

(19)



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11)

EP 0 838 877 A2

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
29.04.1998 Bulletin 1998/18

(51) Int Cl.⁶: **H01Q 15/16, H01Q 1/28**

(21) Application number: **97308214.2**

(22) Date of filing: **16.10.1997**

(84) Designated Contracting States:
**AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC
NL PT SE**
Designated Extension States:
AL LT LV RO SI

(30) Priority: **24.10.1996 GB 9622022**

(71) Applicant: **MATRA MARCONI SPACE UK LIMITED**
Stanmore Middlesex HA7 4LY (GB)

(72) Inventors:
• **Clemmet, James Francis, Dr.**
Biggleswade, Bedfordshire SG18 8HH (GB)
• **Dunbar, Neil William**
Stevenage SG1 3NU (GB)

(74) Representative: **Waters, Jeffrey**
The General Electric Company, p.l.c.
GEC Patent Department
Waterhouse Lane
Chelmsford, Essex CM1 2QX (GB)

(54) Deployable reflectors

(57) An off-set paraboloidal reflector for a space-craft such as a communications satellite is made collapsible by mounting the reflective surface 9 on a number of ribs 8 which extend along generators of the

parent paraboloid and which are hinged eg. to a support rail 10, to enable the reflector 2 to be hinged into a small space adjacent to the space-craft, yet providing a large area when deployed.

