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SEARCH ROOM

June 9, 1964 H. D. FULLER 3,137,000

QUARTER-WAVE REFLECTING PLATE WITH SUPPORT CORE OF RESIN-IMPREGNATED PAPER HONEYCOMB

Filed Aug. 8, 1960 2 Sheets-Sheet 1

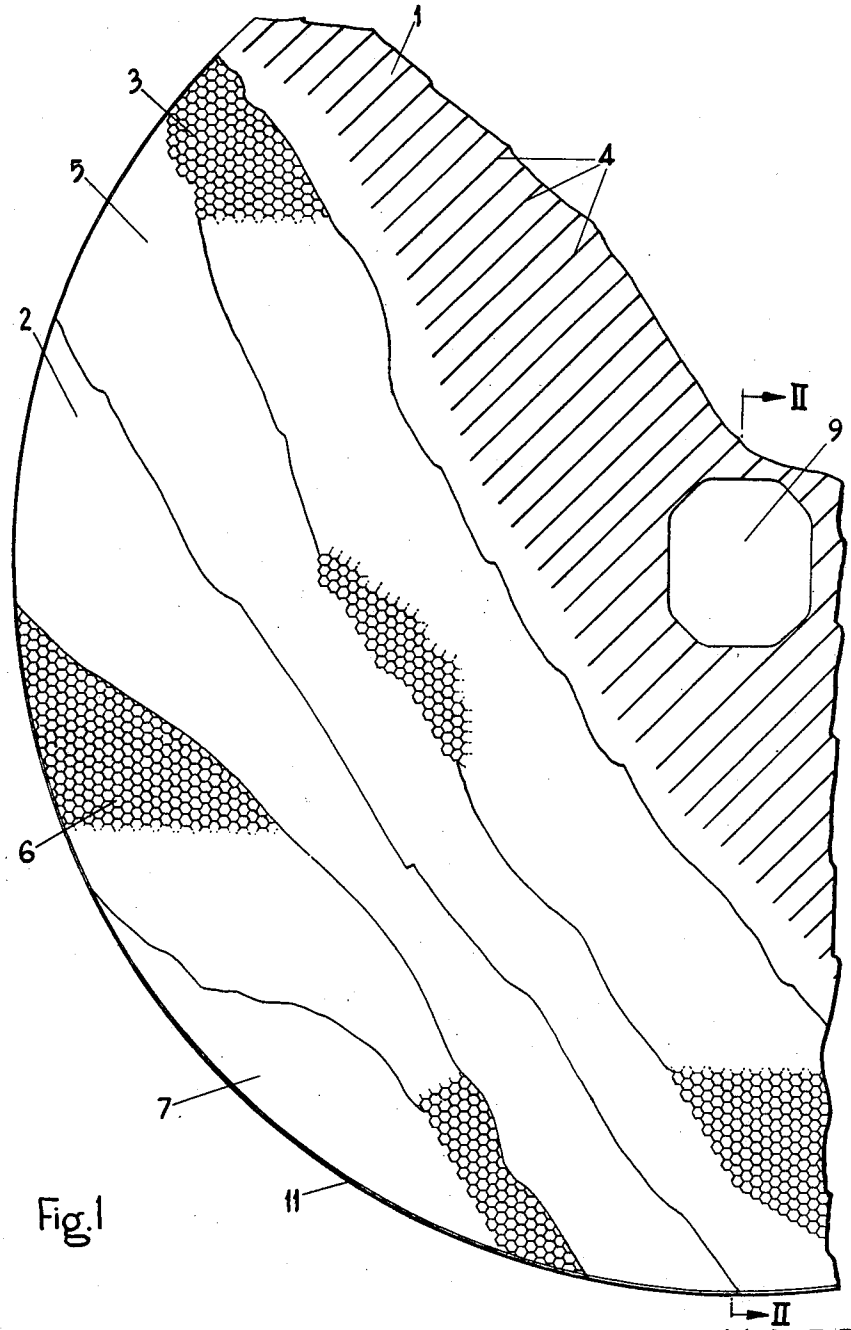


Fig. 1

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Fig. 2

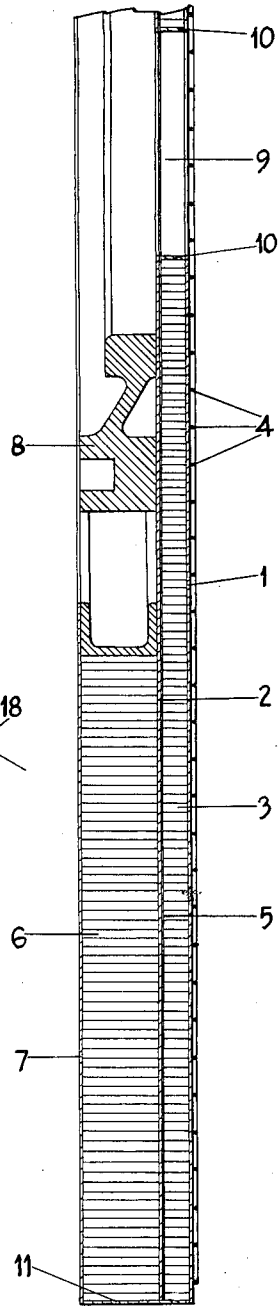
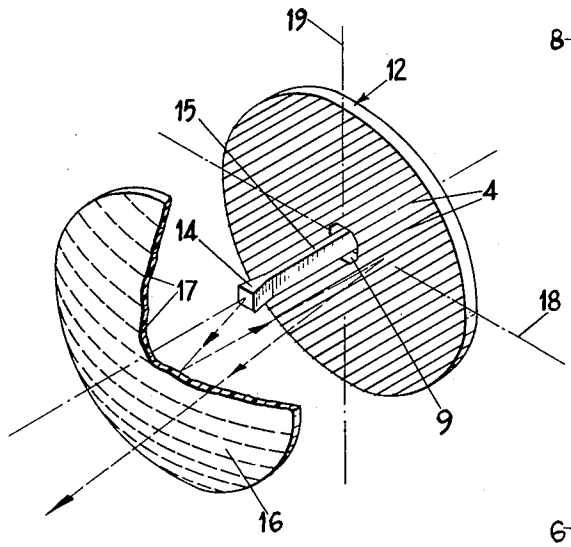


Fig. 3



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QUARTER-WAVE REFLECTING PLATE WITH SUPPORT CORE OF RESIN-IMPREGNATED PAPER HONEYCOMB

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2 Claims. (Cl. 343—756)

This invention relates to passive aerials.

It is sometimes necessary or desirable in, for example, a radar aerial system to provide a passive aerial of the kind in which mutually spaced electrical conductors are supported in the path of electromagnetic waves which are radiated, or which are to be received, by an active aerial of the system. The electrical conductors may be supported, with the appropriate spacing, by means of a substantially rigid body of dielectric material so that those conductors act jointly to modify a parameter of the incident waves. For example the passive aerial may act to redirect the incident waves in the manner of a lens or reflector, or to effect a rotation of the plane of polarisation of the waves.

A passive aerial of the above kind is usually required to have as little weight as possible particularly if it is to be mounted for angular displacement, the moment of inertia of the passive aerial then being an important factor. Although in these circumstances it is desirable to reduce the weight of the passive aerial, it is also in general desirable to retain a certain minimum rigidity. These two desiderata tend to conflict with one another and also with the need to satisfy the necessary electrical requirements of the passive aerial.

It is an object of the present invention to provide a form of passive aerial of the above-mentioned kind which overcomes at least partially the above difficulty.

According to the present invention a passive aerial comprises a substantially rigid dielectric element which is of generally honeycomb structural form, and a plurality of electrical conductors which are carried in a mutually spaced relationship by, and at least in close proximity to, the dielectric element so as to modify a parameter (for example the direction of propagation or the plane of polarisation) of an electromagnetic wave that has a predetermined radio frequency and which is incident upon the dielectric element.

The dielectric element may comprise a honeycomb structure having front and back surfaces between which the individual cells of the structure extend, and two skins of dielectric material which are bonded to the honeycomb structure to cover the two surfaces respectively. The electrical conductors may be disposed upon these skins.

