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(54) Antenna arrangements.

(57) A microwave reflector includes a substrate 4 which is transparent to visible radiation. An array of cavities 5 is distributed over the front surface of the substrate 4 and has dimensions such that thermal radiation is affected by the surface deviations whilst microwave radiation is substantially unaffected. This reduces solar heating at the microwave focus.

Other arrangements include projecting elements and arrays an both the front and rear surface of a substrate.

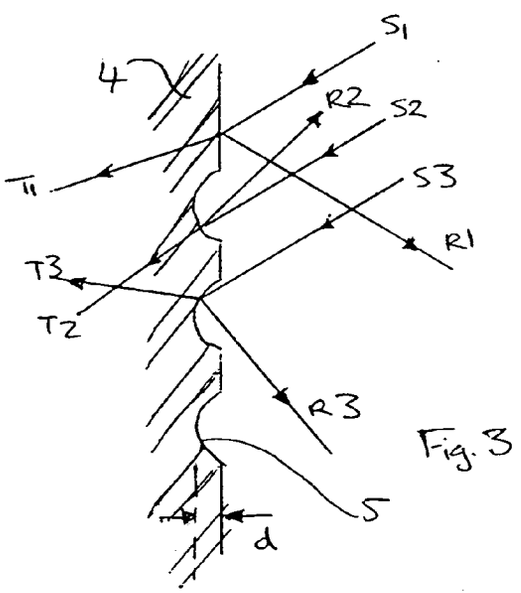


Fig. 3

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This invention relates to antenna arrangements and more particularly, but not exclusively, to arrangements for use in communicating with satellites and especially for receiving satellite television signals.

Microwave reflectors used in the reception or transmission of microwave signals also reflect thermal radiation occupying that part of the electromagnetic spectrum between visible and microwave frequencies. Incident thermal radiation, typically radiated from the sun, is focussed by the reflector in the vicinity of the microwave focus. Thus antenna components located near or at the microwave focus are subjected to heating which may be sufficiently intense to cause irreparable damage. Also, in the case of a satellite receiving antenna, reception is interrupted during the times when the antenna is directed towards the sun.

One technique currently used to reduce the problem of reflected thermal radiation is to include a layer of low emissivity paint on the reflector surface which absorbs and diffuses incident solar radiation. However, this method is not satisfactory where it is wished to employ an antenna substrate which is substantially transparent to visible radiation because the paint renders the substrate translucent.

The present invention arose from the consideration of antenna arrangements used in satellite communication applications where incident solar radiation may cause problems but it is also applicable to situations in which other heat sources are present.

According to the present invention there is provided an antenna arrangement comprising a microwave reflector carried by a substrate which is substantially transparent to visible radiation and which includes deviations in a planar interface between two media, the deviations being such that incident microwave radiation is substantially unaffected by them and thermal radiation is deflected by them whereby heating at the microwave focus is reduced, the transparency of the substrate being substantially unimpaired by the deviations.

By "substantially unimpaired" it is meant that although there may be some reduction in the proportion of visible radiation transmitted through the substrate this is not so great that the substrate becomes translucent and obscures features behind it.

The microwave reflector may be mounted on a surface of the substrate or contained within it, for example as a metallic mesh located between laminated sheets of transparent dielectric material.

The dimensions of the deviations are selected to be significantly greater than the wavelengths of incident thermal radiation such that they deflect the thermal radiation in different directions. The dimensions of the deviations must also be made significantly smaller than the wavelengths of low frequency microwave radiation so that the corresponding transmission and reflection directions of the microwave radiation are almost independent of the surface deviations and depend on the planar surface curvature of the reflector.

Visible radiation has wavelengths which are shorter than the thermal radiation wavelengths and its path is therefore also distorted by the presence of the deviations from a planar interface. The transmission losses of the visible radiation are controllable by ensuring that the surface deviations are sufficiently small so as to substantially avoid total internal reflection of transmitted visible light within the substrate which would otherwise result in translucency, impairing the transmissivity of the substrate.

The inclusion of deviations at an interface effectively defocusses incident thermal radiation without substantially impairing the visible transmissive properties of the substrate. Thus, use of the invention reduces or substantially eliminates the problem of excessive heating of components at the microwave focus whilst still retaining the advantages of low visual intrusion afforded by use of a transparent substrate.

