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Description

The present invention relates to a structure for covering and protecting a radio antenna such as a radar antenna, against weather and moisture, while remaining electromagnetically transparent.

Large radio antennas, such as radar installations and radio telescopes, often need a covering structure of some kind to protect them from the weather, i.e. sunlight, wind, and moisture and which will preferably be gas-tight; this covering structure is referred to as a radome. One type of radome is an inflatable radome. In this case, a gas-tight balloon shrouds the antenna. A blower inflates the balloon and spaces the structure away from the antenna so that the antenna may move or rotate freely. A popular form of such covering is the geodesic dome or metal space frame radome, which is formed from many metal (or other structural material) geometric shaped segments, such as triangles and others, which are covered with an appropriate radio frequency transmitting membrane, then affixed to each other to form a part-spherical dome surrounding the radar antenna, which rotates or moves inside the radome. Positive gas pressure is not required inside the metal space frame radome, but may be useful at times, for example, to dislodge snow from the outside of the dome, or to aid in controlling the environment within the dome. Another type of installation has solid segmented covering doors over the radio antenna which open to allow the antenna to function through the opening.

On each side of the opening is affixed a semi-circular track, up which is drawn each edge of a large, nearly electromagnetically transparent sheet of protective membrane to cover the antenna while in use. Other forms of antennas can also be suitably covered by such membranes held above or affixed around them in various ways to keep out moisture and the effects of weather.

While useful in varying degrees, the various forms and compositions of membrane hitherto known in the art, such as polytetrafluoroethylene fibre-glass laminates, have not solved all of the problems associated with use of this type of covering for protecting radio antennas.

An electromagnetically-transparent laminate according to the preamble of Claim 1 is known from patent document EP-A2-0 155 599. The laminate of the invention is characterised by the features of the characterising portion of claim 1.

The membranes and fibres of porous PTFE and of porous expanded PTFE (EPTFE) may be prepared as described in U.S. Patents 3,953,566; 4,096,227; 4,187,390; 4,110,392; 4,025,679; 3,962,153, and 4,482,516.

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

Figure 1 is a cross-section of a preferred laminate according to the invention;

Figure 2 is a broken-away view of a space frame radome covering and protecting a rotating radio antenna, and

Figure 3 shows a radio telescope housing, where shutter and doors are drawn aside and a covering sheet of composite membrane is being drawn over the antenna.

Figure 1 illustrates a laminate 1 according to the invention in cross-section showing various layers. The outer layer 2 is of polytetrafluoroethylene (PTFE), preferably porous PTFE, and most preferably EPTFE.

EPTFE is the porous expanded PTFE membrane material made by stretching PTFE in the manner described in the U.S. patents listed above. EPTFE has superior dielectric constant and loss tangent characteristics thus aiding electromagnetic transmission. The outer layer 2 is bonded by means of a thermoplastic polymer layer 3 to a second layer 2 of EPTFE which has previously been adhered or bonded to a textile backing layer 4 comprising woven fibres of PTFE. Here again, the preferred form of PTFE is EPTFE.

Layer 3 of thermoplastic polymer is preferably a fluorinated ethylene-propylene co-polymer (FEP), but other fluorinated thermoplastic polymers might be used where their PTFE-adhesive properties, radar wavelength transparency, and gas-resistant properties are suitable for use in the particular laminate being prepared. Other non-fluorinated thermoplastic polymers may be used for layer 3 where they meet the criteria of sufficient adhesiveness, electromagnetic transmission characteristics, and gas-proofness or gas-resistance to be adequately functional and useful. Useful thermoplastic polymers may include perfluoroalkoxytetrafluoroethylene polymers, ethylene-tetrafluoroethylene copolymers, copolymers of vinylidene fluoride and hexafluoropropylene, polychlorotrifluoroethylene, copolymer of hexafluoropropylene and tetrafluoroethylene, polyethylene and polypropylene. Layer 4 is a woven textile backing fabric for the laminate where the fibres are PTFE, preferably porous PTFE, and most preferably EPTFE. Layer 4 provides strength properties to the laminate, and additional layers of this material may be added where an increase in laminate strength is needed and desired.

