PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H01Q 15/00

A1

(11) International Publication Number: WO 98/49750

(43) International Publication Date: 5 November 1998 (05.11.98)

(21) International Application Number: PCT/GB98/00829

(22) International Filing Date: 19 March 1998 (19.03.98)

(30) Priority Data:
9708758.9 29 April 1997 (29.04.97) GB

(71) Applicant *(for all designated States except US)*: ERA PATENTS LIMITED [GB/GB]; Cleeve Road, Leatherhead, Surrey KT22 7SA (GB).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: WILLIAMS, Neil [GB/GB]; Hazel Cottage, Elmers Road, Ockley, Nr. Dorking, Surrey RH5 5TL (GB). PEARSON, Robert [GB/GB]; Rowan Cottage, Highfield Crescent, Hindhead, Surrey GU26 6TG (GB).

(74) Agent: GILL JENNINGS & EVERY; Broadgate House, 7 Eldon Street, London EC2M 7LH (GB).

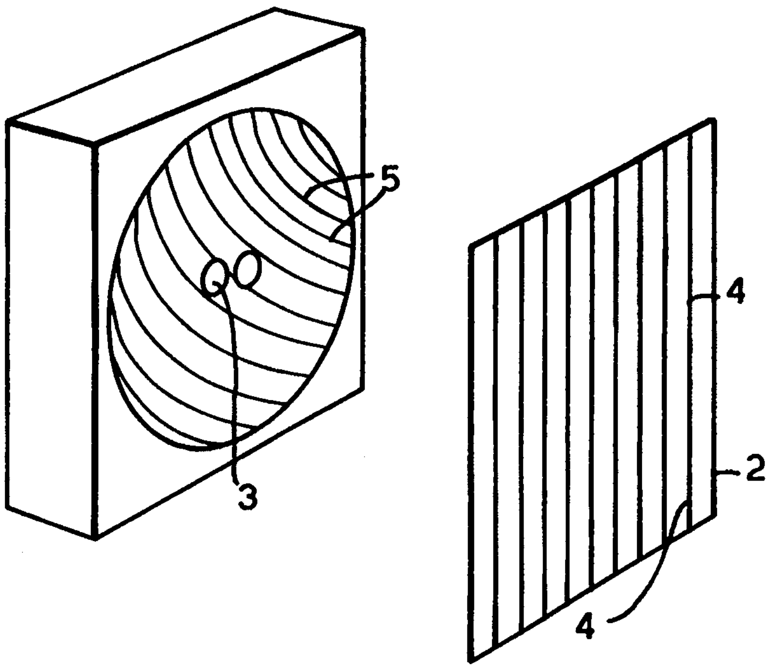
(81) Designated States: JP, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: TWIST REFLECTOR ANTENNA

(57) Abstract

Twist reflector antenna comprises a metallised plastics reflector (1), which is preferably moulded and a sub-reflector (2). The reflector (1) has a reflective surface having a plurality of generally parallel corrugated projections (5) extending across the reflective surface (1). The sub-reflector (2) has a dielectric substrate having a plurality of generally parallel conductors (4) extending across the substrate. The conductors (4) on the sub-reflector (2) extend at an angle of approximately 45° to that of the projections (5) on the reflective surface (1).



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

TWIST REFLECTOR ANTENNA

BACKGROUND TO THE INVENTION

Twist reflector antennas have been known for at least 60 years, and are referred to in the paper "Microwave Antennas Derived from the Cassegrain Telescope", Peter W Hannan, IRE Transactions Antennas Propagat, Col AP-9, pp 140-153, March 1961. These antennas comprise a main reflector in front of which is provided a gridded radome which forms a polarisation sensitive sub-reflector together with a feed system provided at the virtual focus of the main reflector. The main reflector comprises a generally parabolic metal dish on the surface of which is provided a layer of foam, and a plurality of wires overlying the foam and extending in parallel to each other across the dish. The radome comprises a dielectric material having a plurality of parallel conductor strips extending across one surface, and arranged at an angle of about 45° to the wires extending across the reflector. In use signals radiated from the feed horn having a polarisation parallel to the gridded radome are reflected back towards the main reflector which twists the polarisation of the signals by about 90° so that the signals pass through the gridded radome with almost perfect transmission.