Microwave radiation at 3 to 30 GHz has wavelengths in the range 10 to 1cm and, typically, the incident power level at a microwave reflective dish antenna at the surface of the earth is 10^{-10} mW/cm^2. These levels are those which would be expected from signals received from a direct-to-home (DTH) or direct broadcast satellite (DBS) operating at approximately 11 GHz. Solar radiation is substantially in the wavelength range $2.5.10^{-5}$ to 25.10^{-5} cm and at "Air Mass 1.5 Global", which defines a standard set of conditions, has an incident power level of the order of 95 mW/cm^2. Ultra violet and visible radiation have wavelengths at the lower end of the range of solar radiation wavelengths, for example visible light includes wavelengths from $4.5.10^{-5}$cm to $6.5.10^{-5}$cm.

In addition to defocussing thermal radiation, by employing the invention, the intensity of ultra-violet radiation in the region of the microwave focal region is also necessarily reduced. This reduces long term irradiation damage to plastics and painted surfaces near the focal region. Another advantage which accrues from the use of the invention is that gloss and glare of transparent surfaces may be diminished, improving the unobtrusive characteristics of a transparent antenna assembly. Furthermore, the natural resonant frequency vibrations of the substrate, which may be excited by wind turbulence for example, are dampened by the inclusion of deviations. Also, surface blemishes produced during manufacture of a parabolic surface are less noticeable when the invention is employed.

The planar interface between two media may be a boundary between the substrate and surrounding air or could be an internal interface within the substrate between two different media. However, conveniently the deviations are formed in an external surface of the substrate, as manufacture is easier in this

case.

The deviations may cover only part of the interface area but advantageously they are spatially distributed over the whole area to maximise their effectiveness in producing thermal defocussing.

In one embodiment of the invention, the deviations are substantially continuous. For example, they may consist of undulations over the whole of the front surface with no distinct boundaries between different ones of the deviations.

In another, preferred embodiment, the deviations comprise a plurality of elements each of which reflects or refracts incident thermal radiation. In this case, the elements are distinct from one another.

The thermal radiation may be defocussed by using deviations which consist of cavity or projection elements at the substrate surface or between layers of different media within the substrate. The plurality of elements may consist solely of reflector elements, solely of lenses to produce refraction or may be a combination of the two types, to produce deflection or distortion of the reflective and transmissive paths of incident thermal radiation. The dimensions of elements are selected so as to produce efficient defocussing of incident thermal radiation whilst minimising total internal reflections of visible light within the substrate, without interfering to a significant extent with the microwave characteristics of the reflector.

Where cavities are used, a suitable dimension to characterise them is the ratio of the depth-to-diameter of an element. Advantageously, a cavity has a depth-to-diameter ratio of 0.25. However, microwave reflectors having a small focal length-to-diameter ratio, say for ratios less than 0.4, may use elements having a smaller depth-to-diameter ratio to improve transparency to visible radiation at the edge of the substrate. This measurement may also be used to characterise projecting elements.

The depth-to-diameter ratio may be uniform across the whole of the reflector substrate or may be dependent on the location of an element relative to the centre of the reflector. Offset dish antennas may be treated in a similar manner, although the centre of the reflector in this case does not correspond to the point where incident solar and microwave radiation exhibit a zero incident angle.

Preferably, the cavity or projection diameter is less than about one tenth of the longest microwave wavelength with which it is intended to operate. These dimensions are suitable for microwave reflectors using solid transparent dielectric substrates operating below approximately 20 GHz. For example, the cavity (or projection) dimensions at the transparent surface are typically 3mm in diameter and 0.7mm deep for an antenna (dish) operating at 11 GHz.

The elements are advantageously parabolic in transverse section although shallow spherical, conical, pyramidal or other configuration cavities may also be effective. Preferably, the cavities are circular in the plane of the substrate but other shapes such as, for example, elliptical, square or polygonal configurations may be used. Such shapes may also be used where projecting elements are employed. The elements of an array may all be of the same configuration or could be of a variety of shapes.

Using an array of cavity elements is preferred to projecting element surface arrays because there is less risk of surface damage and contamination. Also, a cavity array is more convenient to fabricate and handle during production of the reflector.