The passive aerial may be for example a quarter-wave reflecting plate, that is, a reflector which in reflecting an electromagnetic wave produces a phase difference between two mutually perpendicular components of that wave which is substantially equal to one half wavelength. According to a feature of the present invention a quarter-wave reflecting plate comprises a substantially rigid dielectric element which is of generally honeycomb structural form, a plurality of elongated electrical conductors that are carried by the dielectric element to lie in a substantially parallel spaced relationship with one another in a common plane, and a further electrical conductor that is carried by the dielectric element and has a substantially planar face which is substantially parallel to, and which is separated through the dielectric element from, said common plane, the arrangement being such that an electromagnetic wave that has a predetermined radio frequency and a plane of polarisation which intersects said common plane at forty-five degrees to the elongated conductors, passes between the elongated conductors and through the dielectric element to be reflected back from said planar face of the further conductor, the presence of the elongated conductors imposing a phase difference between two mutually perpendicular components of the incident wave which overall is substantially equal to one half of the wavelength of the incident wave so that the resulting wave transmitted from the quarter-wave reflecting plate has a plane of polarisation which is substantially perpendicular to that of the incident wave.

A quarter-wave reflecting plate according to the present invention, together with a radar aerial system including that plate, will now be described, by way of example, with reference to the accompanying drawings, in which:

FIGURE 1 is a front elevation, partly broken away, of a part of the quarter-wave reflecting plate;

FIGURE 2 is a sectional elevation of part of the quarter-wave reflecting plate, this section being taken on the line II—II of FIGURE 1; and

FIGURE 3 is a view of the radar aerial system including the quarter-wave reflecting plate of FIGURES 1 and 2.

Referring to FIGURES 1 and 2, the reflecting plate includes two fibreglass skins **1** and **2** which cover the front and back surfaces respectively of a paper honeycomb structure **3**. Copper wires **4** are disposed in a parallel spaced relationship over the whole of the front surface of the fibreglass skin **1**. The wires **4** are bonded to the skin **1** with a synthetic resin, the spacings between the wires **4** being sufficient to allow electromagnetic waves which are to be reflected by the reflecting plate to pass between them and into the honeycomb structure **3**.

The fibreglass skin **2** carries on its front surface a zinc layer **5** which completely covers the whole of that surface, this layer **5** providing a reflecting surface for electromagnetic waves incident thereon in operation through the honeycomb structure **3**.

The paper of the honeycomb structure **3** is impregnated with a synthetic resin and the skins **1** and **2** are bonded to the edges of the paper over the respective front and back surfaces of that structure to provide a substantially rigid dielectric element carrying the wires **4** and the layer **5**. In order to provide added rigidity to the element another paper honeycomb structure **6**, similar to the structure **3**, is bonded to the back surface of the fibreglass skin **2**.

The back surface of the honeycomb structure **6** is covered by another fibreglass skin **7**, and a supporting ring **8** for the reflecting plate is bonded between the two skins **2** and **7**. The reflecting plate is mounted in operation with a section of waveguide (not shown in FIGURES 1 and 2) projecting through both the ring **8** and a central hole **9** in the paper honeycomb structure **3**. The inner edge of the structure **3** bounding the hole **9** is protected by a fibreglass strip **10**, and protection is afforded to the outer edges of the two paper structures **3** and **6** in a similar manner by a fibreglass strip **11**.

A radar aerial system including the quarter-wave reflecting plate described above with reference to FIGURES 1 and 2, will now be described with reference to FIGURE 3 in which the reflecting plate is given the general reference **12**.

Referring to FIGURE 3, the aerial system includes, in addition to the reflecting plate **12**, a horn **14** for radiating electromagnetic waves that are supplied thereto from a waveguide **15** which projects through the central hole in the plate **12**. The electromagnetic waves radiated by the horn **14** are directed to be incident upon the front surface of the reflecting plate **12** by a paraboloidal reflector **16**.

The reflector **16** (part of which is shown broken away

for clarity) is formed by metallic foil strips **17** which are spaced apart parallel to one another in expanded ebonite. The strips **17** form a paraboloidal reflecting surface for the waves radiated from the horn **14**. The spacing between the strips **17** is substantially less than half the wave length of the incident waves, and each strip **17** lies substantially parallel to the plane of the electric vector of the waves from the horn **14**.

The reflector **12** is mounted by means of the supporting ring **8** (not shown in FIGURE 3) for angular displacement relative to the horn **14** about two mutually perpendicular axes **18** and **19**, and is so mounted that the wires **4** lie at substantially forty-five degrees to the plane of the electric vector of the waves incident thereon from the paraboloidal reflector **16**.

