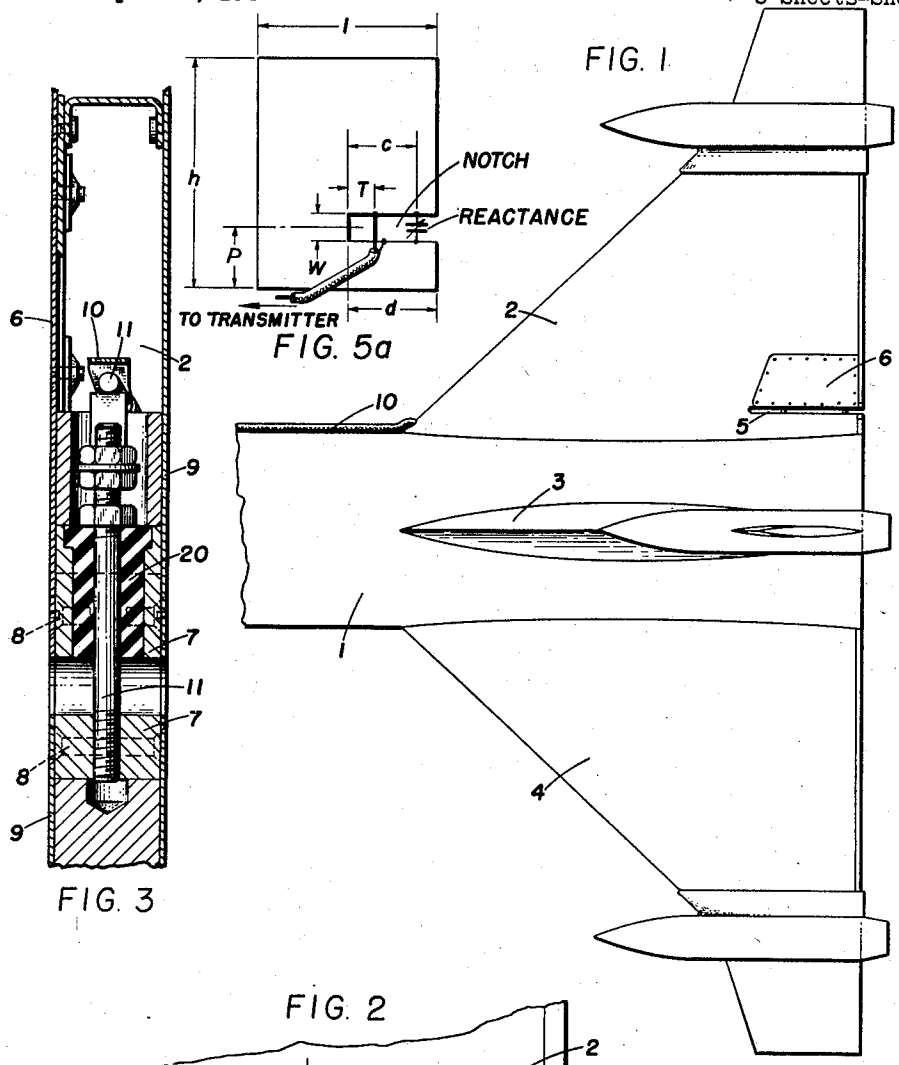
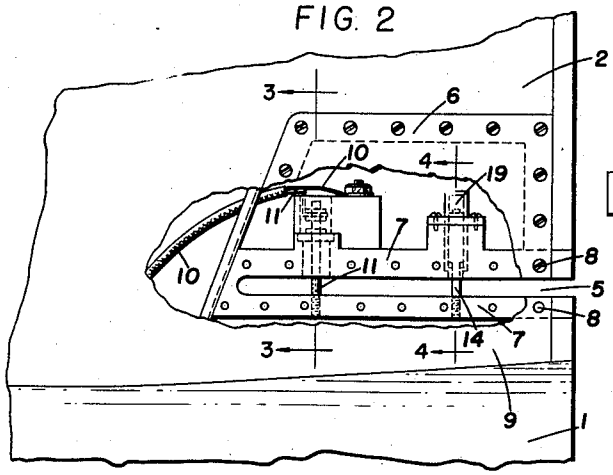
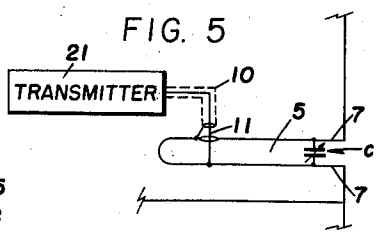
Oct. 6, 1959 R. O. ROBINSON, JR 2,908,000