The elements may be irregularly spaced or arranged as a regular array.

In some communication arrangements, microwave frequencies are polarised in two concurrent states, for example, vertically and horizontally polarised. The array of elements may then conveniently comprise a series of displaced rows and columns of cavities or projections in which one row of elements is offset from adjacent rows.

In another embodiment, the elements are elongate being formed as grooves or ridges, the length of the elements being parallel to the polarisation of incident microwave radiation. In such an arrangement, the length of the elements need not be governed by the microwave wavelengths, but the width must comply with the requirement that it is significantly less than the wavelength of incident microwave radiation.

The deviations may be distributed over only one plane of the substrate or could be distributed in two, or more, approximately parallel planes. For example, arrays of elements may be included over both the front and rear surfaces of the substrate.

Where two or more sets of deviations are included, it is preferred that the pattern sizes of the deviations are different, for example in pitch or element dimensions or shape, so as to avoid fringe effects which might be visually disturbing.

Typical materials for the transparent dielectric substrate are glass or plastic such as PMMA, PVC, Polycarbonate, PET and TPX.

Some ways in which the invention may be performed are now described by way of example with reference to the accompanying drawings in which:

Figure 1 is a schematic transverse section of a previously known antenna arrangement;

Figure 2 is a schematic transverse section of an antenna arrangement in accordance with the invention;

Figure 3 is an enlarged view of part of the surface of the arrangement as shown in Figure 2;

Figure 4 is a front view of the arrangement of Figure 2;

Figures 5 to 10 illustrate in transverse section parts of respective different antenna arrangements in accordance with the invention;

Figure 11 is a transverse sectional view of an-

other arrangement in accordance with the invention;

Figure 12 is a schematic front view of another antenna arrangement in accordance with the invention; and

Figures 13 and 14 schematically illustrate parts of other arrangements in accordance with the invention.

With reference to Figure 1, an antenna arrangement which does not employ the invention is illustrated, being used in the reception of microwave television signals from a satellite. The reflector 1 comprises a laminated substrate 2 which incorporates a metallic mesh 3 defining a microwave parabolic reflecting surface. The substrate 2 is substantially transparent to radiation in the visible part of the electromagnetic spectrum. In the absence of any deflective surface array, both lower frequency microwave and high frequency solar thermal radiation are reflected at three interface layers, that is, at the concave and convex substrate surfaces and at the concave parabolic microwave reflective plane. Microwave radiation is reflected and focussed principally by the mesh 3 at a principal microwave focal point shown as F2 but also from the front concave parabolic surface and the rear convex parabolic surface at focal points F3 and F1 respectively. The transmitted visible radiation is represented by lines T. Incident thermal radiation from the sun is also focussed in the regions F1, F2 and F3, F3 being the principal solar focal point, giving rise to substantial heating effects. The separation distances between the three focal regions F1, F2 and F3 depend upon the dielectric constant of the transparent substrate and the substrate thickness.

With reference to Figure 2 (which is not to scale), an arrangement in accordance with the invention includes an array of cavities having parabolic surfaces distributed over the front surface of a transparent substrate 4 to present a plurality of reflectors 5 to incident thermal radiation, as more clearly shown in Figure 3. The incident solar radiation is shown as rays S1, S2 and S3, the visible component being transmitted through the substrate 2 in the directions shown by lines T1, T2 and T3 and the thermal component being substantially reflected as shown by rays R1, R2 and R3. The concave cavity reflectors 5 present boundaries to the incident solar radiation between the transparent dielectric substrate 4 and surrounding air.

Figure 4 is a schematic plan view of the arrangement of cavities 5 in which it can be seen that they are circular in the plane of the substrate and arranged in offset rows. The diameter of the elements 5 is shown as D and depth as d, and in this case d:D is approximately 0.25. The separation S between adjacent cavities should be kept small in order to maximise the efficiency of the surface arrays and typically S is 1.2D.

The surfaces met by the incident thermal radiation are in different directions, causing the thermal radiation to be reflected in directions which are not wholly dependent on the planar surface, directing it away from the focus and producing defocussing. The dimensions of the cavities are significantly smaller than the shortest microwave wavelength and hence the surface deviations have little effect on the microwave radiation. The use of a surface deflective array results in the intensity of thermal radiation at the focal points F1, F2 and F3 being reduced whereas the intensity of microwaves at these points remains substantially unchanged.

