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(54) **Plane antenna with high gain and antenna efficiency**

Ebene Antenne mit hohem Gewinn und grossem Wirkungsgrad

Antenne plane avec rendement et gain élévés

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- **IEEE TRANSACTIONS ON BROADCASTING. vol. 34, no. 4, December 1988, NEW YORK US pages 457 - 464; ITO ET AL.: 'PLANAR ANTENNAS FOR SATELLITE RECEPTION'**

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Description

The present invention relates to a plane antenna as indicated in the precharacterizing part of claim 1.

Such a prior art (EP-A-0 345 454) plane antenna has been developed as an alternative to a parabola antenna for a microwave communication. In this prior art antenna the radiative element is formed by a slot and a patch, both of which are provided on the second printed board, while only a feed line is provided on the first printed board. The phase difference among the radiating elements is considered for the purpose of tilting the resultant radiation beam. In order to maximize the antenna efficiency in the plane microstrip array antenna with a beam tilt the distance between each two adjacent radiating elements should be 0.8λ to 0.9λ. However, in this type of antenna it is necessary to set the distance between adjacent radiating elements to be 0.64λ or less.

In another example (EP-A-0 345 454) of a plane antenna, there is a microstrip type plane antenna shown in Figures 1(A) and 1(B), where the antenna comprises: a dielectric body 2; a current supply line 5 in a form of a strip line provided on an upper side of the dielectric body 2; and a patch shaped radiative element 4 provided on the upper side of the dielectric body 2 at the end of the current suppy line 5. The antenna for practical use actually has a plurality of the patch shaped radiative elements 4 arranged in an array, among which the current supply lines 5 are arranged with their lengths, branching positions, and line widths appropriately adjusted for the sake of phase matching and impedance matching.

However, in this type of a microstrip type plane antenna, the current supply lines 5 are exposed on the radiation plane, so that there are unnecessary radiations radiated from branching and curving sections and curving sections of the current supply lines 5. As result, the radiation characteristic has been rather low in this type of a microstrip type plane antenna.

As an improvement on such a conventional microstrip type plane antenna, it has been proposed a microstrip type plane antenna shown in Figs. 2(A) and 2(B), where the antenna comprises: a first dielectric body 2; a first grounding conductor body 1 provided on a lower side of the first dielectric body 2; a current supply line 5 in a form of a strip line provided on an upper side of the first dielectric body 2; a patch shaped radiative element 4 provided on the upper side of the first dielectric body 2 at an end of the current supply line 5; a second dielectric body 21 formed on the upper side of the first dielectric body 2 over the radiative element 4 and the current supply line 5; and a second grounding conductor body 11 provided on the upper side of the second dielectric body 21, which has a slot 3 at a position located directly above the radiative element 4.

An antenna of this type is shown in the following document : IEEE TRANSACTIONS ON BROADCASTING, vol 34, no. 4, December 1988, New York US pages 457-464; ITO ET AL.: "PLANAR ANTENNAS FOR SATELLITE RECEPTION", see the figure 11.

In a microstrip type plane antenna formed from a plurality of such antenna units arranged in an array, the current supply lines 5 are arranged in a space sandwiched between the first and second grounding conductor bodies 1 and 11, so that the unnecessary radiations from the branching and curving sections of the current supply lines 5 tend to be suppressed by being obstructed by the second grounding conductor body 11 while the radiations from the radiative elements 4 can be transmitted without any obstruction through the slots 3 as shown in Fig. 2(C), such that the antenna efficiency can be improved.

Although this microstrip type plane antenna is effective in suppressing the unnecessary radiations from the current supply lines, it is also associated with a problem that the radiation efficiency of this antenna becomes low when the area of the slot 3 is small such that the gain is lower by 1 to 4 dB compared with the antenna of Figs. 1 (A) and 1(B). If the area of the slot 3 is increased, the gain may be improved, but the effect of suppressing the unnecessary radiations from the current supply line would be weakened such that the antenna gain becomes low. It is therefore the object of the invention to provide a plane antenna with high gain and antenna efficiency.

According to the invention this object is solved by the features of claim 1.

The array antenna of the present invention is formed by a plurality of antenna units, where each radiative element is in radiative communication with all the slots of the antenna through the second dielectric body which is commonly provided for all the antenna units of the antenna. Here, this array structure of the present invention is realizable because of the characteristic feature concerning the use of the constant slot interval with a value equal to 0.72 to 0.93 times a wavelength corresponding to a central frequency of a frequency band for waves to be used. This constant slot interval is specifically chosen such that the phase of waves radiated from one slot are substantially aligned with the phase of waves radiated from adjacent slots. This consideration concerning the phases of waves radiated from the slots is necessary in realizing the sufficently high antenna efficiency and gain at the same time.

Other features and advantages of the present invention will become apparent from the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1(A) and 1(B) are a top plan view and a cross sectional view, respectively, of an example of a conventional microstrip type plane antenna.

Figs. 2(A) and 2(B) are a top plan view and a cross sectional view, respectively, of another example of a conventional microstrip type plane antenna.

Fig. 2(C) is a cross sectional view of a conventional microstrip type plane antenna constructed from antenna

units in a form shown in Figs. 2(A) and 2(B).

Figs. 3(A) and 3(B) are a top plan view and a cross sectional view, respectively, of a first embodiment of a microstrip type plane antenna according to the present invention.

Figs. 4(A) and 4(B) are top plan views of two configurations of adjacent slots for which a relationship between the gain and the relative slot pitch is examined.

Fig. 5 is a graph of a relationship between the gain and the relative slot pitch obtained for the two configurations of Figs. 4(A) and 4(B).

Fig. 6 is a top plan view of a configuration of neighboring slots for which a relationship between the gain and the relative slot pitch is evaluated.

Fig. 7 is a graph of a relationship between the gain and the relative slot size obtained for an antenna and for a single radiative element.

Figs. 8(A) to 8(F) are illustration of various possible shapes for the radiative element in the microstrip type plane antenna of Figs. 3(A) and 3(B).

Fig. 9 is a top plan view of an array antenna formed by arranging a plurality of the microstrip type plane antennas of Figs. 3(A) and 3(B) in an array.

Figs. 10(A) and 10(B) are a cross sectional view and a top plan view, respectively, of a second embodiment of a microstrip type plane antenna according to the present invention.

Fig. 11 is a graph of a relationship between the gain and the relative slot size obtained for a case using the passive element and for a case not using the passive element.

Fig. 12 is a schematic diagram for a possible arrangement in pair of two radiative elements in the microstrip type plane antenna according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to Figs. 3(A) and 3(B), a first embodiment of a microstrip type plane antenna according to the present invention will be described in detail.

