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(54) **NOTCH ANTENNA**

GEKERBTE ANTENNE

ANTENNE À ENCOCHE

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Description

Field of the Invention

[0001] The invention described herein relates to notch antennas, to plate components of notch antennas, and to related manufacturing and installation methods.

Background to the Invention

[0002] A conventional notch antenna is shown in Figure 1. The antenna comprises a plate P with a notch N, the notch N being coupled to feed line F at a feed point. To give omnidirectional polar characteristics at the centre of a desired operating frequency range the width W of the plate P is chosen to be less than a quarter of one wavelength. The notch N is doglegged to allow the notch to be of sufficient length.

[0003] However, matching the dimensions of the notch and plate to give high efficiency and omnidirectional polar characteristics across a wide operating frequency range is difficult. Further difficulties arise when this type of antenna is installed close to the ground, near to metallic structures or in other areas where the local permittivity differs from that of free space, as such installations can severely effect antenna operation within the intended operating frequency range.

[0004] US2004239575 A1 describes a mobile terminal comprising a broad band notch antenna composed of a fed notch and a parasitic notch operating through electromagnetic coupling with the fed notch. The two notches are of different lengths and cut in parallel with from the same edge of a printed circuit board.

[0005] US5917454 describes a slotted ring-shaped antenna for toroidal radiation in global positioning system comprising a flexible cylindrical copper strip arranged around an electronic package including a driven slot and parasitically driven slots. A copper tape placed over each slot in order to adjust the length thereof such that the slot radiates at the desired frequency.

[0006] US2002171594 describes a dual band slot antenna having a fed slot and a parasitic slot.

[0007] EP1148582 describes a slot antenna with parasitic slots used to influence the beam width of the antenna.

[0008] WO2006/097496 describes a mobile phone comprising a notch antenna with an adjustment component arranged across the notch.

[0009] US2009/273524 describes an antenna which includes: a plate-like base made of an insulating material; and a conductor in a predetermined shape, which has multiple cut-out portions and which is provided at a predetermined position of the base to obtain predetermined antenna characteristics. The antenna is configured so that the antenna characteristics can be mostly maintained even when the base is deformed into a predetermined curved-surface shape.

[0010] WO00/69021 describes a concealed antenna system for a vehicle radio communication system which consists of a slot or notch cut in a conductive panel which is adapted to form part of or be fitted to the structure of a vehicle with which the radio communication system is to be used. In order to produce vertically polarised radiation the antenna is positioned with the slot or notch horizontal and in order to ensure that the antenna operates with a non-resonant feed line matched to the antenna impedance of coaxial cable is connected to the edges of the slot by insulated leads linked to the magnetic field in a portion of the slot. Alternatively a nonmagnetic electrically conductive element is positioned spanning a part of the slot and insulated therefrom.

[0011] It is an aim of example embodiments of the invention to address at least one disadvantage of the prior art.

Summary of the Invention

[0012] According to the present invention there is provided an apparatus and method as set forth in the appended claims. Other features of the invention will be apparent from the dependent claims.

[0013] Suitably, the second notch is arranged with the first to be excited, in use, by currents induced around the first notch.

Suitably, the first notch comprises an open end at an edge of the plate, a closed end, and long edges between the open and closed ends. Suitably, the second notch comprises an open end at an edge of the plate, a closed end, and long edges between the open and closed ends. Suitably, the plate comprises a metallic material. Suitably, the plate comprises a thin, electrically conducting material. Suitably, the plate comprises an elastically deformable material. Suitably, the plate comprises a flexible material. Suitably, the antenna further comprises a cover arranged over one or both faces of the plate. Suitably, the cover is electrically non-conductive. Suitably, the cover is of low electrical permittivity to radio frequency energy within the operating range of the antenna. Suitably, the cover comprises part of a vehicle registration plate.

[0014] Suitably, the plate comprises a component selected from a group including: the ground plane of a circuit-board, metal sheet and expanded metal.

Suitably, the plate has a width, x, dimension, a height, z, dimension and a depth, y, dimension.

Suitably, the depth of the plate is small in comparison to the width and height. Suitably, the plate is generally rectangular.

Suitably, the width of the plate is equal to or greater than one quarter of one wavelength at the centre of the operating frequency range. Suitably, the width of the plate is selected according to the desired frequency for the centre of the operating range.

[0015] Suitably, the first and second notches open on opposite plate edges.

Suitably, the first notch is generally linear. Suitably, the second notch is generally linear.

Suitably the first notch comprises long edges aligned with the width dimension of the plate.
Suitably, the second notch comprises long edges aligned with the width dimension of the plate.
Suitably, the first notch is of length less than or equal to one fifth of one wavelength at the centre of the operating frequency range. Suitably, the second notch is of length less than one fifth of one wavelength at the centre of the operating frequency range. Suitably, the length of the first and/or second notch is selected with a length according to the desired frequency for the centre of the operating range.

