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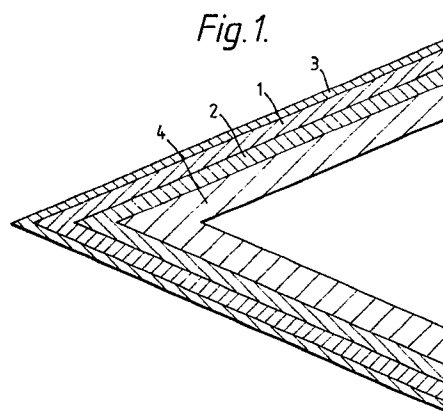
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⑤④ **Radomes.**

⑤⑦ A radome of which the wall comprises a single strength-providing layer made of reinforced plastics material and a syntactic foam layer having a dielectric constant substantially matching that of the reinforced plastics material layer, the thickness of said wall being substantially equal to one half the wavelength of the radiation which is to pass through the radome.



## Description

### RADOMES

This invention relates to Radomes and production thereof.

There are currently three types of radomes used on flight vehicles, ie missiles and aircraft, and these vary according to the flight requirements of the vehicle. The three types are:

1. solid wall radomes

2. sandwich radomes which can be designed using a number of cores and skins

3. thin skin radomes

Typical solid wall radomes are usually of the half wave-length design and vary in thickness according to the dielectric constant of the material and the wavelength of operation. Typical thicknesses would be 8mm at X-band and about 5mm at J-band with material of dielectric constant of about 4 such as can be obtained from a composite of approximately 55% glass fibre and 45% resin matrix by weight. These radomes can be made by hand lay up, autoclave moulding, filament winding and resin transfer moulding. This type of radome is usually selected where a high microwave transparency performance and structural capability are required such as in military fighter and terrain following aircraft and missile applications.

The most common version of a Sandwich Radome is the A-sandwich consisting of a lightweight core between two skins, the core thickness being nominally a quarter of a wavelength thick for narrow-band applications but of a compromise thickness for wideband applications. Typically at X-band the core thickness will be about 8mm with skins of thickness approximately 0.75mm and reinforcement content of around 55% glass fibre by weight as with the solid wall radome. The core of the sandwich is usually either a honeycomb or an expanded foam with a low dielectric constant, although there are applications which use a syntactic foam core of somewhat higher dielectric constant.

Thin Skin Radomes are relatively unsophisticated and are basically single skins which are thin compared with the wavelength of operation. Typically, for covering an X-band radar, the skin thickness would be not greater than 1.5mm which renders them of limited application due to their poor structural capabilities.

Whilst some radomes on missiles need to be protected against rain erosion damage, this is not usually the case and a requirement for protection arises mainly in aircraft nose and wing leading edge applications. Rain erosion protection is normally provided by an elastomeric coating having a uniform thickness of about 0.3mm. This thickness is governed by the minimum thickness required to give protection at the same time as preserving the structural strength and/or the electrical transparency characteristics. Rain erosion coatings have slightly different dielectric constants to traditional laminates and, whilst their presence does not normally lead to a structural problem on solid wall

radomes it can lead to a severe problem on sandwich radomes where the coating thickness of about 0.3mm has to be deducted from the outer skin thickness of about 0.75mm to maintain the electrical balance of the sandwich. This results in a significant thinning of the outer skin of the sandwich radome, weakening it structurally and encouraging failure of the skin/core bond during flight under heavy rain conditions.

By and large, and certainly up to X-band, solid wall half wavelength radomes are structurally over-strong and, as a result, are unnecessarily heavy, a penalty which has to be accepted to achieve satisfactory microwave performance. Radomes tend to fail structurally by buckling.

This invention is intended to provide a half wavelength radome in which sufficient fibre is placed in the axial mode to prevent buckling and in the longitudinal mode to give adequate strength in this direction thus minimising any redundant reinforcement.

According to one aspect of the present invention, there is provided a radome of which the wall comprises a single strength-providing layer made of reinforced plastics material and a syntactic foam layer having a dielectric constant substantially matching that of the reinforced plastics material layer, the thickness of said wall being substantially equal to one half the wavelength of the radiation which is to pass through the radome.

According to another aspect of the present invention there is provided equipment for transmitting and/or receiving electromagnetic radiation and a radome through which said radiation passes and of which the wall comprises a single strength-providing layer made of reinforced plastics material and a syntactic foam layer having a dielectric constant substantially matching that of the reinforced plastics material layer, the thickness of said wall being substantially equal to one half the wavelength of the radiation which is to pass through the radome.

Preferably said wall comprises an outer layer of elastomeric material for rain erosion protection of the radome.

Reference will now be made by way of example to the accompanying drawing in which:-

Figure 1 is cross-sectional diagram of a male mould for use in the invention, and

Figure 2 is a cross-sectional diagram of a female mould for use in the invention.