In this first embodiment shown in Figs. 3(A) and 3 (B), a microstrip type plane antenna 10 is formed from a plurality of antenna units arranged in an array, each of which comprises: a first dielectric body 2; a first grounding conductor body 1 provided on a lower side of the first dielectric body 2; a current supply line 5 in a form of a strip line provided on an upper side of the first dielectric body 2; a patch shaped radiative element 4 provided on the upper side of the first dielectric body 2 at an end of the current supply line 5; a second dielectric body 21 formed on the upper side of the first dielectric body 2 over the radiative element 4 and the current supply line 5; and a second grounding conductor body 11 provided on the upper side of the second dielectric body 21, which has a slot 3 at a position located directly above the radiative element 4.

In this microstrip type plane antenna 10, the radiative elements 4 and the slots 3 are arranged in a planar array with a constant interval d in both of longitudinal and transverse directions, where a value of this interval d is set equal to 0.72 to 0.93 or more preferably 0.85 to 0.93 times a wavelength λ_0 corresponding to a central frequency of a frequency band for the waves to be transmitted or received by this microstrip type plane antenna 10, for the following reason.

Namely, the present inventors conducted an experiment to determine a relationship between a relative slot pitch D/λ_0 and the radiation gain for two cases shown in Figs. 4(A) and 4(B). In a case shown in Fig. 4(A), the radiative element 4 has one slot 3 located directly above it and another slot 31 located at a distance D from the slot 3 in a longitudinal or a transverse direction, while in a case shown in Fig. 4(B), the radiative element 4 has one slot 3 located directly above it and another slot 32 located at a distance D from the slot 3 in a diagonal direction.

The result obtained by this experiment is shown in Fig. 5 along with a case in which the radiative element 4 has only one slot 3 located directly above it. According to this result shown in Fig. 5, it can be observed that the gain for the case of Fig. 4(A) or the case of Fig. 4(B) becomes greater than the case of using a single slot only for the relative slot pitch D/λ_0 within a range of 0.72 to 0.93.

This result implies that the phase of the waves radiated from the slot 31 or 32 and the phase of the waves radiated from the slot 3 are substantially aligned with each other only for the relative slot pitch D/λ_0 within a range of 0.72 to 0.93, and that the gain is affected by the phase difference between these waves for the relative slot pitch D/λ_0 outside of this range.

On a basis of this observation, a case shown in Fig. 6 in which the radiative element 4 has one slot 3 located directly above it and eight other slots neighboring to this slot 3 in the longitudinal, transverse, and diagonal directions is considered, and a range of the relative slot pitch D/λ_0 for which the gain can be greater than that obtained by a single slot and for which the antenna efficiency can be greater than 60% is evaluated to be a range of 0.85 to 0.93.

For this reason, this range is selected as an appropriate one for the interval d between the slots 3 in the first embodiment shown in Figs. 3(A) and 3(B). Thus, in this first embodiment, the radiative elements 4 and the slots 3 are arranged in an array with such an interval for which the phase of the waves radiated from one slot can be aligned with the phase of the waves radiated from adjacent slots, so that it becomes possible to realize a high antenna gain while retaining a feature to suppress the unnecessary radiation from the current supply lines for the sake of the antenna efficiency.

Also, in this first embodiment, the shape of each slot 3 is selected to be a square having a length of each side equal to 0.48 to 0.65 times a wavelength λ_0 correspond-

ing to a central frequency of a frequency band for the waves to be transmitted or received by this microstrip type plane antenna 10, for the following reason.

Namely, the present inventors also conducted an experiment to determine a relationship of a relative slot size $\ell/\lambda_{\emptyset}$ with respect to the gain per antenna including 384 radiative elements which is indicated by an upper curve, or with respect to the gain per single radiative element which is indicated by a lower curve.

The result obtained by this experiment is shown in Fig. 7, from which it can be observed that the gain per single radiative element becomes greater than a conventionally attainable 8 dB for the relative slot size $\ell/\lambda_{\emptyset}$ within a range of 0.48 to 0.65, with a peak at a value approximately equal to 0.59.

For this reason, this range is selected as an appropriate one for the slot size of the slots 3 in the first embodiment shown in Figs. 3(A) and 3(B). Thus, the antenna efficiency in this first embodiment can be further improved by adopting the slot size within this range.

Here, it is to be noted that the shape of each slot 3 may be selected to be a circular disk having a diameter equal to 0.48 to 0.65 times a wavelength $\lambda_{\emptyset}$ corresponding to a central frequency of a frequency band for the waves to be transmitted or received by this microstrip type plane antenna 10, instead of the square shape as described above and depicted in the drawings.

It is also to be noted that the shape of each radiative element 4 in this first embodiment can be selected from various shapes shown in Figs. 8(A) to 8(F). In a case of dealing with linearly polarized waves, the patch shaped radiative element of a square shape as shown in Fig. 8 (A) or of a circular disk shape as shown in Fig, 8(B) may be employed. In a case of dealing with circularly polarized waves, the two-point current supply type radiative element of a square shape as shown in Fig. 8(C) or of a circular disk shape as shown in Fig, 8(D), to which two current supply lines with 90° phase difference are attached, may be employed. Also, in this case, the one-point current supply type radiative element incorporating a so called perturbation in which a ratio with respect to the longitudinal and transverse directions is altered, such as those shown in Fig. 8(E) and Fig. 8(F) may be employed instead.

More specifically, the microstrip type plane antenna 10 of this first embodiment has been actually constructed as follows.

In a configuration shown in Figs. 3(A) and 3(B), the first grounding conductor body 1 is formed from an aluminum plate of 140 mm × 140 mm size and 3 mm thickness. The first dielectric body 2 is formed from a polyethylene foam of 2 mm thickness having the relative dielectric constant approximately equal to 1.1 which is covered on its upper side by a substrate formed by a copper foil attached to a polyethylene film of 25 μm thickness, where the antenna circuit including the radiative elements 4 and the current supply lines 5 are formed on this substrate by etching off the unnecessary parts of the copper foil from the substrate. The second dielectric body 21 is formed from a polyethylene foam of 2 mm thickness having the relative dielectric constant approximately equal to 1.1, and the second grounding conductor body 11 is formed from an aluminum plate of 0.5 mm thickness, on which the slots 3 are formed at positions located directly above the radiative elements 4.