NOTCH ANTENNA

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NOTCH ANTENNA

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FIG. 4

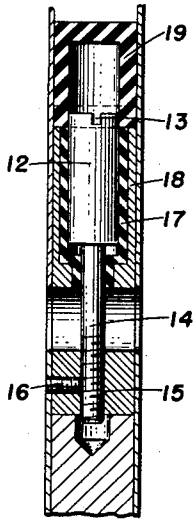


FIG. 6

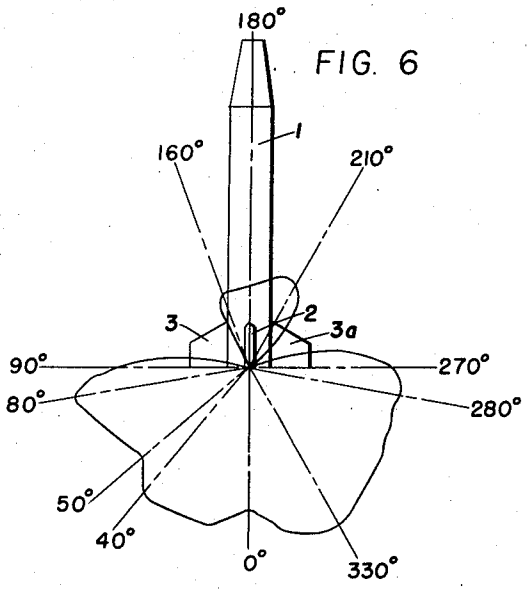


FIG. 8

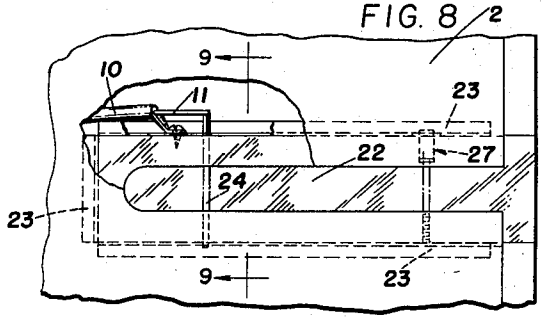


FIG. 7

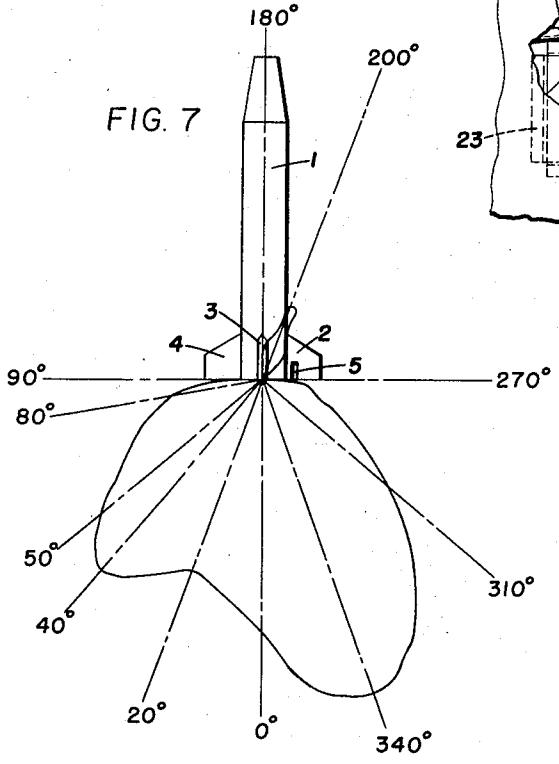
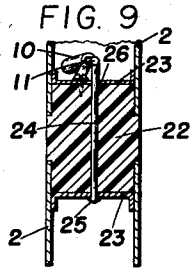


