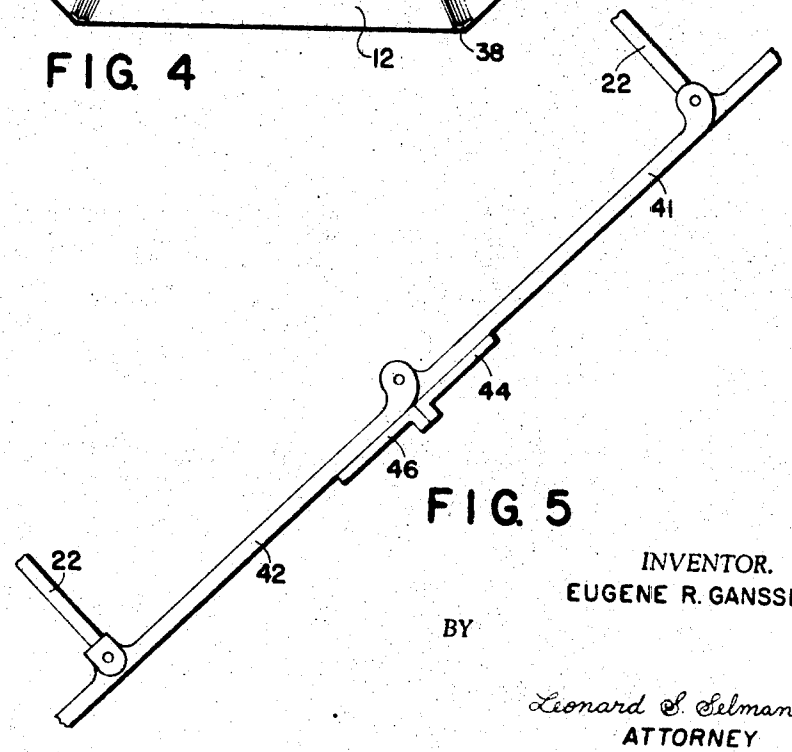

FIG. 5

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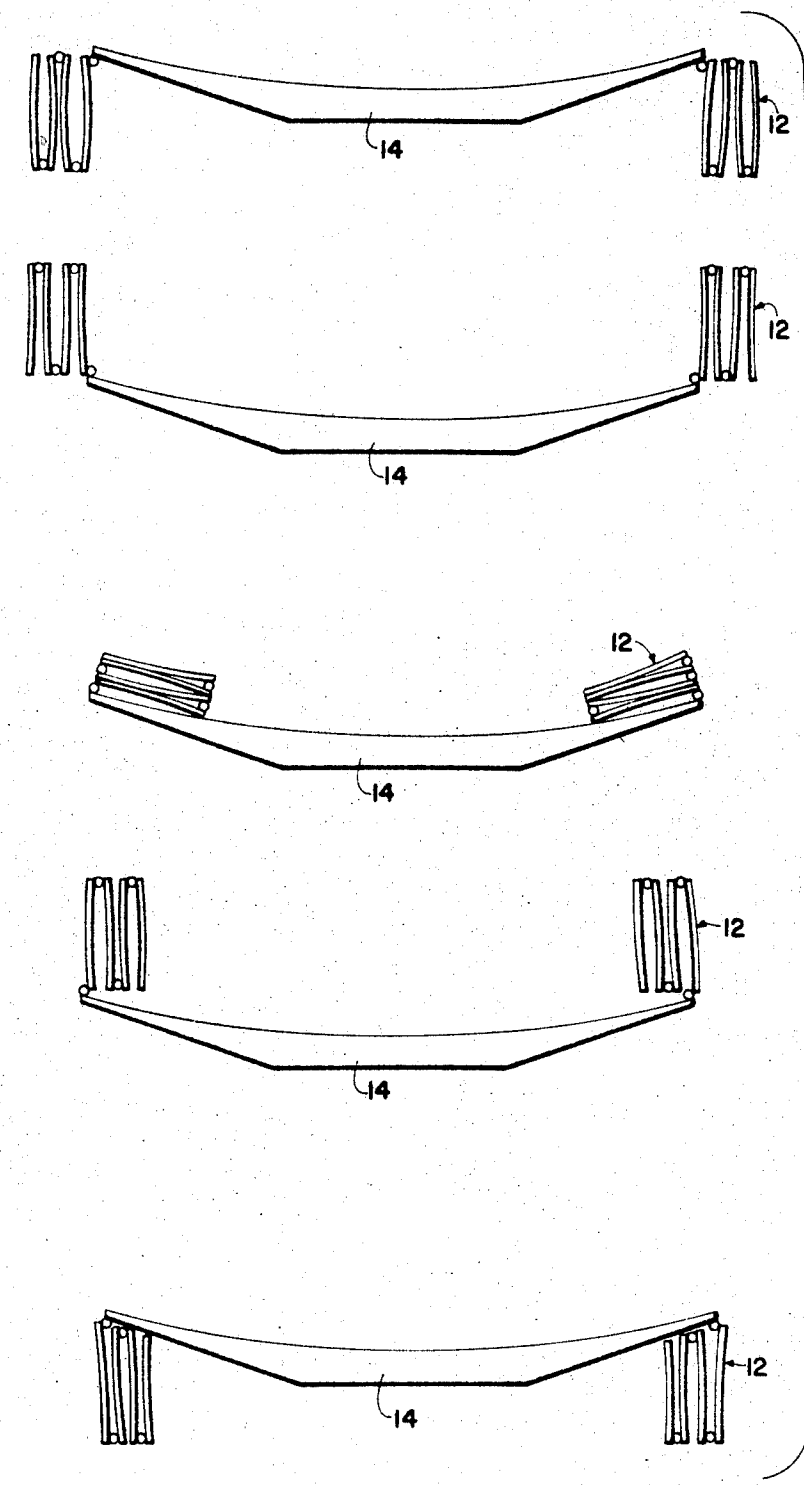