Here, a number of the radiative elements 4 and a number of slots 3 are sixteen respectively, and these sixteen radiative elements 4 and sixteen slots 3 are arranged in a planar array with a constant interval d in both of longitudinal and transverse directions, where a value of this interval d is set equal to 0.89 times a wavelength $\lambda_{\emptyset}$ = 11.85 GHz corresponding to a central frequency of a frequency band for the waves to be transmitted or received by this microstrip type plane antenna 10, while the shape of each slot 3 is selected to be a square having a length of each side equal to 0.51 times the aforementioned wavelength $\lambda_{\emptyset}$, which takes a value of 13 mm.

The measured antenna gain of this microstrip type plane antenna was 19.5 dB, according to which the gain per single radiative element has been improved by approximately 3 dB compared with a case of the radiative element having only one slot directly above it.

Also, twenty-four of the antennas with a configuration of Figs. 3(A) and 3(B) just described above are arranged in a square array as shown in Fig. 9, with a current supply point located at a center of the square array to form an array antenna. The measured antenna gain of this array antenna was 33.2 dB, according to which the gain per single radiative element has been improved by approximately 3.3 dB compared with a case of the radiative element having only one slot directly above it.

In addition, the antenna with a configuration similar to that shown in Figs. 3(A) and 3(B) except that the shape of each slot 3 is selected to be a circular disk having a diameter equal to 0.51 times the aforementioned wavelength $\lambda_{\emptyset}$ was also constructed, and the result similar to that obtained by the configuration of Figs. 3(A) and 3(B) were also obtained.

Referring now to Figs. 10(A) and 10(B), a second embodiment of a microstrip type plane antenna according to the present invention will be described in detail.

In this second embodiment shown in Figs. 10(A) and 10(B), a microstrip type plane antenna is formed from a plurality of antenna units arranged in an array, each of which comprises: a first dielectric body 2; a first grounding conductor body 1 provided on a lower side of the first dielectric body 2; a current supply line 5 in a form of a strip line provided on an upper side of the first dielectric body 2; a patch shaped radiative element 4 provided on the upper side of the first dielectric body 2 at an end of the current supply line 5; a second dielectric body 21 formed on the upper side of the first dielectric body 2 over the radiative element 4 and the current supply line 5; a second grounding conductor body 11 provided on the upper side of the second dielectric body 21, which has a slot 3 at a position located directly above the radiative

element 4; a third dielectric body 22 formed on the upper side of the second grounding conductor body 11; and a passive element 6 provided on the upper side of the third dielectric body 22 at a position directly above the slot 3.

In this microstrip type plane antenna, the radiative elements 4 and the slots 3 are arranged in a planar array with a constant interval d in both of longitudinal and transverse directions, where a value of this interval d is set equal to 0.72 to 0.93 or more preferably 0.85 to 0.93 times a wavelength λ_0 corresponding to a central frequency of a frequency band for the waves to be transmitted or received by this microstrip type plane antenna, as in the first embodiment described above.

Also, in this second embodiment, the shape of each slot 3 is selected to be a square having a length of each side equal to 0.48 to 0.65 times a wavelength λ_0 corresponding to a central frequency of a frequency band for the waves to be transmitted or received by this microstrip type plane antenna 10, as in the first embodiment described above.

The additional feature of the passive element 6 in this second embodiment has the following effect.

Namely, the present inventors conducted an experiment to determine a relationship of a relative slot size ℓ/λ_0 and the gain for a case using the passive element 6 and a case not using the passive element 6.

The result obtained by this experiment is shown in Fig. 11 along with a case of using an optimized microstrip structure, from which it can be observed that the gain becomes greater for the case using the passive element 6 compared with the case not using the passive element 6, for smaller slot sizes.

Here, it is to be noted that the shape of each passive element 6 in this second embodiment can be selected to be any shape used for the usual radiative element, such as a square shape or a circular disk shape.

More specifically, the microstrip type plane antenna of this second embodiment has been actually constructed as follows.

In addition to the specific construction of the microstrip type plane antenna 10 of the first embodiment described above, the third dielectric body 22 is formed from a polyethylene foam of 2 mm thickness having the relative dielectric constant approximately equal to 1.1 which is covered on its upper side by a substrate formed by a copper foil attached to a polyethylene film of 25 μm thickness, where the passive element 6 is formed on this substrate by etching off the unnecessary parts of the copper foil from the substrate at a position located directly above the slot 3 and the radiative element 4.

The value of the interval d is set equal to 0.89 times a wavelength λ_0 = 11.85 GHz corresponding to a central frequency of a frequency band for the waves to be transmitted or received by this microstrip type plane antenna, while the shape of each slot 3 is selected to be a square having a length of each side equal to 0.51 times the aforementioned wavelength λ_0, which takes a value of 13 mm, as in the case of the first embodiment described above.

With this microstrip type plane antenna of the second embodiment, the result similar to that obtained by the configuration of Figs. 3(A) and 3(B) were also obtained.

Thus, in this second embodiment, the antenna efficiency of the microstrip type plane antenna can be further improved by using the additional passive element.

It is to be noted that the radiative elements 4 in the above described embodiments may be arranged in units of pairs, as shown in Fig. 12. Namely, one radiative element 4a and another adlacent radiative element 4b may be arranged such that the radiative element 4a is rotated by 90° with respect to the radiative element 4b, and the radiative element 4a is connected to the common single current supply line 5 a branch 5a while the radiative element 4b is connected to the common single current supply line 5 through another branch 5b which is longer than the branch 5a such that the phases from the radiative elements 4a and 4b can be matched at the common single current supply line 5.

Claims

1. A plane antenna (10) formed by a plurality of antenna units arranged in an array, each of the antenna units comprising:

   a first dielectric body (2);

   a first grounding conductor body (1) provided on a lower side of the first dielectric body (2);

   a current supply line (5) in a form of a strip line provided on an upper side of the first dielectric body (2);

   a patch shaped radiative element (4) provided on the upper side of the first dielectric body (2) at an end of the current supply line (5);

   a second dielectric body (21) formed on the upper side of the first dielectric body (2) over the radiative element (4) and the current supply line (5); and

   a second grounding conductor body (11) provided on the upper side of the second dielectric body (21), which has a slot (3) at a position located directly above the radiative element (4); wherein

   the radiative elements (4) and the slots (3) of the plane antenna (10) are arranged in a planar array with a constant interval (d) in two orthogonal directions and each radiative element (4) is in radiative communication with all the slots

(3) of the plane antenna (10) through the second dielectric body (21) which is commonly provided for all the antenna units of the plane antenna (10), **characterized in that** said constant interval (d) has a value equal to 0.72 to 0.93 times a wavelength (λo) corresponding to a central frequency of a frequency band for waves to be used such that the phase of the waves radiated from a patch through one slot (3) are substantially aligned with the phase of the waves radiated from the same patch through the adjacent slots (3), said wavelength (λo), being measured in the air.

