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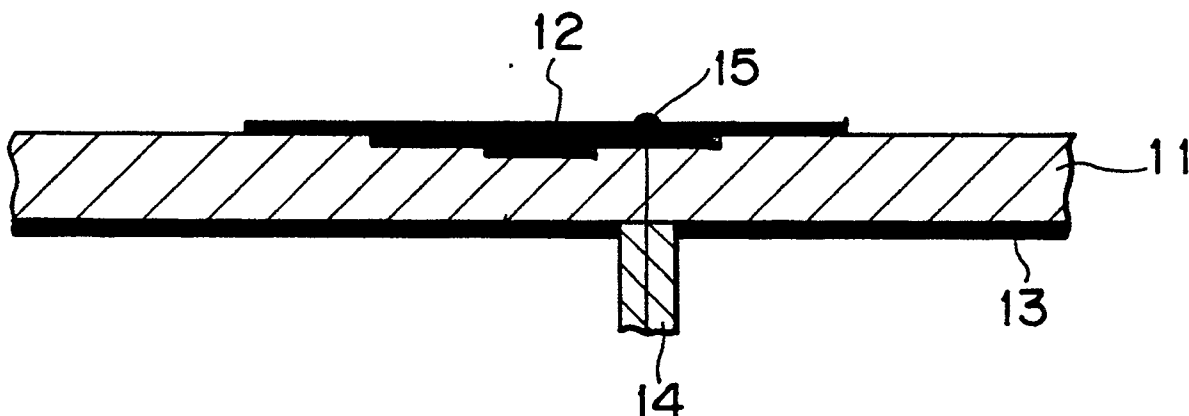
EUROPEAN PATENT APPLICATION

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D-6000 Frankfurt am Main 1(DE)(54) **A microstrip antenna.**

(57) In a microstrip antenna having a radiation conductor (12) and a ground conductor (13) sandwiching a dielectric substrate (11), the spacing between said radiation conductor (12) and said ground conductor (13), or the thickness of the dielectric substrate (11), is larger at the peripheral portion of those conduc-

tors than at the central portion. Because of the large spacing at the peripheral portion, the impedance at the peripheral portion where electromagnetic wave is radiated is close to the free space impedance, and the operational frequency band becomes wider than that of a prior microstrip antenna.

Fig. 1



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A Microstrip Antenna

BACKGROUND OF THE INVENTION

The present invention relates to a microstrip antenna in which a dielectric substrate is sandwiched by a radiation conductor and a ground conductor, and a feeder is coupled with a feed point of the radiation conductor.

A microstrip antenna which has a varied shape of flat radiation conductor facing a ground conductor with a dielectric layer between has been widely used. The shape of the radiation conductor has been circular, square, rectangular, triangular, or pentagonal. As for the structure of a microstrip antenna, many modifications have been known in that the location of a feed point, and the manner for feeding, whether a part of a radiation conductor is grounded or not, and/or the manner of ground.

Fig.5 shows one of prior microstrip antennas, in which Fig.5A is a perspective view, and Fig.5B is a cross section. In the figure, the numeral 1 is a dielectric layer, 2 is a circular radiation conductor, 3 is a ground conductor, 4 is a feeder, and 5 is a feed point on the radiation conductor 2. When the power is supplied to the feed point 5 on the radiation conductor 2 through the feeder 4, the electromagnetic wave is excited between the radiation conductor 2 and the ground conductor 3, and the electromagnetic wave is radiated from the peripheral portion of the radiation conductor 2.