Referring to the figures following impregnation and cure, a syntactic foam mixture 1 having the same dielectric constant as the reinforcing element is applied to a base composite surface 2 to a depth which will allow it to be machined to give a total thickness which is about 0.5mm or more below that of the half wavelength design thickness. The remaining 0.5mm or more is built up by the application of an elastomeric rain erosion coating 3 which is then of increased thickness compared with that conventionally employed. The thickness of the rain erosion

coating is only governed by its dielectric loss properties which will cause a marginal drop in transmission efficiency. Replacing unnecessary reinforcement and resin by syntactic foam reduces the weight to the lowest possible value consistent with structural viability with minimal change in the electrical performance.

As shown in figure 1, which is given by way of example only, the fibre can be laid up on a male mould 4 in a unidirectional manner to avoid any crimping which occurs when using woven material. It can be laid up as a unidirectional weave or it can be filament wound, the latter being less desirable as it leads to a high glass content which, whilst otherwise acceptable, raises difficulties in providing syntactic foam of suitably high matching dielectric constant. Furthermore, the use of filament winding for application of the fibre has to be followed by machining away excess fibre laid in the longitudinal direction whereas, using the other techniques and this invention, machining the glass/resin composite can be avoided altogether.

Alternatively, as shown in figure 2, the basic fibre-resin laminate could be laid up in a female mould 5 and the syntactic foam mixture 1 applied to the inside of the component followed again by machining to a size to allow for the application of the rain erosion coating to the outside.

Using the techniques described above, it may be possible to achieve:-

1. A method of making radomes where the fibres are placed to maximum effect and no machining of the structural element is required.
2. A radome which has the adequate strength and an electrical performance similar to that of a solid half wavelength radome but which is lighter.
3. A method whereby fine tuning of the radome wall can be achieved without interfering with the resin/glass composite, thus preserving the integrity of the structural element.

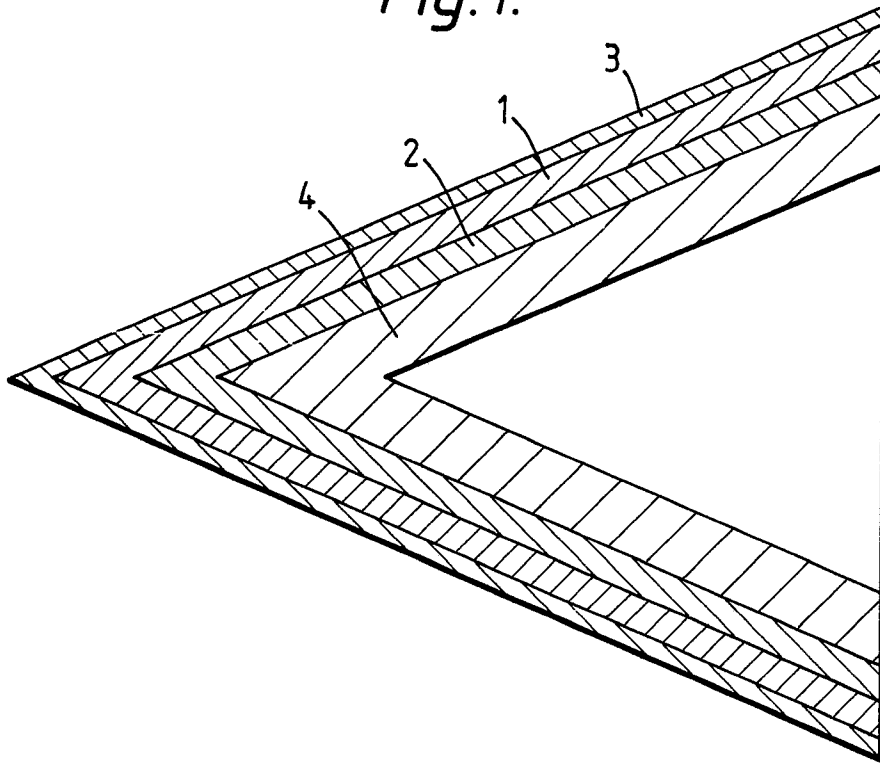
## Claims

1. A radome of which the wall comprises a single strength-providing layer made of reinforced plastics material and a syntactic foam layer having a dielectric constant substantially matching that of the reinforced plastics material layer, the thickness of said wall being substantially equal to one half the wavelength of the radiation which is to pass through the radome.
2. A radome according to claim 1, wherein said wall comprises an outer layer of elastomeric material for rain erosion protection of the radome.
3. A radome according to claim 1 or 2, wherein the foam layer is outside the reinforced plastics material layer.
4. A radome according to claim 1 or 2, wherein the foam layer is inside the plastics material layer.
5. A radome substantially as hereinbefore described with reference to the accompanying

