# United States Patent [19]

**Rushing et al.**

[11] **3,843,238**

[45] **Oct. 22, 1974**


[54] **REFLECTOR**


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[73] Assignee: **Westinghouse Electric Corporation,** Pittsburgh, Pa.



[22] Filed: **Sept. 27, 1972**

[21] Appl. No.: **292,706**

**Related U.S. Application Data**

[63] Continuation of Ser. No. 883,018, Dec. 8, 1969, abandoned.

[52] **U.S. Cl.** ..... **350/310,** 350/288, 272/65, 273/26 A

[51] **Int. Cl.** ..... **G02b 5/08**

[58] **Field of Search** ..... 350/288, 292, 293, 295, 350/310; 272/65; 273/26 A



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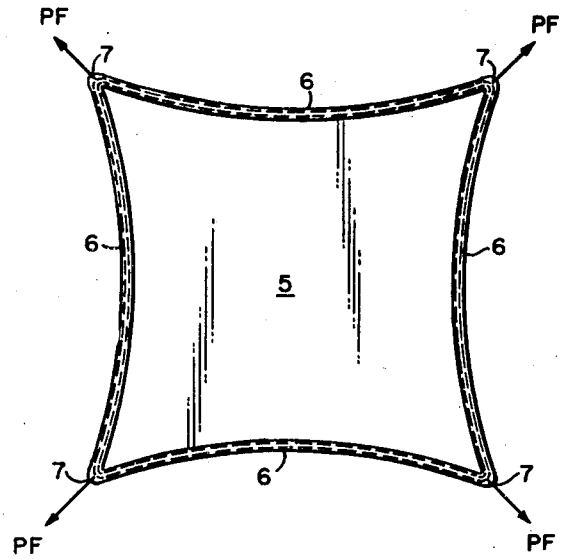
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[57] **ABSTRACT**

Described is a thin membranous reflector adapter by a curvilinear array of reinforcing edge support cables around its perimeter for stretched-flat tension-spring support at discrete coplanar apex locations spaced apart about such perimeter.


**5 Claims, 3 Drawing Figures**



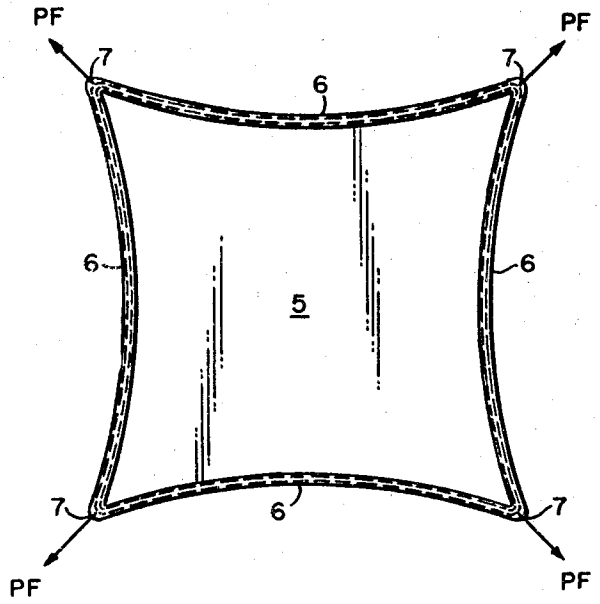

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Fig. 1.