A microstrip antenna uses an open-ended planar circuit resonator which is comprised of a radiation conductor 2, a ground conductor 3 and the peripheral portion of the radiation conductor 2. The Q factor at the resonant frequency f is proportional to h/λ , where h is the thickness of the dielectric layer 1, and λ is the free space wavelength. When the desired VSWR (voltage standing wave ratio) measured from the feeder is ρ (>1), and the VSWR is less than ρ in the frequency band between $f-\Delta f$ and $f+\Delta f$, the following relations are satisfied between the relative bandwidth Br and Q :

$$Br \equiv 2 \Delta f / f \approx (1/Q) \times (\rho^2 - 1) / 2\rho. \quad (1)$$

In other words, the relative bandwidth Br is inverse-proportional to Q , and is proportional to h/λ . Accordingly, the requests for a thin antenna, and wideband characteristics for a microstrip antenna are contradictory.

A prior microstrip antenna has the disadvantage that when exciting frequency changes 2% through 5% from the resonant frequency, the electrical characteristics, including the impedance characteristics, the directivity characteristics and the polarization characteristics are deteriorated.

Further, if we try to use a thick dielectric sub-

strate for wideband characteristics, undesired higher modes are apt to be generated, and it becomes difficult to match the impedance as the reactance component of the input impedance measured from the feeder becomes large.

SUMMARY OF THE INVENTION

It is an object, therefore, of the present invention to overcome the disadvantages and limitations of a prior microstrip antenna by providing a new and improved microstrip antenna.

It is also an object of the present invention to provide a microstrip antenna which has a wide operational frequency band while utilizing a thin structure.

The above and other objects are attained by a microstrip antenna comprising a radiation conductor (12) and a ground conductor (13) sandwiching a dielectric substrate (11) which is thin as compared with operational wavelength, and a feeder (14) coupled with a feed point on said radiation conductor (12), wherein spacing between said radiation conductor (12) and said ground conductor (13) is essentially large at peripheral portion of said radiation conductor as compared with that at central portion of said radiation conductor.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects of the present invention will be appreciated as the same become better understood by means of the following description and the drawings wherein;

Fig.1 is a cross section of a microstrip antenna according to the present invention,

Fig.2A is a cross section of another embodiment of the microstrip antenna according to the present invention,

Fig.2B shows the characteristics curves of the microstrip antenna of Fig.2A,

Figs.3A through 3D are cross sections of other embodiments of the microstrip antenna according to the present invention,

Fig.4 is a cross section of still another embodiment of the microstrip antenna according to the present invention,

Figs.5A and 5B show a prior microstrip antenna, and

Fig.6 shows the production steps of the microstrip antenna according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

(Embodiment 1)

Fig.1 shows the cross section of the embodiment of the microstrip antenna according to the present invention, in which the numeral 11 is a dielectric substrate, 12 is a radiation conductor, 13 is a ground conductor, 14 is a feeder, and 15 is a feed point.

The important feature of the present invention as compared with a prior art resides in that the spacing between the radiation conductor 12 and the ground conductor 13 is large at the peripheral portion of the radiation conductor 12, as compared with that of the central portion.

When the spacing between a radiation conductor 12 and a ground conductor 13 is large at the peripheral portion of those conductors, as compared with that at the central portion of those conductors, the impedance at the peripheral portion where the electromagnetic wave is radiated is close to that of the free space impedance, and the Q factor at the resonant frequency is essentially small.

Since the spacing between two conductors at the central portion of those conductors is not large, undesired higher modes are not generated, and the reactance component of the input impedance measured from the feeder can be small. Therefore, the impedance matching for the maximum bandwidth is possible by proper adjustment of a feed point.

Further, since the physical structure of the body which defines the resonant frequency enclosed by a radiation conductor and a ground conductor changes stepwise or continuously, the resonant frequency is not a point on a frequency axis, but distributes on some extension on a frequency axis.

In the embodiment 1 in Fig.1, the thickness of the radiation conductor 12 changes stepwise so that the spacing between the radiation conductor and the ground conductor is larger at the peripheral portion of those conductors than that at the central portion of those conductors.

It should be appreciated of course that the modification that the thickness of the ground conductor 13 (instead of the radiation conductor), changes stepwise is also possible.