FIG. 6

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COLLAPSIBLE REFLECTOR

BACKGROUND AND SUMMARY OF THE INVENTION

The reflector of the present invention is intended for use as a means for reflecting radiant energy. The radiant energy may be either in the visible light spectrum or it may be microwave energy in which case the reflector may be used as an antenna assuming the shape of a paraboloid of revolution, for example. Since, for normal operating frequencies, the size of the reflector must be quite large, certain problems with respect to handling arise. For use in space, for example, it is desirable that such an antenna be foldable for storage in a launch vehicle and easily and automatically erectable when it reaches its destination.

The present invention not only overcomes the disadvantages of those antennas which are not suited for space application due to their construction using sliding parts and auxiliary means for erecting and locking the reflector in its erected configuration, but it also is superior to other known space antennas in that it is constructed to provide the necessary rigidity and contour control which is lacking in devices suggested heretofore.

The reflector of this invention takes the form of an automatically erecting surface of revolution which consists of a plurality of substantially rigid panels spaced around a central hub member and connected thereto by hinge means so that they may be folded adjacent the hub member for storage. The reflecting surface of the panels can be solid skin, a supported flexible reflecting material or any combination thereof. The panels are each articulated at approximately the center thereof and hinge means are provided so that the outer portion thereof may be folded adjacent the inner portion of the panel hinged to the hub member. Flexible reflecting material is located between the adjacent sets of panels. Contoured radial formers may be spaced across this area sufficiently often to provide an additional degree of contour control for the flexible reflecting material. The formers are each split and the parts hinged together to allow them to be folded adjacent the hub in a manner similar to that of the panels.

Deployment energy can be provided by springs, electric motors, hydraulic, pneumatic or pyrotechnic pressure, or other equivalent means. Restraining means are usually provided which are released at the moment it is most advantageous for the reflector to deploy itself in its operational configuration.

Accordingly, it is an object of this invention to provide a reflector which is collapsible into a minimum space, but which when erected has the required rigidity of structure to provide the optimum contour of the reflector when in operation.

