May 16, 1950 | A. G. KANDOIAN | 2,507,528

ANTENNA

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Fig. 1.

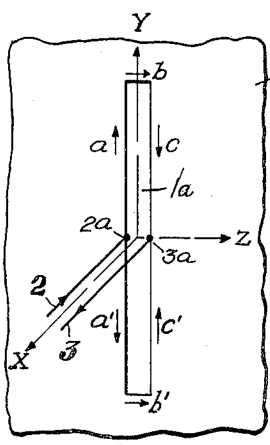

Fig. 2.

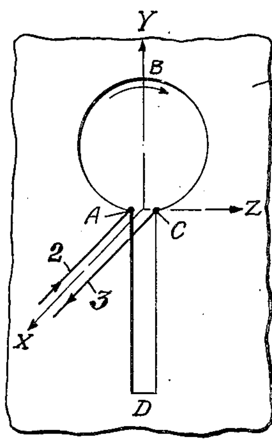

Fig. 3.

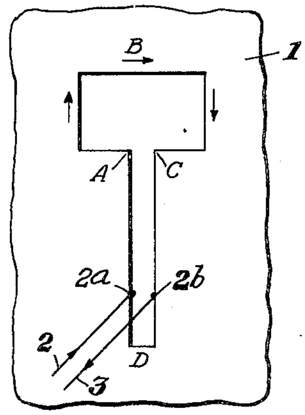

Fig. 4.

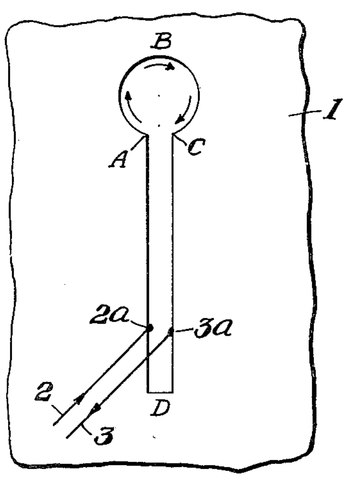

Fig. 5.

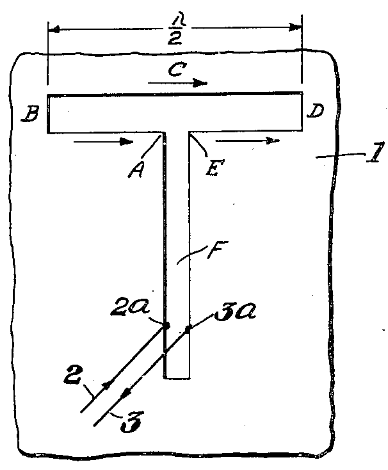

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Fig. 6.

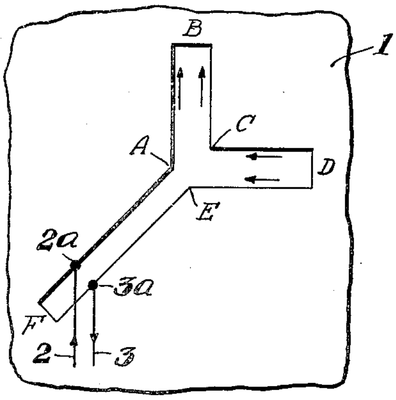


Fig. 7.

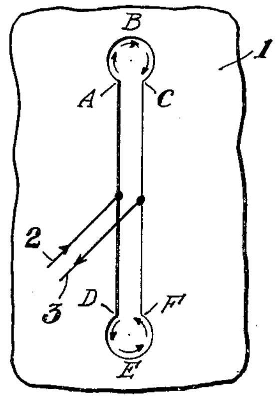


Fig. 8.

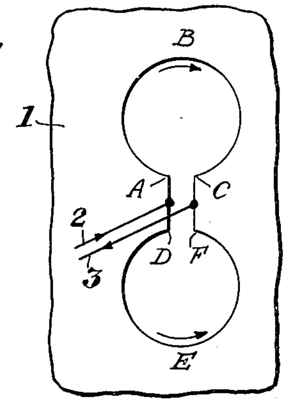


Fig. 9.