The application of known twist reflector antennas has been limited due to the high manufacturing cost of such antennas. This high cost is due primarily to the difficulty in providing the wires across the reflector.

SUMMARY OF THE PRESENT INVENTION

According to the present invention a twist reflector antenna comprises a metallised plastics reflector including a reflective surface having a plurality of generally parallel corrugated projections extending across the reflective surface, and a sub-reflector comprising a dielectric substrate having a plurality of generally parallel conductors extending across the substrate, the conductors extending at an angle of approximately 45° to that of the projections on the reflective surface.

The antenna according to the present invention is much less expensive than conventional twist reflector antennas, both as the material cost is lower, and as it is much easier to form a metallised plastics reflector with projections than to provide individual wires extending over an insulator on a parabolic dish. By significantly reducing the cost of manufacture, the antenna can be used for a far wider range of applications than the prior art. Furthermore, being made of plastics, the antenna is lighter, and is more robust, not having exposed wires extending across the parabolic dish.

For ease of manufacture, the plastics reflector is preferably formed by moulding. The metal layer on the reflector may be formed by sputtering or plating the plastics substrate, or by applying a metal coating to the mould tool prior to moulding the plastics reflector.

The reflector may be parabolic, or may have some other generally concave shape, which may include a generally flat rear portion with a surrounding ridge. In the case of a parabolic reflector, the sub-reflector is preferably planar, though in the case of a shaped reflector, the sub-reflector will usually require reshaping accordingly. Where the reflector is generally planar, the sub-reflector includes a multiple layer grid comprising a single or multi-layer segmented grid in front of a single continuous grid, the segmented grid being analogous to an array of dipoles on an aperiodic lattice.

The reflector can have any desired peripheral shape and in particular may be circular, elliptical, or have a diamond shape. A diamond shaped reflector is beneficial in that it gives low principal plane sidelobes.

The sub-reflector may be formed from a plastics sheet on which parallel conductors are formed by an electro-forming or other deposition method, or may be formed from a metallised dielectric, in which case the conductors may be formed by etching the metal layer. A plurality of plastics layers may be used to form a sandwich construction. By passing an electric current through the conductors to heat the wires and the material of the radome, the antenna may be de-iced.

The sizing and spacing of elements of the antenna is preferably determined by the wavelength of the signals to be transmitted and received. In particular, it is preferred that the height of each of the projections is an odd multiple of quarter the wavelength of the signals, and it is particularly preferred that the projections have a height approximately equal to quarter of the wavelength. This ensures that reflections from the top of the projections are in anti-phase with reflections from the bottom of the projections. This cancels co-polarized reflected fields.

The conductors on the sub-reflector advantageously have a thickness of less than one tenth of the wavelength of the signals to be transmitted or received. This reduces reflections from the grid when this is illuminated by the fields scattered from the reflector. Adjacent conductors on the sub-reflector are preferably spaced from each other by less than half of the wavelength of the signals to be transmitted. This ensures that there is negligible transmission of signals which are polarised parallel to the grid.

The sub-reflector has an electrical thickness substantially equal to a multiple of half the wavelength of the signal to be transmitted or received by the antenna. The electrical thickness of the sub-reflector is preferably tuned by the conductors provided on the sub-reflector.

The antenna includes a feed system such as a horn radiator or a printed or wire element such as a dipole. Where the feed system is a horn radiator, this may be formed integrally with the reflector, or may be in the form of a separate component which is inserted into the reflector. The antenna may have a plurality of feed horns, or be in the form of a line array feed. A line array feed is particularly suitable for a cylindrical reflector arrangement.

By moulding the antenna from a plastics material, it is possible to form a plurality of reflectors in a single piece of material. In this case, a single sub-reflector may be provided for all reflectors. By providing multiple reflectors, it is possible for the antenna to receive and transmit, or to handle multiple receptions and transmissions, simultaneously.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a general view of an antenna according to the present invention;

Figure 2 shows a cross-sectional side view of the antenna of Figure 1;

Figure 3 shows an enlarged view of the surface of the reflector of Figure 2;

Figure 4 shows a front view of an alternative antenna according to the present invention;

Figure 5 shows a cross-sectional side view of a further alternative antenna;

Figure 6 shows a side cross-sectional view of a still further example of the present invention; and,

Figure 7 shows an enlarged view of the sub-reflector of Figure 6.