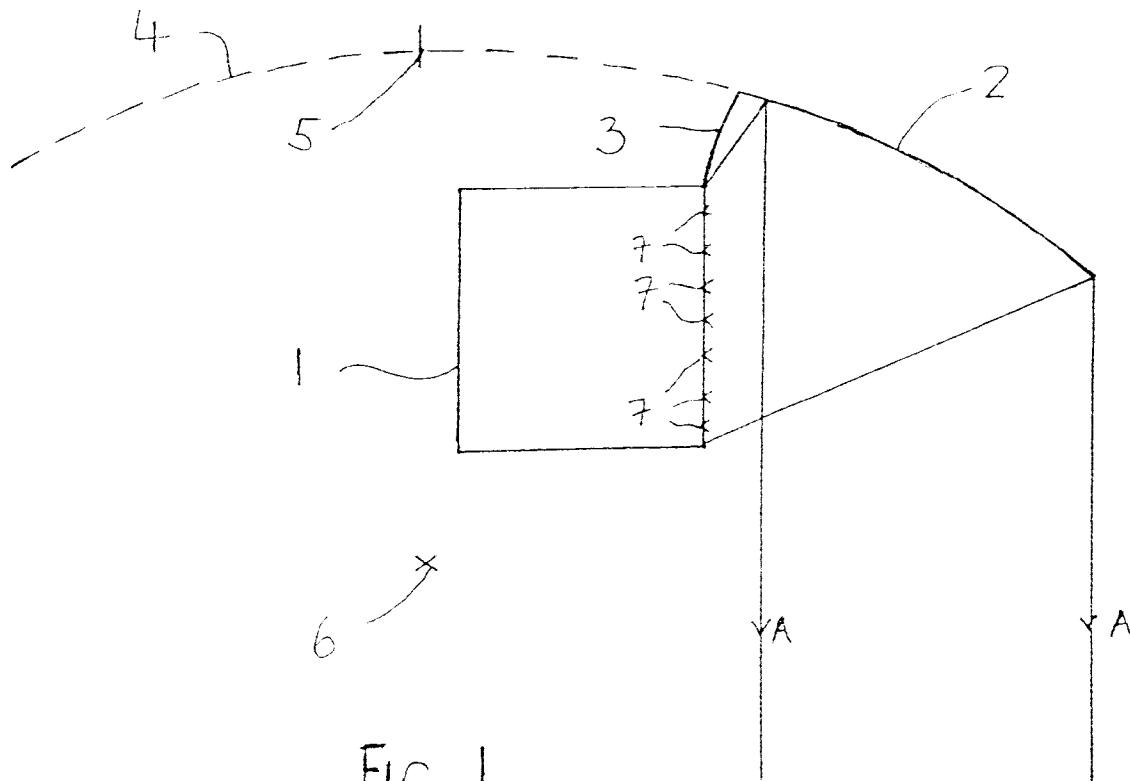


Fig 1

EP 0 838 877 A2

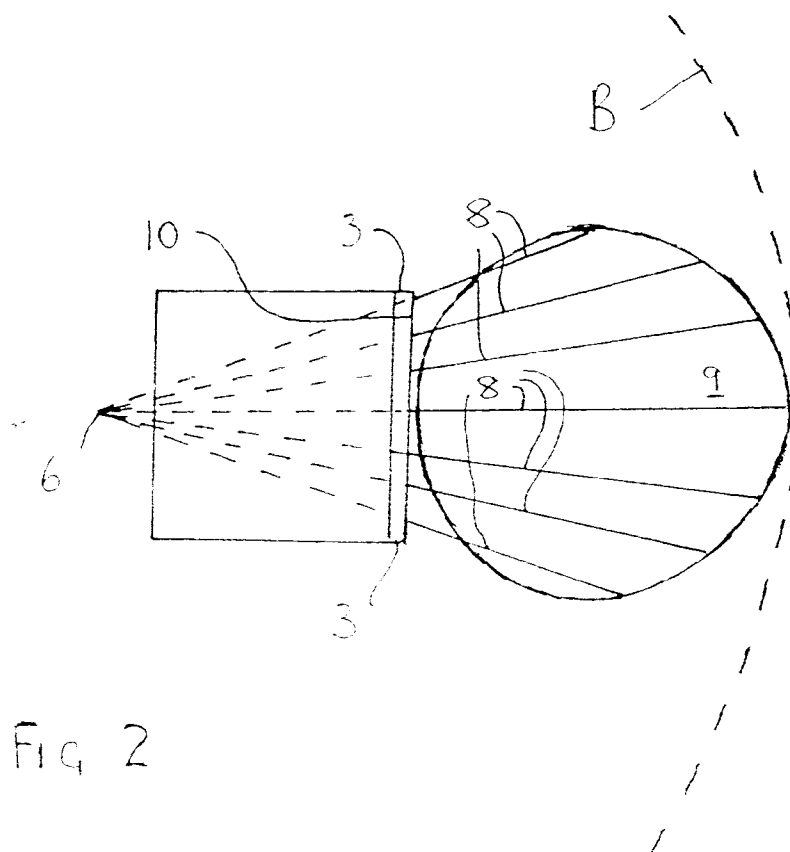


Fig. 2

Description

This invention relates to deployable reflectors.

The invention especially relates to deployable reflectors for communication satellites.

A typical reflector for a satellite would be a solid structure, constructed of honeycomb-type material, about 3½ metres in diameter. Any larger size would be difficult to stow prior to launch.

Such reflectors are used in some cases for mobile telephones, but a relatively large mobile telephone is required eg. briefcase size.

It is desired to be able to use smaller mobiles, but this can only be done by using larger reflectors. To achieve this, the reflector has to be unfurlable.

The most common type of unfurlable reflector is the umbrella type, in which the ribs are pivoted towards each other to provide a compact structure.

However, the nature of mobile telephony is that it is desired to have a large number of small overlapping regions on the ground, and this requires a large feed, perhaps as many as one hundred horns. This complicates an umbrella structure since too much of the reflective surface would be blocked by the feed.

Another type of unfurlable reflector is the expanding type in which a structure unfolds or expands to tension a mesh or membrane (GB-A-2 120 857), but this type tends to be expensive and heavy.

Inflatable structures have also been proposed, but these can go out of shape when thermal stresses or even solar winds are encountered if used in large sizes such as would be needed for the mobile telephone application.

The invention provides a deployable reflector (2) for a space-craft (1), comprising a flexible reflective surface (9) carried by expandable support means (8), characterised in that the surface carries at least one strip (11, 12) impregnated with or coated with a resin system which was cured when the reflective surface was in the shape desired for the reflective surface when unfurled, this strip being elastically deformed when the reflector is stowed.

When the reflector is unfurled, the reflective surface returns to its preformed shape. With such a design it is possible to provide a large area of reflective surface which can still be stowed to a convenient size for launch.

Preferably, the expandable support means comprises a plurality of ribs which, when the reflector is unfurled, extend along generators of a paraboloid over a region off-set from the centre of the paraboloid; and a hinge at one end of each of the ribs to enable the ribs to be pivoted to stow the reflector for launch.

The ribs may also have hinges at one or more points along their lengths, to enable even larger surfaces to be deployed without increasing the size when stowed.

The invention also provides a method of making the reflective surface of a deployable reflector for a space-craft, comprising the steps of applying a strip impreg-

nated or coated with a resin system to a material when in the shape desired for the reflective surface after unfurling, and curing the resin system while the material maintains that shape.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a simplified view of a communications satellite;

Figure 2 is a bottom plan view of a satellite shown in Figure 1;

Figure 3 is a view corresponding to Figure 1 when the ribs have been folded, and omitting the reflective surface;

Figure 4 is a side view corresponding to Figure 3;

Figure 5 shows an alternative form of hinged rib;

Figure 6 shows the rib of Figure 5 when folded up;

Figure 7 illustrates a method of making an area of the reflective surface of the reflector shown in Figures 1 and 2;

Figure 8 shows a practical embodiment of the reflectors shown in Figures 1 and 2, the reflecting surface not being shown;

Figure 9 shows the reflector of Figure 8 in the view corresponding to Figure 3; and

Figure 10 shows the reflector of Figure 8 with the reflective surface present.

Like reference numerals are given to like parts throughout all the drawings.