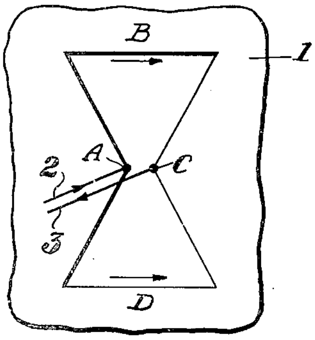


Fig. 10.

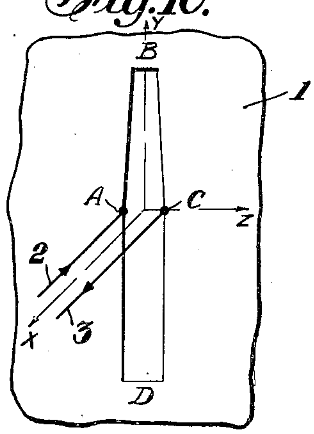
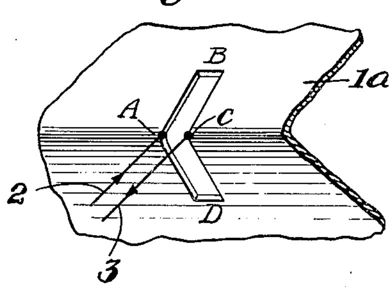


Fig. 11.



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UNITED STATES PATENT OFFICE

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Application August 13, 1945, Serial No. 610,530

3 Claims. (Cl. 250—33.51)

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This invention relates to antenna structures, and especially to structures of the slot antenna type.

One object of the invention is to provide slot antennas less directive than slot antennas heretofore proposed.

Another object of the invention is to devise various forms of slot antennae to suit different radiation requirements.

A further object is to devise slot antenna structures which are suitable for use on aircraft and which may be embodied in the walls or surfaces of the aircraft without increasing the wind resistance of the craft.

Various forms of my invention are illustrated in the accompanying drawings in which:

Fig. 1 shows a simple type of slot antenna heretofore proposed;

Figs. 2 and 3 show two forms of slot antenna according to my invention having radiation characteristics substantially the same as a single dipole antenna;

Fig. 4 shows a slot antenna equivalent to a loop antenna;

Fig. 5 shows a slot antenna equivalent to a folded dipole antenna;

Fig. 6 shows an arrangement equivalent to a folded V antenna;

Fig. 7 shows an arrangement substantially equivalent to two spaced loops excited in out-of-phase relation.

Figs. 8 and 9 show arrangements substantially equivalent to two in-phase dipole antennae;

Fig. 10 shows another form of slot antenna in which the shape of the slot is unsymmetrical on opposite sides of the feeding axis; and

Fig. 11 shows still another embodiment of the invention.

Referring to Fig. 1, a known type of slot antenna is illustrated and comprises a conducting plate 1 having a relatively long and narrow, rectangular slot 1a formed therein, the electrical length of the slot being equal to about one-half the wave length of the operating frequency. The main axis of the slot is along the vertical axis Y and its minor axis is along the axis Z at the plane of the sheet 1 while the axis normal to the plane of sheet 1 is shown at X. The antenna is excited by a balanced transmission line consisting of conductors 2 and 3 connected on opposite sides of the slot at its midpoint. Where the slot has a width which is small by comparison with the wave length being transmitted, and the length of the slot is substantially equal to one-half wave length, the slot acts as a radiating

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antenna having a directive characteristic. Substantially no radiation takes place along the Y and Z axes or in the plane of the sheet 1, and maximum radiation takes place along the X axis which is normal to the plane of sheet 1 and passes through the center of the slot.

A rough analysis of the action of the slot is as follows: The arrows *a*, *b*, *c* and *a'*, *b'*, *c'* represent the direction of current flow around the edges of the slot at a particular instant. In the case of a very narrow slot, the fields of currents *a* and *c* neutralize each other, and the same is true of the fields of currents *a'* and *c'*. In the case of currents *b* and *b'*, due to the relatively wide separation of these currents, the fields do not neutralize each other, and effective radiation takes place from the slot in a manner substantially the same as if two in-phase dipole radiators were located at the two ends of the slot with their axes parallel with the Z axis.