DETAILED DESCRIPTION OF A PREFERRED EXAMPLE

As shown in Figure 1, a twist reflector antenna according to the present invention includes a moulded metallised plastics reflector 1, and a gridded sub-reflector or radome 2. The reflector 1 includes a dish portion including a central feed horn 3 which may be formed integrally with the reflector 1, or may be a separate insert. The dish reflector includes a plurality of projections which extend across the reflector surface, each of the projections being parallel to the other projections.

These projections can be seen in greater detail in Figure 3 in which the plane of the projections is at 45° to the plane of the paper.

The metallised plastics reflector is formed by moulding. The moulding tool is first coated with a thin metal layer, then plastics material is introduced to the mould. This produces a metal coating over the surface of the moulded plastics reflector.

Each of the projections provided on the reflector have a height equal to a quarter of the wavelength of the signals to be received or transmitted. For a signal of 10GHz frequency, each of the projections should have a height of 7.5mm.

The radome 2 is formed of a dielectric substrate on which parallel electric conductors 4 are provided. This may be formed by making the radome 2 from a metallised plastics material and etching the metal layer to form the conductors, or by depositing metal strips onto the dielectric substrate.

The conductors on the radome are spaced by less than half the wavelength of the signals to be transmitted or received by the antenna, and in the case of a signal of 10GHz, the spacing is therefore less than 15mm. To minimize reflections from the radome, the width of each of the conductors is less than one tenth of the wavelength and the case of a 10GHz signal each strip therefore has a thickness of less than 3mm. When made from a simple dielectric sheet, the effective electrical thickness of the radome 2 is half the wavelength of the RF signals to be transmitted or received to give ideal transmission, and in the case of signals of 10GHz, the radome 2 has an electrical thickness of 15mm. The physical thickness of the radome 2 is generally less, and depends on the characteristics of the material, such as its permitivity, and by the grid formed on the radome, which can be used to tune the effective electrical thickness of the material for maximum transmission. Alternatively, the radome 2 can be constructed as a standard A-sandwich with two thin skins surrounding a low permittivity core.

The metallised plastics reflector and gridded radome 2 are arranged with respect to each other so that the projections extend at an angle of approximately 45° to the conductors on the radome 2. This is best seen in Figures 1 and 4 of the present application. In Figure 4, the gridded radome is shown over only half of the antenna for clarity. The antenna shown is horizontally polarised, although the entire antenna can be rotated to give different polarization.

In use, the polarization of the RF signals is twisted by 90° by the projections on the reflector. Due to the quarter wavelength height of the projections, reflections from the top and bottom of the projections are in anti-phase thereby fully cancelling out co-polarized reflected fields at the primary frequency for which the antenna is used. The twist in the polarization of the signals allows these to be transmitted through the gridded radome 2.

Whilst the peripheral shape of the reflector shown in Figure 1 is circular, the reflector may have an elliptical or, as shown in Figure 4 diamond shape.

Figure 5 shows an alternative antenna according to the present invention. In this case, the reflector is not a parabolic reflector as shown in Figures 1 and 2, and is shaped. As can be seen in this case, the radome 2 is not planar as in the case with the arrangement with respect to Figures 1 and 2.

Figure 6 shows a further embodiment which the reflector is generally planar with a surrounding ridge for supporting the radome 2. As shown in Figure 7, in this case the radome 2 is a multi-layer grid comprising an external continuous grid 6, and internal dipole grid 8, and a central di-electric or plastics substrate 7. The dipole grid is analogous to an array of dipoles on an aperiodic lattice arranged to produce or receive a collimated pencil beam or other prescribed shaped pattern. The angle and spacing of the dipole elements and the lengths of the dipoles determines the reflection phase of the structure at any particular point. The continuous grid ensures all of the incident field is reflected, and can be used as a de-icing grid by passing an electric current through the conductors.