In an alternative arrangement, an array is distributed only over the rear surface of the substrate. In this case, only the thermal radiation intensity at the inner focal point F1 tends to be reduced. As typically less than half of the reflective thermal radiation is reflected from the rear convex surface, the use of surface deviations on this surface is relatively inefficient in comparison to deviations at the front surface but is still effective in reducing heating effects at the focal regions.

Figure 5 illustrates another arrangement of defocussing elements 6 which in this case are part spherical and formed as projections from the front surface of a transparent substrate 7. The projections 6 present boundaries to the incident solar radiation between the transparent dielectric substrate and the surrounding air.

Figure 6 illustrates another arrangement in which a combination of projections 8 and cavities 9 are used.

The two types of arrangements shown in Figures 7 and 8 use pyramidal elements formed as projections and cavities respectively.

Figure 9 illustrates another arrangement in accordance with the invention in which surface deviations are present to spherical elements 10 of one material located within corresponding depressions 11 in the front surface of a substrate 12.

Figure 10 shows an arrangement in which cavities 13 are incorporated between laminated sheets 14 and 15 of different materials which define a boundary between them and also include air pockets 16. This arrangement is suitable for laminated type reflectors.

The arrangement shown in Figure 2 incorporates a defocussing array on the concave surface only of the antenna reflector. Figure 11 shows an arrangement in which such arrays 17 and 18 are included on the rear and front surfaces respectively of the antenna substrate. In this case, each array is regular but the elements of one array are at a different pitch to those of the other to avoid the generation of fringe patterns.

The elements of an array may be of uniform dimensions and spatial distribution. Figure 12 shows another arrangement in which elements near the circumference of a parabolic dish are smaller in diameter and depth than those towards the centre.

With reference to Figure 13, in another arrange-

ment in accordance with the invention, a plurality of elongate grooves 19 in the front surface of a substrate 20 present surface deviations to incident thermal radiation. The grooves 19 are aligned parallel to the direction of polarisation of the reflected microwave radiation such that only their width need be sufficiently small to avoid distortion of the returned microwave radiation.

Figure 14 illustrates another arrangement in which the front surface 21 of a substrate 22 bears a continuously deviating surface in contrast to the discrete arrays described above.

The defocussing arrangement may be used on a main reflector or sub-reflector or both where the arrangement includes these.

Claims

1. An antenna arrangement comprising a microwave reflector carried by a substrate (4) which is substantially transparent to visible radiation and which includes deviations (5) in a planar inteface between two media, the deviations being such that incident microwave radiation is substantially unaffected by them and thermal radiation (R1, R2, R3) is deflected by them whereby heating at the microwave focus is reduced, the transparency of the substrate being substantially unimpaired by the deviations.

2. An arrangement as claimed in claim 1 wherein the interface is at a surface of the substrate (Fig. 2).

3. An arrangement as claimed in claim 1 or 2 wherein the deviations are substantially continuous (Fig. 14).

4. An arrangement as claimed in claim 1 or 2 wherein the deviations comprise a plurality of elements (5) each of which reflects or refracts incident thermal radiation.

5. An arrangement as claimed in claim 4 wherein the diameter (D) of each element (5) is less than one tenth of the longest microwave wavelength which the reflector is intended to reflect.

6. An arrangement as claimed in claim 4 or 5 wherein the elements are arranged as an array having a regular pitch (Fig. 4).

7. An arrangement as claimed in claim 4, 5 or 6 wherein the elements are arranged in substantially parallel rows with elements of one row being offset with respect to those of adjacent rows (Fig. 4).

8. An arrangement as claimed in claim 4, 5 or 6 wherein the elements are elongate grooves or ridges (Fig. 13).

9. An arrangement as claimed in any preceding claim wherein the deviations are spatially distributed over substantially the whole of the planar interface (Fig 12).

10. An arrangement as claimed in any preceding claim wherein the substrate includes deivations at two substantially parallel planar interfaces (Fig. 11).