The woven PTFE or EPTFE fabric is coated with commercially available PTFE dispersion or thermoplastic polymer dispersion to about three to ten percent by weight dispersed PTFE add-on and laminated to an EPTFE film under hot pinch-roll

conditions under pressure. Another EPTFE membrane is adhered to FEP film under heat and pressure. The FEP side of this second laminate is then laminated to the EPTFE side of the first laminate by hot pressure rolling to form a four-layer laminate, such as that depicted in cross-section in Figure 1. Additional pairs of layers 2 and 3 may be laminated to the EPTFE face of the laminate in like manner, if desired, to change the electromagnetic transmission characteristics or gas resistance.

Some variation among the fluorinated thermoplastics available for layer 3 may be utilized as well to adjust the electromagnetic transmission characteristics and frequency demand. The laminate provides significant gas-resistance or gas-proof properties associated with the thermoplastic layer (or layers) so as to be useful for positive pressure type structures in which gas pressure within the dome or shelter holds the covering away from the rotating or moving parts of the antenna housed therein.

Figure 2 shows a large metal space frame radome for sheltering and enclosing a radio antenna 5. The segments 6 of the dome have been made by covering geometric shaped frames, usually of metal or other stiff construction materials such as metal or plastic tubing or shaped bar stock, with laminate of this invention. Segments 6 are then assembled into a radome as shown. Other methods for making such a frame, not involving geometric segments, can be made to serve as well and other methods for covering the domes with the laminate 1 of the invention may be used.

Figure 3 depicts a different type of housing or shelter for a radio antenna 9, in which the entire housing revolves, a roof shutter 7 and doors 8 roll out of the way of antenna 9, and a large sheltering sheet 11 of composite membrane of the invention is drawn up track 10 to which it is attached at each end to protect the antenna while it is in use. Sheet 11 of Figure 3 and the covering 6 of each segment of the geodesic dome of Figure 2 each embody one form of the present invention.

The laminates are inert to and unaffected by the elements, including sunlight, ozone, temperature extremes, wind, rain, and snow, and are inert, hydrophobic and gas-resistant. They are very thin and strong, have excellent colour reflectance and electromagnetic transmission, low dielectric constant, and low loss tangent. The laminates when used in radomes reduce maintenance costs, provide lower cost structural enclosures, allow more accurate measurements, and provide for increased viewing time, do not need to be painted or otherwise maintained as do other materials, and have low adhesion and excellent release for snow and ice which might form on the surface of the radome.

Claims

1. An electromagnetically-transparent laminate (1), which is weather, moisture, and gas-resistant, for enclosing and protecting a radio antenna, characterised in having
 - a) a first layer (2) of porous expanded polytetrafluoroethylene (EPTFE);
 - b) a second layer (2) of porous expanded polytetrafluoroethylene (EPTFE);
 - c) a third layer (3) of a thermoplastic polymer adhering the first to the second layer;
 - d) a fourth layer (4) which is a backing fabric comprising woven fibres of porous expanded polytetrafluoroethylene (EPTFE).
2. A laminate according to claim 1 characterised in that the thermoplastic polymer is perfluoroalkoxytetrafluoroethylene (FPA), an ethylenetetrafluoroethylene copolymer, a copolymer of vinylidene fluoride and chlorotrifluoroethylene, a copolymer of vinylidene fluoride and hexafluoropropylene, polychlorotrifluoroethylene, a copolymer of hexafluoropropylene and tetrafluoroethylene, polyethylene, or polypropylene.
3. A laminate according to claim 1, characterised in that the thermoplastic polymer is a fluorinated ethylene-propylene co-polymer (FEP).
4. A process for protecting a radio antenna from weather and moisture characterised in providing the antenna with a covering of a laminate according to any preceding claim.
5. A process according to claim 4 characterised in maintaining a small positive atmospheric pressure differential within the covering to aid in holding the laminate away from the antenna.
6. A process of claim 4, wherein the polytetrafluoroethylene polymer is porous expanded polytetrafluoroethylene.
7. A process of claim 5, wherein the thermoplastic polymer is selected from fluorinated ethylene propylene copolymer, perfluoroalkoxy tetrafluoroethylene, ethylene-tetrafluoroethylene copolymers, copolymer of vinylidene fluoride and chlorotrifluoroethylene, copolymers of vinylidene fluoride and hexafluoropropylene, polychlorotrifluoroethylene, copolymer of hexafluoropropylene and tetrafluoroethylene, polyethylene, and polypropylene.