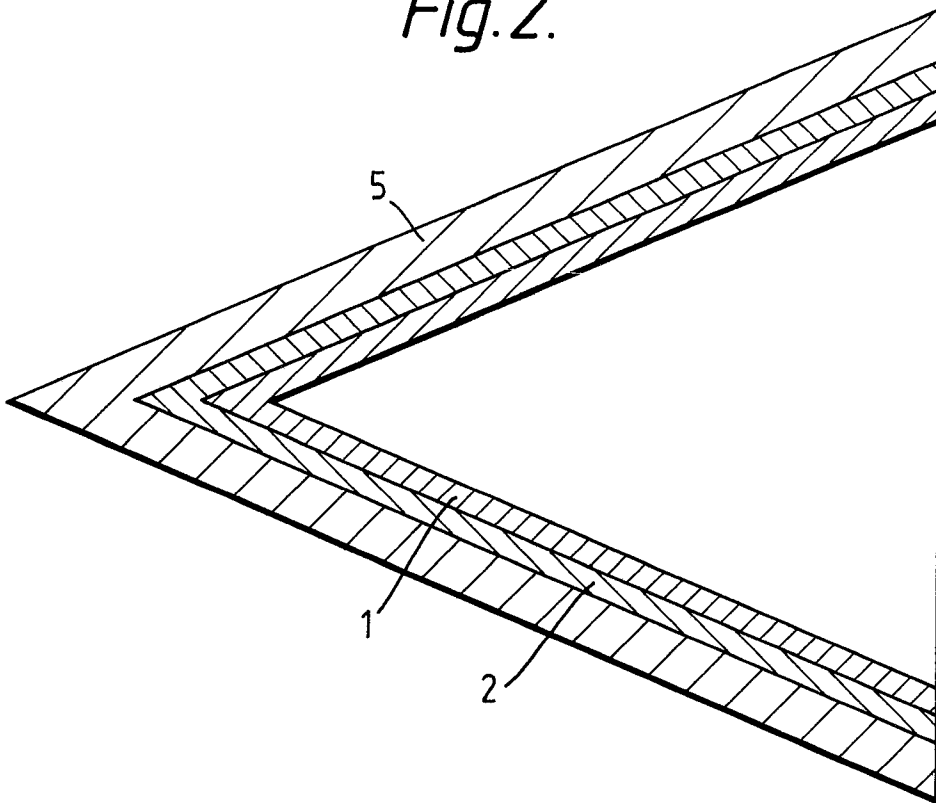
drawings.

6. Equipment for transmitting and/or receiving electromagnetic radiation and a radome through which said radiation passes and of which the wall comprises a single strength-providing layer made of reinforced plastics material and a syntactic foam layer having a dielectric constant substantially matching that of the reinforced plastics material layer, the thickness of said wall being substantially equal to one half the wavelength of the radiation which is to pass through the radome.

*Fig. 1.*



*Fig. 2.*





| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                 |                                                |                                               |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|-----------------------------------------------|
| Category                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Citation of document with indication, where appropriate, of relevant passages                                                                                                                                                                                   | Relevant to claim                              | CLASSIFICATION OF THE APPLICATION (Int. Cl.5) |
| Y                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | EP-A-0 155 599 (DORNIER SYSTEM)<br>* Claims 1,2,7,8 *<br>---                                                                                                                                                                                                    | 1-6                                            | H 01 Q 1/42                                   |
| Y                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | IEE PROCEEDINGS-F, vol. 128, no. 7,<br>December 1981, pages 451-464, Old<br>Woking, Surrey, GB; G.A.E. CRONE et<br>al.: "Design and performance of<br>airborne radomes: a review"<br>* Pages 452,453, section 2; pages<br>454-458, sections 4, 4.1-4.5 *<br>--- | 1-6                                            |                                               |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | GB-A-1 357 003 (BRITISH AIRCRAFT)<br>* Page 1, left-hand column, lines<br>13-42, right-hand column, lines 74-80 *<br>---                                                                                                                                        | 1-6                                            |                                               |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | WO-A-8 100 993 (B.F. GOODRICH)<br>* Abstract; claims 1,4 *<br>---                                                                                                                                                                                               | 1-6                                            |                                               |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | US-A-4 615 933 (TRAUT)<br>* Column 6, line 39 - column 7, line 2;<br>figures 4,5 *<br>---                                                                                                                                                                       | 1-6                                            | TECHNICAL FIELDS<br>SEARCHED (Int. Cl.5)      |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | US-A-3 780 374 (SHIBANO et al.)<br>* Abstract *<br>-----                                                                                                                                                                                                        | 1,6                                            | H 01 Q                                        |
| The present search report has been drawn up for all claims                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                 |                                                |                                               |
| Place of search<br>THE HAGUE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                 | Date of completion of the search<br>29-11-1989 | Examiner<br>ANGRABEIT F.F.K.                  |
| <b>CATEGORY OF CITED DOCUMENTS</b><br>X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document<br>T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>.....<br>& : member of the same patent family, corresponding document |                                                                                                                                                                                                                                                                 |                                                |                                               |