FIG. 9



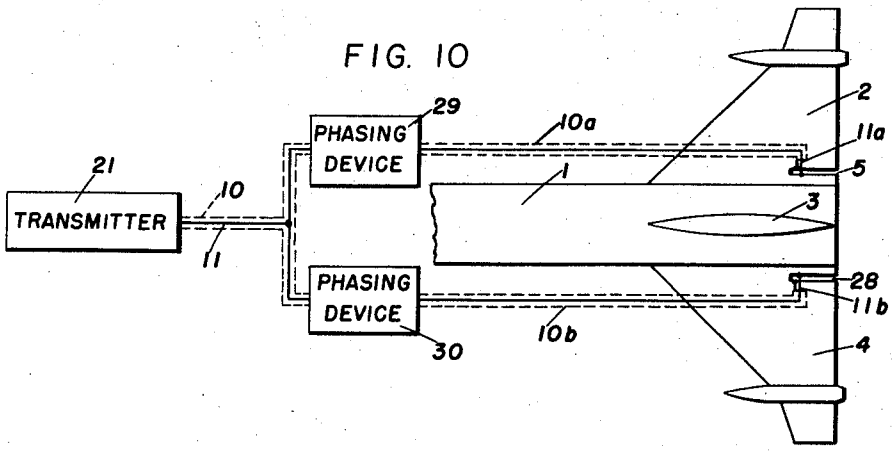
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NOTCH ANTENNA

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FIG. 10



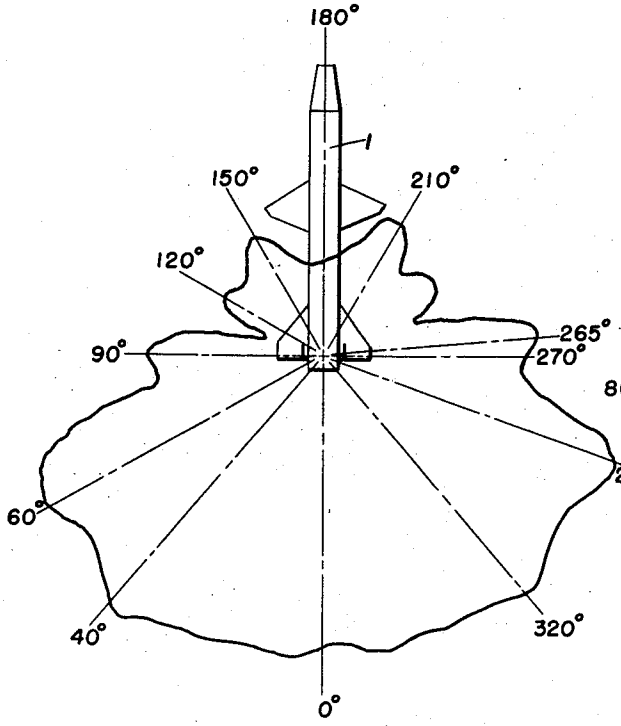


FIG. 12

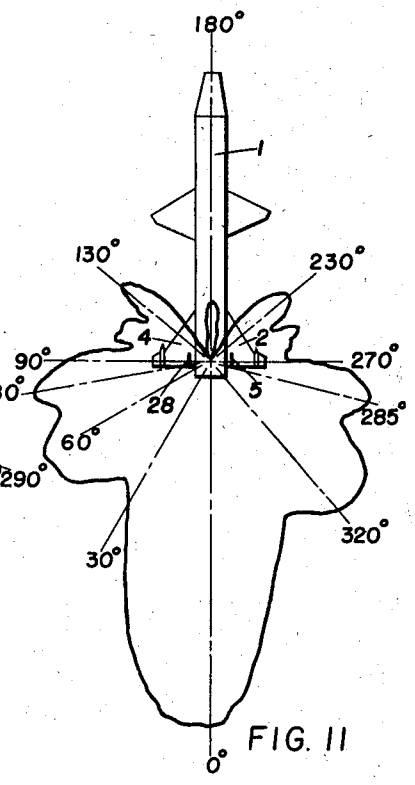


FIG. 11

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2,908,000

NOTCH ANTENNA

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Application April 8, 1949, Serial No. 86,361

15 Claims. (Cl. 343—746)

The present invention relates to a new radiation system, making use of a type of antenna exciting means herein known as a "notch" exciter. More specifically, it relates to a new type of antenna that consists essentially of a conducting sheet having an open-end notch therein, opening on an edge of said sheet, for transmitting or receiving.

Heretofore antennas having a completely surrounded aperture or opening have been known, that is, the aperture did not open at an edge of the conducting sheet. Such antennas are exceeded in convenience of installation, directivity, and efficiency by the notch excited antenna, to be disclosed hereinafter.

An object of the invention is to provide a simple, rigid and electrically effective antenna that may be made relatively small in size, and specifically, may utilize existing metallic sheets, such as the fins of aerial guided missiles and other aerial vehicles.

