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DIPOLE ANTENNA AND FEED ARRANGEMENT THEREFOR

Filed March 5, 1949

2 Sheets-Sheet 1

FIG. 5.

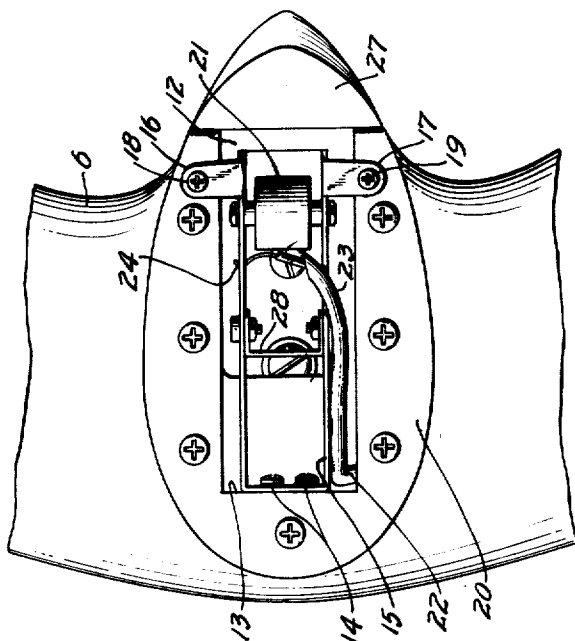


FIG. 4.

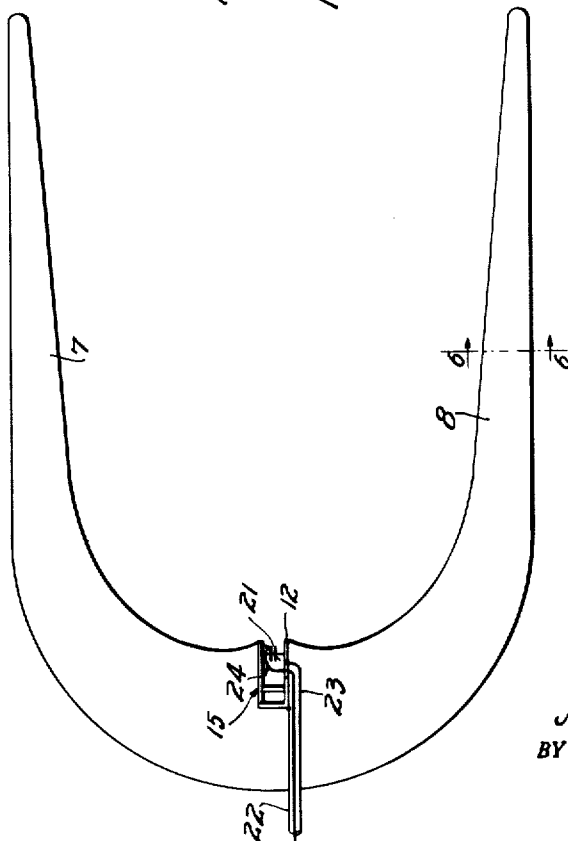


FIG. 2.

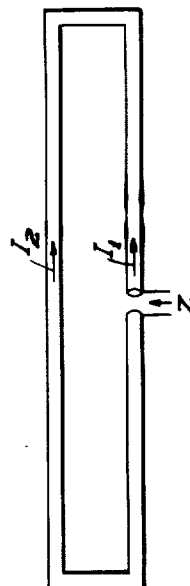
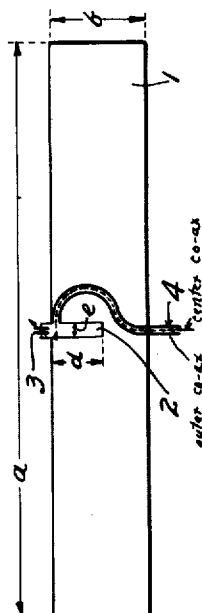


FIG. 1.