Referring to Figures 1 and 2, the communications satellite has the usual components such as solar panels, multiple antennas etc. but the only part illustrated in the drawings is one unfurlable reflector. Together with its feed horn, the reflector forms an antenna.

The satellite 1 carries the reflector 2 on a pair of arms 3 (one arm only could be used if desired) at the sides of the space-craft, and the reflector is an off-set parabolic reflector. This means that the reflecting surface 2 lies on the surface of a parabola 4, but does not include the central region around the centre of the paraboloid 5. Many unfurlable reflectors are actually of the latter type, but the problem with this is that the feed horn, which must be located at the focus 6 of the paraboloid would actually obscure the beam transmitted or received by the antenna. The off-set reflector 2 of the invention receives beams from a number of feed horns 7 mounted on the side of the satellite 1, the horns being

so aligned that the beams strike the reflector 2 in the direction taken had they been transmitted from the focus 6 of the paraboloid of which the off-set reflector forms a part. It will immediately be seen that this results in a parallel beam A-A being generated which would usually be directed downwardly at a region of the earth. For a communication satellite application, the satellite might well be positioned in a geostationary orbit. In fact there will not just be one beam A-A. In fact there will be many such beams, in order to create a pattern of spots on the earth surface which overlap to a sufficient extent to enable cells to be defined for mobile phone usage. A large number of beams is desired so that the same frequency can be used many times.

Such a communication satellite with an off-set reflector is known, but the invention is concerned with the facility to make very large reflectors, for example up to 12 metres in diameter, to permit effective coverage, for example, in underdeveloped regions, using only a small mobile telephone. Of course, the antenna may operate both for transmit and for receive.

This large size of reflector which folds up conveniently for launch, consists of a number of ribs 8, which carry a flexible reflective surface 9.

When Figures 1 and 2 are looked at together, it will be seen that each rib 8, while they are actually of different lengths, nevertheless each lies on the generator of the parent paraboloid. The term "generator" is used to mean a line which lies on the surface of the parent paraboloid and passes through its centre 5 and which when swept around in a circle such as dotted circle B, generates the paraboloidal shape. These ribs 8 are hinged to a rail 10 which is carried by the side arms 3.

Referring to Figures 3 and 4, when the satellite is in a stowed condition, the ribs 8 are hinged in towards the space-craft 1, and do not greatly increase the footprint of the satellite 1 in the direction of ascent of the rocket. In Figures 3 and 4, the reflective material 9 is not shown for the sake of clarity. The ribs 8 are held remote from the rail 10 by some securing system (not shown) which is released when the deployment mechanism is operated.

Because the ribs 8 all form part of a generator, which of course has a parabolic shape, then there need be only one parabolic shaped tool from which to manufacture the ribs.

The reflective surface 9 may be mesh or membrane, and may consist of a metallised plastics material reinforced with fabric. If mesh, the reflective material may be knitted out of wire such as gold plated molybdenum.

If desired, tensioners may be provided behind the reflective surface 9 and connected to a structure (not shown) mounted on the ribs 8. One particularly attractive method of manufacturing the reflective material will now be described as reference to Figure 7. Figure 7 represents a segment between two adjacent ribs 8 in the view shown in Figure 2. Once again, it will be apparent that the segment lies on a segment of the surface of the

parent paraboloid. The reflective surface which consists of metallised plastics such as Kapton (RTM) reinforced with fabric such as Kevlar (RTM), which is not impregnated with any curing agent, is laid over a tool shaped like a segment of the surface of the paraboloid corresponding to the angular separation of two adjacent ribs 8. Then strips such as fabric strips, which are impregnated with or coated with a curing system, are laid over this material which has been pressed against the segment-shaped former. A number of transverse strips 11 are first of all laid across the segment, and then radial strips 12 are laid over these strips 11. While the shape is being held against the former, curing is made to take place, which means that the segment now has a pre-formed shape corresponding to the desired surface of the segment of the surface of the paraboloid.

The same is done for each of the spaces between ribs 8 shown in Figure 2, and it will be noted that only one former is required, the only difference being that different sections need to be laid along the former at different starting positions. The cured strips are now secured to the ribs 8, thereby producing the desired off-set paraboloidal shape. When the hinged ribs are folded for stowage, the reflective material is folded and the cured strips are elastically deformed.

The result is that when the reflector is deployed in use, the cured strips spring back to the position in which they were cured, thereby producing accurately the desired shape of reflector.

As an alternative, all the regions between the ribs 8 could be formed together, although the same transverse layout of strips would be used.

Referring to Figure 5, even larger reflectors may be created by the simple expedient of providing intermediate hinges 13, 14 along the length of each rib, only one of which is shown in Figure 5, so that the framework may be folded as in Figure 6 to make the system compact for launch.

Any extension system for the ribs 8 may be used, for example, springs, or for example the Applicant's powered hinge described in our European Patent Application No. 505134.