8. A process of claim 7 wherein the thermoplastic polymer is fluorinated ethylene propylene copolymer.

Patentansprüche

1. Elektromagnetisch durchlässiges Laminat (1), welches wetter-, feuchtigkeits- und gasbeständig ist, um eine Radioantenne zu umschließen und zu schützen,

gekennzeichnet durch

- a) eine erste Schicht (2) aus porösem expandierten Polytetrafluoräthylen (EPTFE);
- b) eine zweite Schicht (2) aus porösem expandierten Polytetrafluoräthylen (EPTFE);
- c) eine dritte Schicht (3) aus einem thermoplastischen Polymer, die die erste an der zweiten Schicht haften läßt;
- d) eine vierte Schicht (4), die ein Trägerstoff ist, der gewebte Fasern aus porösem expandierten Polytetrafluoräthylen (EPTFE) aufweist.

2. Laminat nach Anspruch 1, **dadurch gekennzeichnet**, daß das thermoplastische Polymer Perfluoralkoxytetrafluoräthylen (FPA), ein Äthylentetrafluoräthylen-Copolymer ein Copolymer aus Vinylidenfluorid und Chlortrifluoräthylen, ein Copolymer aus Vinylidenfluorid und Hexafluorpropylen, Polychlortrifluoräthylen, ein Copolymer aus Hexafluorpropylen und Tetrafluoräthylen, Polyäthylen oder Polypropylen ist.

3. Laminat nach Anspruch 1, **dadurch gekennzeichnet**, daß das thermoplastische Polymer ein fluoriertes Äthylen-Propylen-Copolymer (FEP) ist.

4. Verfahren zum Schützen einer Radioantenne vor Wetter und Feuchtigkeit, **dadurch gekennzeichnet**, daß die Antenne mit einem Überzug aus einem Laminat nach irgendeinem vorhergehenden Anspruch versehen wird.

5. Verfahren nach Anspruch 4, **gekennzeichnet durch** Aufrechterhalten einer kleinen atmosphärischen Überdruckdifferenz im Inneren des Überzugs, um das Fernhalten des Laminats von der Antenne zu unterstützen.

6. Verfahren nach Anspruch 4, bei dem das Polytetrafluoräthylen-Polymer poröses expandiertes Polytetrafluoräthylen ist.

7. Verfahren nach Anspruch 5, bei dem das thermoplastische Copolymer ausgewählt ist aus fluoriertem Äthylenpropylen-Copolymer, Perfluoralkoxy-Tetrafluoräthylen, Äthylen-Tetrafluoräthylen-Copolymeren, Copolymer aus Vinylidenfluorid und Chlortrifluoräthylen, Copolymeren aus Vinylidenfluorid und Hexafluorpropylen, Polychlortrifluoräthylen, Copolymer aus Hexafluorpropylen und Tetrafluoräthylen, Polyäthylen und Polypropylen.

8. Verfahren nach Anspruch 7, bei dem das thermoplastische Polymer fluoriertes Äthylenpropylen-Copolymer ist.

Revendications

1. Stratifié électromagnétiquement transparent (1), qui résiste aux intempéries, à l'humidité et aux gaz et servant à enfermer et à protéger une antenne radio, caractérisé en ce qu'il comporte :

- (a) une première couche (2) en polytetrafluoréthylène poreux expansé (EPTFE);
- (b) une seconde couche (2) en polytetrafluoréthylène poreux expansé (EPTFE);
- (c) une troisième couche (3) en polymère thermoplastique faisant adhérer la première couche à la seconde;
- (d) une quatrième couche (4) qui est une étoffe de soutien comprenant des fibres tissées en polytetrafluoréthylène poreux expansé (EPTFE).