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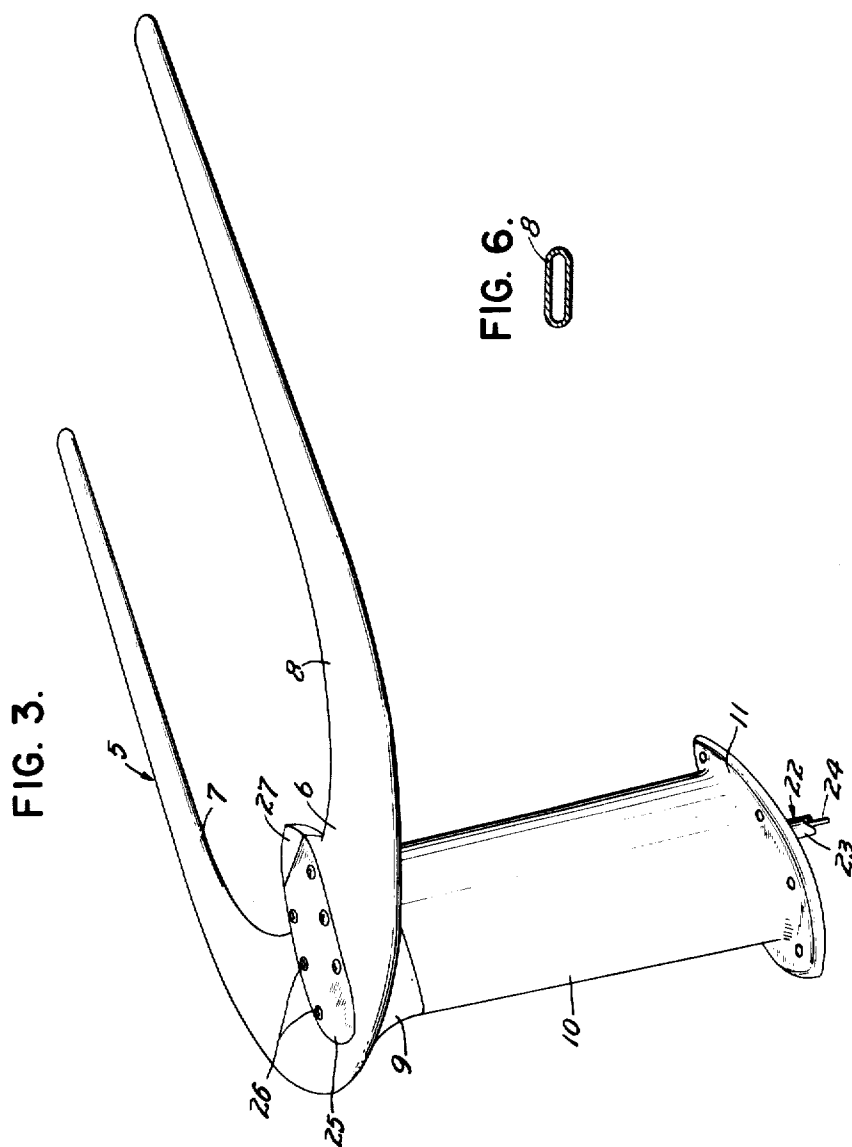
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DIPOLE ANTENNA AND FEED ARRANGEMENT THEREFOR

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2 Sheets-Sheet 2



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DIPOLE ANTENNA AND FEED ARRANGEMENT THEREFOR

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a corporation of Iowa

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16 Claims. (Cl. 250—33)

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This invention relates to antennas and more particularly to dipole antennas and methods of coupling the same to a transmission line.

A principal object is to provide a novel feed or transmission line coupling arrangement for dipole antennas and the like.

Another object is to provide an antenna which has all the operational advantages of the well-known folded half-wave dipole, but which is free from certain disadvantages of that type of antenna.

Another object is to provide an antenna which is eminently well suited for use on aircraft where omnidirectional field pattern and reduced wind resistance are of great importance.

A feature of the invention relates to a rugged dipole antenna which is provided with a "feeding" notch whereby the impedance relations between the antenna and the feed or transmission line can be more efficiently controlled.

Another feature relates to a dipole antenna which is constituted essentially of a metallic sheet having a notch in one edge which acts as an element of an impedance matching network between the antenna and its transmission or feed line.

Another feature relates to a metallic member constituting an unbroken half-wave dipole surface, which member is bent to a substantially U-shape to provide an omni-directional field pattern with a minimum of wind resistance.

A further feature relates to a dipole antenna having a feed notch which serves as a balanced-to-unbalanced line transformer, impedance-level transformer, and also as a broad-banding impedance corrector.

A still further feature relates to the novel organization, arrangement and relative location of parts which cooperate to provide an improved half-wave dipole antenna which is structurally rugged and simple.

Other features and advantages not particularly enumerated will be apparent after a consideration of the following detailed descriptions and the appended claims.

In the drawing which shows, by way of example, certain preferred embodiments,

Fig. 1 is a plan view of an antenna and antenna feed according to the invention.