[0016] Suitably the notch antenna comprises an adjustment portion provided to the second notch to facilitate change to the effective length of the second notch. Suitably, the adjustment portion comprises a conductive patch applied to the second notch, suitably applied across the second notch. Suitably, the adjustment portion is applied at the closed end of the second notch.
Suitably, the adjustment portion comprises a piece of adhesive backed tape, preferably adhesive backed metallic tape. Suitably, the adjustment portion is arranged to bridge the second notch with a conducing element in contact with the plate. Suitably, the adjustment portion is arranged to provide a conductor that is capacitively coupled to the plate. Suitably, the adjustment portion comprises an semiconductor component coupled across the second notch. Suitably, the adjustment portion comprises a switching component coupled across the second notch. Suitably, the adjustment portion comprises a PIN diode coupled across the second notch. Suitably, the adjustment portion comprises a plurality of like or unlike components, including one or more selected from the adjustment portions described above.
Suitably, the feed line comprises a coaxial feed line. Suitably, the feed line comprises a microstrip connection across the first notch. Suitably, the antenna comprises a sealed body provided around the plate. Suitably, the sealed body is an insulating body. Suitably, the adjustment portion is provided outside the sealed body.
Suitably, the first and second notches are manufactured with different lengths. Suitably, the second notch is longer than the first notch. Suitably, the adjustment portion shortens the effective length of the second notch.

[0017] The method of manufacturing a notch antenna comprising the steps of: providing a first notch coupled to a feed line, and providing a second notch in use to be passively excited by a signal supplied to the first notch through the feed line.
Suitably the method further comprises providing an adjustment portion for the second notch to change the effective length of the second notch. Suitably, the method further comprises providing an adjustment portion in the form of a conductive patch applied to the second notch, suitably applied across the second notch. Suitably, the adjustment portion is applied at the closed end of the second notch. Suitably, the adjustment portion comprises a piece of adhesive backed tape, preferably adhesive backed metallic tape. Suitably, the method further comprises providing an adjustment portion in the form of a semiconductor component coupled across the second notch. Suitably, the adjustment portion comprises a switching component coupled across the second notch. Suitably, the adjustment portion comprises a PIN diode coupled across the second notch. Suitably, the adjustment portion comprises a plurality of like or unlike components, including one or more selected from the adjustment portions described above.

[0018] The method comprising installing the antenna at a desired installation position, and providing an adjustment portion for the second notch to change the effective length of the second notch in response to a detected frequency shift from a desired centre frequency caused by electrical permittivity of the installation position.
Suitably, providing the adjustment portion comprises providing a conductive patch applied to the second notch, suitably applied across the second notch. Suitably, the adjustment portion is applied at the closed end of the second notch. Suitably, the adjustment portion comprises a piece of adhesive backed tape, preferably adhesive backed metallic tape.

Brief introduction to the Figures

[0019] For a better understanding of the invention, and to show how embodiments of the same may be carried into effect, reference will now be made, by way of example, to the accompanying diagrammatic drawings in which:

Figure 1 shows a schematic front view of a conventional notch antenna;
Figure 2 shows a schematic front view of a notch antenna according to an example embodiment of the invention described herein;
Figure 3 shows a schematic front view of a plate for a notch antenna according to an example embodiment of the invention described herein;
Figure 4 shows the voltage standing wave ratio (VSWR) of a notch antenna according to an example embodiment of the invention described herein, constructed with the plate of Figure 3; and
Figures 5 and 6 show radiation patterns of a notch antenna according to an example embodiment of the invention described herein, constructed with the plate of Figure 3.

Description of Example Embodiment

[0020] The following description is given to aid understanding of the invention described herein, and to describe how embodiments thereof may be constructed.

[0021] Referring now to Figure 2 there is shown a schematic front view of a notch antenna 10 according to an example embodiment of the invention described herein. The antenna 10 comprises a plate 20, first and second

notches 21,22 and a feed line 30. The feed line 30 may be fed directly, or alternatively via a BALUN. The first notch 21 is operatively coupled to the feed line 30 at a feed point to receive a signal from the feed line 30 when the antenna 10 is used to transmit. Reciprocity applies when the antenna 10 is used to receive. The second notch 22 is in use passively excited by a signal supplied to the first notch 21 through the feed line 30, or by induced currents in the plate for the receive condition. The feed line 30 is suitably a coaxial line. The plate 20 is generally planar, and generally rectangular with characteristic dimensions of width x, height z, and out of plane depth y, that is an out of plane depth y that is orthogonal to the plane of the paper. The depth of the plate 20 is small in comparison to the width and height.