Any wave incident upon the reflecting plate **12** from the reflector **16** may be considered as having two equal components, a first having an electric vector parallel to the wires **4**, and the second an electric vector perpendicular to the wires **4**. Each of these components is propagated through the honeycomb structure **3** (FIGURES 1 and 2) to be reflected from the zinc layer **5** (FIGURES 1 and 2), but the spacing between the wire **4** is less than half the wavelength of the incident wave so that these wires impose an inductive loading upon the first component. On the other hand there is no such loading imposed upon the second component, this second component having an electric vector perpendicular to the wires **4**. Both components are reflected back through the honeycomb structure **3** from the layer **5** to be repropagated from the front surface of the plate **12**.

The magnitude of the inductive loading imposed upon the first component of the incident waves is dependent both upon the diameters of the wires **4** and their spacings, and is such that after passage of the first component of the incident wave through the structure **3** in both directions there is a phase difference of one half wavelength between the first and second components. The plane of the electric vector of the resulting wave reflected from the reflector **12** is in consequence substantially perpendicular to that of the incident wave. As a result, the reflected wave is substantially unaffected by the presence of the reflector **16**, and the direction in which that wave is transmitted from the aerial system is determined by the angular position of the reflecting plate **12** about the two axes **18** and **19**.

The general honeycomb form of the plate **12** results in a low moment of inertia combined with an adequate rigidity so that rapid acceleration of the plate **12** about the axes **18** and **19** is possible. The honeycomb structure **3** not only provides the dielectric for the plate **12**, but in addition contributes to the overall rigidity of that plate. Furthermore the plate **12** has been found to have very good electrical performance and this is thought to be due at least in part to the fact that, with the paper honeycomb structure **3**, the dielectric constant between the wires **4** and the layer **5** is not very different from that of air.

It will be appreciated that it is necessary for the thickness of the structure **3** to be uniform over the whole of the reflector **12**, and that this thickness should be accurately related to the operational wavelength. The paper honeycomb form of the structure **3** assists in the attainment of both of these requirements since this structure is formed by strips of paper and it is the widths of these strips which determines the thickness. The strips of paper may be cut to the required width with a high degree of accuracy.

In one reflecting plate constructed as described above with reference to FIGURES 1 and 2, for operation at frequencies in the region of 9,375 megacycles per second, the thicknesses of the fibreglass skins **1**, **2** and **7** are respectively 0.009 inch, 0.006 inch, and 0.009 inch, and the paper honeycomb structure **3** has a thickness which is approximately 0.4 inch. The wires **4** are 35 S.W.G. and are spaced apart by just over 0.25 inch. Both of the honeycomb structures **3** and **6** is of the kind which is supplied under the registered trademark "Dufaylite" as Core Grade B by Dufaylite Developments Limited, England.

Where a plate **12** of smaller diameter or of lower rigidity is required, it is possible to dispense with the honeycomb structure **6** together with the skin **7**. In this case the thickness of the fibreglass skin **2** should preferably be the same as that of the skin **1**.

The zinc layer **5** may be sprayed on the front surface of the skin **2**, however, it has been found that this does not always provide a satisfactory bond between the layer **5** and the skin **2**. In order to overcome this latter disadvantage the layer **5** may be bonded to the skin **2** by a method including spraying the zinc on one surface of a sheet of cartridge paper. The sheet carrying the zinc layer is bonded with a synthetic resin to the skin **2** so that the zinc layer is face downwards on the skin **2**, and the paper backing is then washed off with water.

I claim:

1. A quarter-wave reflecting plate comprising: a substantially rigid dielectric element that comprises a resin-impregnated paper honeycomb structure that has mutually parallel front and back planar faces between which cells of the honeycomb structure extend, and two dielectric skins that are bonded to said front and back faces respectively, to cover these two faces; a plurality of elongated electrical conductors that are carried by the said skin that is bonded to said front face to lie in a substantially parallel spaced relationship with one another in a common plane; and a further electrical conductor that is carried by the said skin that is bonded to said back face, to have a substantially planar face that is substantially parallel to said common plane; the arrangement being such that an electromagnetic wave that has a predetermined radio frequency and a plane of polarization which intersects said common plane at forty-five degrees to the elongated conductors, passes between the elongated conductors and through the dielectric element to be reflected back from said planar face of said further conductor, the presence of the elongated conductors imposing a phase difference between two mutually perpendicular components of the incident wave which overall is substantially equal to one half of the wavelength of the incident wave so that the resulting wave transmitted from the quarter-wave reflecting plate has a plane of polarization which is substantially perpendicular to that of the incident wave.

2. A quarter-wave reflecting plate according to claim 1 wherein the elongated conductors are metal wires, and the further conductor is a metal layer.

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