Fig. 2 is a diagram of a conventional folded dipole which is useful in comparison with the antenna according to the invention.

Fig. 3 is a perspective view of a modification of the invention of Fig. 1.

Fig. 4 is a top-plan view, partly schematic, of the antenna of Fig. 3.

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Fig. 5 is an enlarged view of the yoke portion of the antenna of Fig. 3 with a cover plate removed to show the interior construction and connections more clearly.

Fig. 6 is a cross-sectional view of Fig. 4, taken along the line 6—6 thereof.

I have discovered that it is possible to use a relatively simple flat metal plate or similar construction as an efficient dipole antenna, by providing one edge of the sheet with a small or constricted notch whose dimensions are chosen so that the peripheral edges of the notch form an inductive reactance for coupling the transmission or feed line properly to the antenna. This reactance can be supplemented by a local capacitance bridged across the notch to provide a coupling impedance between the feed or transmission line and the antenna proper. The dimensions of this notch are chosen so as to be so small in comparison with the physical dimensions of the antenna proper that, at the operating frequency of the antenna, the notch itself is wholly unsuitable as a radiator.

Referring to Fig. 1, there is shown a flat metal plate dipole antenna 1 having a length a and a width b . The length a is preferably somewhat less than $\lambda/2$ at resonance, and the width b can be any arbitrary value but usually substantially less than a ; and wherein λ is the wavelength of the operating frequency for which the antenna is designed. One longitudinal edge of the sheet 1 has a notch 2 having a depth d and a width e , and wherein the width e is preferably substantially less than the depth d . Preferably, although not necessarily, the notch is located midway between the ends of sheet 1. In any event, the depth d should be less than one-quarter λ , so that at its open end the notch possesses the proper inductive reactance at the antenna operating frequency. This inductive reactance of the notch is then resonated by a small condenser or capacitance 3 which is bridged across the notch, preferably adjacent the open end thereof. When the condenser 3 is of the proper value it will resonate with the notch impedance so as to set up, for all practical purposes, the equivalent of an infinite impedance across the notch. If then, a suitable transmission or feed line 4, either of the coaxial type or the balanced type such as the conventional twin lead type, is connected across the notch adjacent the open end thereof, it will feed into whatever impedance the dipole and notch present at the point of connection.

In order that the action of the antenna and feed of Fig. 1 can be more readily understood, it

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can be compared with a conventional folded half-wave dipole such as is shown in Fig. 2. In the case of such a folded dipole, the input impedance Z is dependent upon the ratio of the currents I_1 , I_2 , in the separate "fed" and "un-

$$\frac{Z}{Z_d} = \frac{(I_1 - I_2)^2}{I_1^2}$$

wherein the Z_d equals the feed impedance of a half-wave dipole in free space or about 73.3 ohms.

It has been experimentally determined that the impedance presented to the transmission line in the arrangement of Fig. 1 according to the invention, follows a law comparable to the arrangement of Fig. 2. Thus, it was found that when the dimension $d=b/2$, the ratio Z/Z_d was equal to 4 wherein d is the notch depth considered in the plane of sheet 1. It was also found that higher feed impedances can be obtained in the arrangement of Fig. 1 by making d smaller than

$$\frac{b}{2}$$

and conversely when d was larger than

$$\frac{b}{2}$$

the feed impedance was lowered. It should be observed that the dimensions of the notch are so small in comparison with the dimensions of the antenna proper that the radiation, if any, from the notch itself, is negligible at the operating frequency of the antenna.

Referring to Figs. 3 to 6, a description will now be given of another antenna embodying the principles explained in connection with Fig. 1. As shown in Fig. 3, the antenna 5 consists of a U-shaped metal body having the yoke portion 6 and the tapered arms 7 and 8. While the antenna can be made of a flat metal sheet bent as shown, it can also be made with the yoke portion 6 consisting of a metal casting to which the arms 7 and 8 are integrally attached, and preferably, although not necessarily, the arms 7 and 8 are of flattened tubular metal stock having a very small spacing between the flattened opposite walls as shown in the cross-sectional view of Fig. 6. Also the arms 7 and 8 are tapered towards their forward ends and all the edges are streamlined or smoothly rounded so as to provide a minimum of wind resistance.