An advantage of providing the feed horn 7 directly on one side of the satellite is that losses in the signal to the feed horns, which can be in the region of kilowatts, is minimised. The antenna can operate in the L-band.

While the above description has referred to only one deployable reflector, the space-craft may have other deployable reflectors of the same kind as shown in the drawings.

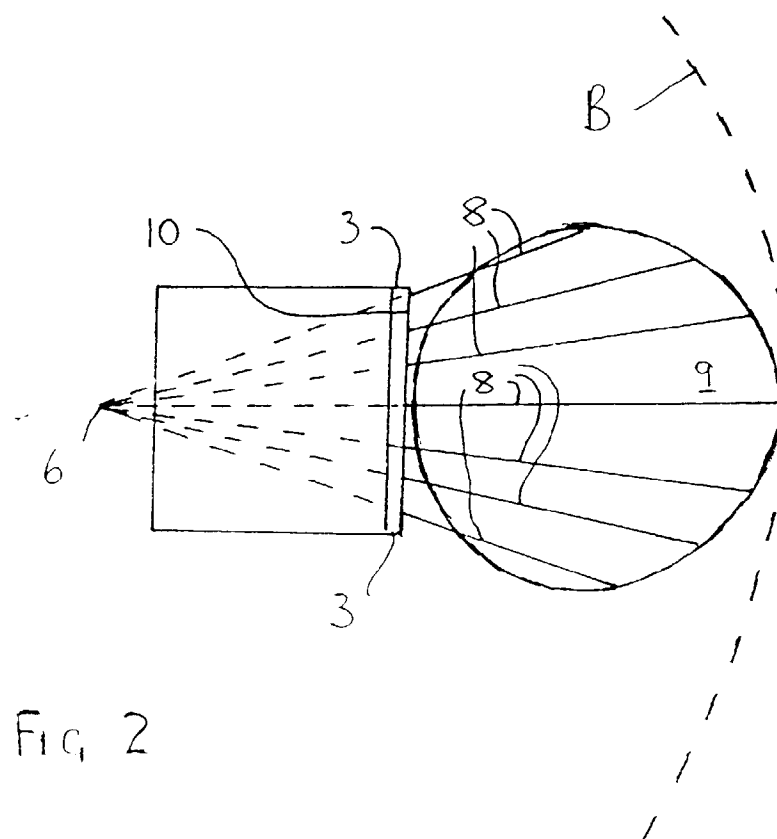
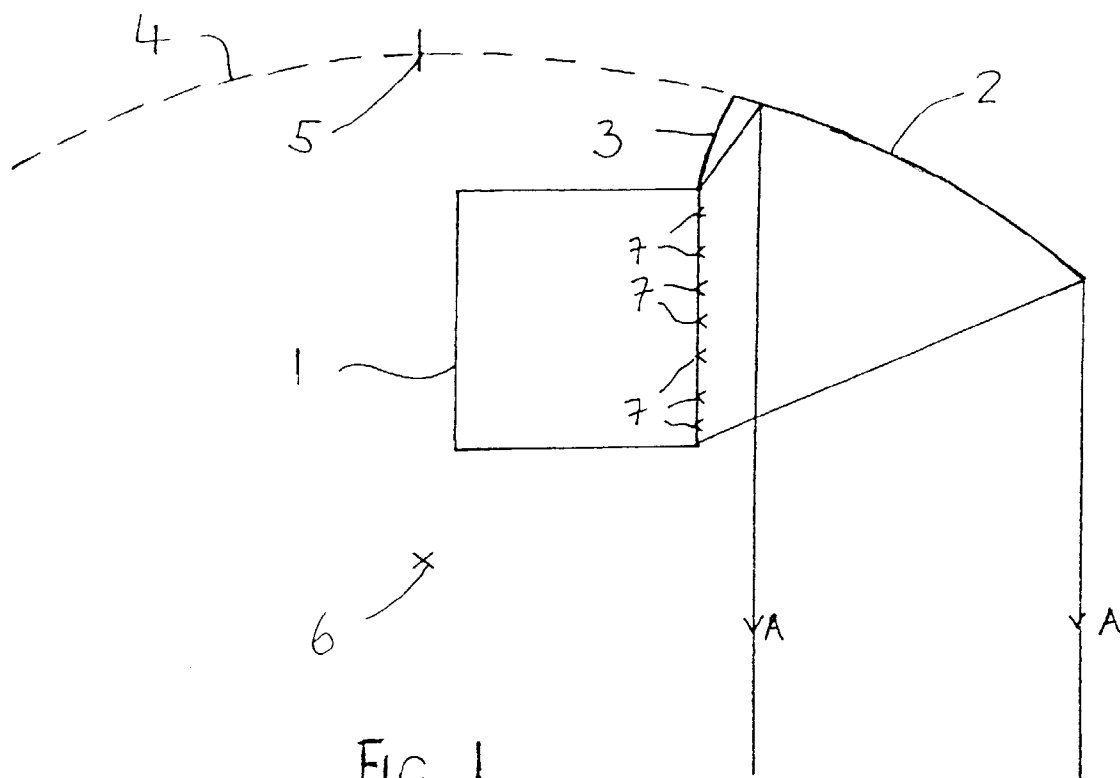
A practical embodiment of the folding ribs is shown in Figures 8 to 10. The feed horn means 7 is shown schematically in Figure 8 but is not shown in Figure 9. In place of the arms 3, a mounting structure 15 is shown.