CLAIMS

1. A twist reflector antenna comprising a metallised plastics reflector (1) including a reflective surface having a plurality of generally parallel corrugated projections (5) extending across the reflective surface, and a sub-reflector (2) comprising a dielectric substrate having a plurality of generally parallel conductors (4) extending across the substrate, the conductors (4) extending at an angle of approximately 45° to that of the projections (5) on the reflective surface.

2. A twist reflector antenna according to claim 1, in which the reflector (1) is parabolic.

3. A twist reflector antenna according to claim 2, in which the sub-reflector is planar (2).

4. A twist reflector antenna according to claim 1, in which the reflector (1) has a generally concave shape.

5. A twist reflector according to claim 4, in which the reflector (1) includes a generally flat rear portion with a surrounding ridge.

6. A twist reflector according to any one of claim 5, in which the sub-reflector (2) includes a multiple layer grid comprising a single or multi-layer segmented grid (8) in front of a single continuous grid (6), the segmented grid (8) being analogous to an array of dipoles on an aperiodic lattice.

7. A twist reflector antenna according to any one of the preceding claims, in which the reflector (1) has a diamond peripheral shape.

8. A twist reflector according to any one of the preceding claims, in which the height of each of the projections (5) is an odd multiple of quarter the wavelength of the signals to be transmitted and/or received.

9. A twist reflector antenna according to claim 8, in which the projections (5) have a height approximately equal

to quarter of the wavelength of the signals to be transmitted and/or received.

10. A twist reflector antenna according to any one of the preceding claims, in which the conductors (4) on the sub-reflector (2) have a thickness of less than one tenth of the wavelength of the signals to be transmitted and/or received.

11. A twist reflector antenna according to any one of the preceding claims, in which adjacent conductors (4) on the sub-reflector (2) are spaced from each other by less than half of the wavelength of the signals to be transmitted and/or received.

12. A twist reflector antenna according to any one of the preceding claims, in which the sub-reflector (2) has an electrical thickness substantially equal to a multiple of half the wavelength of the signal to be transmitted and/or received.

13. A twist reflector antenna according to any one of the preceding claims, in which the antenna includes a horn radiator (3).

14. A twist reflector antenna according to claim 13, in which the horn radiator (3) is formed integrally with the reflector (1).

15. An twist reflector antenna according to claim 13 or 14, in which the antenna includes a plurality of feed horns (3).

16. A twist reflector antenna array comprising a plurality of twist reflector antennas according to any one of the preceding claims formed in a single piece of material.

17. A twist reflector antenna array according to claim 16, in which a single sub-reflector (2) is provided for all reflectors.

18. A method of manufacturing a twist reflector antenna according to any one of the preceding claims, in which the metallised plastics reflector (1) is formed by moulding.

19. A method according to claim 18, in which the metal layer on the reflector (1) is formed by sputtering or plating the plastics substrate.

20. A method according to claim 18, in which the metal layer on the reflector (1) is formed by applying a metal coating to the mould tool prior to moulding the plastics reflector (1).

21. A method of manufacturing a twist reflector antenna according to any one of the preceding claims, in which the sub-reflector (2) is formed from a plastics sheet on which parallel conductors are formed by an electro-forming or other deposition method.

22. A method according to claim 21, in which a plurality of plastics layers are used to form a sandwich construction.

Fig.1.