(Embodiment 2)

Fig.2 shows another embodiment according to the present invention, in which Fig.2A shows a cross section of a microstrip antenna according to

the present invention, and Fig.2B shows the curves which show the improvement of a return loss according to the present invention.

In Fig.2A, the spacing $h(r)$ between the ground conductor and the radiation conductor is expressed as follows:

$$h(r) = h_0 + (h_e - h_0)(r/r_e)^2, \quad (2)$$

where h_0 and h_e are spacing between the ground conductor and the radiation conductor at the center and the end, respectively, of the radiation conductor, r_e is the radius of the radiation conductor, and r is a variable indicating the radial length from the center of the radiation conductor. The equation (2) shows that the curve $h(r)$ is a parabola, and the spacing between the ground conductor and the radiation conductor is larger at the peripheral portion of the radiation conductor than the center of the same.

Fig.2B shows the curves of the return loss of a microstrip antenna with the parameters h_0 , h_e , and the value (a) which is the length between the feed point 15 and the center of the radiation conductor. In the figure, the abscissa shows the frequency in GHz, and the ordinate shows the return loss in dB. The thick curve (d) shows the characteristics of the present invention, and other curves (a), (b) and (c) show the prior characteristics.

It should be noted in Fig.2B that the present invention indicated by the curve (d) has the wider bandwidth than that of the prior arts.

The prior curve (c) which has the thin spacing 3.2 mm has the bandwidth approximately 31 MHz (2%) in which the return loss is less than -10 dB. On the other hand, according to the present invention in curve (d) in which $h_e = 2h_0 = 6.4$ mm has the bandwidth approximately 89 MHz (6%) which is wider than that of the prior curve (c). The prior curve (a) shows that even when the spacing (=6.4 mm) between the ground conductor and the radiation conductor is uniformly large, the resonant frequency shifts to the lower frequency side, and because of the longer feed line 14, the reactance component of the input impedance increases, and the return loss at the resonant frequency is large. The prior curve (b) shows that the decrease of said reactance component is accomplished by adjusting the feed point, and the return loss is slightly improved, but the improvement is not sufficient enough for practical use.

It should be appreciated in Fig.2B that the bandwidth of the present invention is wide enough for covering the operational frequency of the prior antennas with equal thickness of dielectric layer between that having the center spacing h_0 and that having the end spacing h_e .

(Embodiment 3)

Figs.3A through 3D show other embodiments of the cross section of the present microstrip antenna.

In Fig.3A, the surface of the radiation conductor 22 facing the ground conductor 13 is conical, so that the spacing between the radiation conductor 22 and the ground conductor changes linearly.

In Fig.3B, the radiation conductor 32 is a part of a sphere.

In Fig.3C, the surface of the ground conductor 23 facing the radiation conductor 12 is conical.

In Fig.3D, the ground conductor 33 is a part of a sphere so that the spacing at the central portion of the conductors is smaller than that at the peripheral portion.

As mentioned above, according to the embodiment 3, one of the radiation conductor or the ground conductor is conical or spheric, and the other conductor flat, so that the spacing between two conductors at the peripheral portion is larger than that at the central portion.

(Embodiment 4)

Fig.4 shows the cross section of still another embodiment of a microstrip antenna according to the present invention.

The feature of the embodiment of Fig.4 is that both the radiation conductor and the ground conductor are either conical or spherical so that the spacing at the central portion is smaller than that at the peripheral portion.

Fig.6 shows the production steps of the microstrip antenna according to the present invention.

First, the surface of a dielectric substrate 11 is ground by a grinder 100 which is spheric and rotates around the center spindle, as shown in Fig.6A. Then, the structure as shown in Fig.6B is obtained.

Next, a conductive thin layer 22 is deposited on the ground surface of the dielectric substrate 11 through the evaporation process, and the structure as shown in Fig.6C is obtained.