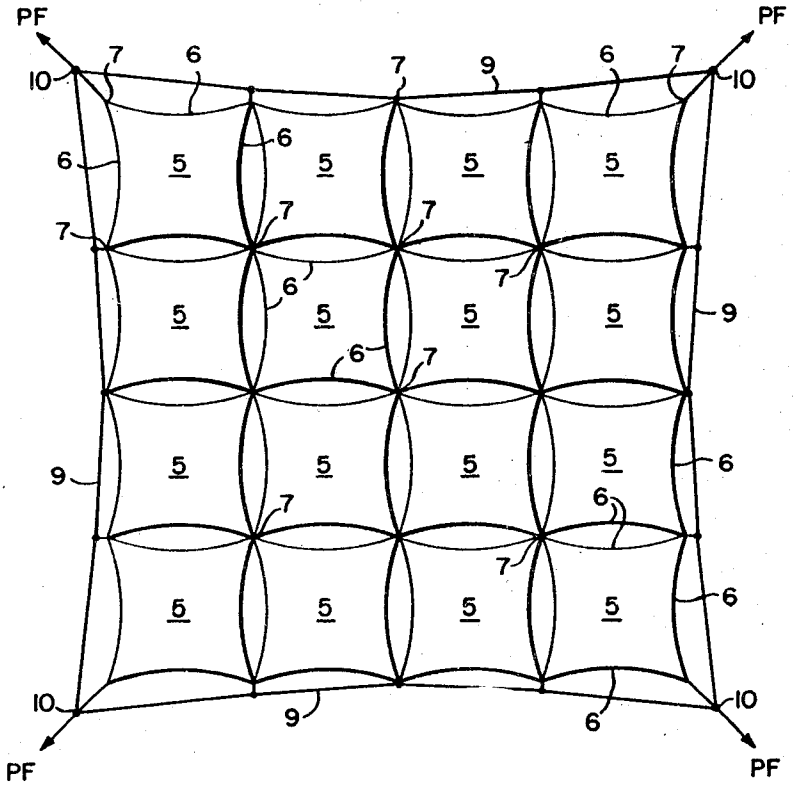

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Fig. 2.

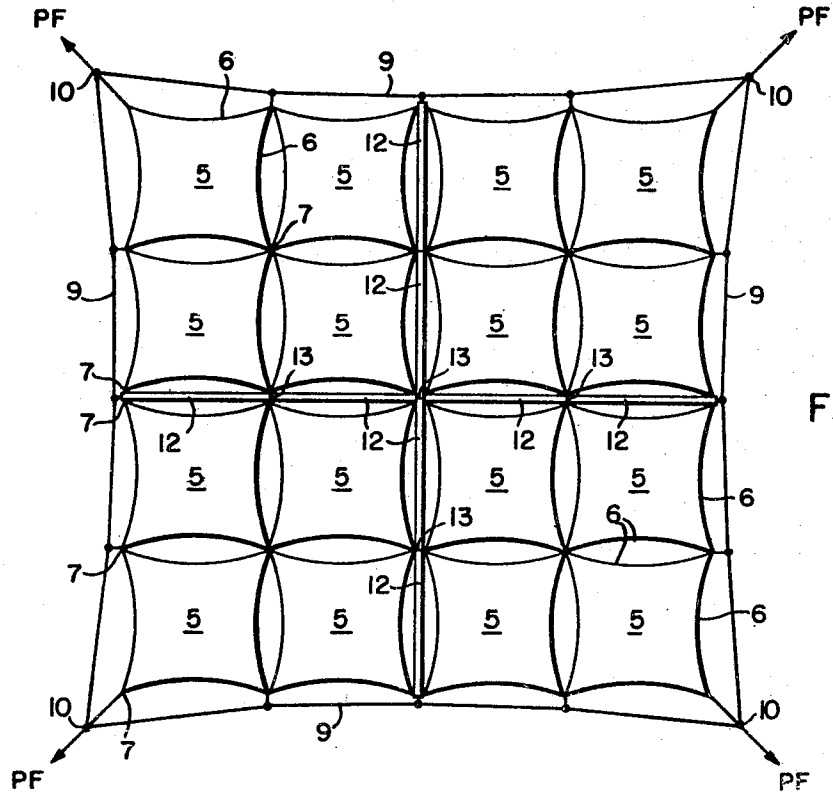

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Fig. 3.

# REFLECTOR

This is a continuation of application Ser. No. 883,018 filed Dec. 8, 1969 now abandoned.

## BACKGROUND OF THE INVENTION

1. Field of the Invention: Compactable, lightweight, planar reflectors.

2. Description of the Prior Art: It has been proposed heretofore to place a planar reflector in orbit above the earth to reflect energy from the sun onto selected earth areas for purposes such as lighting and heating. It also has been proposed by Frank C. Rushing et al., as described in copending U.S. patent application Ser. No. 883,016 filed concurrently herewith, to provide a lightweight reflector construction suitable for such solar reflection purpose which embodies a membranous reflector that is held in a stretched-flat state by a plurality of rigidized support arms at intervals about the perimeter of such reflector.

## SUMMARY

The present invention provides a membranous reflector which affords an ability to be stretched flat between coplanar support points about its perimeter by virtue of including a curvilinear array of reinforcing cables associated with such perimeter that transformer unidirectional pulling forces at apices around such cable array into bidirectional stretch forces in the membranous component of the reflector.

## BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** is a plan view of a reflector constructed in accord with the present invention.

FIG. **2** is a similar view of a second embodiment of the present invention; and

FIG. **3** is a similar view of a modification of the FIG. **2** embodiment.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the several Figures in the drawings, the reflector of the present invention comprises one or more flexible membranes **5** of relatively strong plastic material such as sold in thin film form several mils and less in thickness under the trade names Mylar and Kapton, for example, having thin reflective coatings thereon, such as by deposition of aluminum vapor. Such plastic membranes can be folded and/or rolled up for storage, as during compaction and deployment into space for subsequent unfolding, and can be drawn flat into a planar mirror configuration in which they are shown in the drawings.