Another object of this invention is to provide a reflector which is automatically erectable when it reaches a predetermined destination.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the apparatus possessing the construction, combination of elements and arrangement of parts which are exemplified in the following detailed disclosure, and the scope of the application of which will be indicated in the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of the reflector of this invention shown in its erected configuration;

FIG. **2** is a front view of the reflector partially broken away to show the internal structure;

FIG. **3** is a side view of the reflector shown in its collapsed condition and in dotted lines in its open position;

FIG. **4** is a back view of the reflector shown in its collapsed condition;

FIG. **5** is a segmented view of the outside support ring; and

FIG. **6** are schematic representations of some of the other possible configurations the reflector may have in its collapsed condition.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, there is shown in FIG. **1** a reflector **10** erected in operational configuration for use as a reflector of microwave energy. The reflector comprises a plurality of panels **12** spaced around a central hub **14**. The panels **12** consist of a substantially rigid frame composed of struts **16**, as shown exposed in FIG. **2**, and each panel is covered with a reflecting material **18**. The reflecting material **18** may be a relatively stiff copper or aluminum mesh, for example, or even a solid sheet of metal stretched across the frame. Between each alternating pair of substantially rigid panels **12** is a sheet of flexible reflecting material **20** which may be composed, for example, of a flexible mesh of expanded aluminum fixed to a sheet of Mylar. Contoured radial formers **22**, as shown in FIG. **2**, are spaced sufficiently often to provide the desired degree of contour control for the flexible reflecting material **20**.

The broken away portion of FIG. **2** shows the internal structure of the antenna in detail. The hub structure is substantially circular in shape and is composed of supports **24** covered by a solid skin **26** which is a reflecting material. In the preferred embodiment of the invention the hub has a diameter no larger than the diameter of the antenna in its collapsed condition. The panel struts **16** are hinged at joints **28** to the hub **14** and each panel **18** is articulated at approximately its midpoint and is hinged to itself at joints **30**. The articulation joints **30** as well as joints **28** comprise spring biased hinge means **31**, shown schematically in FIG. **3**, which supply energy for erecting the antenna. The formers **22** are also articulated at approximately their midpoint and the two portions of each former may similarly be joined by spring biased hinge means **31**. The formers are also hinged to the panels **12** and/or to the hub **14** where they intersect these structures.

Restraining means **32**, as shown in FIG. **2**, may comprise a simple link cable which with connecting cables **33** attach to a number of latches **34** which engage holding means **36** on the outer portions of panels **12**, more clearly shown in FIG. **3**. The cables may be released by detonating upon signal an exploding link **39** which will release latches **34** and allow the antenna to deploy itself to its operational configuration. Alternate means of restraining the panels include individual solenoid released latches, individual pyrotechnical releases, or push rod actuated latches, or the like. To control the

rate of deployment, a hydraulic damper **35** or equivalent structure is provided on hub **14** as shown in FIG. **2**. Other means of rate control include pneumatic dampers, escapement mechanisms or a centrifugal brake. Most reliable deployment will occur if all the panels **12** are synchronized to deploy at the same rate. This can be accomplished by a cable system which is constrained to deploy simultaneously by attachment to a common rotating fitting **37**, as shown in FIG. **2**, or other means such as synchronized motors, push rods, torque rods, or the like. The cable system consists of two cables attached to the panels **12**. Cable **47**, as shown in FIG. **3**, extends from the common rotating fitting **37**, through the hub, around pulley **35** and attaches to the inboard section **43** of the panels **12** thus constraining all inboard sections to the motion of the rotating fitting **37**. Cable **49** is attached at one end to the hub structure, passes around pulleys **48** and **50** and is attached at its other end to outboard section **45** of the panels **12**, thus constraining the motion of the outboard sections to that of the inboard sections. Deployment energy can be provided by springs such as the spring biased hinge means mentioned and additionally by electric motors or hydraulic, pneumatic, or pyrotechnic pressure or other means which will be apparent to those familiar with such deployment systems.