Among the advantages of the illustrated arrangements are light weight, elimination of fragile folding mechanisms, accurate surface control through shaped ribs, and minimum stowed volume. If desired, all ribs

could be formed from the same tool.

Claims

1. A deployable reflector (2) for a space-craft (1), comprising a flexible reflective surface (9) carried by expandable support means (8), characterised in that the surface carries at least one strip (11, 12) impregnated with or coated with a resin system which was cured when the reflective surface was in the shape desired for the reflective surface when unfurled, this strip being elastically deformed when the reflector is stowed. 5
2. A deployable reflector as claimed in claim 1, characterised in that the strip (11, 12) includes fabric material. 10
3. A deployable reflector as claimed in claim 1 or claim 2, characterised by the inclusion of two strips (11, 12) which intersect transversely. 15
4. A deployable reflector as claimed in any one of claims 1 to 3, characterised in that at least a part of the surface (9) is held against a former when the strips (11, 12) are applied and cured. 20
5. A deployable reflector as claimed in any one of claims 1 to 4, characterised in that the reflective surface (9) is metallised plastics material reinforced with fabric. 25
6. A deployable reflector as claimed in any one of claims 1 to 5, characterised in that the expandable support means comprises a plurality of ribs (8) which, when the reflector is unfurled, extend along generators of a paraboloid over a region off-set from the centre (5) of the paraboloid, and a hinge at one end of each of the ribs to enable the ribs to be pivoted to stow the reflector (2) for launch. 30
7. A deployable reflector as claimed in claim 6, characterised in that the ribs (8) fold in towards an adjacent face of the space-craft (1). 35
8. A deployable reflector as claimed in claim 6 or claim 7, characterised in that at least some of the ribs (8) have hinges (13, 14) between their ends. 40
9. A deployable reflector as claimed in any one of claims 6 to 8, characterised in that the hinges are connected to the space-craft structure (1) by an extension. 45
10. A method of making a reflective surface of a deployable reflector (2) for a space-craft, characterised by the steps of applying a strip (11, 12) impregnated with or coated with a resin system to a material when in the shape desired for the reflective surface (9) in use after deployment, and of curing the resin system while the material maintains that shape. 50
11. A method as claimed in claim 10, characterised in that the strip (11, 12) applied includes fabric material. 55
12. A method as claimed in claim 10 or claim 11, characterised in that two strips (11, 12) which intersect transversely are applied.
13. A method as claimed in any one of claims 10 to 12, characterised in that the material is held against a former when the strips (11, 12) are applied and cured.
14. A method as claimed in any one of claims 10 to 13, characterised in that the material is plastics material reinforced with fabric and coated with a metallic layer to make it reflective.