In accord with the invention, the perimeters of the membranes are defined by and attached to a continuous array of flexible-cable-reinforced curvilinear edges **6** which merge at a plurality of apices **7** spaced at equal intervals around such perimeters. By exertion of equal outward pulling forces at the apices **7**, the reinforced curvilinear edges **6** transform such radial forces into biaxial stress of the membrane **5**. When all of such pulling forces are directed in a common plane, the membrane can be made to assume a stretched-flat or planar shape without significant surface distortion. Equal biaxial stresses (stresses in mutually perpendicular directions) of about 150 lbs. per square inch have been shown experimentally to be a threshold level required by commercially available membranes to remove wrinkles and



to overcome inherent nonflatness. By virtue of support of the membrane **5** via its cable-supported edges which in turn are supported at discrete points, apices **7**, greatly simplifies the construction of a large size, compactable, lightweight, planar mirror, which requires accuracy only in the support points rather than the continuous accuracy that would be required for direct continuous support around the membrane perimeter.

In the embodiment of FIG. **1**, a single reflector membrane **5** is employed to constitute the planar reflector, with its apices **7** supported by pulling forces indicated by arrows PF at discrete points about its perimeter. Such forces may be provided by tension springs (not shown) carried on the projecting ends of support arms (not shown) such as shown in aforementioned copending U.S. patent application Ser. No. 883,016 of Frank C. Rushing et al., which provides for the accurate coplanar location of such springs.

Where it may not be feasible to produce a large membrane surface with suitable accuracy, a modular construction of reflector membranes **5** can be employed as exemplified in the embodiments shown in FIGS. **2** and **3**. Each membrane module **5** will be within a size limit to permit its being accurately constructed, inspected, and adjusted.

In the FIGS. **2** and **3** embodiments, a square array of sixteen membrane **5** modules is exemplified with their adjacent apices **7** joined together and the outermost ones of the array being connected to flexible support cables **9** around the perimeter which meet at support points **10** to accept the pulling forces PF for erecting and stretching the module array into a flat multielement reflector, such pulling forces being delivered directly to the outermost ones of the modules **5** via the cables **9**, and thence throughout the array via the apices-joined cable-reinforced edges of the membrane **5** modules making up the array.

In such an assembly of cable-supported membrane **5** modules, compression members **12** may be employed to reduce loading on the surrounding cables **9**, as shown in FIG. **3**. By attachment of the apices **7** of adjacent membrane **5** module edges along such as the mid region of the square array in both of its mutually perpendicular directions of extension, a prestretched condition of such edges can be provided and maintained to relieve the cables **9** of the burden of performing such stretching function at such mid regions of the array; it being appreciated that such compression members may be employed elsewhere in the same or other array configurations when found to be of advantage. By interconnection of adjacent ends of the compression members **12** with hinges **13**, foldup and erection of array in a prescribed manner is enhanced.

Whereas each reflector membrane **5** may be composed of a single continuous sheet of plastic film material, suitably contoured at its edges and provided with cable reinforcement, it will be appreciated that such need not necessarily be the case, inasmuch as it might in certain cases more conveniently be composed of carefully proportioned segments suitably joined at their edges to provide a built-up membrane possessing reinforced properties at the segment joints.

Also, whereas each reflector membrane **5** and the modular arrays of same have been exemplified in the drawings as being of four-point support configuration, it should be understood that other curvilinear-edged

shapes having at least a three-point support configuration can be suitable.

We claim as our invention:

**1.** A reflector comprising,

a flexible reflector membrane having a perimeter defined by a continuous series of tension-reinforced concave edge regions which meet at spaced-apart apices support points.

**2.** A reflector assembly consisting of a sheet-like array of reflector modules each of which comprises,

a flexible reflector membrane having a continuous series of tension-reinforced concave edge regions defining its perimeter which meet at spaced-apart apices, and, in which,

the apices of adjacent reflector modules are joined together to transmit pulling forces therebetween.



**3.** The reflector assembly of claim **2,** wherein compression members extend between at least certain of said apices to maintain respective membrane edge regions in a prestretched state.

**4.** The reflector of claim **3,** wherein,

a number of such compression members extend in continuous series and are interconnected by hinges.

**5.** The reflector of claim **4,** wherein,

two such hinge-interconnected series of compression members are included which extend in mutually perpendicular directions when the array of reflector modules is in its erected drawn-flat state.

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