[0022] The first and second notches 21,22 are provided in the plate 20 close to one another such that the second notch 22 is excited, in use, by currents induced around the first notch 21 in response to a signal applied to the first notch 21 from the feed line 30, or by induced plate currents in the case or reception.

[0023] The first notch 21 comprises an open end 211 at an edge of the plate, a closed end 212, and long edges 213 between the open and closed ends 211,212. The second notch 22 comprises an open end 221 at an edge of the plate, a closed end 222, and long edges 223 between the open and closed ends 221,222. The long edges 213,223 are linear, and are aligned with the width of the plate 20. The open ends 211,221 of the first and second notches 21,22 are located on opposing plate edges.

[0024] In preferred embodiments the width of the plate 20 is greater than one quarter of one wavelength at the centre of the operating frequency range. In such embodiments the first and second notches 21,22 are of length less than one fifth of one wavelength at the centre of the operating frequency range.

[0025] The plate 20 comprises a metallic material which in example embodiments may be flexible to allow the antenna 10 to be bent out of planar arrangement around a substrate to which it is to be installed. In other example embodiments the plate 20 is arranged with a non-conductive cover arranged over one or both faces of the plate, and for example may be integrated with a cover in the guise of a vehicle registration plate. Flexible plates may for example comprise an electrically conductive metallic mesh, for example expanded metal. Rigid plates may for example comprise a circuit board with its ground plane, or metal sheet. Copper is a particularly suited metal for any of these plate constructions owing to its excellent electrical conduction properties. In the case of either rigid or flexible plate, the antenna produced is conveniently sized and shaped to enable it to be hermetically sealed, thereby reducing the risk of degradation in performance over time due to corrosion or other environmental effects. Furthermore, the relatively simple construction and convenient dimensions enable a relatively robust antenna package to be produced, with the antenna being easily mountable and concealable in a range of applications.

[0026] The area around the closed end 222 of the second notch 22 comprises an adjustment portion provided to facilitate change to the effective length of the second notch 22. Initially, the second notch 22 is relatively longer than required. If required, a conductive patch can be applied across the second notch 22 at the closed end 222 thereof, effectively reducing the length of the second notch 22. The change in length of the second notch 22 enables frequency response of the antenna to be easily adjusted to suit its environment. For example, shift in the centre frequency of the desired operating frequency range caused by permittivity of the structure on which the antenna 10 is mounted, or that of nearby metallic structures, can now be compensated for.

[0027] In effect, the two linear notches provide a circular polar response with high efficiency over a significant bandwidth range. A high efficiency is achievable over more than a 10% of the bandwidth.

[0028] Furthermore, since the centre frequency of the antenna can be altered by simply adjusting the length of the unfed second notch 22 there is no need to reposition the feed line when installing and tuning the antenna.

[0029] Methods of manufacturing and installing a tuneable notch antenna are now described. The manufacturing method comprises the steps of providing a first notch coupled to a feed line, and providing a second notch in use to be passively excited by a signal supplied to the first notch through the feed line, in the case of transmission. The notch antenna manufacturing method suitably further comprises providing an adjustment portion for the second notch. The adjustment portion is provided along the second notch to enable a change in the effective electrical length of the second notch. The installation method comprises the steps of providing a notch antenna comprising a first notch coupled to a feed line, and a second notch, in use to be passively excited by a signal supplied to the first notch through the feed line, installing the antenna at a desired installation position, and providing an adjustment portion for the second notch to change the effective length of the second notch in response to a detected frequency shift from a desired centre frequency caused by the local environmental effects about the installation position. In both methods the step of providing the adjustment portion comprises providing a piece of adhesive backed metallic tape at the closed end of the second notch. In alternative embodiments the step of providing the adjustment portion comprises providing a suitable electronically activated semiconductor device or devices to bridge the second notch at an appropriate position, for example providing one or more PIN diode switches.

Figure 3 shows a schematic front view of a plate 20 for a tuneable notch antenna according to an example embodiment of the invention described herein. The plate 20 is intended for an antenna designed to operate at a lowest frequency of 405 MHz in free space.

It can be seen in Figure 3 that the unfed notch has been,

coincidently, reduced to half the width of the plate to give a modified centre frequency of 430 MHz. By scaling the antenna, example embodiments of the invention described herein are operable over frequencies in the lower UHF band, up to and including the S-Band, for example in the range 0.2GHz to 4GHz.

Figure 4 shows the VSWR of an antenna constructed from the plate of Figure 3, and Figures 5 and 6 show the radiation characteristics of the antenna. Figure 5 shows the pattern in the yz plane and Figure 6 shows the pattern in the xy plane. As will be appreciated, Figures 5 and 6 show radiation patterns similar to those produced by a dipole aligned on the z axis, with the antenna providing a complete 360 degree azimuth radiation pattern.