The yoke portion 6 has a downwardly extending integral portion 9 which can be suitably attached to a hollow metal pedestal 10 having at its lower end an integral flange 11 for fastening the antenna to a suitable support such as an aeroplane or the like. The yoke portion 6 is cut out to provide a rectangular chamber 12 (see Fig. 5). Attached to the end wall 13 of this chamber by means of screws 14 is a U-shaped metal bracket 15. The free ends of this bracket carry a pair of outwardly extending lugs 16, 17, which are fastened by means of screws 18, 19, to the flat surface 20 of the yoke portion 6. The lugs 16 and 17 are fastened to the opposite side walls of the chamber 12 adjacent the open end thereof. Also bridged across the bracket 15 adjacent the open end of the notch is a condenser 21. It will be seen therefore, that the bracket 15 corresponds functionally to the notch 2 of Fig. 1, and the condenser 21 corresponds functionally to the condenser 3 of Fig. 1. A suitable feed line or transmission line 22, for example a coaxial transmission line, has its outer conductor 23 electrically

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connected, for example by soldering to the bracket 15 preferably all along the side of the bracket so as to leave the bracket near its "ground" end, that is, near screws 14; while the inner conductor 24 of this line is connected to the bracket 15 at a point adjacent to the lug 16. If desired, the inner conductor 24 can be fastened directly to the lug 16.

In order to protect the parts against weathering the flattened top 20 of the yoke can be provided with a covering plate 25 of insulation material (Fig. 3) which can be fastened in place by suitable screws 26. The open end of the chamber 12 can also be protected by a streamlined closure member 27 of a suitable electrical insulator material. Fig. 4 shows in schematic form the equivalent electrical connections between the transmission line 22 and the longitudinal edges of the bracket 15. It will be understood, of course, that the invention is not limited to the connection of the transmission line to a separate U-shaped member or bracket. Thus, if desired, the line conductors 23 and 24 can be connected directly to the side walls of the chamber 12, it being understood of course that this chamber is appropriately dimensioned so as to provide the proper inductance corresponding to the notch 2 of Fig. 1. The purpose of using the bracket 15 in the chamber 12 is merely to provide a convenient way of adjusting the inductance of the feed notch. Thus the side arms of the U-shaped bracket can be bridged by a metal member 28 which can be adjusted in position along the length of the said side arms so as to correspondingly adjust the inductance of the feed notch. In other words, in Fig. 5 the feed notch is essentially the area enclosed by bracket 15 and member 28. If desired, the space between the sides of the bracket 15 and the side walls of chamber 12 can be filled-in with a suitable metal as can the space between the bridge member 28 and the bottom wall 13 of the chamber 12, thus in effect providing a feed-notch whose width is equal to the lateral spacing between the side arms of bracket 15, and whose depth is determined by the location of bridge 28 with respect to the free ends of the side arms.

The notch feed above described lends itself well to act as an impedance correcting network to increase the frequency coverage of an antenna. For example, if an antenna of the construction shown in Fig. 3 were excited or connected in the conventional way, its frequency coverage would be approximately 50% less than when provided with the notch feed above described. This increase in frequency coverage results from the paralleling of the "LC" circuit of the notch of the proper electric parameters, with the feed of a center fed one-half wave dipole. This method of feeding also enables the dipole to be formed of a plain unbroken piece of metal which can be supported by a metallic support at its center or ground potential point.

While certain specific particular embodiments have been described herein, it will be understood that the invention is not limited thereto and furthermore while the notch feeding principle has been disclosed in connection with one particular type of antenna, namely a half-wave dipole, it will be understood that it can be applied to any other kind of antenna where the antenna consists of a plate-like continuous surface having substantially greater physical dimensions than the dimensions of the feeding notch. Furthermore, while the feeding notch is shown as

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being provided in one edge of the plate-like antenna, it will be understood that it can be provided in the opposite edge from that shown in Figs. 1 and 5. While the drawing shows a notch which is rectangular in shape, it will be understood that any other shape of notch may be employed providing its dimensions are correlated with the operating frequency of the antenna, to provide the required inductive reactance in the notch for the purposes described hereinabove.

It will be understood of course, that the feed impedance between the feed line and the antenna proper can be adjusted over a considerable range by varying the effective depth d of the notch and also by adjusting the particular point along the notch at which the feed line is connected. Thus, the construction shown in Fig. 5 enables this adjustment to be readily made by adjusting the position of the tie member 28 along the length of the bracket 15 and by adjusting the points of connection of the conductors 23 and 24 along this bracket. It is probably desirable in most cases that the antenna proper be near its fundamental resonance or some harmonic thereof. If the antenna proper is somewhat off resonance, the resulting equivalent reactance can be tuned out by tuning the notch "LC" circuit either by adjusting the effective depth of the notch as above mentioned or by adjusting the points of connection of the transmission line along the sides of the notch.

