May 28, 1946. A. J. MADDOCK 2,400,937

ANTENNA SYSTEM

Filed Nov. 24, 1942 2 Sheets-Sheet 1

Fig. 1.

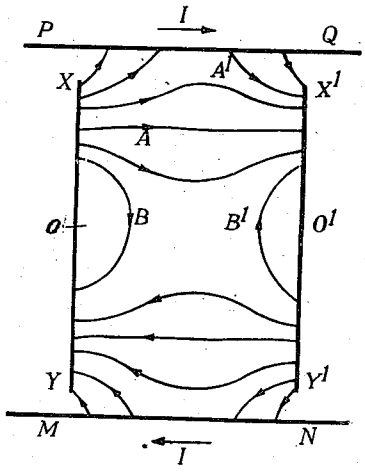
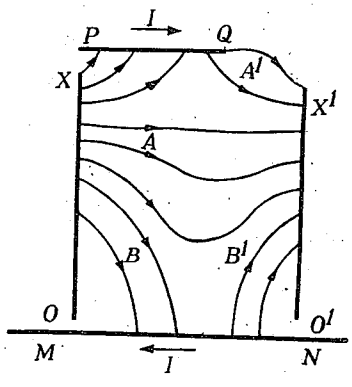


Fig. 2.



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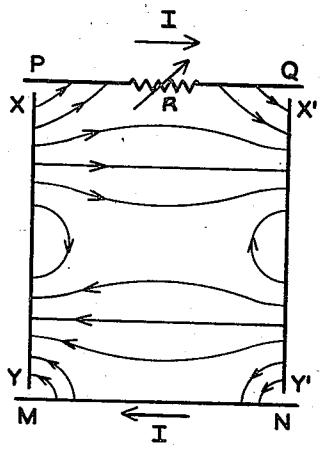


FIG. 3

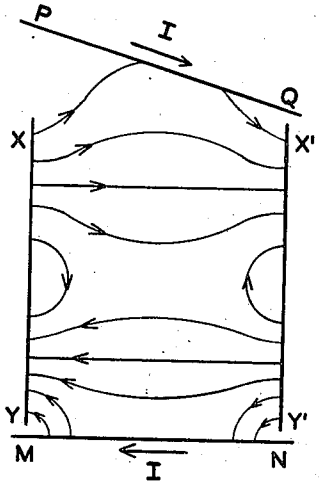


FIG. 5

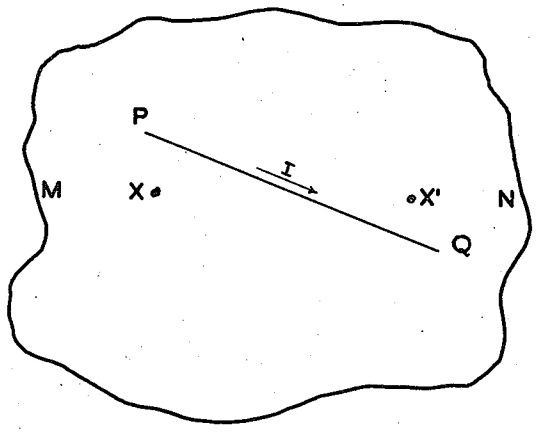


FIG. 4

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ANTENNA SYSTEM

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Application November 24, 1942, Serial No. 466,718
In Great Britain December 9, 1941

9 Claims. (Cl. 250—11)

In radio antenna systems which have directive properties it is often desirable and in many cases necessary that the antenna system should emit radiation of one characteristic polarisation only, while radiation of any other polarisation should be suppressed. For example, in a system employing vertical antennae it is desirable that only waves of vertical polarisation should be emitted while all horizontal polarisation is suppressed and vice versa.

Polarisation of opposite characteristic can arise from currents induced in objects such as screens, towers, etc., which may be present and which can radiate in the unwanted mode. As an example, a directive antenna system consisting of vertical elements placed above the horizontal screened roof of a building or vehicle will radiate mainly waves of vertical polarisation but due partly to the limitation in size of such roof or screen and partly to the different potentials assumed by the various antennae elements near to said surface, currents will flow in the surface and may give rise to radiation which is horizontally polarised. Similarly an array of horizontal elements supported by structures such as metal poles or towers will radiate principally waves of horizontal polarisation but currents will be set up in the vertical members which may then radiate in the vertical mode. A single vertical antenna if located with one end in proximity to a conductor or sheet of limited dimensions can also give rise to horizontal polarisation due to the concentration of the current in the sheet more in one direction than in others.