As above, simple, effective and readily tunable antenna constructions with related componentry, and related method steps have been described, able to produce a notch antenna that operates efficiently over a useful range of frequencies.

Claims

1. A notch antenna (10) comprising:

an electrically conductive plate (20);
first and second notches (21, 22) formed in said plate (20), wherein the first notch (21) comprises an open end (211) at an edge of the plate (20), a closed end (212), and long edges (213) between the open and closed ends (211, 212) and wherein the second notch (22) comprises an open end (221) at an edge of the plate (20), a closed end (222), and long edges (223) between the open and closed ends (221, 222);
a feed line (30) coupled to the first notch (21), wherein the second notch (22) is arranged close to the first notch (21) and configured to be passively excited by a signal supplied to the first notch (21) through the feed line (30);
an adjustment portion comprising one of a conducting element, a semiconductor and/or a switch provided across the second notch (22) to shorten the effective length thereof;
wherein the first and second notches (21, 22) open on opposite plate edges to provide a circular polar response.

2. The notch antenna of claim 1, wherein the plate (20) comprises an elastically deformable material.

3. The notch antenna of claim 1 or 2, wherein the notch antenna (10) further comprises an electrically non-conductive cover arranged over at least one face of the plate (20).

4. The notch antenna of any one of claims 1-3, wherein the plate (20) is generally rectangular.

5. The notch antenna of any preceding claim, wherein the width of the plate is equal to or greater than one quarter of one wavelength at the centre of the operating frequency range.

6. The notch antenna of claim 4 or5, wherein the first notch (21) and the second notch (22) comprise long edges aligned with the width dimension of the plate.

7. The notch antenna of any preceding claim, wherein the first notch (21) and the second notch (22) are of length less than or equal to one fifth of one wavelength at the centre of the operating frequency range specified for the notch antenna (10).

8. The notch antenna of any preceding claim, comprising an electrically sealed body provided around the plate (20), and wherein the adjustment portion comprises a conductor that is capacitively coupled to the plate (20).

9. The notch antenna of claim 8, wherein the adjustment portion comprises a piece of adhesive backed metallic tape.

10. The notch antenna of any preceding claim, wherein the first and second notches (21,22) have different lengths and wherein the second notch (22) is longer than the first notch (21).

11. A vehicle registration plate comprising the notch antenna of any preceding claim.

12. A method of manufacturing the notch antenna of any preceding claim, the method comprising the steps of: providing an electrically conductive plate comprising a first notch coupled to a feed line, and providing a second notch in use to be passively excited by a signal supplied to the first notch through the feed line;
the method further comprising providing the adjustment portion for the second notch to change the effective length of the second notch.

13. The method of claim 12, comprising installing the antenna at a desired installation position, and providing the adjustment portion for the second notch to change the effective length of the second notch in response to a detected frequency shift from a desired centre frequency caused by electrical permittivity of the installation position.

Patentansprüche

1. Kerbantenne (10), umfassend:

eine elektrisch leitfähige Platte (20);

eine erste und zweite Kerbe (21, 22), die in der Platte (20) ausgebildet sind, wobei die erste Kerbe (21) ein offenes Ende (211) an einer Kante der Platte (20), ein geschlossenes Ende (212) und lange Kanten (213) zwischen dem offenen und dem geschlossenen Ende (211, 212) umfasst und wobei die zweite Kerbe (22) ein offenes Ende (221) an einer Kante der Platte (20), ein geschlossenes Ende (222) und lange Kanten (223) zwischen dem offenen und dem geschlossenen Ende (221, 222) umfasst;
eine Zuführungsleitung (30), die mit der ersten Kerbe (21) gekoppelt ist, wobei die zweite Kerbe (22) in der Nähe der ersten Kerbe (21) angeordnet ist und dazu ausgelegt ist, passiv durch ein Signal, mit dem die erste Kerbe (21) über die Zuführungsleitung (30) versorgt wird, angeregt zu werden;
einen Anpassungsteil, der entweder ein leitendes Element, einen Halbleiter oder einen Schalter umfasst, das bzw. der über die zweite Kerbe (22) bereitgestellt ist, um deren effektive Länge zu verkürzen;
wobei die erste und zweite Kerbe (21, 22) an gegenüberliegenden Plattenkanten offen sind, um eine kreisförmige Richtcharakteristik bereitzustellen.