2. Stratifié selon la revendication 1, caractérisé en ce que le polymère thermoplastique est choisi parmi le perfluoralkoxytetrafluoréthylène (FPA), un copolymère éthylène/tetrafluoréthylène, un copolymère fluorure de vinylidène/chlorotrifluoréthylène, un copolymère fluorure de vinylidène/hexafluoropropylène, le polychlorotrifluoréthylène, un copolymère hexafluoropropylène/tetrafluoréthylène, le polyéthylène et le polypropylène.

3. Stratifié selon la revendication 1, caractérisé en ce que le polymère thermoplastique est un copolymère éthylène/propylène fluoré (FEP).

4. Procédé de protection d'une antenne radio contre les intempéries et l'humidité, caractérisé en ce qu'on munit l'antenne d'un recouvrement en stratifié selon l'une quelconque des revendications précédentes.

5. Procédé selon la revendication 4, caractérisé en ce qu'on maintient une pression atmosphérique positive différentielle faible dans le re-

couvrement pour contribuer au maintien du stratifié à l'écart de l'antenne.

6. Procédé selon la revendication 4, dans lequel le polytetrafluoréthylène polymère est un polytetrafluoréthylène poreux expansé. 5
7. Procédé selon la revendication 5, dans lequel le polymère thermoplastique est choisi parmi un copolymère éthylène/propylène fluoré, le 10
perfluoralkoxy-tetrafluoréthylène, les copolymères éthylène/tetrafluoréthylène, le copolymère fluorure de vinylidène/chlorotrifluoréthylène, les copolymères fluorure de vinylidène/hexafluoropropylène, 15
le polychlorotrifluoréthylène, le copolymère d'hexafluoropropylène et de tetrafluoréthylène, le polyéthylène et le polypropylène.
8. Procédé selon la revendication 7, dans lequel le polymère thermoplastique est un copolymère éthylène/propylène fluoré. 20

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FIG. 1.

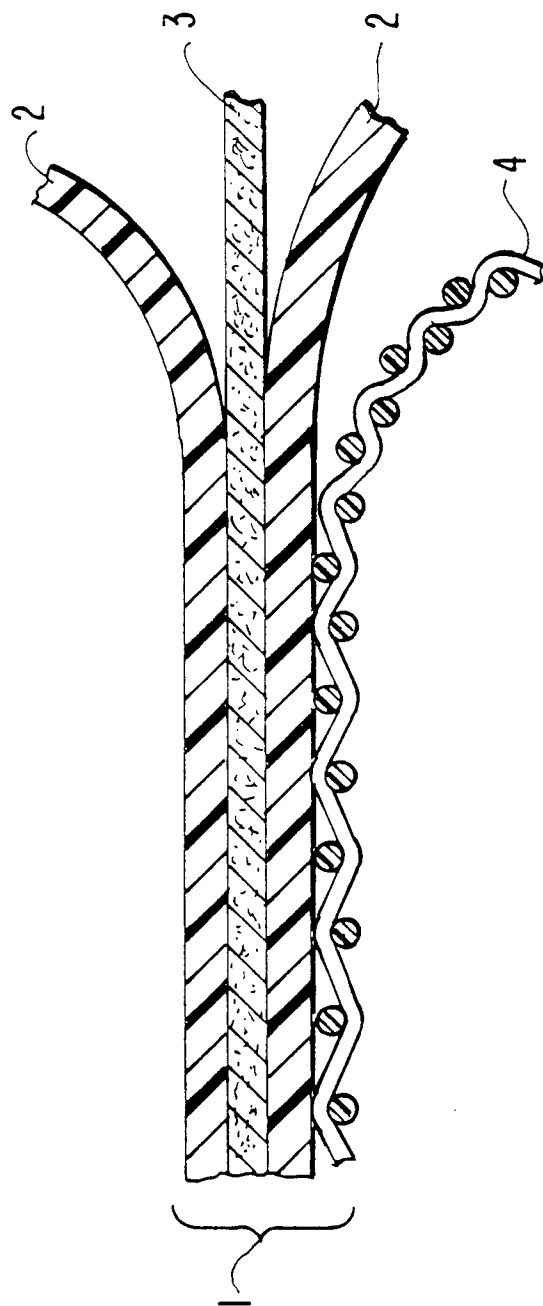


FIG. 2.