Next, the unnecessary portion of the conductive layer 22 is removed by cutting the structure along the line 102 as shown in Fig.6C, and the structure of Fig.6D is obtained.

Finally, a feeder 14 is coupled with the conductive layer 22 as shown in Fig.6E.

In the above steps, it is supposed that a ground conductor 13 is deposited at the rear surface of the dielectric substrate 11 through, for instance, the evaporation process.

As mentioned above, according to the present invention, the spacing between a radiation conductor 12 and a ground conductor 13 is large at the peripheral portion of those conductors as com-

pared with that at the central portion of those conductors. Therefore, the present microstrip antenna has wide operational frequency band while maintaining the advantages of a microstrip antenna.

Therefore, the present microstrip antenna is applicable to a mobile communication and/or aeronautical communication, which requires a thin antenna.

From the foregoing, it will now be apparent that a new and improved microstrip antenna has been found. It should be understood of course that the embodiments disclosed are merely illustrative and are not intended to limit the scope of the invention. Reference should be made to the appended claims, therefore, rather than the specification for indicating the scope of the invention.

Claims

(1) A microstrip antenna comprising a radiation conductor (12) and a ground conductor (13) sandwiching a dielectric substrate (11) which is thin as compared with operational wavelength, and a feeder (14) coupled with a feed point on said radiation conductor (12),

wherein the improvements comprise that spacing between said radiation conductor (12) and said ground conductor (13) is essentially large at the peripheral portion of said radiation conductor as compared with that at central portion of said conductor.

(2) A microstrip antenna according to claim 1, wherein spacing between said radiation conductor (12) and said ground conductor (13) changes continuously in the radial direction of those conductors.

(3) A microstrip antenna according to claim 1, wherein spacing between said radiation conductor (12) and said ground conductor (13) changes stepwise in the radial direction of those conductors.

(4) A microstrip antenna according to claim 1, wherein at least one of said radiation conductor (12) and said ground conductor (13) is one selected from either a conical curve, spherical curve, and parabolic curve.

(5) A microstrip antenna according to claim 1, wherein a radiation conductor is curved, and a ground conductor is flat.

(6) A microstrip antenna according to claim 1, wherein a radiation conductor is flat, and a ground conductor is curved.

(7) A microstrip antenna according to claim 1, wherein both radiation conductor and ground conductor are curved.