2. Kerbantenne nach Anspruch 1, wobei die Platte (20) ein elastisches verformbares Material umfasst.

3. Kerbantenne nach Anspruch 1 oder 2, wobei die Kerbantenne (10) ferner eine elektrisch nicht leitfähige Abdeckung umfasst, die über mindestens einer Fläche der Platte (20) angeordnet ist.

4. Kerbantenne nach einem der Ansprüche 1-3, wobei die Platte (20) im Allgemeinen rechteckig ist.

5. Kerbantenne nach einem vorangegangenen Anspruch, wobei die Breite der Platte gleich oder größer als ein Viertel einer Wellenlänge in der Mitte des Betriebsfrequenzbereichs ist.

6. Kerbantenne nach Anspruch 4 oder 5, wobei die erste Kerbe (21) und die zweite Kerbe (22) lange Kanten umfassen, die mit der Breitenabmessung der Platte ausgerichtet sind.

7. Kerbantenne nach einem vorangegangenen Anspruch, wobei die erste Kerbe (21) und die zweite Kerbe (22) eine Länge besitzen, die kleiner oder gleich einem Fünftel einer Wellenlänge in der Mitte des Betriebsfrequenzbereichs ist, der für die Kerbantenne (10) spezifiziert ist.

8. Kerbantenne nach einem vorangegangenen Anspruch, umfassend einen elektrisch abgedichteten Körper, der um die Platte (20) herum bereitgestellt ist, und wobei der Anpassungsteil einen Leiter umfasst, der kapazitiv mit der Platte (20) gekoppelt ist.

9. Kerbantenne nach Anspruch 8, wobei der Anpassungsteil ein Stück eines Metallbandes mit haftender Rückseite umfasst.

10. Kerbantenne nach einem vorangegangenen Anspruch, wobei die erste und zweite Kerbe (21, 22) unterschiedliche Längen aufweisen und wobei die zweite Kerbe (22) länger als die erste Kerbe (21) ist.

11. Kraftfahrzeugkennzeichen, das die Kerbantenne nach einem vorangegangenen Anspruch umfasst.

12. Verfahren zur Herstellung der Kerbantenne nach einem vorangegangenen Anspruch, wobei das Verfahren die folgenden Schritte umfasst:

Bereitstellen einer elektrisch leitfähigen Platte, die eine erste Kerbe umfasst, die mit einer Zuführungsleitung gekoppelt ist, und Bereitstellen einer zweiten Kerbe, die bei Verwendung passiv durch ein Signal, mit dem die erste Kerbe über die Zuführungsleitung versorgt wird, angeregt werden soll;
wobei das Verfahren ferner ein Bereitstellen des Anpassungsteils für die zweite Kerbe umfasst, um die effektive Länge der zweiten Kerbe zu ändern.

13. Verfahren nach Anspruch 12, umfassend Installieren der Antenne an einer gewünschten Installationsposition und Bereitstellen des Anpassungsteils für die zweite Kerbe, um die effektive Länge der zweiten Kerbe als Reaktion auf eine detektierte Frequenzverschiebung von einer gewünschten Mittenfrequenz zu ändern, die durch die elektrische Permittivität der Installationsposition verursacht wird.

Revendications

1. Antenne (10) à encoches comportant :

une plaque électriquement conductrice (20) ;
des première et deuxième encoches (21, 22) formées dans ladite plaque (20), la première encoche (21) comportant une extrémité ouverte (211) à un bord de la plaque (20), une extrémité fermée (212), et des bords longs (213) entre les extrémités ouverte et fermée (211, 212) et la deuxième encoche (22) comportant une extrémité ouverte (221) à un bord de la plaque (20), une extrémité fermée (222), et des bords longs (223) entre les extrémités ouverte et fermée (221, 222) ;

une ligne (30) d'alimentation couplée à la première encoche (21), la deuxième encoche (22) étant disposée près de la première encoche (21) et configurée pour être excitée passivement par un signal fourni à la première encoche (21) via la ligne (30) d'alimentation ;
une partie de réglage comportant un composant parmi un élément conducteur, un semi-conducteur et/ou un interrupteur placé en travers de la deuxième encoche (22) pour en raccourcir la longueur effective ;
les première et deuxième encoches (21, 22) s'ouvrant sur des bords opposés de la plaque pour assurer une réponse polaire circulaire.

2. Antenne à encoches selon la revendication 1, la plaque (20) comportant un matériau élastiquement déformable.

3. Antenne à encoches selon la revendication 1 ou 2, l'antenne (10) à encoches comportant en outre une couverture électriquement non conductrice disposée pardessus au moins une face de la plaque (20).

4. Antenne à encoches selon l'une quelconque des revendications 1-3, la plaque (20) étant généralement rectangulaire.

5. Antenne à encoches selon l'une quelconque des revendications précédentes, la largeur de la plaque étant supérieure ou égale à un quart d'une longueur d'onde au centre de la plage de fréquences de fonctionnement.