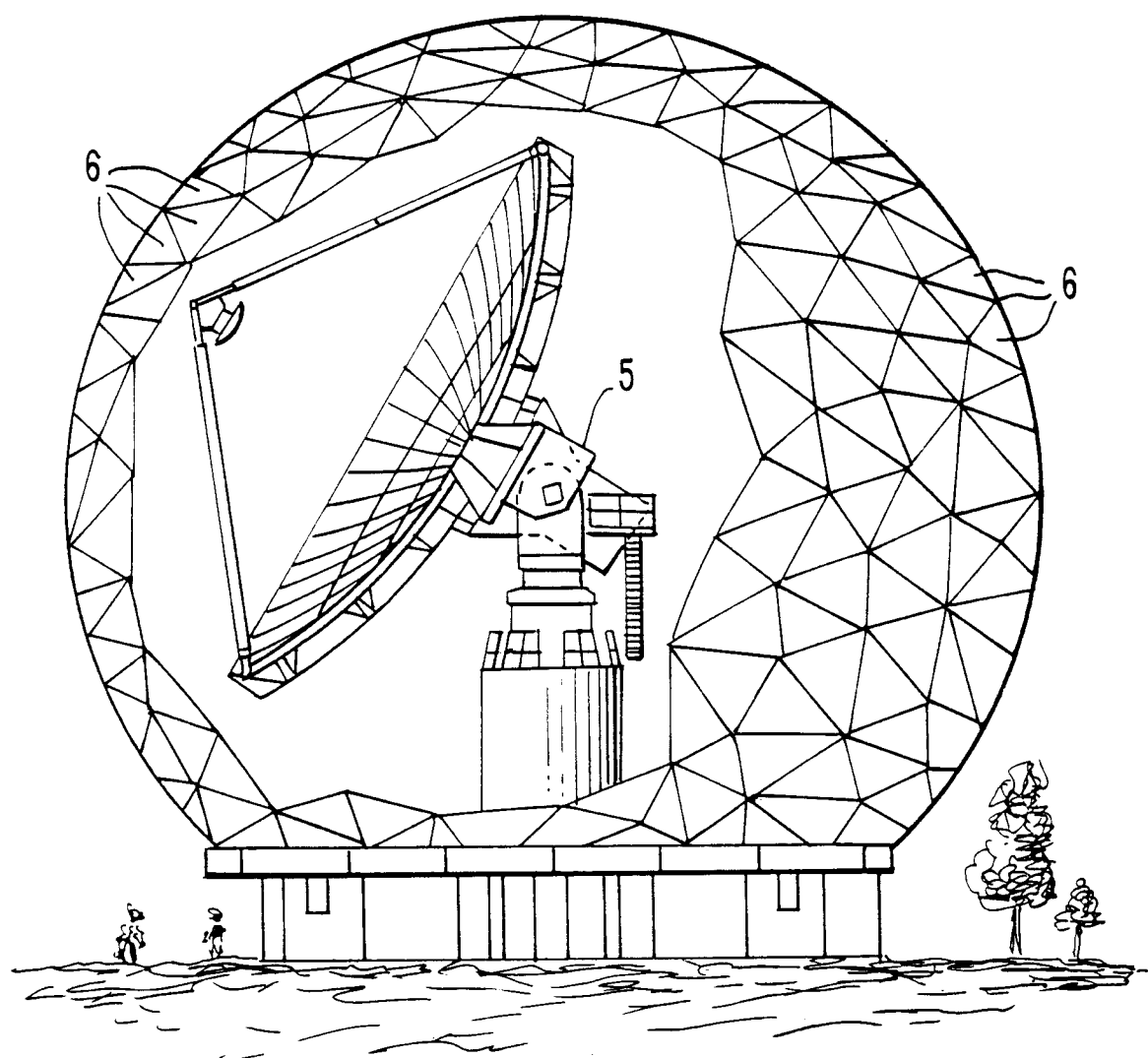


FIG. 3.