The disadvantage of the arrangement shown in Fig. 1 for general application to aircraft installations is that it has too much directivity, and in many applications it is necessary to have radiation along more than one axis. The antenna structures which I have devised are more suitable for general application and do not have the same highly directive characteristic as the arrangement of Fig. 1.

In Fig. 2, I have shown a slot type of antenna according to my invention for producing a radiation characteristic substantially like that of a single dipole antenna having its axis parallel with the Z axis. In this arrangement a substantially round aperture ABC is formed in the sheet 1 and a narrow gap is formed in the edge of the aperture between the points A and C and therefrom a slot extends down to the point D. The antenna is excited by connection of the balanced lines 2—3 to the points A and C on opposite sides of the gap. The perimeter of aperture ABC is approximately equal to one-half the wave length of the energizing current, and the perimeter of the slot or gap ADC is also approximately equal to one-half the wave length of the energizing current. The slot ADC will have a length equal substantially to one-quarter wave length. With this arrangement there will be substantially no radiation from the gap or slot ADC, and the radiation from the aperture ABC will be substantially the same as in the case of a dipole antenna located at the center of the aperture with its axis parallel to the Z axis. In other words, the much larger aperture ABC at one end of the antenna slot presents a current at

B which, while in phase with the current at D is much greater in amplitude. This provides a preponderance of radiation from the loop end, resulting in radiation in the plane common to the axes X and Y, but no radiation along the X axis.

The point of connection of the lines 2 and 3 to the narrow slot or gap should be at the point of highest impedance, or the point of connection may be selected so that the impedance presented by the slot will match the impedance of the feeder line. This may be accomplished by shifting the point of connection of the lines 2 and 3 along the slot to the desired point, such as shown in Fig. 3.

The arrangement illustrated in Fig. 3 is substantially the same as shown in Fig. 2 except for the shape of the aperture ABC. In this case the aperture has a rectangular shape but the perimeter of the aperture is approximately equal to one-half wave length, and the perimeter of the slot ADC is also approximately equal to one-half wave length. The radiation characteristic of Fig. 3 is substantially like that of Fig. 2.

In Fig. 4, I have illustrated an antenna having a radiation characteristic substantially like that of a loop antenna. This arrangement is substantially the same as that of Fig. 2 except for the dimensions of the aperture ABC and the slot ADC. The substantially circular aperture ABC has a perimeter substantially less than one-half wave length, and preferably not more than a quarter of a wave length. On the other hand, the slot ADC has a total perimeter greater than one-half wave length, and the feeder conductors 2 and 3 are connected to a point of maximum impedance. In this case substantially no radiation takes place from the slot ADC, and the radiation from the aperture ABC is maximum in the plane of the sheet 1 and is substantially the same as in the case of a loop antenna with its plane located in the plane of sheet 1. Further, the longer the slot is, the greater is its radiation resistance, thereby lowering its highest impedance points and raising its lowest impedance points.

The arrangement of Fig. 5 produces a radiation substantially equivalent to a folded dipole antenna. Here an elongated aperture ABCDE is formed in plate 1, and a narrow slot AFE is formed in one side of the aperture at the center thereof and extends at right angles to the aperture. By forming the aperture ABCDE with a length approximately equal to one-half wave length, and with the perimeter of the slot AFE also equal to approximately one-half wave length, the radiation produced from the aperture will be substantially the same as that of a folded dipole antenna. The arrows indicate the direction of current flow for a given instant.

The arrangement of Fig. 6 is equivalent to a folded V type of antenna. In this arrangement the aperture ABCDE is formed with two equal arms located at right angles to each other, and the narrow slot AFE is formed at the outer corner of the arms along an axis which bisects the angle between the arms. By forming the aperture such that the total length of the two arms ABC and CDE is substantially one-half wave length, the relative current directions will be as shown in Fig. 6 and the radiation will be that corresponding to a folded V antenna. It will be noted that the form in Fig. 6 is the form in Fig. 5 folded 90°.