Other objects and many of the attendant advantages of this invention will be appreciated readily as the same becomes understood by reference to the following detailed description, when considered in connection with the accompanying drawings, wherein:

Fig. 1 is a fragmentary side elevation showing the rear end of a guided missile, having an antenna embodying the invention, incorporated in one of the tail fins;

Fig. 2 is a fragmentary side elevation, with part of the outer covering broken away, showing the notch exciter and adjacent structures, on an enlarged scale;

Fig. 3 is a sectional view, on a still larger scale, in plane 3—3 of Fig. 2;

Fig. 4 is a sectional view on the same scale as Fig. 3, in plane 4—4 of Fig. 2;

Fig. 5 is a circuit diagram showing a transmitter connected to a notch exciter;

Fig. 5*a* is a diagram of a conductive sheet containing a notch exciter;

Fig. 6 is one of a number of different desirable radiation distribution patterns that may be secured by means of the invention;

Fig. 7 is another attainable pattern;

Fig. 8 is a fragmentary side elevation of a modified form of notch exciter;

Fig. 9 is a sectional view, in the plane 9—9 of Fig. 8;

Fig. 10 is a fragmentary elevation showing the rear end of a guided missile, and also showing, in block diagram, a transmitter connected to excite two notched fins; and

Figs. 11 and 12 illustrate radiation distribution patterns that may be produced by such simultaneous excitation of two notched fins.

Referring first to Fig. 1, there is shown the rear end of the tail pipe 1 of a ram jet forming part of a guided missile. Fins, 2, 3, 4 are secured to said pipe 1, in two axial planes, at right angles to one another, a fourth fin (3*a*, Fig. 6) that is hidden behind fin 3, being also present.

These fins are of the standard types, and customarily

are made hollow, of relatively thin sheet metal, for strength combined with lightness. A notch 5 is cut into fin 2 near its junction with the tail pipe 1. This notch, as illustrated, opens to the rear, is parallel-sided and extends substantially normal to the fin and parallel to the axis of the tail pipe. A removable plate 6 may be provided just above the notch, to give access to the structural elements associated with the notch, such as the tuning means and the electrical conductors, all of which are described hereinbelow.

Referring now more particularly to Figs. 2, 3 and 4, the mechanical and electrical details of the antenna will be described. As best seen in Fig. 2, the antenna notch 5 is formed in a rigid U-shaped metal insert 7, secured to the sheet metal walls 9 of the fins by any suitable fastenings 8, such as screws, for example. The notch thus is electrically continuous from one outer fin surface to the other.

The radio-frequency energy is fed to the antenna through suitable conductors, such as a coaxial cable 10, 11 consisting of the outer conductor 10 or sheath, and the inner conductor 11. These are connected to opposite faces of the notch, as shown in Fig. 2. It will be seen that the central conductor 11 is connected to the lower surface of the notch, and the sheath 10 is similarly connected to the upper surface. The location of these connections is chosen properly to secure the desired impedance.

In order to tune the antenna to the frequency of the oscillations supplied from the transmitter, a variable capacitor is connected across the notch, usually near the open end of the latter, as shown. The mechanical structure of such a capacitor is shown best in Fig. 4. It comprises essentially a cylindrical head 12, slotted at 13 to receive a screw driver or similar tool whereby it may be turned. A screw threaded stem 14 extends from the other end of the head, whereby the head 12 may be adjusted axially by causing said screw to enter to the desired extent into the threaded bore 15. When the correct position has been found, the stem 14 may be secured against rotation by any suitable means, such as the set screw 16.

The head 12 moves in a cavity formed by a tubular insulating sleeve 17, fittted in a conducting shell 18. The head 12 and the shell 18 form the plates of the capacitor, while the sleeve 17 forms the dielectric. Materials of good electrical quality, such as polystyrene, are suitable dielectrics for the purpose. A protective cap 19 may be provided, to cover the end of the head 12 after proper adjustment has been made, to prevent access of dirt and moisture, which might interfere with the efficient operation of the device.

The details of the electrical connections are shown in Fig. 3 wherein the terminal of the central conductor 11 is shown as a rod threaded at one end into the metal insert 7 and insulated from the other arm of said insert by the bushing 20, where it passes through said arm. The plate 6 is removed whenever it is desired to obtain access to the terminals or to the tuning capacitor, but normally is kept in place to protect them against dirt and moisture, as well as to improve the aerodynamic properties of the fin.