6. Antenne à encoches selon la revendication 4 ou 5, la première encoche (21) et la deuxième encoche (22) comportant des bords longs alignés avec la dimension de largeur de la plaque.

7. Antenne à encoches selon l'une quelconque des revendications précédentes, la première encoche (21) et la deuxième encoche (22) étant de longueur inférieure ou égale à un cinquième d'une longueur d'onde au centre de la plage de fréquences de fonctionnement spécifiée pour l'antenne (10) à encoches.

8. Antenne à encoches selon l'une quelconque des revendications précédentes, comportant un corps électriquement hermétique placé autour de la plaque (20), et la partie de réglage comportant un conducteur qui est couplé de façon capacitive à la plaque (20).

9. Antenne à encoches selon la revendication 8, la partie de réglage comportant un morceau de ruban métallique à revers adhésif.

10. Antenne à encoches selon l'une quelconque des revendications précédentes, les première et deuxième encoches (21, 22) présentant des longueurs différentes et la deuxième encoche (22) étant plus longue que la première encoche (21).

11. Plaque d'immatriculation de véhicule comportant l'antenne à encoches selon l'une quelconque des revendications précédentes.

12. Procédé de fabrication de l'antenne à encoches selon l'une quelconque des revendications précédentes, le procédé comportant les étapes consistant à :

réaliser une plaque électriquement conductrice comportant une première encoche couplée à une ligne d'alimentation, et réaliser une deuxième encoche destinée, en cours d'utilisation, à être excitée passivement par un signal fourni à la première encoche via la ligne d'alimentation ;
le procédé comportant en outre l'étape consistant à munir la deuxième encoche de la partie de réglage pour modifier la longueur effective de la deuxième encoche.

13. Procédé selon la revendication 12, comportant les étapes consistant à installer l'antenne dans une position d'installation souhaitée, et à munir la deuxième encoche de la partie de réglage pour modifier la longueur effective de la deuxième encoche en réponse à un décalage détecté de fréquence par rapport à une fréquence centrale souhaitée, causé par la permittivité électrique de la position d'installation.

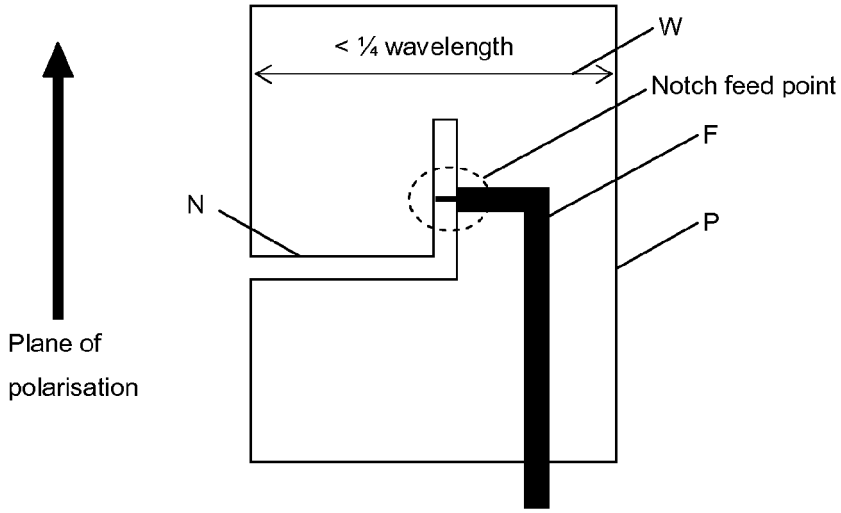

FIGURE 1 (PRIOR ART)