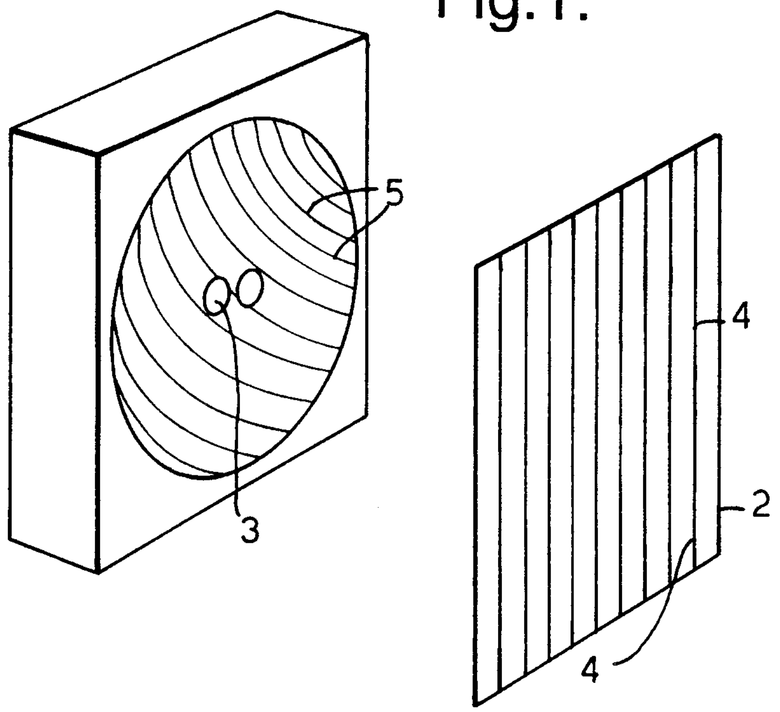

5
4
2
4
3

Fig.2.

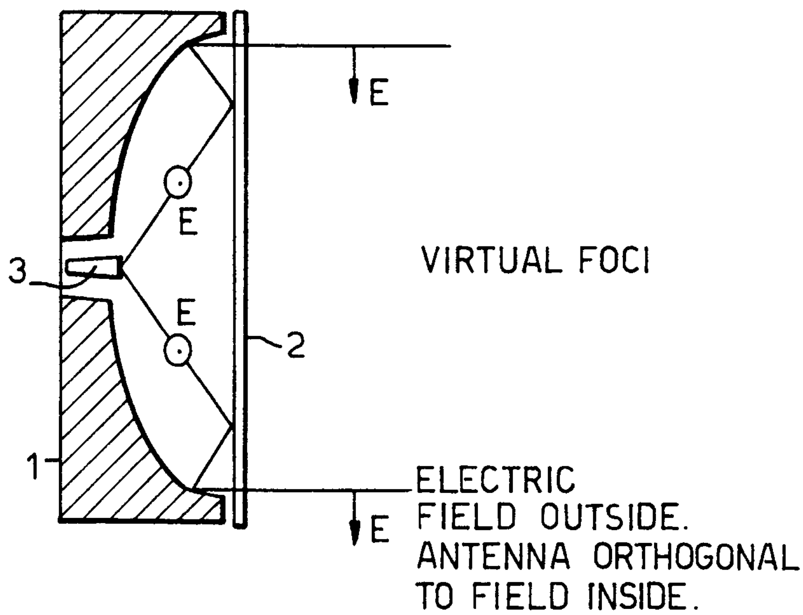

E
E
VIRTUAL FOCI
3
E
2
1
ELECTRIC
FIELD OUTSIDE.
ANTENNA ORTHOGONAL
TO FIELD INSIDE.
E

Fig.3.

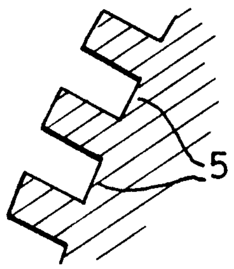


Fig.4.