In many applications it is necessary to suppress these unwanted radiations, and a particular example of a system in which it is essential that this should be done is that in which two or more vertical elements are used to radiate electromagnetic waves which have intersecting polar diagrams in a horizontal plane and in which radiation is modulated in some rhythmic sequence between the two patterns, for example in the form of dots and dashes. With this arrangement an aircraft, fitted with suitable receiving apparatus including a vertical receiving antenna, receives dots or dashes according to the side of the intersecting line on which it is located; and along the line of intersection and for a small angle on each side of it the dots and dashes merge into a continuous signal giving an approach line for the aircraft along which it can be guided. Such systems are well known and in the past have usually taken the form of half-wave vertical elements supported at least a half wavelength above the earth and connected to the transmitter by a suitable transmission line or lines.

It is often desired, however, that the antennae be placed on the top of a building or vehicle which latter contains the transmitter below the antenna system, the roof of said building or vehicle often being screened or covered with mesh for reasons well known to those experienced in the art. As explained above currents set up in the horizontal roof or screen will radiate horizontally polarised waves and it is usually the case that the polar patterns of the radiation emitted in this sense are not the same as those of the primary emission, in this case that due to the vertical antennae. It is apparent then that should the receiving antenna not be vertical, for example in the case of an aeroplane when it banks, then a component of horizontally polarised radiation will be received and it may be that the signal will be of different character, e. g., dots may be received due to the horizontal polarisation where dashes would be received due to the vertically polarised radiation. Similar remarks apply when the main radiation is horizontally polarised.

It is the object of this invention to provide a means for eliminating the radiation of the unwanted characteristic at least over a considerable angle where its effects would be most harmful and in most instances it is found that immunity can be obtained at all points if conditions are satisfied at the most crucial points.

According to the present invention, in an antenna system comprising one or more antennae, which has one end of said antenna or antennae in close proximity to a conducting sheet or other conducting system and from which radiation is emitted polarised in a different sense from the radiation emitted by the main antenna system, a further conducting sheet or other conducting system is placed in close proximity to and beyond a point of the antenna system at which a current reversal takes place, in such manner that a current is induced in said conducting sheet or system in phase opposition to the current already existing in the first mentioned conducting sheet or system.

The conducting systems at both ends of the antenna system may be similar and may comprise, for instance, a conductor or a plurality of conductors suitably positioned, a conducting screen, sheet or mesh or other network of conductors. The said further conducting system may be placed between the ends of the antenna or an-

tennae, or beyond the end thereof remote from the first-mentioned conducting system.

The invention will be further described in conjunction with the accompanying drawings in which:

Fig. 1 shows diagrammatically one form of my invention;

Fig. 2 shows diagrammatically another form of my invention; and

Figs. 3, 4 and 5 show modifications of the embodiment shown in Fig. 1.

For convenience of description in what follows the case of vertical antennae will be treated in detail; but it will be understood that the discussion is equally applicable to the case of horizontal antennae or inclined antennae.

Fig. 1 of the accompanying drawings is a diagrammatic representation of two antennae XY and X'Y' which are symmetrical about the points O and O' and may for example be half-wave antennae. The method of feeding power to the antennae is not shown as it is immaterial to the invention and may be carried out in well-known ways such as centre feeding at the points O and O', end feeding at the points Y and Y', feeding one and exciting the other parasitically and so on. The antennae are considered located above the surface of conductor MN which, as stated hereinbefore may be the roof of a building, vehicle or part of the antenna supporting structure. If the curved lines A, B and A', B', are taken to represent the distribution of electric lines of force at a given instant in the two antennae then it can be seen that since a certain number of lines of force from the bottom ends of the antennae terminate on the conductor MN a difference of potential will exist between the points M and N and a current I will flow in this conductor as shown by the arrow.

The invention consists in placing a similar conductor, plurality of conductors, sheet, or the like PQ above the antennae similarly disposed relative to said antennae as the conductor MN. Then since this is situated at such a position that all voltages in PQ are in phase opposition to those in MN but of equal magnitude, the resulting current in PQ will again be I but will be 180° out of phase with that in MN as shown. The conductors PQ and MN thus act as radiators spaced a distance PM (=QN) apart and carrying currents of equal magnitude but differing in phase by 180°. It is well known that two such antennae spaced any distance apart, give zero field in a region perpendicular to the plane joining them. Thus in the direction perpendicular to the plane of the paper where it is considered in this example that the useful radiation from the vertical antennae is located, the horizontal polarisation which would have been set up by MN has been neutralised by the added conductor PQ.

It is not always necessary that the conductor PQ be placed beyond the ends of the antennae for it is evident that so long as it is placed above the point at which a reversal of potential occurs—in the example considered, that is above the points O and O'—then a current in opposite phase will flow in the conductor and thus tend to neutralise the effect of the current in MN. Control of the current magnitude in the added conductor can then be effected not only by its height above the point of reversal but by its capacity to the main antennae, thus permitting the correcting conductor to be placed only a short distance above the voltage antinode if the capacity is large enough. A further simple method of control, to obtain a large current so that the conductor need not be very far above said point is to make the conductor resonant or nearly so at the operating frequency of the main antennae and to control its magnitude to the correct value for complete cancellation of the unwanted polarisation by alteration of its distance beyond the voltage antinode in the main antennae.