11. An arrangement as claimed in claim 10 wherein two sets of deviations are included in respective different planes, the deviations of one set being of a different configuration with respect to those of the other set.

12. An arrangement as claimed in any preceding claim wherein the deviations are of non-uniform dimensions (Fig. 12).

13. An arrangement as claimed in claim 12 wherein the deviations have a depth and width, those nearer the periphery of the substrate having a smaller depth-to-width ratio to those nearer the centre (Fig. 12).

14. An arrangement as claimed in any preceding claim wherein the deviations comprise cavities in a surface of the substrate (Fig. 3).

15. An arrangement as claimed in any preceding claim wherein the deviations comprise projections from a surface of the substrate (Fig. 5).

16. An arrangement as claimed in claim 14 or 15 wherein each deviation has a parabolic surface (Fig. 3, Fig. 5).

17. An arrangement as claimed in claim 14, 15 or 16 wherein each deviation has a depth-to-diameter ratio which is greater than the wavelength of thermal radiation and smaller than microwave wavelengths.

18. An arrangement as claimed in any preceding claim and adapted for receiving signals from satellites.

19. An arrangement as claimed in any preceding claim wherein the microwave reflector is embedded in the substrate (4).

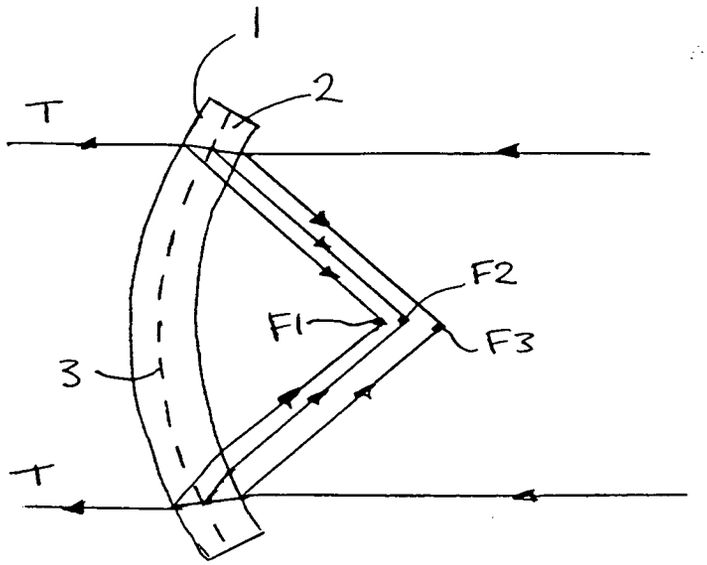


Fig. 1

PRIOR ART

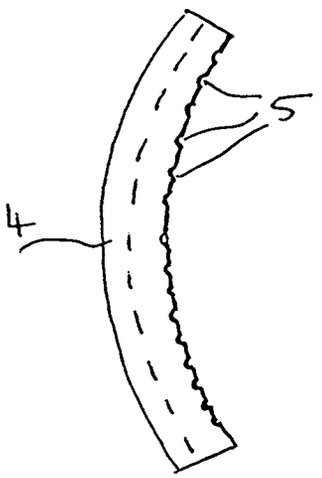


Fig. 2

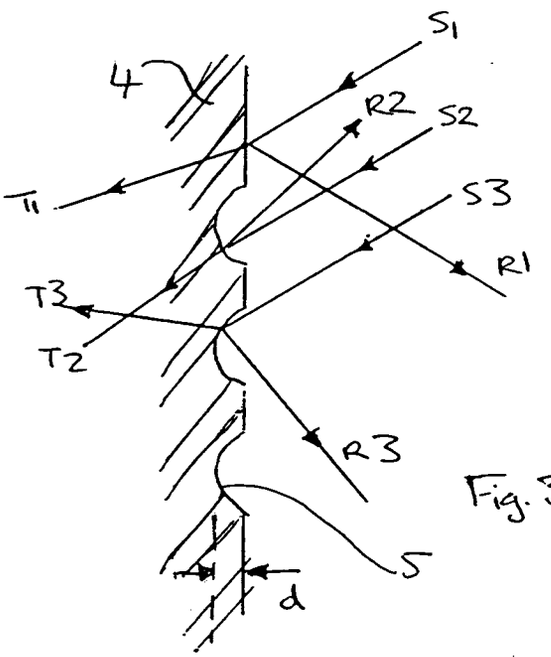


Fig. 3

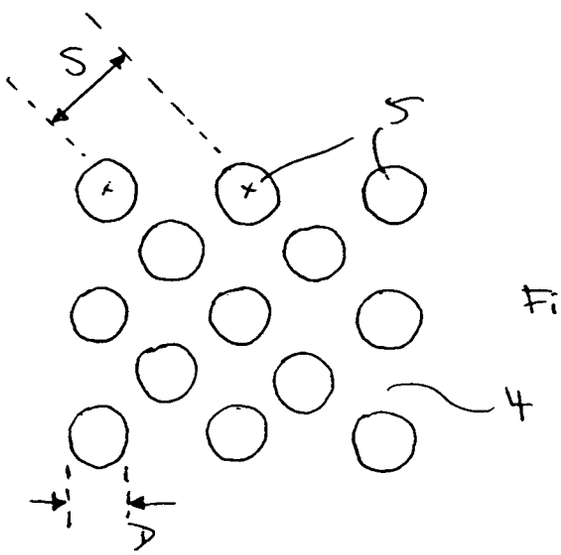


Fig. 4

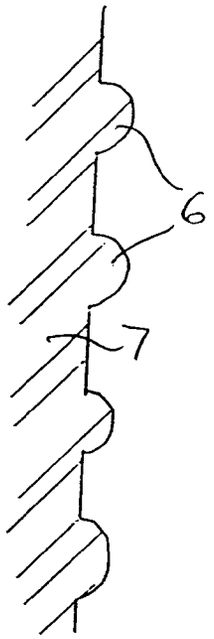


Fig. 5

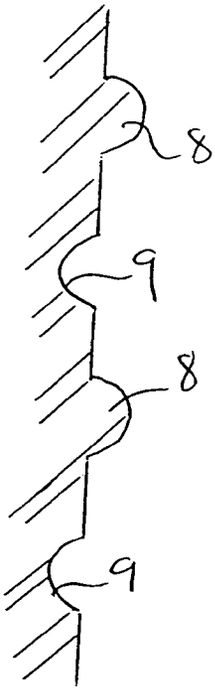


Fig 6

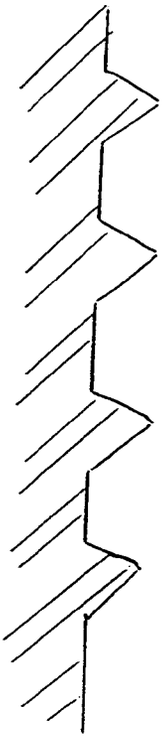


Fig 7

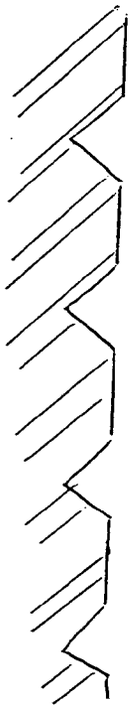


Fig 8

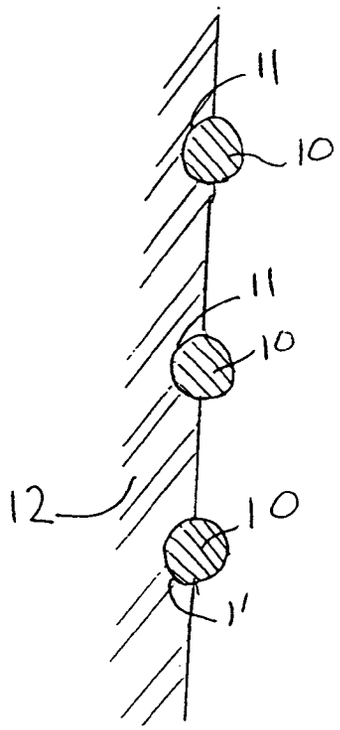


Fig. 9

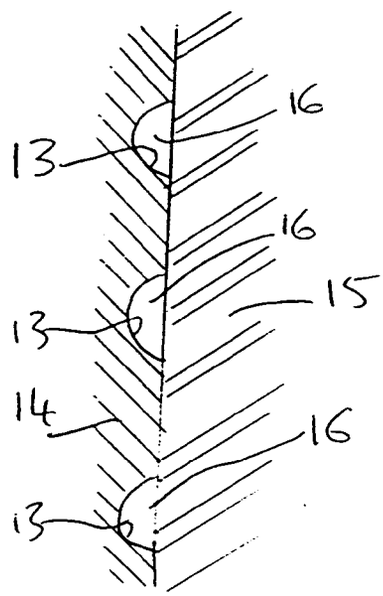


Fig. 10

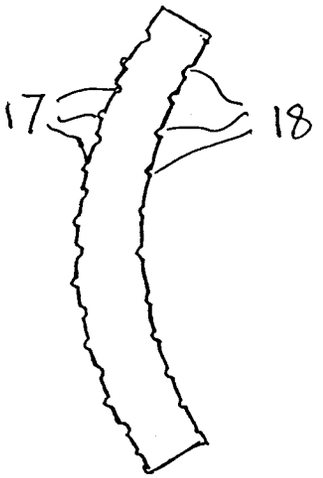


Fig. 11

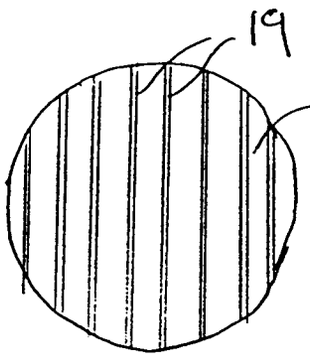


Fig 13