FIG. **4** of the drawing shows the collapsed reflector from the rear with all the panels **12** folded substantially flat upon themselves and against the hub as shown in solid lines in FIG. **3**. Between the panels **12** the flexible material **20** is shown forming radial pleats **40** and also folded upon itself. The formers **22** supporting the flexible material are also folded at joints **38** substantially flat against themselves and against hub **14**.

For optimum stiffness and contour control, the outboard tips of the formers **22** should be structurally interconnected by a peripheral set of links as shown in the enlarged fragmentary view of FIG. **5**. Each link **41** and **42** is pivotally connected to the formers **22** and to each other to allow the formers to come together when the reflector is collapsed with the flexible material **20** radially pleated between the pair of formers. To provide a positive restraint for the formers upon deployment of the reflector, a pair of stop members **44** and **46** are provided on links **41** and **42**, respectively. The two stop members will come into abutment with each other, as shown in FIG. **5**, as the formers spread apart to their proper deployed positions. It should be understood that other means such as support wires or expandable metal members might also be used interconnecting the former tips.

FIG. **6** is a series of schematic representations of some of the other possible configurations the reflector may have in its collapsed condition. These are only some of the variations of the invention which may become apparent from this disclosure. One other extremely important variation of the invention is the aspect that within a given allowable stowed diameter in a space vehicle, for example, further growth in reflector size is achievable by adding outboard sections to a panel such as panel **12** in a radial direction, i.e., going from a two section panel to a panel having three, four or more sections as shown in FIG. **6**.

Since certain changes may be made in the above apparatus without departing from the scope of the invention herein involved, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. A collapsible reflector adapted to automatically erect to the operational configuration of a surface of revolution, comprising:

a substantially circular hub member, said hub member having a diameter no larger than said reflector in its collapsed condition;

a plurality of substantially rigid folding panels spaced around said hub member and connected thereto by hinge means so that they may fold substantially flat against said hub member when said reflector is collapsed, each of said panels being articulated so that the outer portion thereof may also be folded substantially flat against the inner portion of said panels hinged to said hub member;

flexible reflecting material spaced between said panels; and

relatively stiffer reflecting material than said flexible reflecting material covering said folding panels, said flexible reflecting material being pleated when said reflector is in its collapsed condition in contrast to said relatively stiffer reflecting material on said panels which remains stretched sheet-like across said folding panels when said reflector is either collapsed or in its operational configuration, the rigidity of said folding panels providing the required stiffness and contour control for the reflector.

2. A collapsible reflector as described in claim **1** including a plurality of formers supporting said flexible reflecting material when said reflector is in its erected configuration, an inner portion of said formers being hinged to said hub member and folded substantially flat against said hub member when said reflector is collapsed and said formers being articulated so that an outer portion thereof may be folded substantially flat against the inner portion when said reflector is in its collapsed condition.

3. A collapsible reflector as described in claim **2** including linking members connecting the outer tips of said formers with one another to enhance the rigidity of said reflector, said linking members being foldable when said reflector is collapsed and having stop members thereon to aid them in unfolding to their proper connecting position as said reflector unfolds from its collapsed condition to its operational configuration.

4. A collapsible reflector as described in claim **1** including at least one other set of substantially rigid folding panels connected to the outer portion of said folding panels connected to said hub member.

5. A collapsible reflector as described in claim **1** wherein its operational configuration assumes the shape of a paraboloid of revolution.

6. A collapsible reflector as described in claim **1** wherein said hub member is covered with reflecting material.

7. A collapsible reflector as described in claim **2** including means for providing the force required to cause said reflector to automatically erect to its operational configuration from its collapsed condition.

8. A collapsible reflector as described in claim 7 including means for releasably restraining the reflector in its collapsed condition and means for releasing said restraining means to allow said reflector to unfold to its operational configuration.

9. A collapsible reflector as described in claim 8 wherein spring biased hinge means connect said folding panels to said hub and also connect the outer portion of said panels to the inner portion thereof to provide the force required to cause said reflector to automatically erect to its operational configuration.

10. A collapsible reflector as described in claim 9 including link cable means to releasably restrain said reflector in its collapsed condition and exploding link means which are exploded to release said restraining means to allow said reflector to erect to its operational configuration.

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