Single notch plate, fixed frequency

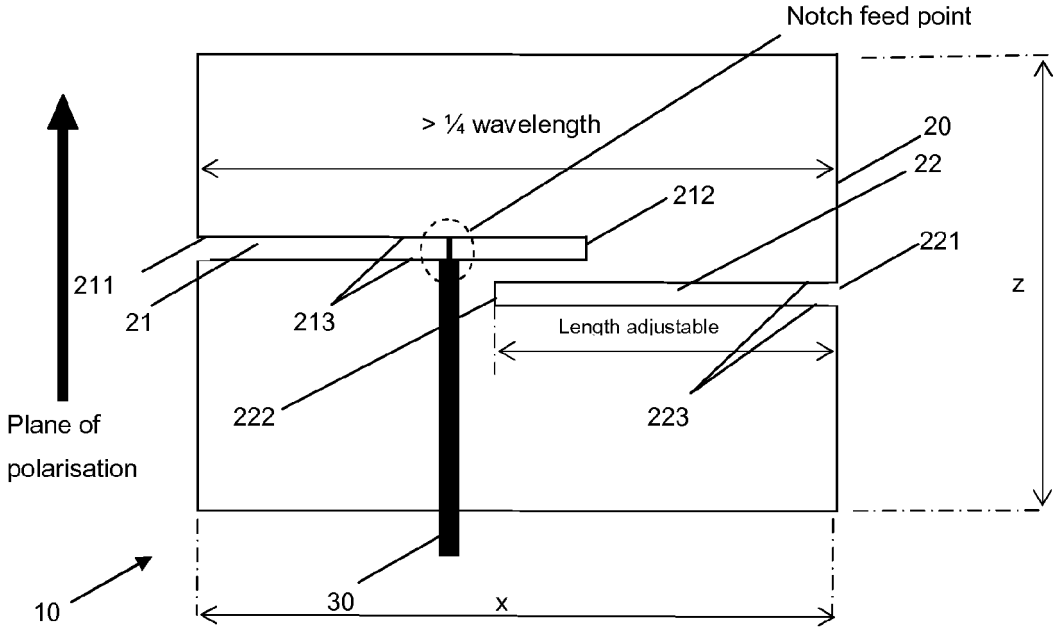

FIGURE 2

Twin notch plate, variable frequency

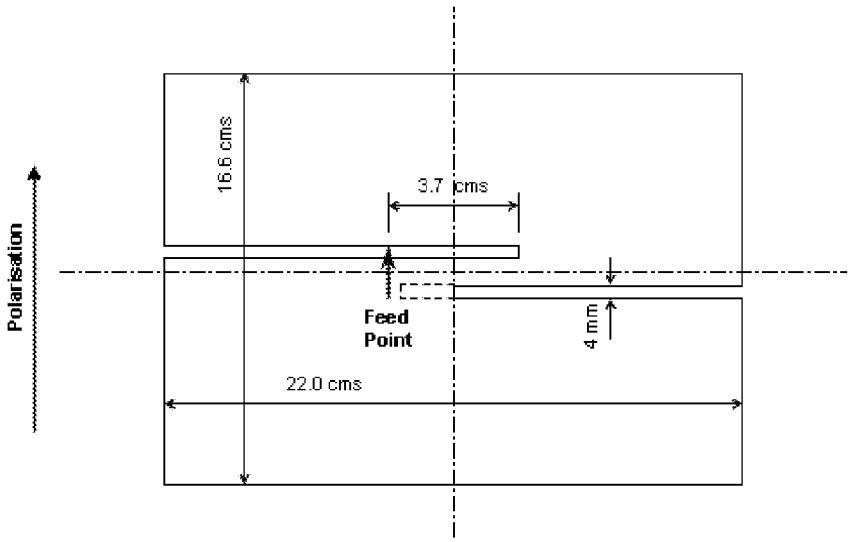

FIGURE 3

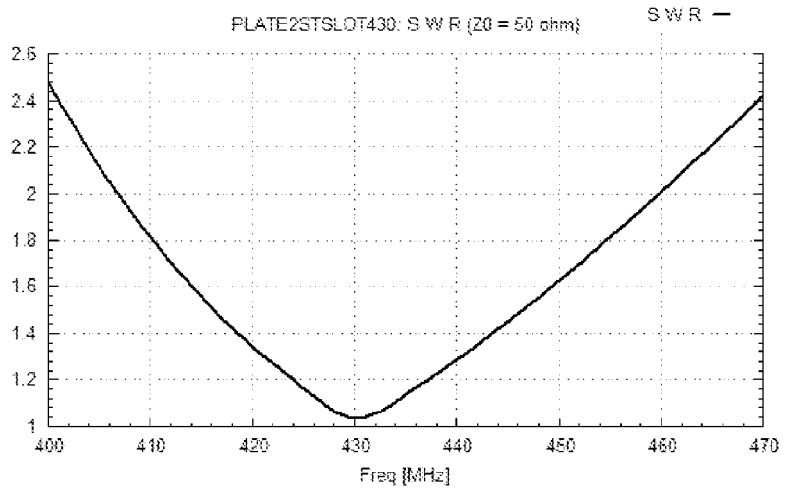

FIGURE 4
VSWR Plot