2. The plane antenna of claim 1, wherein the constant interval (d) of the planar array has a value equal to 0.85 to 0.93 times the wavelength (λo) corresponding to the central frequency of the frequency band for waves to be used.

3. The plane antenna of claim 1, wherein the slot (3) of each antenna unit is in a square shape having a length of each side equal to 0.48 to 0.65 times the wavelength (λo) corresponding to the central frequency band for the waves to be used.

4. The plane antenna of claim 1, wherein the slot (3) of each antenna is in a circular disk shape having a diameter equal to 0.48 to 0.65 times the wavelength (λo) corresponding to the central frequency of the frequency band for the waves to be used.

5. The plane antenna of claim 1, wherein each antenna unit further comprises:

a third dielectric body (22) formed on the upper side of the second grounding conductor body; and

a passive element (6) provided on the upper side of the third dielectric body (22) at a position directly above the slot (3).

6. The plane antenna of claim 1, wherein the radiative elements of the plane antenna are arranged in units of pairs.

Patentansprüche

1. Ebene Antenne (10), die von einer Vielzahl von in einem Feld angeordneten Antenneneinheiten gebildet ist, mit:

einem ersten dielektrischen Körper (2) ;

einem ersten erdenden Leiterkörper (1), der auf einer Unterseite des ersten dielektrischen Körpers (2) vorgesehen ist;

einer Stromzuführungsleitung (5) in Form einer Streifenleitung, die auf einer Oberseite des ersten dielektrischen Körpers (2) vorgesehen ist;

einem fleckenförmigen Strahlerelement (4), das auf der Oberseite des ersten dielektrischen Körpers (2) an einem Ende der Stromzuführungsleitung (5) vorgesehen ist;

einem zweiten dielektrischen Körper (21), der auf der Oberseite des ersten dielektrischen Körpers (2) über dem Strahlerelement (4) und der Stromzuführungsleitung (5) gebildet ist, und

einem zweiten erdenden Leiterkörper (11), der auf der Oberseite des zweiten dielektrischen Körpers (21) vorgesehen ist und einen Schlitz (3) an einer Stelle hat, die unmittelbar oberhalb des Strahlerelements (4) angeordnet ist; wobei

die Strahlerelemente (4) und die Schlitze (3) der ebenen Antenne (10) in einem ebenen Feld mit einem konstanten Intervall (d) in zwei orthogonalen Richtungen angeordnet sind und jedes Strahlerelement (4) sich in strahlender Verbindung mit allen Schlitzen (3) der ebenen Antenne (10) durch den zweiten dielektrischen Körper (21) befindet, der für alle Antenneneinheiten der ebenen Antenne (10) gemeinsam vorgesehen ist, **dadurch gekennzeichnet**, daß das konstante Intervall (d) einen Wert gleich 0,72 bis 0,93 mal einer Wellenlänge (λ_0) hat, die einer Mittenfrequenz eines Frequenzbandes für Wellen entspricht, die so benutzt werden, daß die Phase der von einem Fleck durch einen Schlitz (3) abgestrahlten Wellen im wesentlichen mit der Phase der Wellen ausgerichtet ist, die von dem gleichen Fleck durch die benachbarten Schlitze (3) abgestrahlt werden, wobei die Wellenlänge (λ_0) in Luft gemessen wird.

2. Ebene Antenne nach Anspruch 1, wobei das konstante Intervall (d) des ebenen Feldes einen Wert gleich 0,85 bis 0,93 mal der Wellenlänge (λ_0) hat, die der Mittenfrequenz des Frequenzbandes für die zu benutzenden Wellen entspricht.

3. Ebene Antenne nach Anspruch 1, wobei der Schlitz (3) jeder Antenneneinheit eine quadratische Form mit einer Seitenlänge von 0,48 bis 0,65 mal der Wellenlänge (λ_0) hat, die der Mittenfrequenz des Frequenzbandes für die zu benutzenden Wellen entspricht.

4. Ebene Antenne nach Anspruch 1, wobei der Schlitz

(3) jeder Antenne eine kreisförmige Scheibenform hat mit einem Durchmesser gleich 0,48 bis 0,65 mal der Wellenlänge (λ_0), die der Mittenfrequenz des Frequenzbandes für die zu benutzenden Wellen entspricht.

5. Ebene Antenne nach Anspruch 1, wobei jede Antenneneinheit außerdem aufweist:

einen dritten dielektrischen Körper (22), der auf der Oberseite des zweiten erdenden Leiterkörpers gebildet ist, und

ein passives Element (6), das auf der Oberseite des dritten dielektrischen Körpers (22) an einer Stelle unmittelbar oberhalb des Schlitzes (3) vorgesehen ist.

6. Ebene Antenne nach Anspruch 1, wobei die Strahlerelemente der ebenen Antenne in Einheiten von Paaren angeordnet sind.

Revendications

1. Antenne plane (10) formée par une pluralité d'unités formant antenne agencées en une matrice, chacune des unités formant antenne comprenant :

un premier corps diélectrique (2) ;
un premier corps conducteur de mise à la masse (1) disposé sur une face inférieure du premier corps diélectrique (2) ;
une ligne d'alimentation en courant (5) sous la forme d'une microbande disposée sur une face supérieure du premier corps diélectrique (2) ;
un élément radiatif en forme de pastille (4) disposé sur la face supérieure du premier corps diélectrique (2) au niveau d'une extrémité de la ligne d'alimentation en courant (5) ;
un second corps diélectrique (21) formé sur la face supérieure du premier corps diélectrique (2) au-dessus de l'élément radiatif (4) et de la ligne d'alimentation en courant (5) ; et
un second corps conducteur de mise à la masse (11) disposé sur la face supérieure du second corps diélectrique (21), lequel possède une fente (3) à une position située directement au-dessus de l'élément radiatif (4) ;
dans laquelle les éléments radiatifs (4) et les fentes (3) de l'antenne plane (10) sont agencés selon une matrice plane avec un intervalle constant (d) dans deux directions perpendiculaires et chaque élément radiatif (4) est en communication radiative avec toutes les fentes (3) de l'antenne plane (10) par l'intermédiaire du second corps diélectrique (21) qui est habituellement prévu pour toutes les unités formant antenne de l'antenne plane (10), caractérisée en ce que ledit intervalle constant (d) a une valeur égale à 0,72 à 0,93 fois une longueur d'onde (λo) correspondant à une fréquence centrale d'une bande de fréquences pour des ondes à utiliser de sorte que la phase des ondes émises à partir d'une pastille par l'intermédiaire d'une fente particulière (3) est sensiblement alignée avec la phase des ondes émises à partir de la même pastille par l'intermédiaire des fentes adjacentes (3), ladite longueur d'onde (λo) étant mesurée dans l'air.