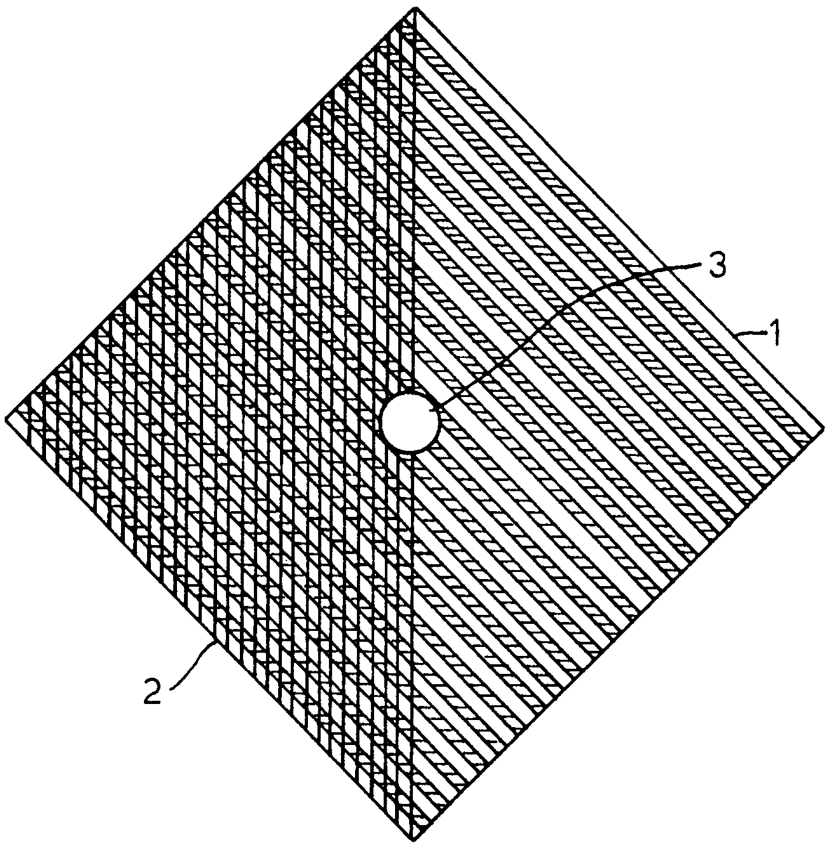


Fig.5.

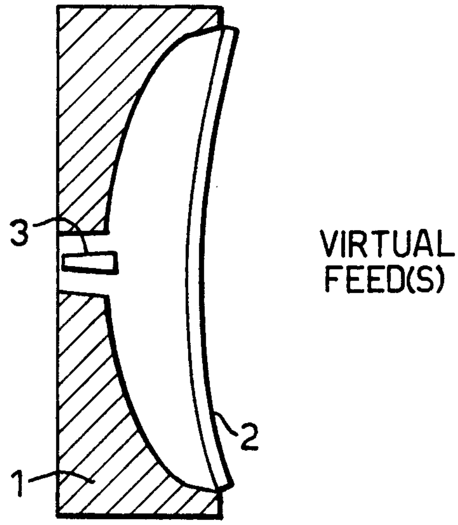


Fig.6.

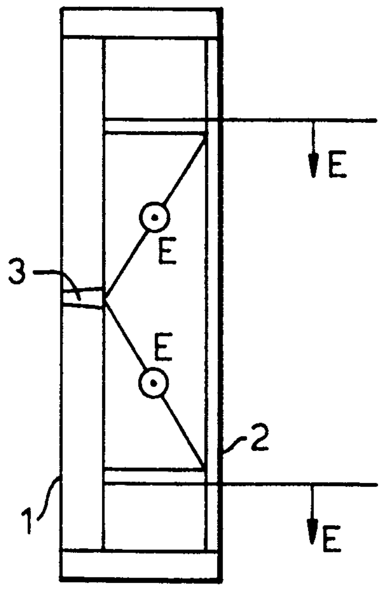
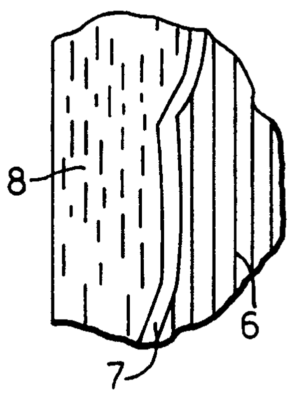


Fig.7.



INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 98/00829

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H01Q15/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H01Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 771 160 A (LAVERICK E) 6 November 1973 see column 2, line 23 - column 3, line 22; figure 1	1
A	EP 0 080 319 A (MARCONI CO LTD) 1 June 1983 see page 10, line 14 - page 11, line 33; figure 1	1-22
A	US 5 319 379 A (WAKEMAN DAVID R ET AL) 7 June 1994 see column 2, line 50 - column 4, line 10; figure 1	1-22

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
29 April 1998	20/05/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Villafuerte Abrego

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte onal Application No
PCT/GB 98/00829

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 3771160 A	06-11-73	DE 2139076 A	10-02-72
		FR 2101220 A	31-03-72
		GB 1330175 A	12-09-73
EP 0080319 A	01-06-83	GB 2110003 A	08-06-83
US 5319379 A	07-06-94	NONE	