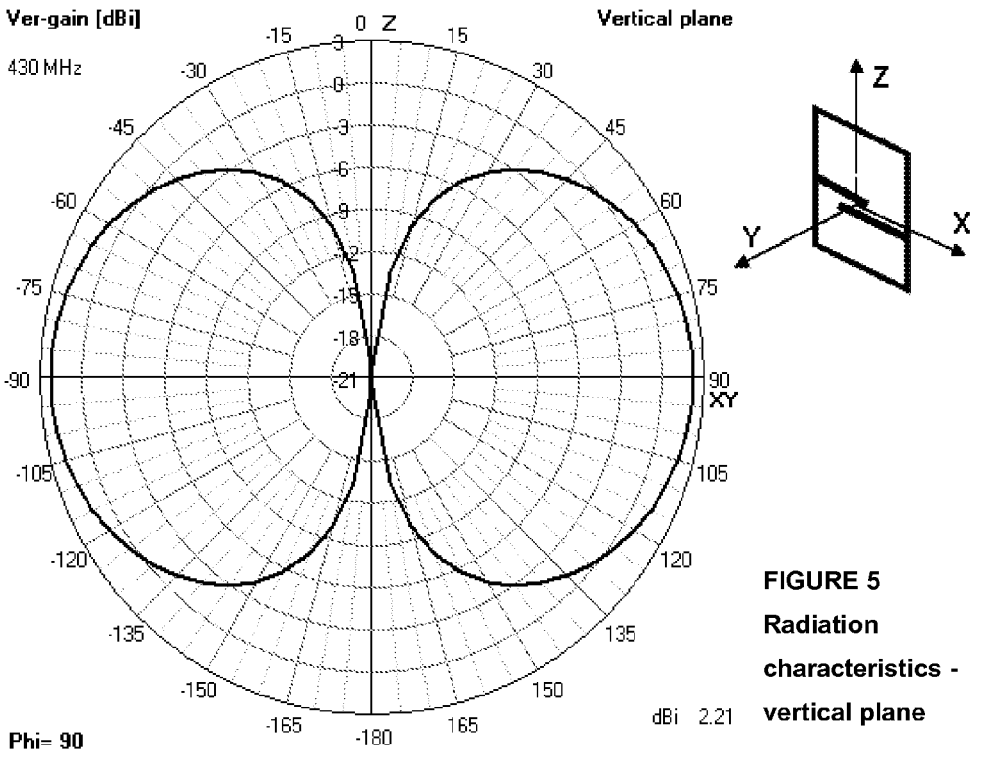

FIGURE 5
Radiation characteristics - vertical plane

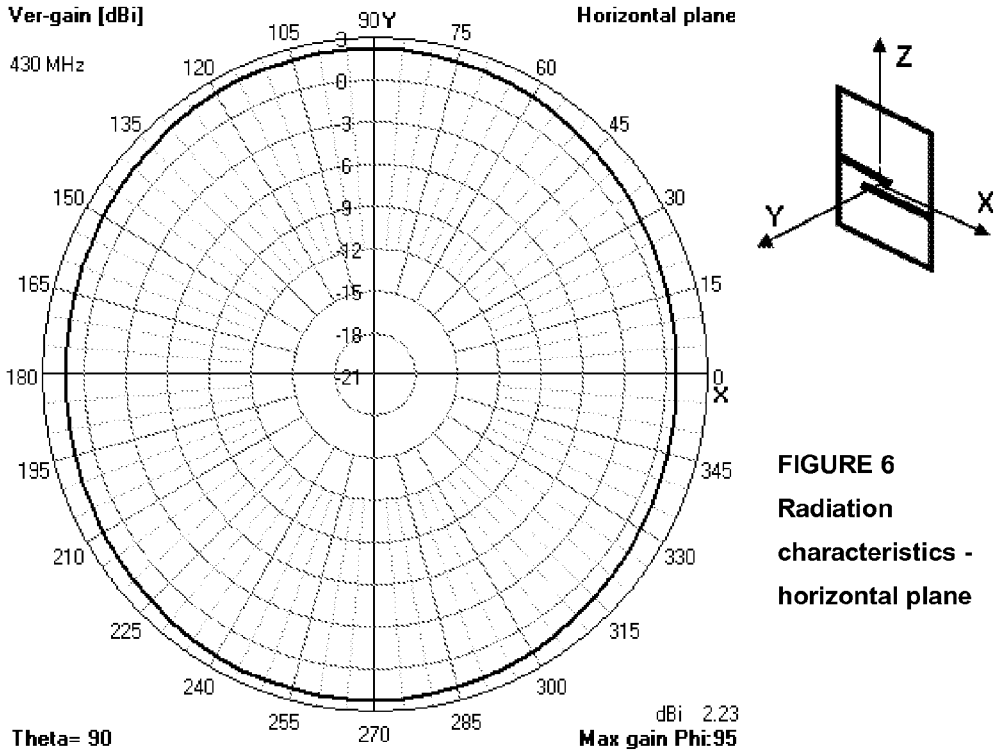

FIGURE 6
Radiation characteristics - horizontal plane

REFERENCES CITED IN THE DESCRIPTION

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