In Fig. 7, I have shown a doublet of the arrangement shown in Fig. 4 which produces a radiation characteristic equivalent to two spaced loops excited in out-of-phase relation. In this arrangement two circular apertures ABC and DEF are formed in plate 1 with a common feeding slot, and both apertures are formed with a perimeter substantially less than one-half wave length as in the case of Fig. 4. The periphery of each half, above and below the connections 2, 3 is equal to approximately one-half wave length. As shown by the arrows in Fig. 7, the two apertures are excited by currents flowing in opposite directions, and the radiations from the two apertures will therefore be 180° out of phase with each other.

In Fig. 8, I have shown a doublet arrangement of the antenna shown in Fig. 2. In this case two circular apertures ABC and DEF are provided with a common feeder slot, and the two apertures are formed so that the total distance from the point of connection of conductor 2 around the perimeter of each aperture to the point of connection of the conductor 3 is equal substantially to one-half wave length. In this case the radiation from the two apertures is substantially the same as from two spaced dipoles excited in the same phase relation. The overall length of this aperture is thus considerably under one-half wave length. Thus, the length as well as the shape of the aperture tend to soften the directivity thereof.

The arrangement illustrated in Fig. 9 produces substantially the same radiation pattern as that shown in Fig. 8. In this case, however, the two apertures are of triangular shape and they merge into each other at the points A—C which constitutes a common gap for the two apertures across which the feeding conductors 2 and 3 are connected. Since parts B and D in Figs. 8 and 9 are spaced a distance less than half a wave length, total cancellation is prevented.

Fig. 10 shows a modified slot type of antenna for producing a radiation along the Y axis. This arrangement is the same as that shown in Fig. 1 except that the upper half of the slot is formed with a tapered shape so that the upper end-edge of the slot is shorter than the lower end-edge. With this arrangement, the fields due to the currents flowing around the upper and lower halves of the aperture or slot will be unsymmetrical and will therefore not completely cancel each other along the Y axis. This result is secured by the fact that the slot or aperture is unsymmetrical on opposite sides of the feeding axis containing the points of connections of the feeding conductors 2 and 3. This same function exists except in a greater degree in the forms shown in Figs. 2 to 5, for example.

In Fig. 11, I show a form of slot substantially as indicated in Fig. 1 but here I distort the slot by bending the sheet 1a containing it. Where the slot is one-half a wave length in length, this distortion shortens the distance between the ends B and D. Thus, while the currents at B and D are in phase, their amplitudes differ so that there is not complete cancellation. If desired, the distortion may be such as to dispose the portions B and D at right angles. The two dipole polarizations will then be in quadrature and will not cancel.

From the foregoing it will be seen that I have devised various antenna arrangements having different radiation patterns from the arrangement shown in Fig. 1. It will be obvious how these arrangements may be embodied in the wall structures of aircraft to produce radiation in one or more desired directions. While my antenna structures are especially suited for use on aircraft, they are not limited to this use but are capable of general application.

While for the purpose of explanation I have described the antenna structures as being excited by a feeder line, it will be understood that the structures are not limited in use for transmitting purposes but are equally useful as receiving antennae. Accordingly, the term "exciting currents" and equivalent terms as used herein are to be interpreted broadly as applying to either a transmitting antenna or a receiving antenna.

I claim:

1. An antenna structure comprising a sheet of conducting material having an aperture formed therein, said aperture having a slot extending therefrom and a pair of feeding conductors connected to points located on opposite sides of said slot, said aperture and slot forming an unsymmetrical shape on opposite sides of the axis passing through said connection points and having unsymmetrical currents in the end portions on opposite sides of said axis.

2. An antenna structure according to claim 1 wherein said slot has a width dimension greater than the maximum width dimension of the aperture portion on the other side of said axis.

3. An antenna structure according to claim 1 wherein the end portions furthest from said axis are less than a half wave length apart.

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