Fig. 1

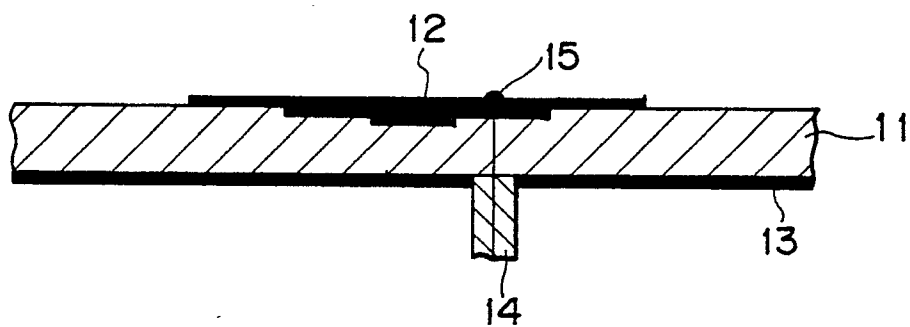


Fig. 3A

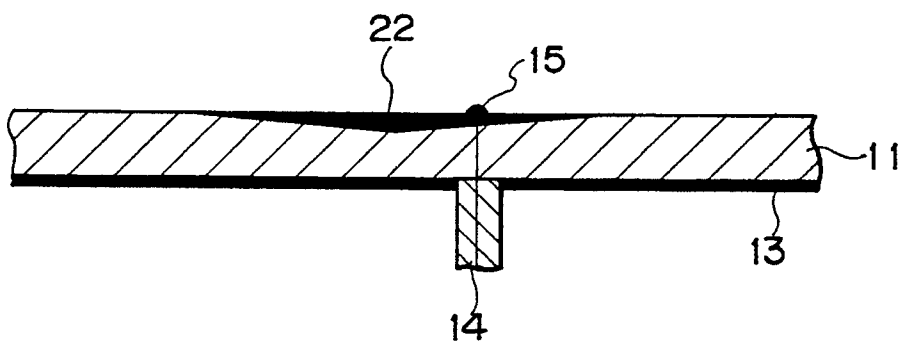


Fig. 3B

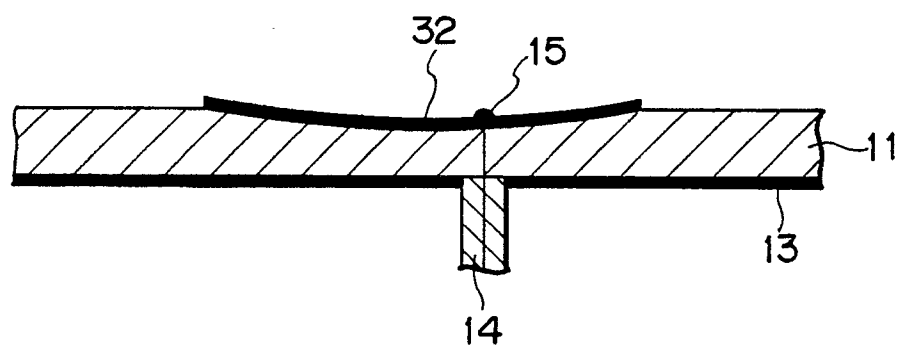