The circuit employed is shown in Fig. 5. The coaxial cable 10, 11 leads from the transmitter 21 to the two sides of the notch 5 in the insert 7. The capacitor C, which comprises the plates 12 and 18 and dielectric 17 shown in detail in Fig. 4, is connected across the two faces of the notch, to provide tuning.

Referring now to Fig. 5*a*, the characteristic dimensions of the notched sheet are shown. Here the sheet is of height *h* and length *l*. The notch is of width W and depth *d*, and its center line is at the distance P from the base of the sheet. The cable is connected to the notch

at the distance T from the inner end thereof, and the tuning reactance is connected at the distance *c* from said inner end.

When *d* is less than about 0.2 wave length, or when greater flexibility of choice of operating frequency is desired, a reactance, here shown as a capacitor, may be connected across the mouth of the notch, as shown. It is possible to match the usual transmission line into such a system provided that the dimensions are of the right order of magnitude for the wave lengths concerned.

Assuming that *d* is less than a quarter wave length, the inductive reactance measured at point T decreases as *d* is diminished. This imposes several requirements. First, a low impedance transmission line can be matched into the notch by proper choice of feed point until the tap occupies a point so near the shorted end of the notch that it becomes difficult to handle properly. Second, the decrease of inductive reactance must be compensated for by increasing the capacity of the tuning condenser. Depths of as little as 1/50 wave length have been satisfactorily matched in the laboratory.

The dimensions *l*, *h*, P and frequency of excitation will determine the radiation pattern resulting from the excitation provided by the notch.

A modified antenna structure is shown in Figs. 8 and 9. The chief difference between this form and the one already described is that in place of the solid metallic insert 7, surrounding the notch, here the notch is filled with an insert 22 made of dielectric material. In order to provide adequate mechanical strength, the insert 22 extends beyond the edges of the individual notches in the walls of the fin 2, and, on the other hand, to provide a conductive surface for the notch, a channel-shaped sheet metal element 23, bent into a U-shape, is mounted around the dielectric 22.

A metal pin or rod 24 passes through the insert 22, and is electrically connected to the lower arm of the element 23 as shown at 25, while the other end of said rod 24 passes through a hole 26 in the upper arm with sufficient clearance to provide electrical insulation therefrom. The said upper arm is connected directly to the sheath 10 of the coaxial cable, as shown. A tuning capacitor 27, similar in construction and purpose to the capacitor shown in Fig. 4, is also provided.

Electrically there is little difference in these two forms. The presence of the dielectric in the notch, which adds mechanical rigidity and provides a smooth outer surface that improves the aerodynamic properties of the fin, detracts slightly from the electrical excellence, but not seriously enough to make its use undesirable.

Although the invention has been disclosed above as applied to a single notch antenna and a single transmitter, obviously it is possible to provide a plurality of notches, even one in each tail fin if desired, and likewise a number of transmitters, connected separately or in parallel, as preferred, to the various antennas.

The radiation pattern obtained from a multiple-element notch-excited antenna may be treated in much the same manner as those of conventional wire or slot multiple element arrays, with the possible difference that the major portion of the radiation emanates from the conducting regions which are driven by the notch exciters.

As the notch antenna has directional characteristics, it is clear that a different pattern of electromagnetic field will result for different positions of the fin that carries the notch. If the missile is rolling, this will result in a rotating "plane of polarization" of the emitted signals. However, this makes no difference if the receiver cooperating with the missile is non-directive, and may sometimes be an advantage with a polarized or "directive" receiver, as it will make possible the determination of the "radial" position of the missile when rolling.

Fig. 6 illustrates the type of pattern that may be expected from a notch antenna in a vertical fin, while Fig. 7 shows that obtained from a notch to the right of the missile, in a horizontal fin, as seen from above. The pattern would of course be reversed for an oppositely extending notched horizontal fin.

Fig. 10 shows another possible arrangement, wherein two notched fins are excited by a transmitter. For comparison, one of the fins will be assumed to be the fin 2 of Fig. 1, already having notch 5 therein, and the other fin will then be fin 4, having a notch 28, similar to notch 5 in all respects, and located symmetrically thereto, with respect to the axis of the missile 1.

The transmitter 21 which may be identical with that of Fig. 5 is shown connected to two phase-adjusting devices 29 and 30 respectively, through its output coaxial cable 10, 11. From the phasing device 29, a coaxial cable 10*a*, 11*a* proceeds to the notch 5 in fin 2, while similarly from the phasing device 30 a second cable 10*b*, 11*b* proceeds to the notch 28 in the radially-opposite fin 4. Adjustment of the two phasing devices 29 and 30 gives control of the relative phases of the excitations of the said two notches.