Fig. 2 of the accompanying drawings shows similar conditions for the case of quarter-wave antennae located above a conductor or conductors or surface MN. Here quite appreciable currents flow in MN and even if this is not of limited extent there is a concentration of current between the two antennae due to the mutual coupling between them and horizontal polarisation is usually very evident. The addition of the conductor or screen PQ above the ends of the antennae will annul the effects of this at least in a direction perpendicular to the plane of the paper as it will be seen that here again, a current of exact phase opposition to that in MN can be made to flow in PQ. However in this case, if the conductor PQ were extended to cover a similar area to MN and located only a little way above the points X and X' then a larger current might flow in PQ than in MN since X and X' are points of much greater voltage on the antennae than O and O'. There would then be set up horizontal polarisation in the opposite sense, but this can be overcome and the current in PQ made equal in magnitude but in phase opposition to that in MN either by limiting the length of the conductor PQ until cancellation is effected or by maintaining the length of PQ constant and varying its distance above the points X and X' or by a combination of the two methods or as a further means by moving PQ further from X and X' in a direction at right angles to the plane containing the antennae. By these means also the positions of cancellation in space can be varied at will.

It is evident that the position of the correcting conductor depends on the position of the conductor causing the unwanted polarisation and from what has been said hereinbefore it will be observed that if the initial conducting surface is situated near a voltage node then the correcting conductor may be placed beyond the next voltage antinode (e. g., the half-wave case) and if situated near a voltage antinode then the correcting conductor must be placed beyond the next voltage node (e. g., the quarter-wave case). Other cases correspondingly handled.

A still further method of control of the current magnitude is to insert a resistance in the element PQ by which control can be effected. An embodiment of this modification is shown in Fig. 3 wherein the resistance R in the element PQ controls the current in PQ.

Directional and magnitude control may also be effected by rotation of the compensating conductor or sheet about a vertical axis or about a horizontal axis or combination of the two. Fig. 4 is a plan view illustrating the rotation of conductor PQ about a vertical axis, and Fig. 5 is an elevational view illustrating the rotation of conductor PQ about a horizontal axis.

It will be observed that the arrangements are equally applicable to horizontal antennae when correction must be applied to eliminate vertical polarisation. In this case XY and X'Y' are horizontal radiating elements and PQ and MN vertical members. Further, extension to inclined antennae will now be evident to those skilled in the art.

While the foregoing discussion has dealt with half-wave and quarter-wave antennae the method is equally applicable to antennae of any length, for a position can be chosen for the added conductor which gives a current in phase opposition to that in the surface or conductor which would, of itself, radiate in the unwanted mode.

What is claimed is:

1. In an antenna system including an antenna structure arranged to radiate polarized waves and a first conducting element located in the field of said antenna structure substantially at right angles to said structure, and radiating waves having a different polarization and caused by currents generated in the element by said field, means for neutralizing the waves from said conducting element, comprising a second conducting and energy translating element located in a part of said field characterized by a zone of voltage reversal opposite from that part in which said first conducting element is located, whereby current induced in said second conducting element by said field generates radiated waves of similar plane polarization but of opposed phase to the waves from said first conducting element, also including means for adjusting the energy translation of said second conducting element in said field, to vary the induced current therein and to obtain accurate neutralization of the waves from said first conducting element by the radiation from said second conducting element, said second conducting element lying in a plane substantially parallel to the plane in which said first conducting element lies.

2. An antenna system as set forth in claim 1, in which the second conducting element is made of a length sufficient to pick up and radiate the amount of energy required for such neutralization.

3. An antenna system as set forth in claim 1, in which the antenna structure includes a plurality of antennae arranged along a plane, and in which the second conducting element is located transversely to said plane.

4. An antenna system as set forth in claim 1, in which the second conducting element is resonant to a frequency similar to the operating frequency of the antenna structure.

5. An antenna system as set forth in claim 1, in which the second conducting element is coupled to the antenna structure by the capacity existing therebetween.

6. An antenna system as set forth in claim 1, in which the second conducting element includes a variable energy control resistance.

7. An antenna system as set forth in claim 1, in which the second conducting element is adjustable by rotation into different positions in said field.

8. An antenna system as set forth in claim 1, in which the conducting elements are symmetrically located at opposite ends of the antenna structure.

9. An antenna system as set forth in claim 1, in which the antenna structure comprises a directional beacon the first conducting element is positioned substantially at right angles thereto, and the second conducting element is positioned at right angles to the direction of said beacon, whereby said second element neutralizes waves from said first conducting element in a direction perpendicular to the direction of said beacon.

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