2. Antenne plane selon la revendication 1, dans laquelle l'intervalle constant (d) de la matrice plane a une valeur égale à 0,85 à 0,93 fois la longueur d'onde (λo) correspondant à la fréquence centrale de la bande de fréquences pour les ondes à utiliser.

3. Antenne plane selon la revendication 1, dans laquelle la fente (3) de chaque unité formant antenne est de forme carrée ayant une longueur de côté égale à 0,48 à 0,65 fois la longueur d'onde (λo) correspondant à la bande de fréquence centrale pour les ondes à utiliser.

4. Antenne plane selon la revendication 1, dans laquelle la fente (3) de chaque unité formant antenne a une forme de disque circulaire ayant un diamètre égal à 0,48 à 0,65 fois la longueur d'onde (λo) correspondant à la fréquence centrale de la bande de fréquences pour les ondes à utiliser.

5. Antenne plane selon la revendication 1, dans laquelle chaque unité formant antenne comprend :

un troisième corps diélectrique (22) formé sur la face supérieure du second corps conducteur de mise à la masse ; et
un élément passif (6) disposé sur la face supérieure du troisième corps diélectrique (22) à une position directement au-dessus de la fente (3).

6. Antenne plane selon la revendication 1, dans laquelle les éléments radiatifs de l'antenne plane sont agencés en unités formant des paires.

FIG. 1 (A)
PRIOR ART

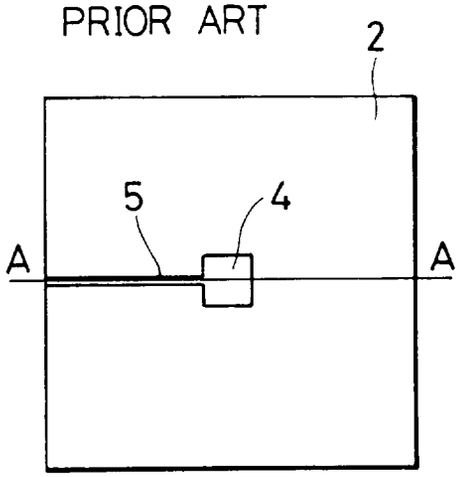


FIG. 2 (A)
PRIOR ART

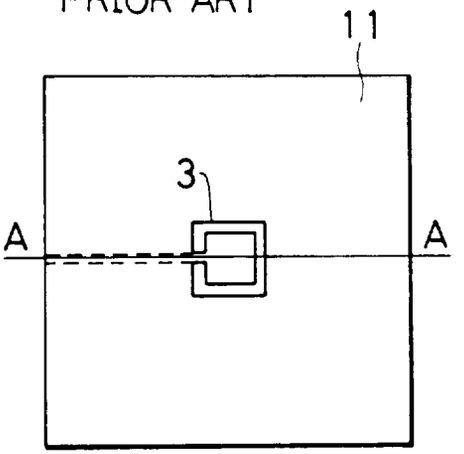


FIG. 1 (B)
PRIOR ART

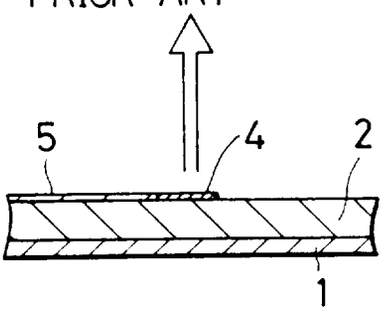


FIG. 2 (B)
PRIOR ART

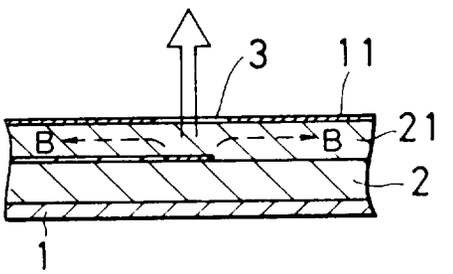


FIG. 2 (C)
PRIOR ART

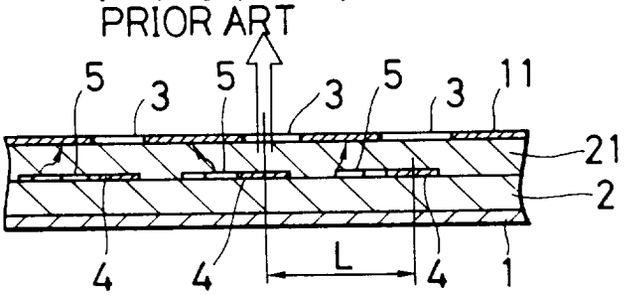


FIG. 3 (A)