Various changes and modifications can be made in the disclosed embodiments without departing from the spirit and scope of the invention.

What is claimed is:

1. An antenna in the form of an elongated conductive radiating member having a substantially greater length than width, and means defining a notch in an edge of said member, said notch having a depth and width which are only a small fraction of the length of said member whereby said notch has a substantial inductive reactance at the operating frequency of the antenna, and means for connecting the opposite side edges of the notch to a feed line, said notch constituting a coupling impedance between said line and said radiating member and having in itself substantially negligible radiating efficiency at the radiating frequency of said member.

2. An antenna in the form of an elongated conductive radiating member, said member having means defining a feed notch in one edge, the opposite sides of which are arranged to be connected to a transmission line, said notch having a depth and width which are only a small fraction of the length of said member, and forming a coupling impedance for coupling said radiating member to a transmission line, said notch having substantially negligible radiating efficiency at the radiating frequency of said member.

3. An antenna in the form of a conductive radiating member having a substantially continuous surface across its length and width, and means defining a notch in the edge of said member, said notch having its dimensions correlated with the operating frequency of the antenna to provide a high coupling impedance between the antenna and a transmission line connected to the sides of said notch, and possessing negligible radiating efficiency at the radiating frequency of said member.

4. An antenna in the form of a substantially continuous flattened conductive radiating member, said member having a substantially rec-

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tangular notch in one edge, the dimensions of said notch being correlated with the operating frequency of the antenna to provide a high coupling impedance between the antenna and a transmission line connected to said notch, means for connecting the opposite sides of the notch to said line, said notch having substantially negligible radiating efficiency at the radiating frequency of said member.

5. An antenna in the form of a substantially continuous metal plate radiator, said plate having a cutout notch portion in one of its edges the dimensions of which are correlated with the operating frequency of the antenna for the purposes set forth, and means connecting the opposite sides of the notch to a feed line, said notch having substantially negligible radiating efficiency at the radiating frequency of said plate.

6. An antenna in the form of a conductive member, said member having means defining along a portion of its surface a cutout portion, said cutout portion having dimensions to form at the operating frequency of the antenna a predetermined transmission line coupling reactance, a capacitance bridged across said cutout portion to resonate with said inductive reactance, and a transmission line connected to opposite edges of said cut-out portion.

7. An antenna according to claim 6 in which said cutout portion is in the form of a notch and said condenser is bridged across said notch adjacent the open end thereof.

8. An antenna according to claim 6 in which a transmission line is connected to the said notch adjacent the open end thereof.

9. A half-wave dipole antenna, comprising a substantially flattened metal member having a notch in one longitudinal edge thereof facing the direction of radiation to provide a predetermined inductive reactance determined by the dimensions of the notch, and a transmission line connected to the opposite sides of said notch.

10. An antenna according to claim 9 in which said flattened metal member is of substantially U-shape with said notch located at the yoke of the U.

11. An antenna according to claim 9 in which said notch has a length which is less than one-quarter of the operating wavelength of the antenna.

12. An antenna according to claim 9 in which said notch has a length substantially equal to one-half the width of said flattened member.

13. An antenna comprising a substantially continuous metal surface having a notch to the opposite sides of which a transmission line is connected, and an adjustable condenser also connected to said opposite sides of said notch, said notch and condenser being mutually proportioned to resonate and thereby produce a very high impedance at the point where said transmission line is connected.

14. An antenna comprising a rigid U-shaped member which is substantially flattened in the plane of the U, a transmission line feed notch located at the yoke of the U, a transmission feed line connected to opposite sides of said notch, said notch having its dimensions correlated with the operating frequency of the antenna to control the impedance relations between the antenna and its feed line.

15. An antenna according to claim 14 in which the arms of the U are of tapered formation extending from the said yoke to the free ends of the arms.

16. An antenna comprising a substantially flattened metal member having a cutout portion in one longitudinal edge thereof, a conductive bracket fastened to the bottom of said cutout, said bracket having a pair of arms extending parallel to the sides of said cutout, means connecting the free ends of said bracket to the side walls of said cutout adjacent the open end of said cutout, a condenser bridged across said bracket adjacent said open end of the cutout, and a balanced transmission line having one conductor connected to one arm of said bracket and the other conductor connected to the other arm of said bracket.

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