Fig. 3C

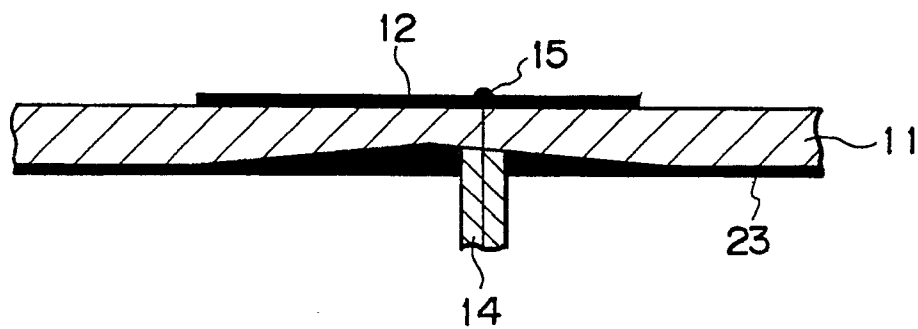


Fig. 3D

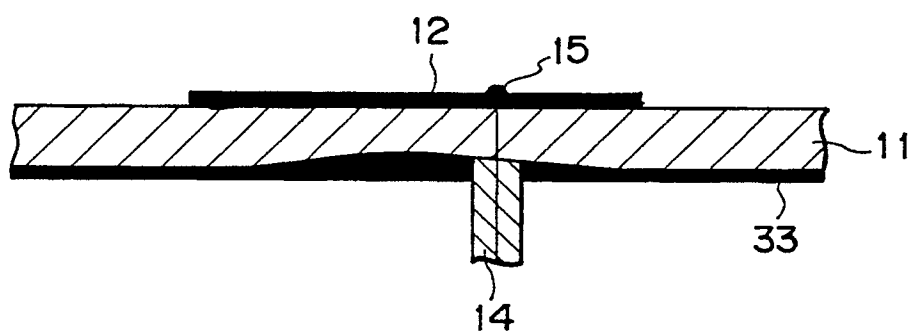


Fig. 4