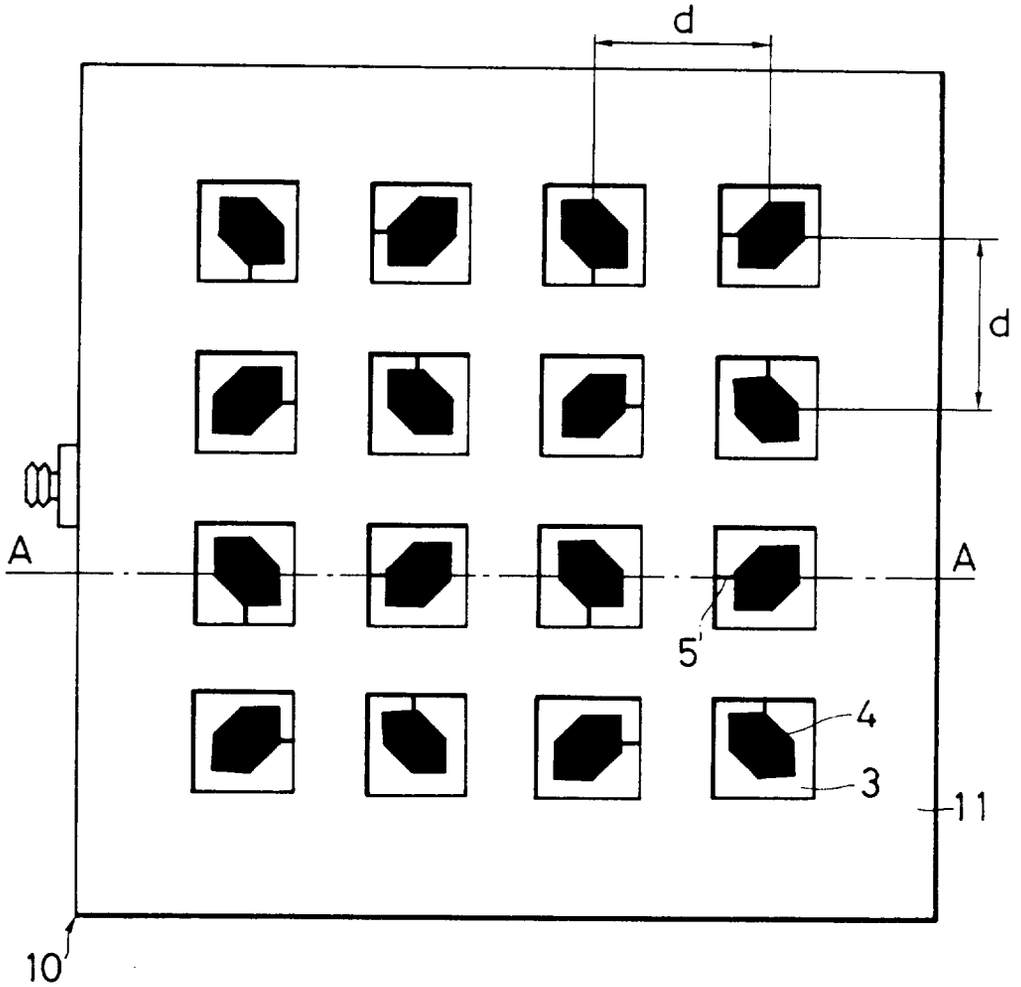


FIG. 3 (B)

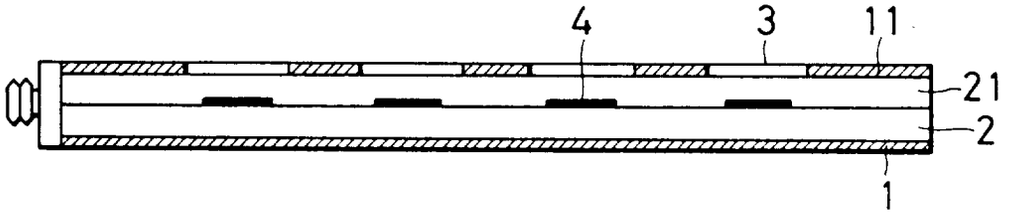


FIG.4(A)

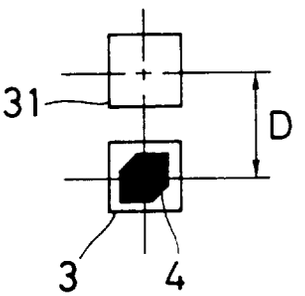


FIG.4(B)

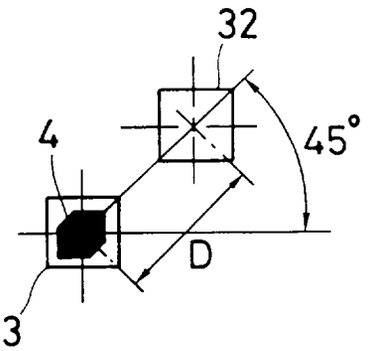


FIG.5

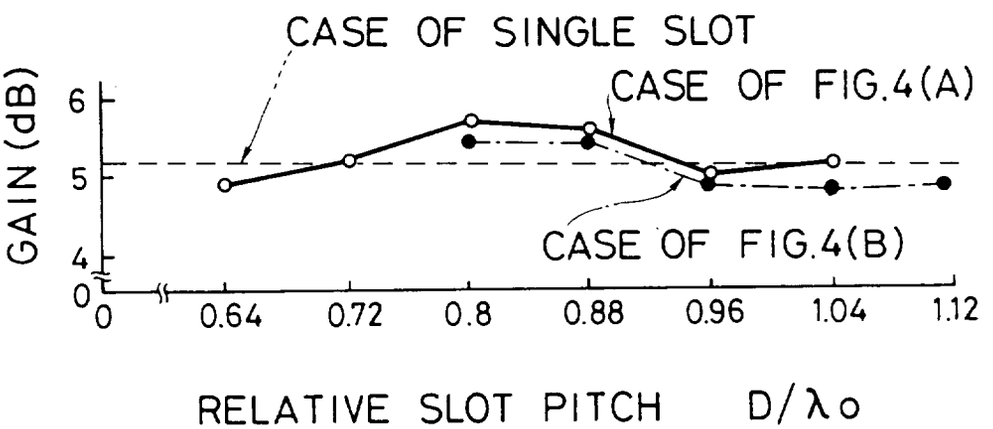
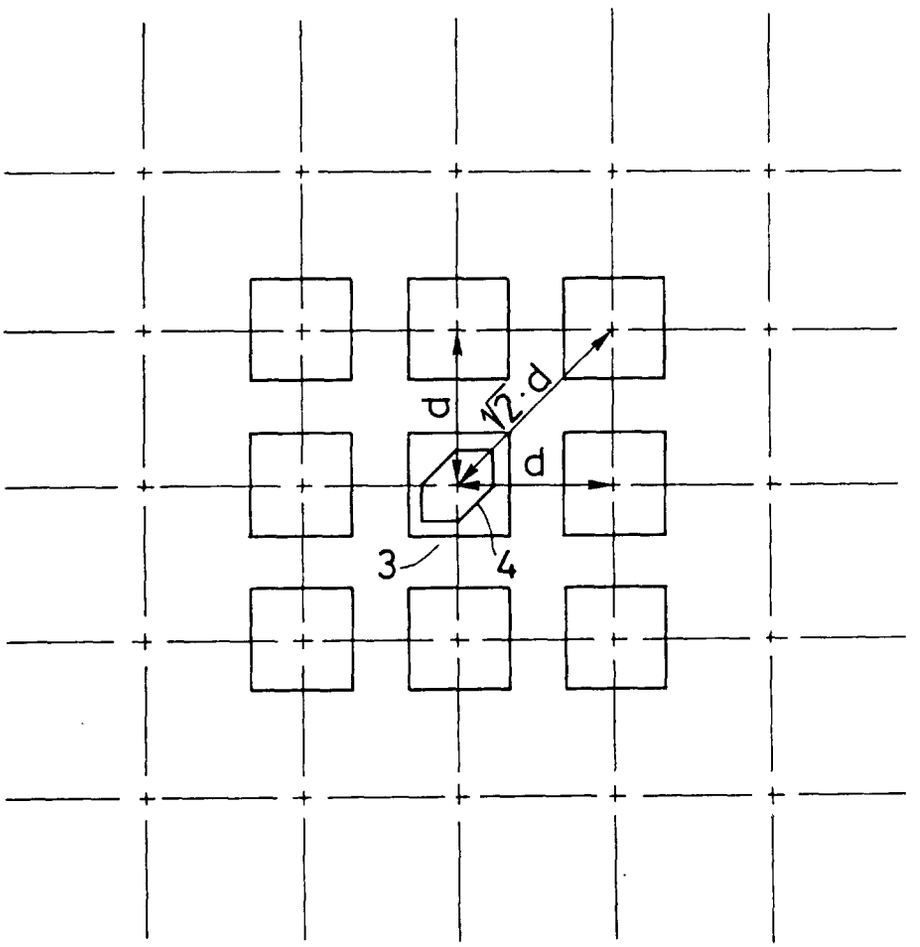