It will be noted that a very close approach to symmetry in the distribution patterns results, as shown in Figs. 11 and 12, upon careful adjustment of 29 and 30. The phasing devices may be of any suitable types, and customarily include a variable reactance, such as a capacitor and/or inductance, and sometimes also a resistor, or a transmission line having distributed constants.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specificaly described.

What is claimed is:

1. In an antenna system, a conductive sheet having an edge formed with a recess extending from said edge into said sheet, said recess having one end open at the edge, the end remote from said open end of said recess being conductively terminated by said sheet thereby to form a notch, said sheet having a thickness dimension less than that of the depth of the recess, the depth dimension being the longitudinal distance from the open end of the notch to the terminated end thereof, a transmission line having terminals connected to walls defining the recess, said transmission line functioning to introduce electromagnetic energy into the notch for energizing the conductive sheet, and a capacitor having terminals connected to opposite walls defining the notch and being adjustable for resonating said notch.

2. In an antenna system, a conductive sheet having an edge formed with a recess extending from said edge into said sheet, said recess having one end open at the edge, the end remote from said open end of said recess being conductively terminated by said sheet thereby to form a notch, said sheet having a thickness dimension less than that of the depth of the recess, the depth dimension being the longitudinal distance from the open end of the notch to the terminated end thereof, a transmission line having terminals connected to walls defining the recess, said transmission line functioning to introduce electromagnetic energy into the notch for energizing the conductive sheet, and a reactance device having terminals connected to opposite walls defining the notch and being adjustable for resonating said notch.

3. 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.

4. 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.

5. An antenna in the form of a substantially continuous flattened conductive radiating member, said member having a substantially rectangular 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.

6. 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, 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.

7. 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 coupling reactance, and a transmission line connected to opposite edges of said cut-out portion.

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

9. An antenna according to claim 7 in which a transmission line is connected to the said notch adjacent the open end thereof.

10. 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.

11. An antenna according to claim 10 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 10 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 aerial system comprising a metal skinned aerofoil, a non-conductive gap formed in and running into the aerofoil from an edge thereof in a position to intercept a substantial part of any current in the aerofoil at a predetermined operating frequency, the maximum width of the gap being less than the maximum length of the gap measured inwardly of the aerofoil from the said edge and the said maximum length of the gap being small compared with a quarter wavelength at the operating frequency, a conductive sheet part bounding the gap on its sides lying inwardly from the edge, a condenser connected to the sheet part across the mouth of the gap for tuning the gap to resonance about the mid-operating frequency and means for connecting a feed cable to the sheet part at opposite points across the gap at a position where the impedance at the operating frequency most nearly equals the characteristic impedance of the cable.

15. A notch unit for an aircraft aerial system and comprising a U-shaped metallic plate part defining three sides of a non-conductive medium which has the form of a gap formed in and running into an aerofoil from an edge thereof, the maximum width of the gap being less than the maximum length of the gap measured inwardly of the aerofoil from the said edge and the said maximum length being small compared with a quarter wavelength at a predetermined operating frequency, capacity means connected electrically across the two limbs of the U-shaped metallic plate part for tuning the notch unit to resonance and means for connecting a feeder across the two limbs of the metallic plate part.

References Cited in the file of this patent

UNITED STATES PATENTS

2,250,096	Engbert	July 22, 1941
2,276,497	Kroger	Mar. 17, 1942
2,414,266	Lindenblad	Jan. 14, 1947
2,425,303	Carter	Aug. 12, 1947
2,433,368	Johnson et al.	Dec. 30, 1947
2,452,822	Wolf	Nov. 2, 1948
2,479,227	Gilbert	Aug. 16, 1949
2,487,622	Wehner	Nov. 8, 1949
2,507,528	Kandoian	May 16, 1950
2,543,130	Robertson	Feb. 27, 1951
2,543,468	Riblet	Feb. 27, 1951
2,567,220	Litchford	Sept. 11, 1951
2,652,492	Shanklin	Sept. 15, 1953

FOREIGN PATENTS

590,413	Great Britain	July 17, 1947

OTHER REFERENCES

Journal of Institution of Electrical Engineers, vol. 93, part III A, No. 4, May 1946, page 617.

Proc. IRE, vol. 35, No. 12, December 1947 pages 1472–1479.