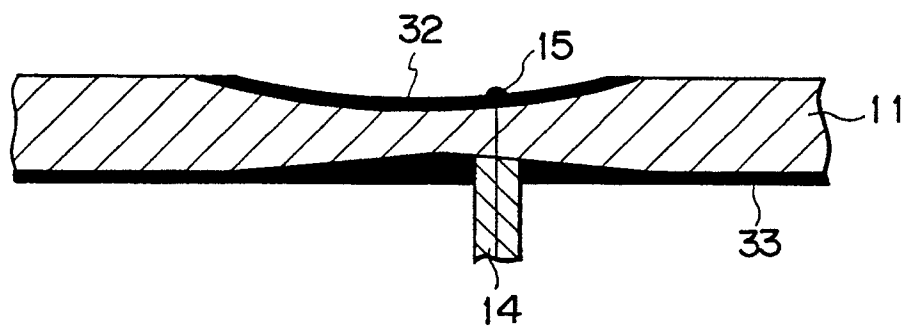


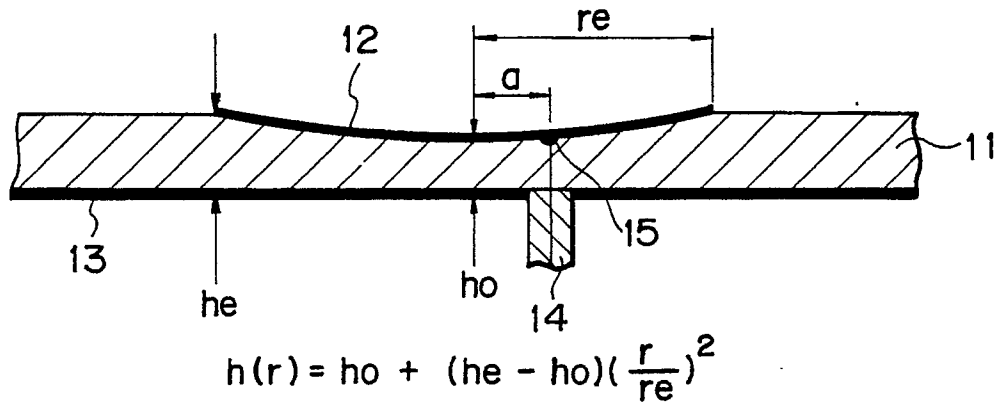
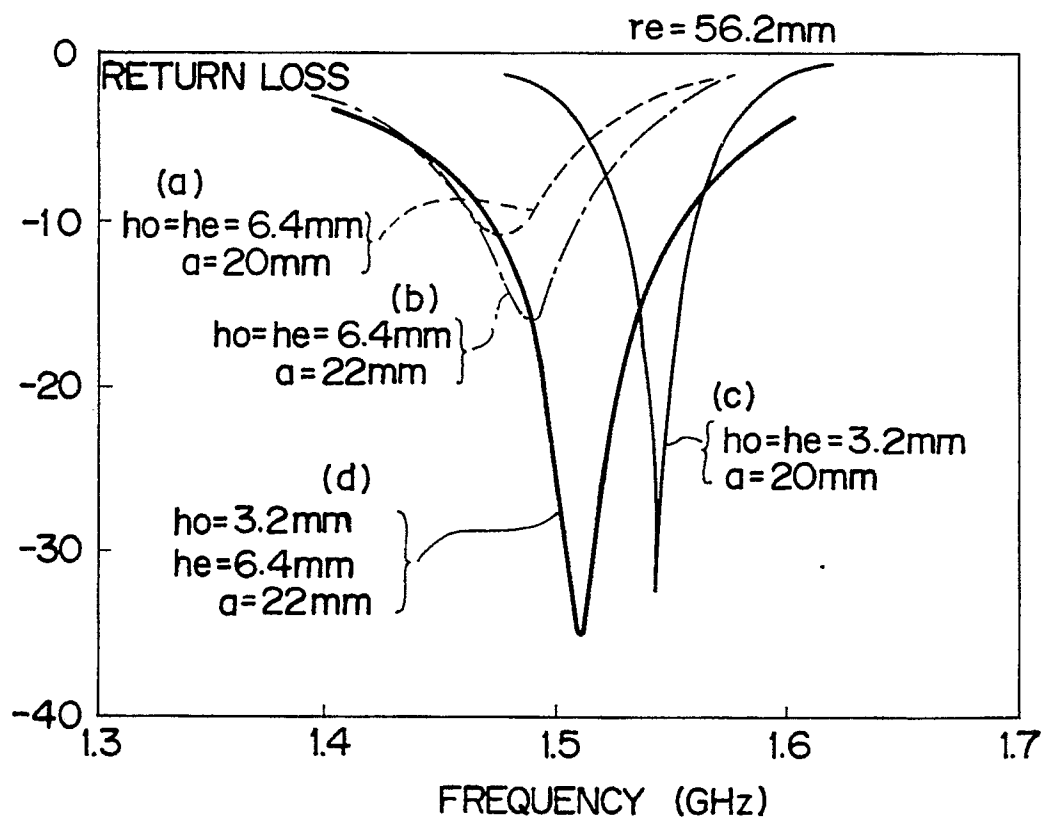
Fig. 2A*Fig. 2B*