FIG.6



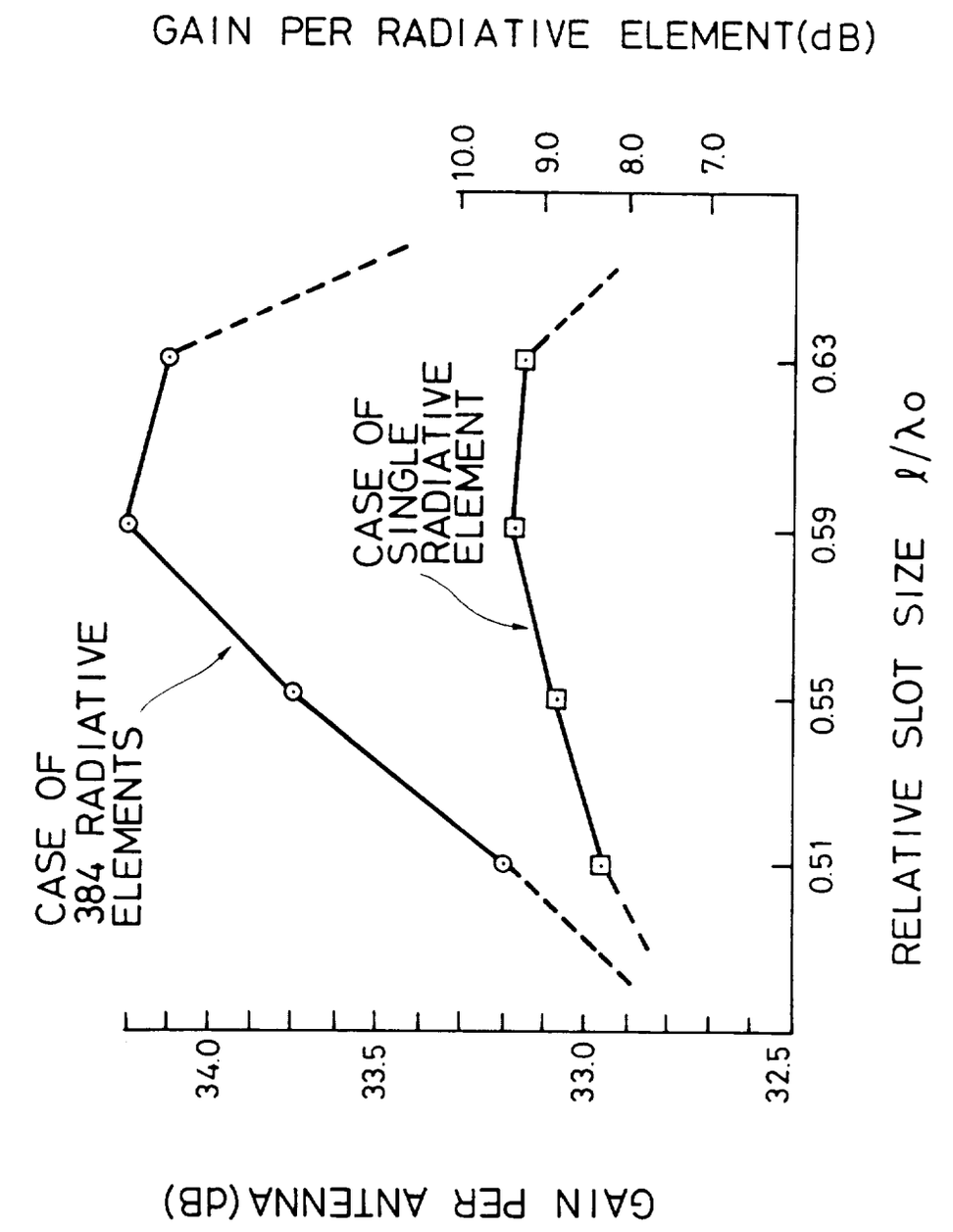

GAIN PER RADIATIVE ELEMENT(dB)
10.0
9.0
8.0
7.0
CASE OF SINGLE RADIATIVE ELEMENT
CASE OF 384 RADIATIVE ELEMENTS
34.0
33.5
33.0
32.5
GAIN PER ANTENNA (dB)
0.51
0.55
0.59
0.63
RELATIVE SLOT SIZE ℓ/λo

FIG. 7

FIG.8(A) FIG.8(B)

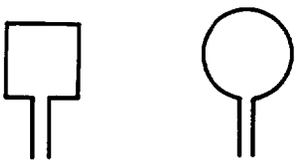


FIG.8(C) FIG.8(D)

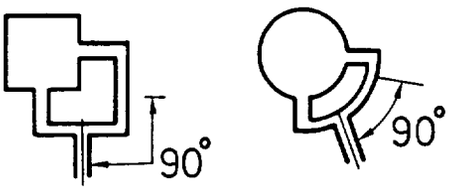


FIG.8(E) FIG.8(F)