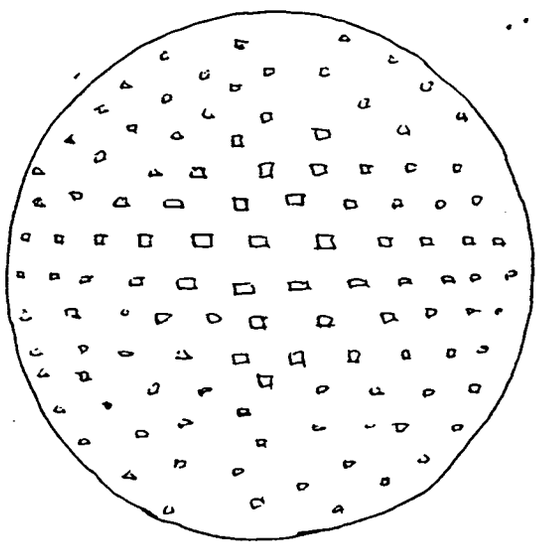


Fig. 12

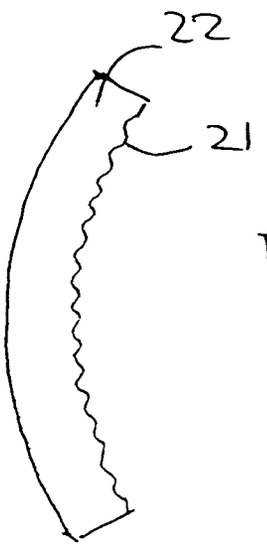


Fig 14

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 30 6085

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	WO-A-91 08598 (GLASNOST INTERNATIONAL PLC) * claims 1-12; figures 1,2 *	1-8, 17-19	H01Q15/16 H01Q1/00
Y	US-A-3 108 279 (EISENTRAUT) * column 1, line 11 - line 20; claims 1-4; figures 1-4 *	1-8, 17-19	
A	US-A-3 427 625 (KAZIMI) * claims 1-3; figures 1-7 *	1-8, 14-19	
A	FR-A-1 004 622 (COMPAGNIE GENERALE DE TELEGRAPHIE SANS FIL) * figures 3-9 *	1,9-12	
A	US-A-4 479 131 (ROGERS ET AL.) * claims 1-4; figures 1-4 *	1-8	
A	DE-U-90 01 255 (HAGENBUSCH) * claims 1-15; figures 1-3 *	1	TECHNICAL FIELDS SEARCHED (Int.Cl.5) H01Q
P,A	EP-A-0 507 543 (MARCONI ELECTRONIC DEVICES) * claims 1-14; figures 1-5 *	1	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24 November 1993	Angrabeit, F

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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