Fig. 5A

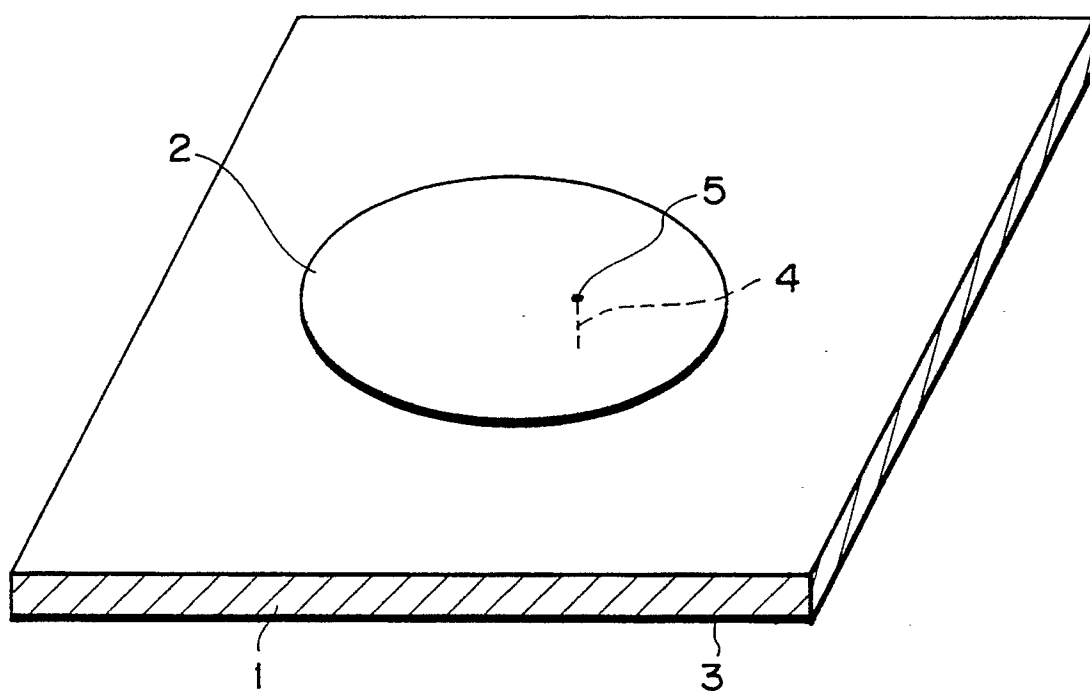


Fig. 5B

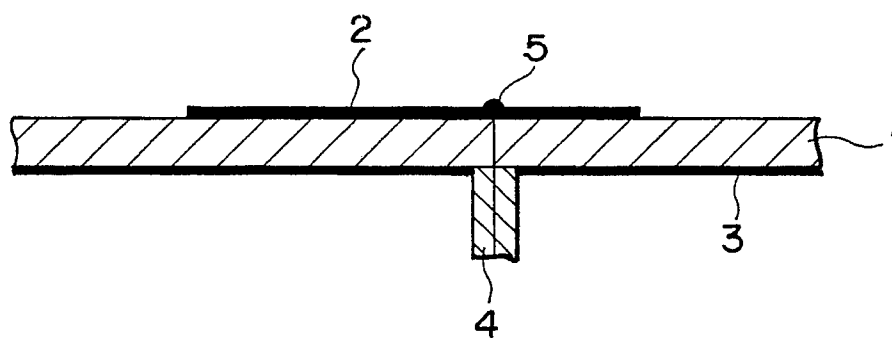


Fig. 6A

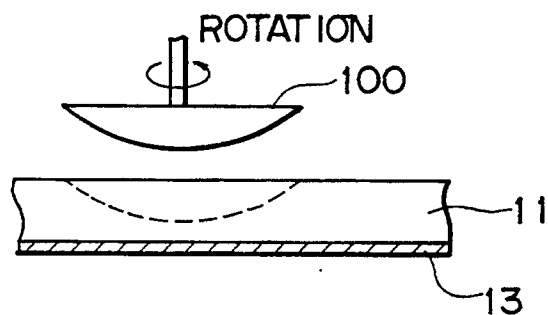


Fig. 6B



Fig. 6C

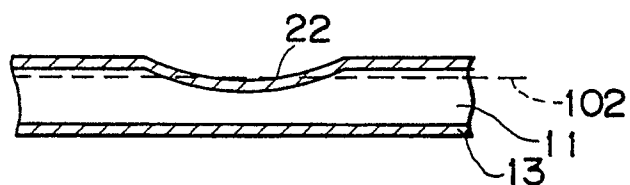


Fig. 6D

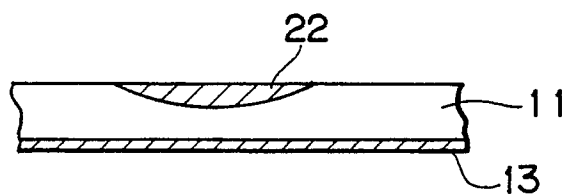
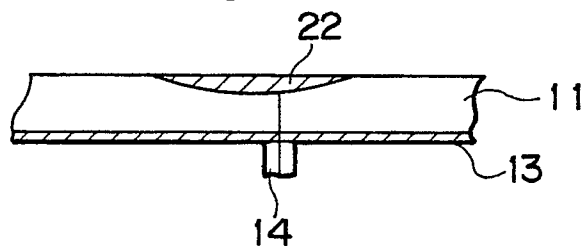


Fig. 6E





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)
X	I.E.E. PROCEEDINGS, SECTION A-I vol. 130, no. 3, part H, April 1983, pages 193-196, Old Working, GB; N. DAS et al.: "Conically Depressed Microstrip Patch Antenna" * page 193; Figure 1; Column 1 *	1,2	H 01 Q 9/04
A	--- ELECTRONICS LETTER vol. 21, no. 20, September 1985, pages 896-898, Stevenage, GB; L. JEDDARI et al.: "Broadband Conical Microstrip Antenna" * page 896; figure 1 *		
P,A	--- US-A-4 835 540 (T. HARUYAMA et al.) * figure 6; abstract *		
A	--- EP-A-0 279 050 (BALL CORPORATION) * figure 4; abstract *		
A	--- US-A-3 618 107 (W.M. SPANOS) * figure 1; column 1, lines 5-23 *		
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			H 01 Q
The present search report has been drawn up for all claims			
Place of search BERLIN		Date of completion of the search 03-07-1990	Examiner BREUSING J
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			