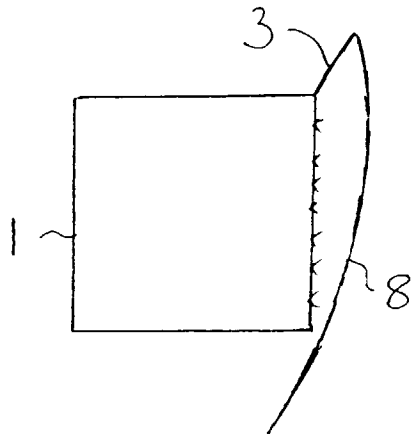


Fig 3

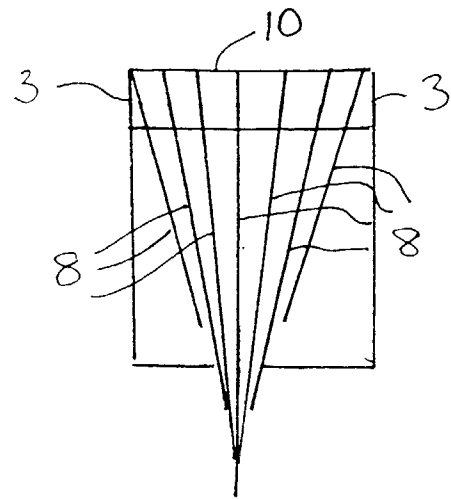


Fig 4