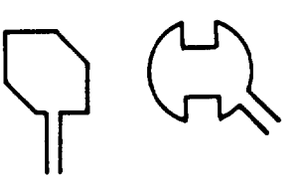


FIG.9

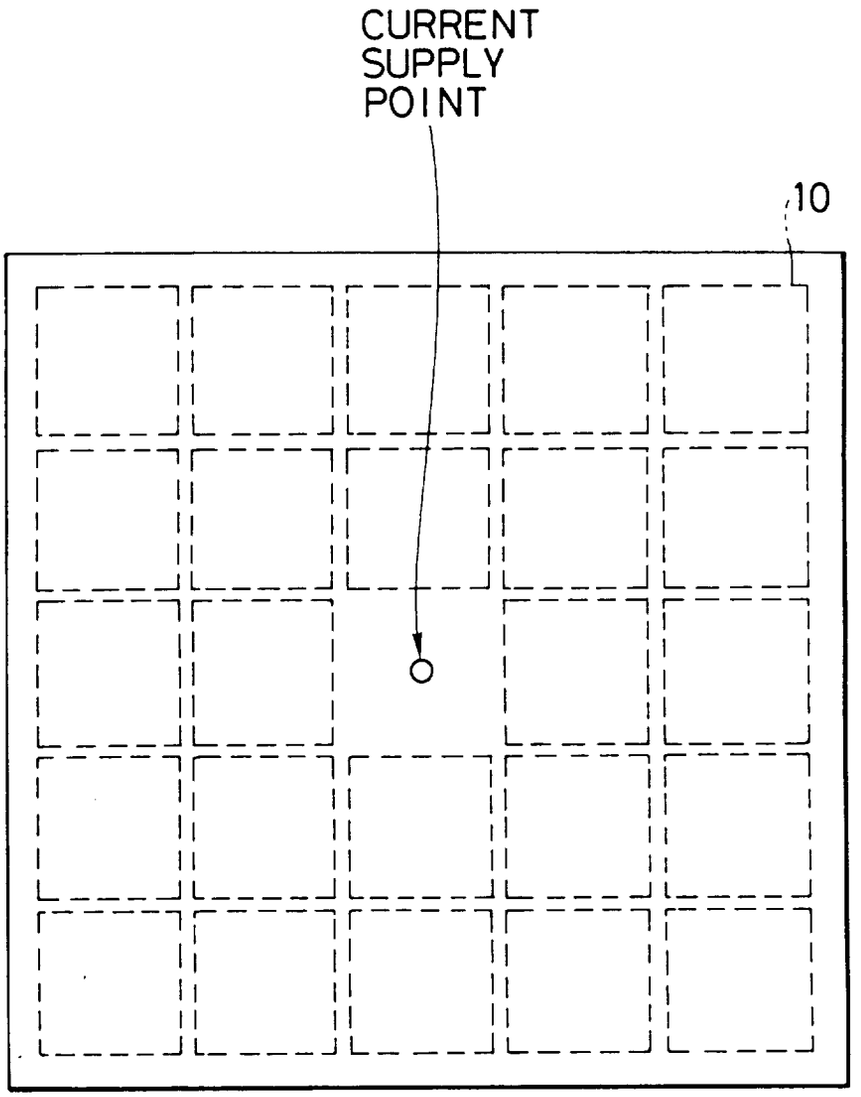


FIG.10 (A)

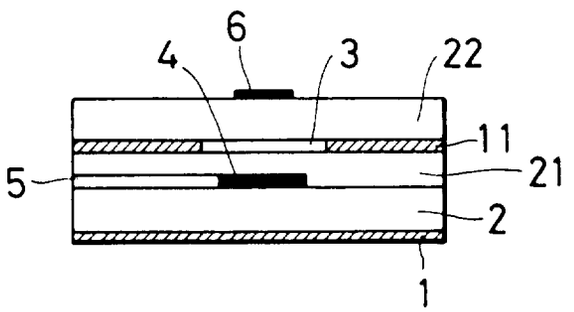
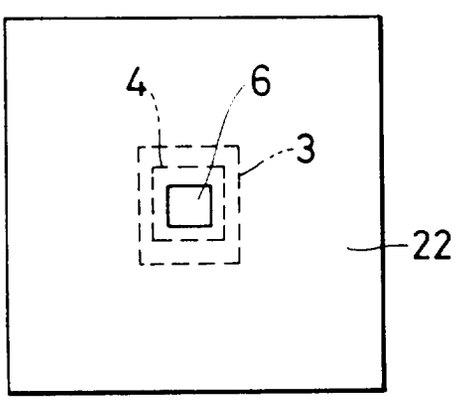


FIG.10 (B)



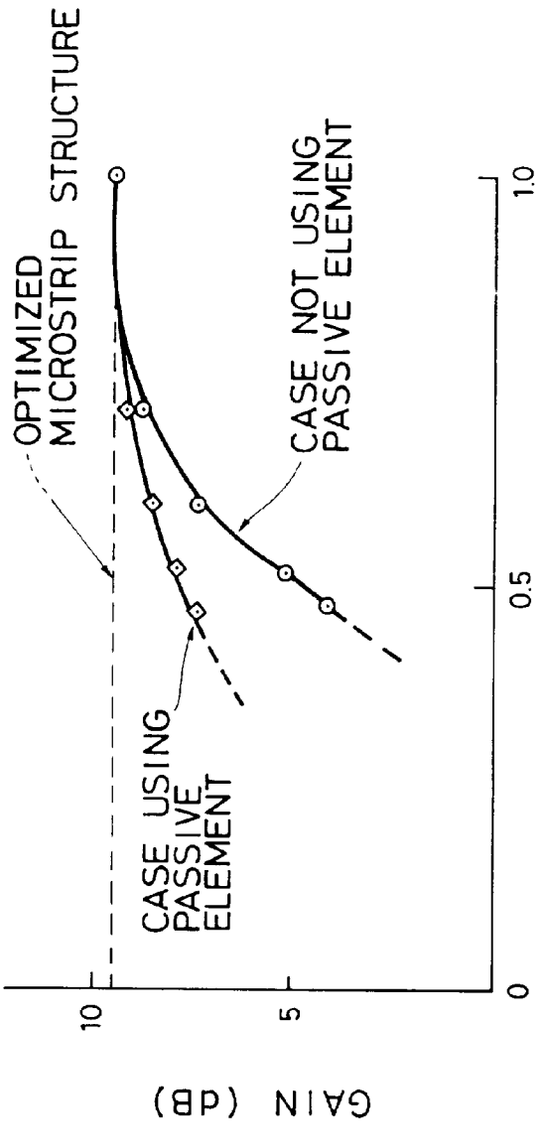

OPTIMIZED MICROSTRIP STRUCTURE
CASE NOT USING PASSIVE ELEMENT
CASE USING PASSIVE ELEMENT
GAIN (dB)
10
5
0
0.5
1.0
RELETIVE SLOT SIZE ℓ/λo

FIG.11

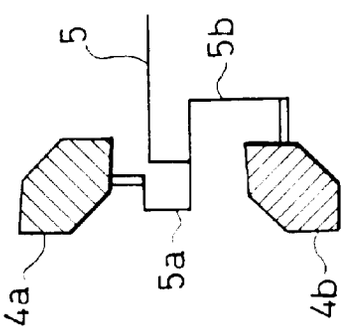

5
5b
4a
5a
4b

FIG.12