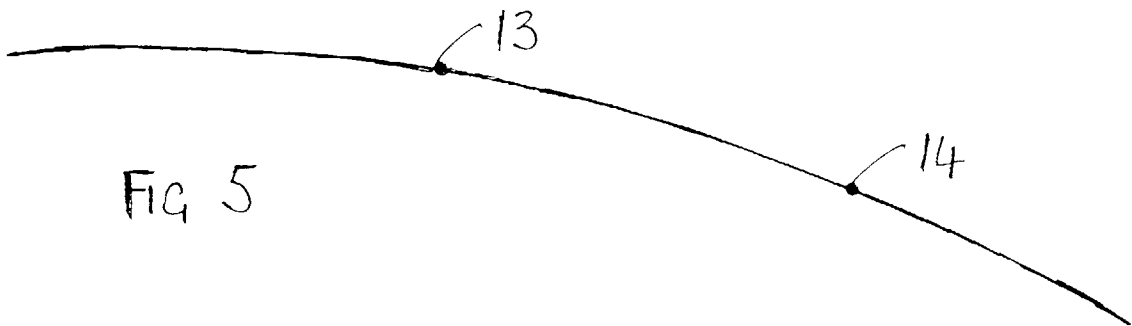


Fig 5



Fig 6

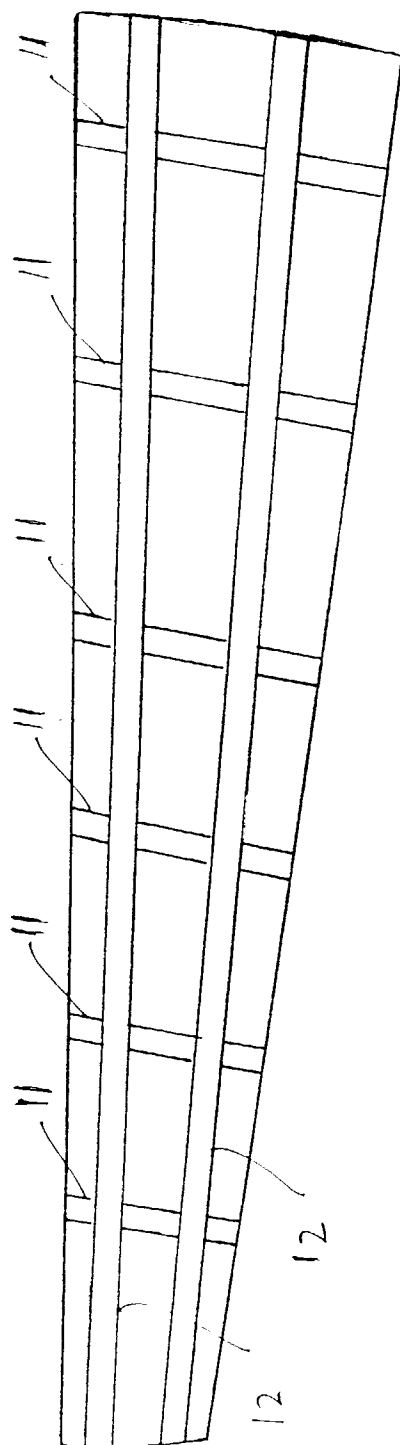


Fig 7

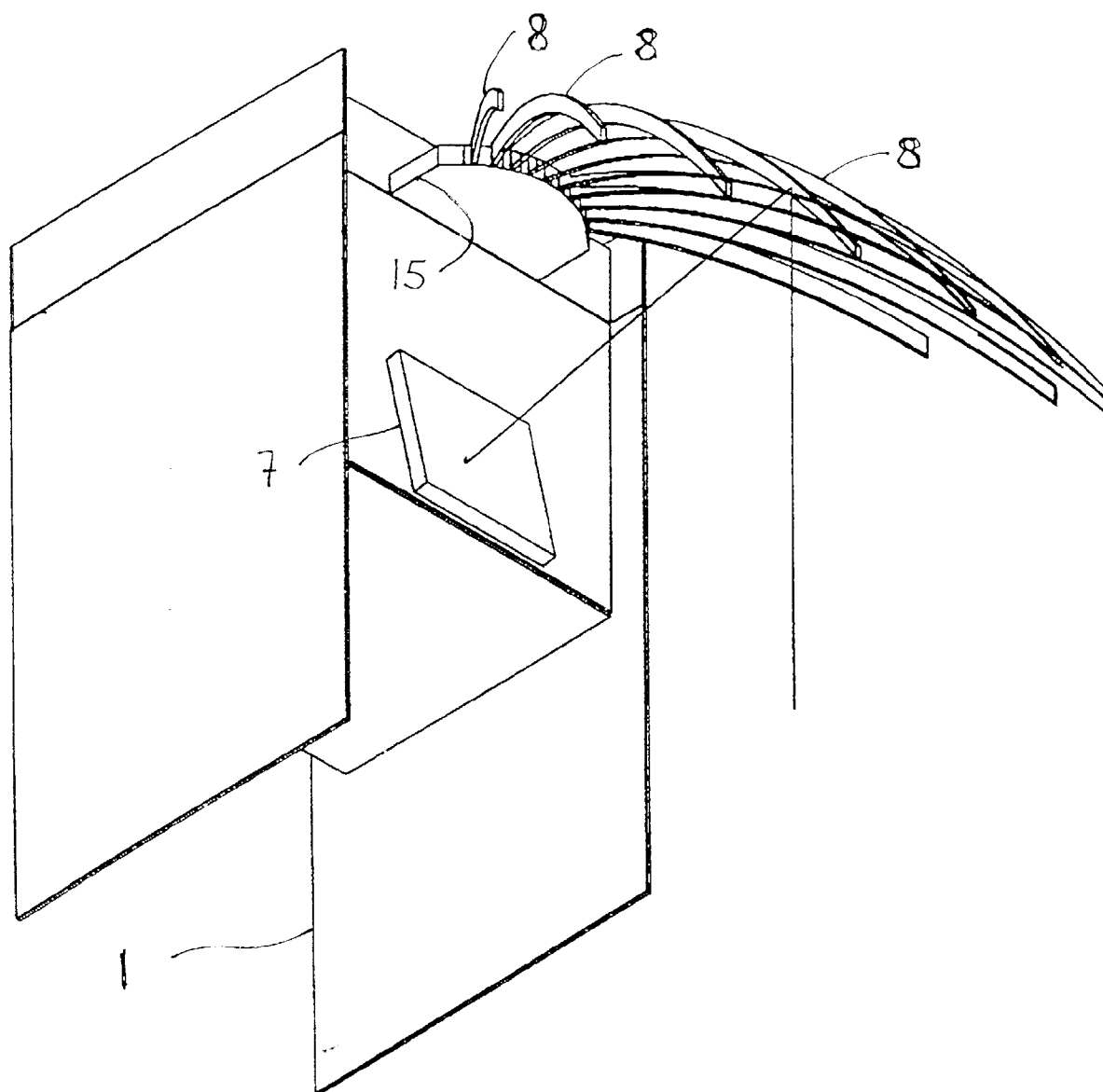


Fig 8

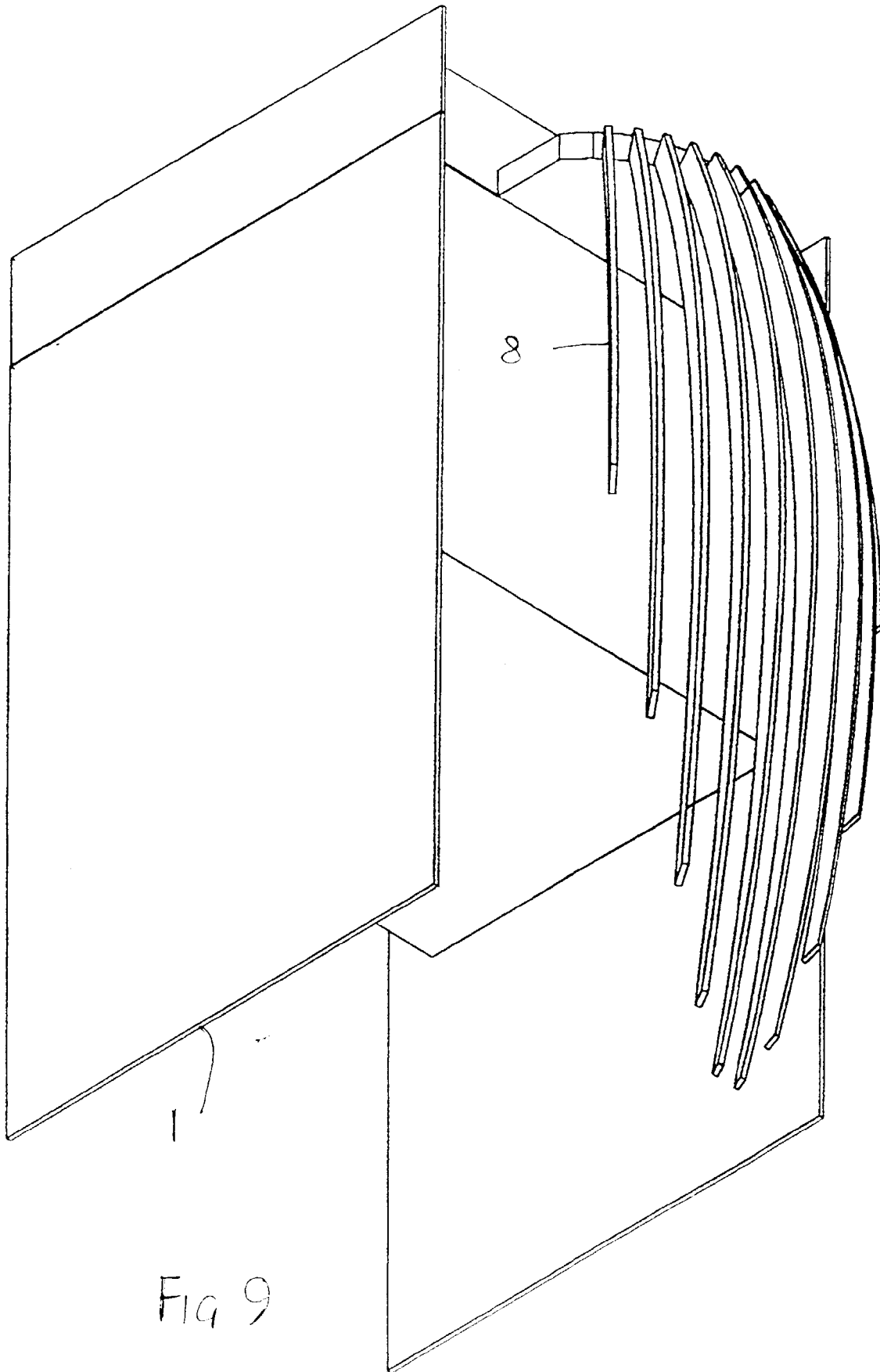


Fig 9

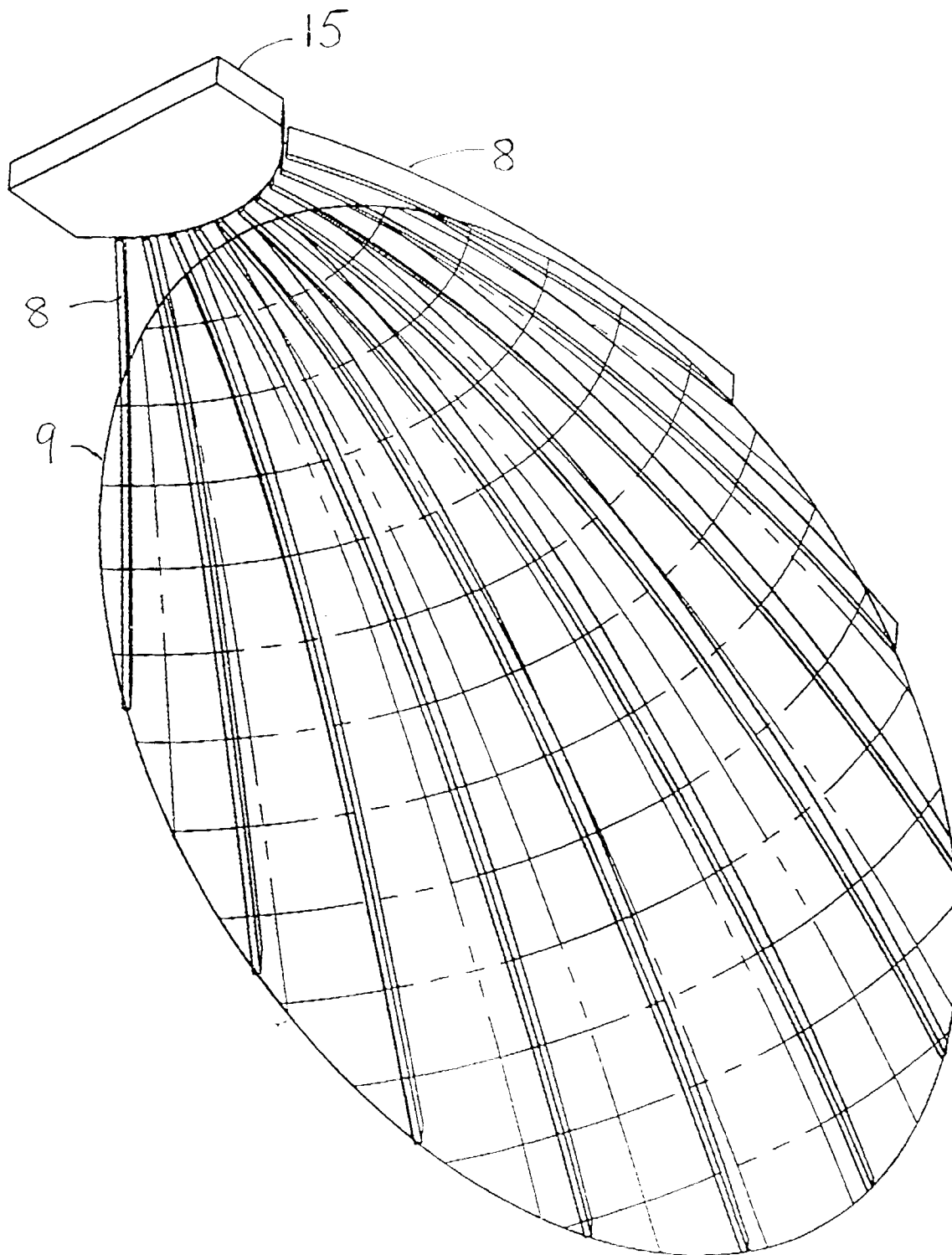


FIG 10